Active Control of Wind Turbines Through Varying Blade Tip Sweep

In this research work an introduction to the concept of an actively controlled horizontal axis wind turbine through varying blade tip sweep, is presented. The concept refers to variable tip swept rotor blades, that have the ability to pivot collectively aft, about an axis located at the blade tips. Quantities to be controlled are power production and blade loads. The investigation is carried out with a modified Blade Element Momentum (BEM) model that takes into account variable tip swept rotor blades and the modifications are based on results from a lifting line theory based model. The simulations refer to the 5MW NREL reference wind turbine that incorporates a suitable controller and preliminary results show beneficial behaviour in all of the investigated areas.
Dynamic Thévenin equivalent and reduced network models for PMU-based power system voltage stability analysis

Measurement-based real-time voltage stability assessment methods typically use a Thévenin Equivalent (TE) model. The TE is computed under the assumption that all generators and loads seen from an individual load-bus are constant during the time-window when measurements are obtained. This assumption does not hold in actual power systems. In fact, load changes at other load-buses result in variations on the voltage of a single-port equivalent model of the power system as seen from a load-bus. To consider these variations, this paper uses an interpolation method to develop a dynamic TE model from synchrophasor measurements, which is suitable for measurement-based real-time voltage stability assessment. In addition, a reduced network model is proposed to separate and quantify the impact of other loads and generators on the voltage stability of an interested load-bus in networks without full observability. The proposed method has been assessed through various simulation scenarios, and illustrated using actual field measurements.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning, Rensselaer Polytechnic Institute
Authors: Bidadfar, A. (Intern), Hooshyar, H. (Ekstern), Vanfretti, L. (Ekstern)
Pages: 126-135
Publication date: 1 Dec 2018
Main Research Area: Technical/natural sciences

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Journal: Sustainable Energy, Grids and Networks
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PMU, Reduced network model, Voltage stability
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http://www.scopus.com/inward/record.url?scp=85049780725&partnerID=8YFLogxK (Link to publication in Scopus)
Source: Scopus
Source-ID: 85049780725
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Experimental investigation on ultimate strength and failure response of composite box beams used in wind turbine blades

This study focuses on the ultimate strength and failure response of composite box beams under three-point bending. The box beams consist of spar caps and shear webs and they are typically used in wind turbine blades as load-carrying members. Different spar cap configurations and loading directions are examined experimentally to investigate structural behavior associated with multiple nonlinearities leading to structural collapse. Global displacements, local strains and video images are recorded throughout the loading history to capture failure initiation, propagation and the strain state contributing to post-collapse characteristics. The failure mechanisms of the box beams involving geometric, material and contact nonlinearities are discussed in detail. The study shows that compressive crushing failure, driven by local buckling of shear webs, determines the ultimate strength of the box beams under flapwise loading, and adhesive joint debonding, initiated by local adhesive cracking and spar cap buckling, is the critical failure mode of the box beams under edgewise loading. The Brazier effect and shear nonlinearity contribute to the initial failure depending on the loading directions. Debonding rather than delamination characterizes post-collapse behavior of all box beams examined in this study.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design, Chinese Academy of Sciences
Probabilistic structural assessment of conical grouted joint using numerical modelling

Conical grouted joints have been proposed as a solution for the relative settlement observed between the sleeve and the pile on monopiles for wind turbines. In this paper, the influence of the design parameters such as steel wall thicknesses and conical angle on the failure modes associated to continual loadings are assessed based on finite element analysis. It is found that both the sleeve's and pile's wall thicknesses have a significant impact on the grouted joint health. Namely, the larger are the wall thicknesses, the more vulnerable the grout is with respect to fatigue and material degradation but the more limited the progressive settlement is, and inversely. This implies that the appropriate wall thicknesses should be chosen by designers having in mind that neither extreme is conservative. Based on statistical modeling, the grout length is found to be the most influential parameter of the settlement caused by extreme loadings: longer grout significantly contributes to the reduction of extreme settlement. To ensure that the inevitable settlement does not jeopardize the joint's structural integrity, a probability-based method has been developed to estimate the minimal gap between the pile top and the brackets required to achieve a targeted annual reliability index (of 3.3).

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Njomo-Wandji, W. (Intern), Natarajan, A. (Intern), Dimitrov, N. (Intern)
Pages: 232-252
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Main Research Area: Technical/natural sciences

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Journal: Ocean Engineering
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Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.7 SJR 1.284 SNIP 1.929
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.46 SJR 1.258 SNIP 1.975
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.235 SNIP 1.908 CiteScore 2.19
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.188 SNIP 2.249 CiteScore 2.11
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.129 SNIP 2.719 CiteScore 2.2
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.14 SNIP 2.407 CiteScore 1.71
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.952 SNIP 2.411 CiteScore 1.85
ISI indexed (2011): ISI indexed yes
Estimation and Control of Wind Turbine Tower Vibrations Based on Individual Blade-Pitch Strategies

In this brief, we present a method to estimate the tower fore-aft velocity based upon measurements from blade load sensors. In addition, a tower dampening control strategy is proposed based upon an individual blade pitch control architecture that employs this estimate. The observer design presented in this brief exploits the Coleman transformations that convert a time-varying turbine model into one that is linear and time-invariant, greatly simplifying the observability analysis and subsequent observer design. The proposed individual pitch-based tower controller is decoupled from the rotor speed regulation loop and hence does not interfere with the nominal turbine power regulation. Closed-loop results, obtained from high fidelity turbine simulations, show close agreement between the tower estimates and the actual tower velocity. Furthermore, the individual-pitch-based tower controller achieves a similar performance compared with the collective-pitch-based approach but with negligible impact upon the nominal turbine power output.

General information
State: Accepted/In press
Organisations: Technical University of Denmark, Department of Wind Energy, Wind turbine loads & control, University of Sheffield
Authors: Lio, W. H. (Intern), Jones, B. L. (Ekstern), Rossiter, J. A. (Ekstern)
Publication date: 16 May 2018
Main Research Area: Technical/natural sciences

Publication information
Journal: IEEE Transactions on Control Systems Technology
ISSN (Print): 1063-6536
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 5.89 SJR 1.832 SNIP 2.728
Web of Science (2017): Indexed Yes
Active damping control, Kalman filter, state estimation of dynamical systems, wind energy.

A conservative approach for mode I-II fatigue analysis under residual stresses: The RSIF proportionality conjecture

Residual stresses are a crucial aspect of fatigue life predictions of welded structures. However, their implementation in fatigue crack growth simulations can be tedious. In this paper, a novel approach is proposed that considers the effects of residual stresses in a worst-case scenario by applying the maximum tangential stress criterion and maximising the crack growth rate. Results demonstrate that computationally demanding analysis of residual stresses can be avoided by assuming the residual stress intensity factors are proportional to the stress intensity factors induced by the externally applied cyclic load. This approach is referred to as the residual stress intensity factors proportionality conjecture, which is particularly useful for inspection planning of complex structures subject to mixed-mode crack propagation situations, where the computational recovery of current residual stress states by consideration of their temporal evolution is cumbersome.

General information
Aerodynamic and load control performance testing of a morphing trailing edge flap system on an outdoor rotating test rig:

Paper
A testing campaign utilizing DTU’s outdoor rotating rig is described, where a novel morphing flap system developed in collaboration with the University of Bristol within the INNWIND.eu project has been evaluated and successfully demonstrated. In addition, the aerodynamic performance of ECN’s newly designed aerofoil has been evaluated in atmospheric conditions. The morphing wing is shown to achieve good performance in terms of aerodynamic lift control, and compares well with computational fluid dynamics predictions. Moreover, simple feed-forward controller implementations, also utilizing inflow sensors, show promising results in terms of dynamic load alleviation.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design, Composites and Materials Mechanics, University of Bristol
Authors: Barlas, T. K. (Intern), Olsen, A. S. (Intern), Madsen, H. A. (Intern), Andersen, T. L. (Intern), Ai, Q. (Ekstern), Weaver, P. M. (Ekstern)
Number of pages: 8
Publication date: 2018
Main Research Area: Technical/natural sciences

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Volume: 1037
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Article number: 022018
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BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.351
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.259 SNIP 0.346
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.264 SNIP 0.301
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.258 SNIP 0.399
Aerodynamic effects of compressibility for wind turbines at high tip speeds

In the present work two dimensional airfoil computations are used to investigate the effects of compressibility in the tip region of large scale wind turbines of 20 MW+ size. In the past application of incompressible CFD solvers have been widespread for wind turbine aerodynamics, due to their efficiency and robustness at the near incompressible conditions experienced near the rotor center. With the increasing size of modern wind turbines and the desire to approach high tip speeds, the incompressible assumption might be violated in the tip region of the turbine. To investigate the effects of compressibility and the possibility of correcting incompressible flow solutions using explicit compressibility corrections, a CFD study of 2D airfoil aerodynamics at conditions of a large scale wind turbine is performed. The present study show that classical compressibility corrections can be successfully applied as a post-processing step to incompressible solutions, reducing the error in the predicted lift and drag to within a few percent for attached flow conditions where viscous effects are limited at Mach numbers upto 0.3.
Aero-elastic Wind Turbine Design with Active Flaps for AEP Maximization

In optimal wind turbine design, there is a compromise between maximizing the energy producing forces and minimizing the absolute peak loads carried by the structures. Active flaps are an attractive strategy because they give engineers greater freedom to vary the aerodynamic forces under any condition. Flaps can be used in a variety of different ways (i.e. reducing fatigue, peak loads etc.), however this article focuses on how quasi-static actuation as a function of mean wind speed can be used for Annual Energy Production (AEP) maximization. Numerical design optimization of the DTU 10MW Reference Wind Turbine (RWT), with the HAWTOpt2 framework, was used to both find the optimal flap control strategy and the optimal turbine designs. The research shows that active flaps can provide a 1% gain in AEP for aero-structurally optimized blades in both add-on (i.e. the flap is added after the blade is designed) and integrated (i.e. the blade design and flap angle is optimized together) solutions. The results show that flaps are complementary to passive load alleviation because they provide high-order alleviation, where passive strategies only provide linear alleviation with respect to average wind speed. However, the changing loading from the flaps further complicates the design of torsionally active blades, thus, integrated design methods are needed to design these systems.
Aero-structural optimization of wind turbine blades using a reduced set of design load cases including turbulence

Modern wind turbine aero-structural blade design codes generally use a smaller fraction of the full design load base (DLB) or neglect turbulent inflow as defined by the International Electrotechnical Commission standards. The current article describes an automated blade design optimization method based on surrogate modeling that includes a very large number of design load cases (DLCs) including turbulence. In the present work, 325 DLCs representative of the full DLB are selected based on the message-passing-interface (MPI) limitations in Matlab. Other methods are currently being investigated, e.g. a Python MPI implementation, to overcome the limitations in Matlab MPI and ultimately achieve a full DLB optimization framework. The reduced DLB and the annual energy production are computed using the state-of-the-art aero-servo-elastic tool HAWC2. Furthermore, some of the interior dimensions of the blade structure are optimized using the finite-element based cross-sectional analysis tool BECAS. The optimization framework is applied to redesign the NREL 5 MW wind turbine blade to obtain improvements in rotor performance and blade weight.
Airfoil Blender for Blade Optimizations

An airfoil database was developed in the present work. The database includes a multivariate, unstructured grid, Radial Basis Function (RBF), optimization-compatible interpolator for airfoil aerodynamic coefficients. The database was designed to aid complex blade design optimizations carried out in a novel optimization framework, HAWTOpt2, being currently developed at DTU Wind Energy. In the database, the lift, drag and moment coefficients are stored as functions of airfoil family, thickness, Reynolds number and angle of attack. Aerodynamic add-ons and airfoil modifications are included in the database as separate airfoil families. Additionally, the database includes two different 3D correction methods and two different 360 degree extrapolation methods. Further, the database stores airfoil coordinates as functions of airfoil family and thickness. Those coordinates may also be interpolated using the RBF method. Present work included a demonstration of the coefficient interpolator in an optimization aimed at indicating the optimal layout of Vortex Generators on eroded blades of the DTU 10MW Reference Wind Turbine in order to maximize the Annual Energy Production.
A multimodal data-set of a unidirectional glass fibre reinforced polymer composite

A unidirectional (UD) glass fibre reinforced polymer (GFRP) composite was scanned at varying resolutions in the micro-scale with several imaging modalities. All six scans capture the same region of the sample, containing well-aligned fibres inside a UD load-carrying bundle. Two scans of the cross-sectional surface of the bundle were acquired at a high resolution, by means of scanning electron microscopy (SEM) and optical microscopy (OM), and four volumetric scans were acquired through X-ray computed tomography (CT) at different resolutions. Individual fibres can be resolved from these scans to investigate the micro-structure of the UD bundle. The data is hosted at https://doi.org/10.5281/zenodo.1195879 and it was used in [1] to demonstrate that precise and representative characterisations of fibre geometry are possible with relatively low X-ray CT resolutions if the analysis method is robust to image quality.

Bibliographical note
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Source-ID: 2435911278
Publication: Research - peer-review › Conference article – Annual report year: 2018

A multimodal data-set of a unidirectional glass fibre reinforced polymer composite

A unidirectional (UD) glass fibre reinforced polymer (GFRP) composite was scanned at varying resolutions in the micro-scale with several imaging modalities. All six scans capture the same region of the sample, containing well-aligned fibres inside a UD load-carrying bundle. Two scans of the cross-sectional surface of the bundle were acquired at a high resolution, by means of scanning electron microscopy (SEM) and optical microscopy (OM), and four volumetric scans were acquired through X-ray computed tomography (CT) at different resolutions. Individual fibres can be resolved from these scans to investigate the micro-structure of the UD bundle. The data is hosted at https://doi.org/10.5281/zenodo.1195879 and it was used in [1] to demonstrate that precise and representative characterisations of fibre geometry are possible with relatively low X-ray CT resolutions if the analysis method is robust to image quality.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Statistics and Data Analysis, Department of Wind Energy, Composites and Materials Mechanics
Authors: Emerson, M. J. (Intern), Dahl, V. A. (Intern), Conradsen, K. (Intern), Mikkelsen, L. P. (Intern), Dahl, A. B. (Intern)
Pages: 1388-1393
Publication date: 2018
Main Research Area: Technical/natural sciences
Analysis of winglets and sweep on wind turbine blades using a lifting line vortex particle method in complex inflow conditions: Paper

An in-house aero-elastic vortex code, called MIRAS, is used to investigate the aerodynamic performance of winglets and sweep on horizontal-axis wind turbine (HAWT) blades in simple and complex inflow conditions. Previous studies using vortex codes applied to study winglets and blade sweep on HAWTs have typically not considered complex inflow conditions such as turbulent wind and shear. The reasons may include the absence of modeling capability, the computational cost associated with simulating long turbulent time series, and/or the computational cost associated with resolving the blade tips to a very fine level. A preliminary study is performed here, where the MIRAS code is applied on the NREL 5MW wind turbine with an arbitrary winglet shape and blade sweep. Results indicate that wind turbine blades with sweep or winglets might be better in performance compared to their straight blade counterparts.
An Analytical Model for the Effect of Vertical Wind Veer on Wind Turbine Wakes

In this study, an analytical wake model for predicting the mean velocity field downstream of a wind turbine under veering incoming wind is systematically derived and validated. The new model, which is an extended version of the one introduced by Bastankhah and Porté-Agel, is based upon the application of mass conservation and momentum theorem and considering a skewed Gaussian distribution for the wake velocity deficit. Particularly, using a skewed (instead of axisymmetric) Gaussian shape allows accounting for the lateral shear in the incoming wind induced by the Coriolis force. This analytical wake model requires only the wake expansion rate as an input parameter to predict the mean wake flow downstream. The performance of the proposed model is assessed using the large-eddy simulation (LES) data of a full-scale wind turbine wake under the stably stratified condition. The results show that the proposed model is capable of predicting the skewed structure of the wake downwind of the turbine, and its prediction for the wake velocity deficit is in good agreement with the high-fidelity simulation data.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Aarhus University, Ecole Polytechnique Federale de Lausanne (EPFL)
Authors: Abkar, M. (Ekstern), Sørensen, J. (Intern), Porté-Agel, F. (Ekstern)
Publication date: 2018
Main Research Area: Technical/natural sciences

Publication information
Journal: Energies
Volume: 11
Issue number: 7
Article number: 1838
ISSN (Print): 1996-1073
Ratings:
BFI (2018): BFI-level 2
Application for planning purposes: Interim High-Resolution Wind Resource Map for Strategic Environmental Assessment in South Africa

General information
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Organisations: Department of Wind Energy, Resource Assessment Modelling, Integration & Planning, Council for Scientific and Industrial Research
Authors: Mortensen, N. G. (Intern), Hahmann, A. N. (Intern), Hansen, J. C. (Intern), Mabille, E. (Ekstern), Prinsloo, E. (Ekstern)
Number of pages: 21
Publication date: 2018

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Original language: English
Main Research Area: Technical/natural sciences
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Source-ID: 2437796474
Publication: Research - peer-review › Journal article – Annual report year: 2018

WASA_2_Application_for_planning_purposes.pdf
Source: PublicationPreSubmission
Source-ID: 149771081
Publication: Research › Sound/Visual production (digital) – Annual report year: 2018
Assessing the Utility of Early Warning Systems for Detecting Failures in Major Wind Turbine Components

This paper provides enhancements to normal behaviour models for monitoring major wind turbine components and a methodology to assess the monitoring system reliability based on SCADA data and decision analysis. Typically, these monitoring systems are based on fully data-driven regression of damage sensitive-parameters. Firstly, the problem of selecting suitable inputs for building a temperature model of operating main bearings is addressed, based on a sensitivity study. This shows that the dimensionality of the dataset can be greatly reduced while reaching sufficient prediction accuracy. Subsequently, performance quantities are derived from a statistical description of the prediction error and used as input to a decision analysis. Two distinct intervention policies, replacement and repair, are compared in terms of expected utility. The aim of this study is to provide a method to quantify the benefit of implementing the online system from an economic risk perspective. Under the realistic hypotheses made, the numerical example shows for instance that replacement is not convenient compared to repair.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design, University of Zaragoza, Technical University of Munich
Authors: Colone, L. (Intern), Reder, M. (Ekstern), Dimitrov, N. K. (Intern), Straub, D. (Ekstern)
Number of pages: 10
Publication date: 2018

Assessment and propagation of mechanical property uncertainties in fatigue life prediction of composite laminates

A probabilistic model for estimating the fatigue life of laminated composite materials considering the uncertainty in their mechanical properties is developed. The uncertainty in the material properties is determined from fatigue coupon tests. Based on this uncertainty, probabilistic constant life diagrams are developed which can efficiently estimate probabilistic $\Delta$-N curves at any load level and stress ratio. The probabilistic $\Delta$-N curve information is used in a reliability analysis for fatigue limit state proposed for estimating the probability of failure of composite laminates under variable amplitude loading cycles. Fatigue life predictions of unidirectional and multi-directional glass/epoxy laminates are carried out to validate the proposed model against experimental data. The probabilistic fatigue behavior of laminates is analyzed under constant amplitude loading conditions as well as under both repeated block tests and spectral fatigue using the WISPER, WISPERX, and NEW WISPER load sequences for wind turbine blades.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Castro, O. (Intern), Branner, K. (Intern), Dimitrov, N. K. (Intern)
Publication date: 2018
Main Research Area: Technical/natural sciences

Assessment and propagation of mechanical property uncertainties in fatigue life prediction of composite laminates

A probabilistic model for estimating the fatigue life of laminated composite materials considering the uncertainty in their mechanical properties is developed. The uncertainty in the material properties is determined from fatigue coupon tests. Based on this uncertainty, probabilistic constant life diagrams are developed which can efficiently estimate probabilistic $\Delta$-N curves at any load level and stress ratio. The probabilistic $\Delta$-N curve information is used in a reliability analysis for fatigue limit state proposed for estimating the probability of failure of composite laminates under variable amplitude loading cycles. Fatigue life predictions of unidirectional and multi-directional glass/epoxy laminates are carried out to validate the proposed model against experimental data. The probabilistic fatigue behavior of laminates is analyzed under constant amplitude loading conditions as well as under both repeated block tests and spectral fatigue using the WISPER, WISPERX, and NEW WISPER load sequences for wind turbine blades.

General information
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Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Castro, O. (Intern), Branner, K. (Intern), Dimitrov, N. K. (Intern)
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Main Research Area: Technical/natural sciences

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Article number: 002199831876562
ISSN (Print): 0021-9983
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.57 SJR 0.555 SNIP 0.898
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.42 SJR 0.528 SNIP 0.803
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.573 SNIP 0.876 CiteScore 1.4
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.612 SNIP 1.188 CiteScore 1.44
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.625 SNIP 1.186 CiteScore 1.45
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.599 SNIP 1.239 CiteScore 1.21
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.649 SNIP 1.242 CiteScore 1.23
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.667 SNIP 1.093
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.721 SNIP 1.055
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.782 SNIP 1.131
Scopus rating (2007): SJR 0.703 SNIP 1.203
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.6 SNIP 1.257
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.732 SNIP 1.16
Scopus rating (2004): SJR 0.767 SNIP 1.092
Scopus rating (2003): SJR 0.693 SNIP 0.945
Scopus rating (2002): SJR 1.525 SNIP 1.29
Scopus rating (2001): SJR 1.247 SNIP 1.48
Scopus rating (2000): SJR 1.155 SNIP 1.588
Scopus rating (1999): SJR 1.16 SNIP 1.332
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Publication: Research - peer-review › Journal article – Annual report year: 2018
Assessment of inflow boundary conditions for RANS simulations of neutral ABL and wind turbine wake flow

It is known that wind turbines actually operate in the lower part of the atmospheric boundary layer (ABL), the modelling of this ABL flow is an important precondition for the simulations of wind turbine wakes. So, the capabilities of various inlet boundary conditions with related modelling methodologies in constructing equilibrium ABL are assessed firstly through cases of ABL flows over uniformly rough terrain, to ascertain that there are no substantial changes in the prescribed profiles throughout the whole computational domain. In this process, six popular turbulence inflow profiles, including four uniform and two non-uniform ones, are considered and investigated. Then, sensitivity studies on inflow profiles for predicting wind turbine wake development are carried out. Through comparing with the Sexbierum field experimental data, in terms of wake velocity and turbulence intensity along the cross-wind direction at several downstream positions, this study finds out that the shape and magnitude of wake velocity and wake turbulence profiles are significantly affected by different inflow profiles. Possible reasons for this sensibility are discussed, and accordingly, some suggestions are given to improve the accuracy of wind turbine wake simulation.

General information
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Organisations: Department of Wind Energy, Fluid Mechanics, Nanjing University of Aeronautics and Astronautics
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Main Research Area: Technical/natural sciences

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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
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Scopus rating (2017): CiteScore 3.42 SJR 1.264 SNIP 2.071
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.61 SJR 0.992 SNIP 1.929
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.976 SNIP 1.939 CiteScore 2.51
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.902 SNIP 2.282 CiteScore 2.13
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.8 SNIP 2.68 CiteScore 2.43
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.642 SNIP 2.431 CiteScore 1.81
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.902 SNIP 3.236 CiteScore 2.3
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.907 SNIP 2.197
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.737 SNIP 1.406
BFI (2008): BFI-level 1
A systematic approach to transforming composite 3d images into meso-scale computational models

High performance polymer matrix composites (PMC) have a high specific stiffness and can be used to easily manufacture highly complex components. Many types of defects can occur during molding. Flaws and damage degrade the resulting mechanical properties of the composites material. It is difficult to assess the actual stiffness, strength and fatigue limit of flawed and damaged structures. Among these the fatigue limit is the most difficult to predict. Through a combination of modern imaging techniques and finite element analysis of in-situ fiber bundles, it is now becoming possible to estimate fatigue limits for polymer matrix composites structures with flaws or damage. Composite materials can be imaged with 3D X-ray Computed Tomography (CT) in a sufficient detail to view 3D fiber bundle matrix interfaces. These images can then be directly imported into physical models to be used in finite element analysis. The process of converting these images into computer models for analysis is currently extremely time consuming, difficult and subjective. The method presented here has been developed to bridge this gap.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Department of Wind Energy, Chalmers University of Technology, Waseda University
Authors: Blinzler, B. (Ekstern), Wilhelsson, D. (Ekstern), Asp, L. E. (Ekstern), Jespersen, K. (Ekstern), Mikkelsen, L. P. (Intern)
Number of pages: 6
Publication date: 2018
Main Research Area: Technical/natural sciences
Electronic versions:
A_Systematic_Approach_to_Transforming_ECCM18.pdf

Atmospheric stability and topography effects on wind turbine performance and wake properties in complex terrain

This paper evaluates the influence of atmospheric stability and topography on wind turbine performance and wake properties in complex terrain. To assess atmospheric stability effects on wind turbine performance, an equivalent wind speed calculated with the power output and the manufacture power curve is proposed and calibrated with the mast hub-height wind speed. After estimating the thrust coefficient and turbulence dissipation, this paper examines wind turbine performance curves and wake profiles segregated by atmospheric stability. Results show that the equivalent wind speed at a given mast wind speed can increase by 2% under stable conditions and decrease by 5% under unstable conditions as compared with that under neutral conditions, yielding about 16% reductions of power output and thrust coefficient from stable conditions to unstable conditions. Due to the lower thrust coefficient and the enhanced turbulence, the wind turbine wakes are found to recover faster under unstable conditions than under other stability conditions. Differences in wind turbine performance and asymmetric wake profiles due to topographic effects are also observed. Results suggest that
atmospheric stability and topography have significant influences on wind turbine performance and wake properties. Considering effects of atmospheric stability and topography will benefit the wind resource assessment in complex terrain.

**General information**

State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Hohai University
Authors: Han, X. (Ekstern), Liu, D. (Ekstern), Xu, C. (Ekstern), Shen, W. Z. (Intern)
Pages: 640-651
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- Web of Science (2018): Indexed yes
- BFI (2017): BFI-level 1
- Scopus rating (2017): CiteScore 5.38 SJR 1.847 SNIP 2.008
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 1
- Scopus rating (2016): CiteScore 4.83 SJR 1.661 SNIP 2.05
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 1
- Scopus rating (2015): SJR 1.767 SNIP 2.085 CiteScore 4.51
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 1
- Scopus rating (2014): SJR 1.925 SNIP 2.621 CiteScore 4.51
- Web of Science (2014): Indexed yes
- BFI (2013): BFI-level 1
- Scopus rating (2013): SJR 1.989 SNIP 2.719 CiteScore 4.63
- ISI indexed (2013): ISI indexed yes
- Web of Science (2013): Indexed yes
- BFI (2012): BFI-level 1
- Scopus rating (2012): SJR 1.787 SNIP 2.699 CiteScore 3.97
- ISI indexed (2012): ISI indexed yes
- Web of Science (2012): Indexed yes
- BFI (2011): BFI-level 1
- Scopus rating (2011): SJR 1.634 SNIP 2.349 CiteScore 3.9
- ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 1
- Scopus rating (2010): SJR 1.459 SNIP 2.215
- Web of Science (2010): Indexed yes
- BFI (2009): BFI-level 1
- Scopus rating (2009): SJR 1.272 SNIP 1.963
- Web of Science (2009): Indexed yes
- BFI (2008): BFI-level 2
- Scopus rating (2008): SJR 1.436 SNIP 1.891
- Web of Science (2008): Indexed yes
- Scopus rating (2007): SJR 1.194 SNIP 1.63
- Web of Science (2007): Indexed yes
- Scopus rating (2006): SJR 1.112 SNIP 1.469
- Web of Science (2006): Indexed yes
- Scopus rating (2005): SJR 1.177 SNIP 1.271
Blade-Pitch Control for Wind Turbine Load Reductions

Large wind turbines are subjected to the harmful loads that arise from the spatially uneven and temporally unsteady oncoming wind. Such loads are the known sources of fatigue damage that reduce the turbine operational lifetime, ultimately increasing the cost of wind energy to the end-users. In recent years, a substantial amount of studies has focused on blade pitch control and the use of real-time wind measurements, with the aim of attenuating the structural loads on the turbine blades and rotor. However, many of the research challenges still remain unsolved. For example, there are many classes of blade individual pitch control (IPC) techniques, but the link between these different but competing IPC strategies was not well investigated. In addition, another example is that many studies employed model predictive control (MPC) for its capability to handle the constraints of the blade pitch actuators and the measurement of the approaching wind, but often, wind turbine control design specifications are provided in frequency domain that is not well taken into account by the standard MPC. To address the missing links in various classes of the IPCs, this thesis aims to investigate and understand the similarities and differences between each of their performance. The results suggest that the choice of IPC designs rests largely with preferences and implementation simplicity. Based on these insights, a particular class of the IPCs lends itself readily for extracting tower motion from measurements of the blade loads. Thus, this thesis further proposes a tower load reduction control strategy based solely upon the blade load sensors. To tackle the problem of MPC on wind turbines, this thesis presents an MPC layer design upon a predetermined robust output-feedback controller. The MPC layer handles purely the feed-forward and constraint knowledge, whilst retaining the nominal robustness and frequency-domain properties of the predetermined closed loop. Thus, from an industrial perspective, the separate nature of the proposed control structure offers many immediate benefits. Firstly, the MPC control can be implemented without replacing the existing feedback controller. Furthermore, it provides a clear framework to quantify the benefits in the use of advance real-time measurements over the nominal output-feedback strategy.
Calibrating a wind turbine model using diverse datasets

This paper presents a model calibration investigation using a wide range of available data. The wind turbine under investigation was the V52 research turbine located at Denmark Technical University (DTU) Risø campus. The data included drawings and static and dynamic tests for both the entire wind turbine and the isolated blades. Each set of data was used to calibrate some aspect of the final model. There are three main parts of this paper. First, the different data sources are outlined, including an overview of the experimental procedures and the key results. Second, the model calibration procedure for each set of experimental data is explained. Third, recommendations for the calibration procedure are presented for future researchers and the key outcomes of our calibration investigation are discussed.

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control, University of Southern Denmark
Authors: Rinker, J. M. (Intern), Hansen, M. H. (Ekstern), Larsen, T. J. (Intern)
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BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
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Web of Science (2014): Indexed yes
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Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
ISI indexed (2011): ISI indexed no
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Scopus rating (2010): SJR 0.288 SNIP 0.351
Web of Science (2010): Indexed yes
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Scopus rating (2009): SJR 0.259 SNIP 0.346
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.264 SNIP 0.301
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.258 SNIP 0.399
Web of Science (2007): Indexed yes
CFD Simulations of Flows in a Wind Farm in Complex Terrain and Comparisons to Measurements

This article describes Computational Fluid Dynamics (CFD) simulations of flows in a wind farm in complex terrain in Shaanxi, China and the comparisons of the computational results with utility scale field measurements. The CFD simulations performed in the study are using either a Reynolds-Averaged Navier–Stokes (RANS) or Large-Eddy Simulation (LES) solver. The RANS method together with an Actuator Disc (AD) approach is employed to predict the performance of the 25 wind turbines in the farm, while the LES and Actuator Line (AL) technique is used to obtain a detailed description of the flow field around a specific wind turbine #14 near two met masts. The AD-RANS simulation results are compared with the mean values of power obtained from field measurements. Furthermore, the AL-LES results are compared with the mean values of power, rotor speed, and wind speed measured from the wind turbine and its nearby two masts. Results from the simulations indicate that both AD-RANS and AL-LES methods can reasonably predict the performance of the wind farm and wind turbine #14, respectively, in complex terrain in Shaanxi. The mean percent difference obtained for power in the AD-RANS simulations was approximately 20%. Percent differences obtained for power and rotor RPM in the AL-LES varied between 0.08% and 11.6%. The mean percent differences in the AL-LES for power and rotor RPM are approximately 7% and 1%, respectively.

Challenges in using scanning lidars to estimate wind resources in complex terrain

Pairs of synchronously scanning Doppler lidars measure the average wind speed of flows crossing the parallel ridges at Perdígado, Portugal, with the ultimate purpose of wind resource estimation. The availability of the data from the lidars when they are running is quite low (50–70%). Furthermore, the instruments did only run less than half the time of the experimental period. These figures have to be improved in order for scanning lidars to be a viable option for wind resource
estimation. The variations along the ridges are compared to neutral LES calculations making a good match at the upstream ridge but a significantly worse prediction at the downstream ridge. One reason could be an insufficient representation of the terrain. Another unknown is the influence of the atmospheric stability on the flow which is clearly seen by the scanning lidars.

**General information**

State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling, Aerodynamic design
Authors: Mann, J. (Intern), Menke, R. (Intern), Vasiljević, N. (Intern), Berg, J. (Intern), Troldborg, N. (Intern)
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  - BFI (2016): BFI-level 1
  - Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
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  - BFI (2015): BFI-level 1
  - Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
  - Web of Science (2015): Indexed yes
  - BFI (2014): BFI-level 1
  - Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
  - Web of Science (2014): Indexed yes
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  - BFI (2012): BFI-level 1
  - Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
  - ISI indexed (2012): ISI indexed no
  - BFI (2011): BFI-level 1
  - Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
  - ISI indexed (2011): ISI indexed no
  - BFI (2010): BFI-level 1
  - Scopus rating (2010): SJR 0.288 SNIP 0.351
  - Web of Science (2010): Indexed yes
  - BFI (2009): BFI-level 1
  - Scopus rating (2009): SJR 0.259 SNIP 0.346
  - BFI (2008): BFI-level 1
  - Scopus rating (2008): SJR 0.264 SNIP 0.301
  - Web of Science (2008): Indexed yes
  - Scopus rating (2007): SJR 0.258 SNIP 0.399
  - Web of Science (2007): Indexed yes
  - Scopus rating (2006): SJR 0.272 SNIP 0.311
  - Web of Science (2006): Indexed yes
Characterization report of selected RET and SPIFT samples characterized by electron microscopy and X-ray tomography

RET (rain erosion test) samples tested to failure were investigated by electron microscopy at locations with surface erosion, close to areas with surface erosion and very far from the eroded area. In all three cases, cracks were found at the peel-ply interface and at the outermost interface of the laminate. The top coating was found to contain flaky particles consisting of a compound of Si, Al and K. Cracks were seen to develop at the flaky particles close to eroded areas and evidence of degradation by spalling from the flaky particles were found. The top coating was observed to have a high porosity and microscopic cracks was found connecting the holes in the porous structure. A black interface was observed through the whole sample in both the top coating and the filler, indicating that they have been applied as several layers. The black line in the filler was observed to have a porous structure most likely caused by microscopic bubbles. SPIFT samples (single point impact fatigue tester) tested to failure had cracks close to the degraded area that were pointing directly into the top coating and no cracks at the flaky particles in the top coating. In the SPIFT sample tested with 100 impacts at 150 m/s no visual damage was observed on the surface but a crack was observed by X-ray tomography below the surface at the location of the black interface line in the filler. Based on the observations it is concluded that the RET and SPIFTs tests seem to activate different damage mechanisms in the samples. However, a more detailed study needs to be carried out to compare the two methods at all stages of the damage.
Community benefits from offshore renewables: The relationship between different understandings of impact, community, and benefit

This paper presents the findings of a research project evaluating community benefit models for offshore renewables. We identify and analyse UK and international case studies of different forms of community benefit, and provide evidence of how such benefits are delivered. In particular we consider the key relationship between the identification of communities, perception of impact, and the apportionment of benefits. In doing so, we develop a range of different definitions of 'community', 'benefit', and 'impact' when considering community benefits. We propose that the way in which community, benefit, and impact are understood is crucial in determining whether or how benefits should be apportioned and delivered; and that these definitions are closely connected to each other. We develop a new series of typologies as a way to understand this. Finally, we assess different mechanisms and schemes of community benefits to identify good practice and key points of learning for policy and planning.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning, University of Edinburgh
Authors: Rudolph, D. P. (Intern), Haggett, C. (Ekstern), Aitken, M. (Ekstern)
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Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): SNIP 0.89 SJR 0.965 CiteScore 2.01
Web of Science (2017): Indexed Yes
Scopus rating (2016): CiteScore 1.59 SJR 0.934 SNIP 0.947
Scopus rating (2015): SJR 1.509 SNIP 1.496 CiteScore 2.65
Scopus rating (2014): SJR 1.04 SNIP 1.297 CiteScore 1.73
Scopus rating (2013): SJR 0.862 SNIP 1.064 CiteScore 1.58
Scopus rating (2012): SJR 0.87 SNIP 1.018 CiteScore 1.37
Scopus rating (2011): SJR 0.98 SNIP 1.201 CiteScore 1.44
Scopus rating (2010): SJR 1.05 SNIP 1.106
Scopus rating (2009): SJR 0.848 SNIP 1.181
Scopus rating (2008): SJR 0.628 SNIP 1.064
Comparison of 3D transitional CFD simulations for rotating wind turbine wings with measurements: Paper

Since the investigation of van Ingen et al., attempts were undertaken to search for laminar parts within the boundary layer of wind turbines operating in the lower atmosphere with much higher turbulence levels than seen in wind tunnels or at higher altitudes where airplanes usually fly. Based on the results of the DAN-Aero experiment and the Aerodynamic Glove project, a special work package Boundary Layer Transition was embedded in IAEwind Task 29 MexNext 3rd phase (MN3).

Here, we report on the results of the application of various CFD tools to predict transition on the MEXICO blade. In addition, recent results from a comparison of thermographic pictures (aimed at detecting transition) with 3D transitional CFD are included as well. The MEXICO (2006) and NEW MEXICO (2014) wind tunnel experiments on a turbine equipped with three 2.5 m blades have been described extensively in the literature. In addition, during MN3, high-frequency Kulite data from experiments were used to detect traces of transitional effects. Complementary, the following set of codes were applied to cases 1.1 and 1.2 (axial inflow with 10 m/s and 15 m/s respectively) – elsA, CFX, OpenFOAM (with 2 different turbulence/transitional models), Ellipsys, (with 2 different turbulence models and eN transition prediction tool), FLOWer and TAU – to search for detection of laminar parts by means of simulation. Obviously, the flow around a rotating blade is much more complicated than around a simple 2D section. Therefore, results for even integrated quantities like thrust and torque are varying strongly. Nevertheless, visible differences between fully turbulent and transitional set-ups are present. We discuss our findings, especially with respect to turbulence and transition models used.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design, Fachhochschule Kiel - University of Applied Sciences Kiel, ONERA, ECN, University of Oldenburg, University of Stuttgart, Fraunhofer Institute for Wind Energy and Energy System Technology (IWES)
Authors: Schaffarczyk, A. P. (Ekstern), Boisard, R. (Ekstern), Boorsma, K. (Ekstern), Dose, B. (Ekstern), Lienard, C. (Ekstern), Lutz, T. (Ekstern), Madson, H. Å. (Intern), Rahimi, H. (Ekstern), Reichstein, T. (Ekstern), Scheper, G. (Ekstern), Sørensen, N. (Intern), Stoevesandt, B. (Ekstern), Weiheing, P. (Ekstern)
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BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35

Aero-elastic solver predictions are compared to measured data from the NENUPHAR's 1HS prototype, with a focus on the blade loads. Two solvers are investigated, namely the HAWC2 solver, and DeepLinesWindTM, respectively based on a linear and a non-linear formulation of the Timoshenko beam theory. Various aerodynamic models are used, from simple Multiple Streamtube models up to the Actuator-Cylinder flow model and 2D/3D Vortex flow solvers. A special attention is also given to the influence of the dynamic stall on the results. Aero-elastic solvers predictions are accurate and fit well with the measured blade loads, but this work emphasizes the fact that suitable aerodynamic model and stall model should be used.

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control, Aerodynamic design, IFP Energies nouvelles, Nenuphar
Authors: Blondel, F. (Ekstern), Galinos, C. (Intern), Paulsen, U. (Intern), Bozonnet, P. (Ekstern), Cathelain, M. (Ekstern), Ferrer, G. (Ekstern), Madsen, H. A. (Intern), Pirrung, G. (Intern), Silvert, F. (Ekstern)
Number of pages: 11
Publication date: 2018
Comparison of four large-eddy simulation research codes and effects of model coefficient and inflow turbulence in actuator-line-based wind turbine modeling

Large-eddy simulation (LES) of a wind turbine under uniform inflow is performed using an actuator line model (ALM). Predictions from four LES research codes from the wind energy community are compared. The implementation of the ALM in all codes is similar and quantities along the blades are shown to match closely for all codes. The value of the Smagorinsky coefficient in the subgrid-scale turbulence model is shown to have a negligible effect on the time-averaged loads along the blades. Conversely, the breakdown location of the wake is strongly dependent on the Smagorinsky coefficient in uniform laminar inflow. Simulations are also performed using uniform mean velocity inflow with added homogeneous isotropic turbulence from a public database. The time-averaged loads along the blade do not depend on the inflow turbulence. Moreover, and in contrast to the uniform inflow cases, the Smagorinsky coefficient has a negligible effect on the wake profiles. It is concluded that for LES of wind turbines and wind farms using ALM, careful implementation and extensive cross-verification among codes can result in highly reproducible predictions. Moreover, the characteristics of the inflow turbulence appear to be more important than the details of the subgrid-scale modeling employed in the wake, at least for LES of wind energy applications at the resolutions tested in this work.

General information
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Organisations: Department of Wind Energy, Fluid Mechanics, Johns Hopkins University, National Renewable Energy Laboratory, KU Leuven
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.41 SJR 0.44 SNIP 0.588
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.2 SJR 0.416 SNIP 0.55
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.369 SNIP 0.534 CiteScore 1.02
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.407 SNIP 0.712 CiteScore 1.05
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Comparison of Levelized Cost of Energy of superconducting direct drive generators for a 10 MW offshore wind turbine

A method for comparing the Levelized Cost of Energy (LCoE) of different superconducting drive trains is introduced. The properties of a 10 MW MgB$_2$ superconducting direct drive generator are presented in terms weight scaled to a turbine with a rotor diameter up of 280 m and the cost break down of the nacelle components. The partial load efficiency of the generator is evaluated for a constant cooling power of 0, 50 kW and 100 kW and the annual energy production is used to determine the impact on Levelized Cost of Energy.

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Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design, Delft University of Technology
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.45 SJR 0.408 SNIP 0.962
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.42 SJR 0.398 SNIP 1.145
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.403 SNIP 1.06 CiteScore 1.27
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.478 SNIP 1.13 CiteScore 0.83
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.443 SNIP 1.156 CiteScore 1.32
ISI indexed (2013): ISI indexed yes
Comparisons of winds from satellite SAR, WRF and SCADA to characterize coastal gradients and wind farm wake effects at Anholt wind farm

General information
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Authors: Hasager, C. B. (Intern), Ahsbahs, T. T. (Intern), Badger, M. (Intern), Hansen, K. S. (Intern), Volker, P. (Intern)
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Computational fluid dynamics-based surrogate optimization of a wind turbine blade tip extension for maximising energy production

This article presents a design study into the redesign of a wind turbine blade tip seeking to increase the energy production subject to the loads constraints of the existing blade. The blade shape is parameterized to allow for planform changes in the tip region with respect to chord, twist and blade length extension, and additionally three parameters that allow to explore winglet-like shapes. The design strategy uses 3D computational fluid dynamics computations of the geometrically resolved rotor to create a surrogate model, after which the tip shape is numerically optimized based on the surrogate model, subject to a number of geometric and loads-based constraints. The study shows that it is possible to increase power production by 2.6% for a blade extension with a winglet, without increasing the flapwise bending moment at 90% radius, whereas for a straight blade extension it was only possible to achieve an increase of 0.76%.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design
Authors: Zahle, F. (Intern), Sørensen, N. N. (Intern), McWilliam, M. K. (Intern), Barlas, A. (Intern)
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BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed no
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BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.351
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.259 SNIP 0.346
BFI (2008): BFI-level 1
Controlled annealing of sandwich-structured aluminum AA1050 for optimized combinations of strength and ductility

A heavily rolled AA1050 sample with a microstructurally continuous sandwich structure, characterized by distinct microstructural evolution in the center and subsurface layers, has been annealed at different temperatures for 2 h with the objective of establishing optimized combinations of strength and ductility. It is observed that a large reduction in the fraction of high angle boundaries taking place during recovery in the subsurface layers results in delayed onset of recrystallization compared to that in the center layer, where the change in the fraction of high angle boundaries during recovery is small. The different recrystallization rates in this sandwich structure facilitate control of the overall recrystallized fraction, and can therefore be advantageous in obtaining a desired combination of both strength and ductility. A good combination of moderate strength and intermediate ductility is obtained in the material annealed at 250 °C and 270 °C, where the area fractions of recrystallized microstructure in the center are 7% and 36%, respectively. By analyzing the dependence of mechanical strength on the microstructure it is found that the mechanical properties can be described by a simple composite model using a rule of mixtures.

**General information**

State: Accepted/In press  
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering, Materials science and characterization, Tsinghua University  
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Web of Science (2017): Indexed yes  
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Web of Science (2016): Indexed yes  
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Scopus rating (2015): SJR 1.742 SNIP 1.858 CiteScore 3.01  
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Organisations: Department of Wind Energy, Aerodynamic design
Authors: Bertagnolio, F. (Intern), Aagaard Madsen , H. (Intern), Fischer, A. (Intern), Bak, C. (Intern)
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Publication information
Data assimilation of ocean surface waves using Sentinel-1 SAR during typhoon Malakas

In this study, a data assimilation system is constructed in a third generation ocean surface wave model, MASNUM-WAM, to improve wave simulations. The data assimilation system uses Ensemble Adjustment Kalman Filter (EAKF) method, which is based on dynamic sampling. Difference between 24 h-interval wave parameter fields during the period 7-day before and after assimilation time, is used to construct dynamic ensemble, which is an approximation to background error. Eight experiments are carried out during typhoon Malakas to investigate the impact of different assimilating wave parameters to the simulation errors of significant wave height (SWH). Wave spectrum observations from satellite Sentinel-1 SAR are used for data assimilation. SWH, peak wave period, mean wave direction and wave spectrum are adjusted simultaneously when an observation is available. Results show that the data assimilation system improves the simulation of SWH during typhoon Malakas.

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Organisations: Department of Wind Energy, Resource Assessment Modelling, State Oceanic Administration, China
Authors: Sun, M. (Ekstern), Yang, Y. (Ekstern), Yin, X. (Ekstern), Du, J. (Intern)
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BFI (2017): BFI-level 1
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BFI (2016): BFI-level 1
Scopus rating (2016): SJR 1.477 SNIP 2.028 CiteScore 4.14
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.68 SNIP 2.034 CiteScore 4.17
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.526 SNIP 2.16 CiteScore 3.95
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.074 SNIP 1.778 CiteScore 2.5
ISI indexed (2013): ISI indexed no
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ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.968 SNIP 1.687 CiteScore 2.49
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.963 SNIP 1.871
BFI (2009): BFI-level 1
**Data-driven Wake Modelling for Reduced Uncertainties in short-term Possible Power Estimation: Paper**

One of the ancillary services the wind farms are required to provide to the system operators is reserve power, which is achieved by down-regulating the wind farm from its possible power. In order to estimate the reserves, the possible power needs to be calculated by correcting the reduced wake effects behind the down-regulated turbines. The most recent grid codes dictate the quality of the possible power at the wind farm level to be assessed within 1-min intervals for offshore wind power plants. Therefore, the necessity of a fast and reliable wake model is more prominent than ever. Here we investigate the performance of two engineering wake models with 1-sec resolution SCADA data on three different offshore wind farms, given the quantified input uncertainty. The preliminary results show that, even wind farm specific training of the model parameters might fail to comply with the strict criteria stated in the grid codes, especially for the layouts with significant wake losses. In order to tackle the inadequacy of the engineering wake models to capture some of the dynamics in the wind farm flow due to the embedded assumptions, purely data-driven techniques are evaluated. The flexibility of such an on-line model enables ‘site-turbine-time-specific’ modelling, in which the parameters are defined per turbine and updated with each time-step in a specific wind farm.
Decomposing the Bragg glass and the peak effect in a Type-II superconductor

Adding impurities or defects destroys crystalline order. Occasionally, however, extraordinary behaviour emerges that cannot be explained by perturbing the ordered state. One example is the Kondo effect, where magnetic impurities in metals drastically alter the temperature dependence of resistivity. In Type-II superconductors, disorder generally works to pin vortices, giving zero resistivity below a critical current $j(c)$. However, peaks have been observed in the temperature and field dependences of $j(c)$. This peak effect is difficult to explain in terms of an ordered Abrikosov vortex lattice. Here we test the widespread paradigm that an order-disorder transition of the vortex ensemble drives the peak effect. Using neutron scattering to probe the vortex order in superconducting vanadium, we uncover an order-disorder transition from a quasi-long-range-ordered phase to a vortex glass. The peak effect, however, is found to lie at higher fields and temperatures, in a region where thermal fluctuations of individual vortices become significant.
Design for manufacturability of macro and micro products: a case study of heat exchanger design

In this paper, a novel methodology in designing a micro heat exchanger is proposed by modifying a conventional design methodology for macro products with the considerations of differences between design of a micro and a macro product. The methodology starts with the identification of differences in design considerations for micro scale products compared to the macro scale. These design considerations consist of material selection, manufacturing process, physical phenomena and shape and geometry design. Manufacturability criteria are defined and various potential manufacturing processes for fabricating micro heat exchangers are ranked based on the defined criteria. Following the design methodology, primary design ideas for micro heat exchangers are generated according to the heat transfer principles for macro heat exchangers. Taking micro design considerations into account, the designs from next iteration are created. Finally, the performances of the designs for micro heat exchangers are compared with their macro counterparts. The most appropriate designs for micro heat exchangers are finalized. The micro specific design guidelines obtained by the designer through evaluating the modeling results and the design criteria are formulated in a knowledge-based unit called “Rules To Consider” (RTC). The proposed methodology provides an interactive design process through the RTC unit. The RTC data is used by the designer in the subsequent iterations of the micro-product design as well as can be used by designers/engineers in design of the same category of micro products. Furthermore, through utilization of the proposed methodology by designers/engineers for design of other micro products, the RTC unit can be enriched with micro-oriented design principles and accordingly provide a basic guideline for design of micro products.
Design of four-point SENB specimens with stable crack growth

A four-point single-edge-notch-beam (SENB) test specimen loaded in displacement control (fixed grip) is proposed for studying crack deflection at bi-material interfaces. In order to ensure stable crack growth, a novel analytical model of the four-point SENB specimen in fixed grip is derived and compared with numerical models. Model results show that the specimen should be short and thick, and the start-crack length should be deep for the crack to propagate stable towards the bi-material interface. Observations from experimental tests of four-point SENB specimens with different start-crack lengths, confirmed that the crack grows stable if the start-crack length is deep and unstable if not.
Detached Eddy Simulation Model for the DU-91-W2-250 Airfoil

This paper presents aerodynamic investigations of the DU-91-W2-250 airfoil at Reynolds number of 3 \cdot 10^6 employing 2D Reynolds-averaged Navier–Stokes (RANS) solver and 3D detached eddy simulation (DES) technique. RANS simulations are performed in the angle of attack range between -20° and +20° whereas DES results are given only for the angle of attack of 7.08°. Measurements have been done at the LM Wind Power Low Speed Wind Tunnel. The lift and drag are obtained from airfoil pressure and wake rake respectively. The obtained numerical results, lift and drag coefficients as well as static pressure distributions are in a good agreement with the experimental results in the linear part of the lift coefficient curve. The Transition SST turbulence model gives much more appropriate results in comparison with the k-\omega SST model, especially for the drag at low angles of attack. The DES approach allows to obtain 3D flow characteristics near the S-shaped airfoil tail.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, LM Wind Power, Warsaw University of Technology
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General information
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Organisations: Department of Wind Energy, Composites and Materials Mechanics, Department of Physics, Neutrons and X-rays for Materials Physics, Rockwool International, Xnovo Technology ApS
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Web of Science (2016): Indexed yes
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Scopus rating (2015): SJR 0.792 SNIP 1.059 CiteScore 2.36
Web of Science (2015): Indexed yes
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Scopus rating (2014): SJR 0.963 SNIP 1.388 CiteScore 2.54
Development and interaction of rotor wakes

The present work shows the results of a series of experimental investigations of the wake development behind a model rotor subject to upstream disturbances created either by another rotor or by a disk. The experiments are carried out in a water flume in order to control the flow and to carry out visualizations and to perform optical diagnostics. The aim of the work is to clarify similarities and differences in the wake of a wind turbine subject to different inflow disturbances, and in particular to see if there is any difference in the rotor wake resulting from a upstream disturbance created by a rotor and one created by an immobile disk. The background for the study is an on-going discussion if disks can replace rotors in laboratory experiments. In the paper, we will also show new experimental data that support our main conclusion, which is that strong differences exist between the near wakes characteristics of a rotor and a disk.
Development of Goss texture in Al–0.3%Cu annealed after heavy rolling

The evolution of the microstructure and texture during annealing has been studied in the center layer of 95% cold rolled Al–0.3%Cu with a large initial grain size. The cold-rolled condition is characterized by a strong Brass texture component and a deformed microstructure comprising lamellar structures intersected by a large number of shear bands. Recrystallization and precipitation take place during annealing at 200°C, and a strong Goss texture develops. In the beginning of recrystallization, Goss oriented grains nucleate preferentially at the shear bands. At a later stage of recrystallization, new Goss nuclei can appear in regions where lamellae of the dominant Brass component are interspersed with Goss-oriented subgrains. When recrystallization is almost complete, recrystallized Goss-oriented grains grow into grains of other orientations, which results in a rapid increase in the average grain size of Goss-oriented grains and strengthening of the Goss texture. As a result, new low angle boundaries are formed between Goss-oriented grains in this strongly textured material.
Development of new methodologies to assess the structural integrity of the grouted joint of a 10MW wind turbine substructure

Monopiles are currently the most commonly used substructure in the offshore wind market due to their ease of installation in shallow to medium waters. The monopile and the transition piece are connected by a grouted joint. Fatigue and corrosion are two of the most important degradation mechanisms in this type of support structures. These mechanisms increase the costs and compromise the reliability of the structures. The development of new models and methodologies for the analysis of these degradation mechanisms is crucial. For this reason, a methodology to analyze the behavior of grouted joints has been developed considering the effect of corrosion on the steel parts of the grouted joints, along with the consideration of stiffness degradation of the concrete structure and the reliability of the joint under fatigue. One type of grouted joint connection is considered: the conventional cylindrical joint with shear keys. Fully coupled load simulations are made to determine the fatigue resistance and ultimate load resistance of the joint.

General information
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Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design, Fundacion centro tecnologico de componentes, Aalborg University
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Development of Single Point Impact Fatigue Tester (SPIFT)
Impact fatigue damage caused by rain droplets, also called rain erosion, is a severe problem for wind turbine blades. In the present report, an assessment of impact fatigue on a glass fibre reinforced polymer laminate with a gelcoat is presented and the damage mechanisms are investigated. A single point impact fatigue tester is developed to generate impact fatigue damage and SN data. Rubber balls are repeatedly impacted on a single location of the coated laminate. Each impact induces transient stresses in the coated laminate. After repeated impacts, these stresses generate cracks, leading to the removal of the coating and damage to the laminate. High-resolution digital imaging is used to determine the incubation time until the onset of coating damage. An acoustic emission sensor placed at the back of the laminate monitors changes in acoustic response as damage develops in the coated laminate. The subsurface cracks are studied and mapped by 3D X-ray computed tomography. A finite element method model of the impact shows the impact stresses in the coating and the laminate. The stresses seen in the model are compared to cracks found by 3D X-ray computed tomography. The damage is also evaluated by ultrasonic scanning.

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Downstream effects from contemporary wind turbine deployments
High-resolution regional simulations of the downstream effects of wind turbine arrays are presented. The simulations are conducted with the Weather Research and Forecasting (WRF) model using two different wind turbine parameterizations for a domain centered on the highest density of current wind turbine deployments in the contiguous US. The simulations use actual wind turbine geolocations and turbine specifications (e.g. power and thrust curves). Resulting analyses indicate that for both WT parameterizations impacts on temperature, specific humidity, precipitation, sensible and latent heat fluxes from current wind turbine deployments are statistically significant only in summer, are of very small magnitude, and are highly localized. It is also shown that use of the relatively recently developed new explicit wake parameterization (EWP) results in faster recovery of full array wakes. This in turn leads to smaller climate impacts and reduced array-array interactions, which at a system-wide scale lead to higher summertime capacity factors (2-6% higher) than those from the more commonly applied ‘Fitch’ parameterization. Our research implies that further expansion of wind turbine deployments can likely be realized without causing substantial downstream impacts on weather and climate, or array-array interactions of a magnitude that would yield substantial decreases in capacity factors.

General information
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Organisations: Department of Wind Energy, Resource Assessment Modelling, Cornell University
Authors: Pryor, S. (Ekstern), Barthelmie, R. (Ekstern), Hahmann, A. N. (Intern), Shepherd, T. (Ekstern), Volker, P. (Intern)
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Dynamic stall model modifications to improve the modeling of vertical axis wind turbines

The Beddoes-Leishman type dynamic stall model was originally implemented in HAWC2 with a focus on horizontal axis wind turbines. In case of HAWTs, some terms in the unsteady airfoil lift and drag are very small and can be neglected, which are very important for VAWTs. Furthermore, the angle of attack variations during normal operation of VAWTs are by far larger than those occurring on HAWTs. This posed a challenge to the Beddoes-Leishman-type dynamic stall model, which had previously been validated for small variations in angle of attack against CFD and measurements. This report contains some necessary modifications of the Beddoes-Leishman type dynamic stall model in HAWC2 to enable unsteady aerodynamic computations on VAWTs. A short validation against measurements of the NREL/NASA Ames Phase VI rotor in standstill is included. There, it is shown that the model changes have only a small, but beneficial effect at small angle of attack variations.
Effect of inter-fibre bonding on the fracture of fibrous networks with strong interactions

Abstract The mechanical response of cellulose nanopaper composites is investigated using a three-dimensional (3D) finite element fibrous network model with focus on the effect of inter-fibre bonds. It is found that the Young’s modulus and strength, for fixed fibre properties, are mainly controlled by the density and strength of the inter-fibre bonds. An increase of the inter-fibre bond density and inter-fibre bond strength results in an increase of both the Young’s modulus and strength of the fibrous network materials. The fracture energy of the inter-fibre bonds has a minor effect on the mechanical properties of the cellulose nanopapers. The inter-fibre bond properties and density have a minor effect on the strain to failure of the cellulose nanopaper. The effect of the fibre properties, through the ratio of fibre tensile strength to fibre Young’s modulus, has also a significant impact on mechanical response of the network including the strain to failure.
Effect of the coating properties on the deformation and wave distribution in the leading edge erosion system

The model is an expanded and modified version of the model by V. Fedorov, see for instance [1]. The material under droplet was designed as multilayered materials, with two layer protective coating, gelcoat, and filler, all on the top of laminate. The model is designed in such a way that it can be easily expanded to simulate the interlayer debonding, coating/gelcoat, gelcoat/filler, and filler/laminate debonding. It is realized by creating “interphase/interface” layers between the coatings, following the concept of 3D interfaces by Povl Brandstedt and Leon Mishnaevsky Jr [2]. In this way, the model can be used for optimization of protective coatings and their structures, testing various parameters of the protective systems and development of recommendations to their improvement. In order to demonstrate the application of the model for the analysis, we used the model to study various coating structures, and compare two extreme cases, namely, stiff upper coating/soft lower coating and, inversely, soft upper coating/stiff lower coating placed on homogeneous gelcoat, filler and laminate. The properties of gelcoat, filler and laminate remained the same in all cases, however, the stiff and soft phases have had drastically changed properties. The developed computational model allows numerical testing of various protective systems. The models is expandable and allows also to add specific damage mechanisms, as well as more complex (plastic, viscous, damping) behavior of protective layers. Further, more detailed models of filler and gelcoat should be added. Varying the stiffness and amount of protective layers, one can control the damage initiation and growth in composites.
Effects of an Oscillating Flap on the Main Airfoil Unsteady Lift in Grid Turbulence

A wing of NACA 0015 profile and Aspect Ratio 2.4 fitted with a Trailing Edge Flap was tested in a wind tunnel for both smooth and turbulent flow conditions at a Re number 108000. The unsteady lift on the wing was measured with and without the flap. Two types of flap excitation were tried: One was of the “open loop” type in which the flap was subjected to sinusoidal pitching oscillations while the wing was set to a constant angle of attack. In the second, “closed loop” mode, the excitation signal fed into the flap originated from the unsteady lift of the wing itself. The phase lag between those signals was changed and it was found that it played a significant role in the suppression of the main wing unsteady lift.

Effects of Coatings on the High-Cycle Fatigue Life of Threaded Steel Samples

In this work, high-cycle fatigue is studied for threaded cylindrical high-strength steel samples coated using three different industrial processes: black oxidation, normal-temperature galvanization and high-temperature galvanization. The fatigue performance in air is compared with that of uncoated samples. Microstructural characterization revealed the abundant presence of small cracks in the zinc coating partially penetrating into the steel. This is consistent with the observation of multiple crack initiation sites along the thread in the galvanized samples, which led to crescent type fracture surfaces governed by circumferential growth. In contrast, the black oxidized and uncoated samples exhibited a semicircular segment type fracture surface governed by single-sided growth with a significantly longer fatigue life. Numerical fatigue life prediction based on an extended Paris-law formulation has been conducted on two different fracture cases: 2D axisymmetric multisided crack growth and 3D single-sided crack growth. The results of this upper-bound and lower-bound approach are in good agreement with experimental data and can potentially be used to predict the lifetime of bolted components.
Engineering an optimal wind farm using surrogate models: EOWF using SUMO

A framework for optimal design of wind farm layouts using a surrogate-based Dynamic Wake Meandering model is presented. The optimization platform is set-up as a hybrid strategy combining genetic search with the gradient-based algorithm. The design variables are the number of turbines in the layout and their relative position within the bounded area. The objective function is defined as the net present value of the wind farm's profit, thus including the relevant expenditures throughout the farm's lifespan. Results show that an optimal design is reached by maximizing investment and accepting a minor sacrifice of the wind farm performance.

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Organisations: Department of Wind Energy, Wind turbine loads & control, Technische Universität Braunschweig, Technical University of Denmark
Engineering hybrid epitaxial InAsSb/Al nanowires for stronger topological protection

The combination of strong spin-orbit coupling, large g factors, and the coupling to a superconductor can be used to create a topologically protected state in a semiconductor nanowire. Here we report on growth and characterization of hybrid epitaxial InAsSb/Al nanowires, with varying composition and crystal structure. We find the strongest spin-orbit interaction at intermediate compositions in zinc-blende InAs$_{1-x}$Sb$_x$ nanowires, exceeding that of both InAs and InSb materials, confirming recent theoretical studies. We show that the epitaxial InAsSb/Al interface allows for a hard induced superconducting gap and 2e transport in Coulomb charging experiments, similarly to experiments on InAs/Al and InSb/Al materials, and find measurements consistent with topological phase transitions at low magnetic fields due to large effective g factors. Finally we present a method to grow pure wurtzite InAsSb nanowires which are predicted to exhibit even stronger spin-orbit coupling than the zinc-blende structure.

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Evaluating Humidity and Sea Salt Disturbances on CO2 Flux Measurements

Global oceans are an important sink of atmospheric carbon dioxide (CO2). Therefore, understanding the air–sea flux of CO2 is a vital part in describing the global carbon balance. Eddy covariance (EC) measurements are often used to study CO2 fluxes from both land and ocean. Values of CO2 are usually measured with infrared absorption sensors, which at the same time measure water vapor. Studies have shown that the presence of water vapor fluctuations in the sampling air potentially results in erroneous CO2 flux measurements resulting from the cross sensitivity of the sensor. Here measured CO2 fluxes from both enclosed-path Li-Cor 7200 sensors and open-path Li-Cor 7500 instruments from an inland measurement site are compared with a marine site. Also, new quality control criteria based on a relative signal strength indicator (RSSI) are introduced. The sampling gas in one of the Li-Cor 7200 instruments was dried by means of a multitube diffusion dryer so that the water vapor fluxes were close to zero. With this setup the effect that cross sensitivity of the CO2 signal to water vapor can have on the CO2 fluxes was investigated. The dryer had no significant effect on the CO2 fluxes. The study tested the hypothesis that the cross-sensitivity effect is caused by hygroscopic particles such as sea salt by spraying a saline solution on the windows of the Li-Cor 7200 instruments during the inland field test. The results confirm earlier findings that sea salt contamination can affect CO2 fluxes significantly and that drying the sampling air for the gas analyzer is an effective method for reducing this signal contamination.

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Uppsala University, National University of Ireland, Galway
Evaluating Mesoscale Simulations of the Coastal Flow Using Lidar Measurements

The atmospheric flow in the coastal zone is investigated using lidar and mast measurements and model simulations. Novel dual-Doppler scanning lidars were used to investigate the flow over a 7 km transect across the coast, and vertically profiling lidars were used to study the vertical wind profile at offshore and onshore positions. The Weather, Research and Forecasting model is set up in 12 different configurations using 2 planetary boundary layer schemes, 3 horizontal grid spacings and varied sources of land use, and initial and lower boundary conditions. All model simulations describe the observed mean wind profile well at different onshore and offshore locations from the surface up to 500 m. The simulated mean horizontal wind speed gradient across the shoreline is close to that observed, although all simulations show wind speeds that are slightly higher than those observed. Inland at the lowest observed height, the model has the largest deviations compared to the observations. Taylor diagrams show that using ERA-Interim data as boundary conditions improves the model skill scores. Simulations with 0.5 and 1 km horizontal grid spacing show poorer model performance compared to those with a 2 km spacing, partially because smaller resolved wave lengths degrade standard error metrics. Modeled and observed velocity spectra were compared and showed that simulations with the finest horizontal grid spacing resolved more high-frequency atmospheric motion.

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BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.754 SNIP 1.605 CiteScore 3.39
Web of Science (2015): Indexed yes
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Scopus rating (2014): SJR 2.853 SNIP 1.757 CiteScore 3.27
Web of Science (2014): Indexed yes
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Scopus rating (2013): SJR 3.088 SNIP 1.809 CiteScore 3.38
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.917 SNIP 1.522 CiteScore 2.93
ISI indexed (2012): ISI indexed yes
Evaluation of different methods for determining the angle of attack on wind turbine blades with CFD results under axial inflow conditions

This work presents an investigation on different methods for the calculation of the angle of attack and the underlying induced velocity on wind turbine blades using data obtained from three-dimensional Computational Fluid Dynamics (CFD). Several methods are examined and their advantages, as well as shortcomings, are presented. The investigations are performed for two 10 MW reference wind turbines under axial inflow conditions, namely the turbines designed in the EU AVATAR and INNWIND.EU projects. The results show that the evaluated methods are in good agreement with each other at the mid-span, though some deviations are observed at the root and tip regions of the blades. This indicates that CFD results can be used for the calibration of induction modeling for Blade Element Momentum (BEM) tools. Moreover, using any of the proposed methods, it is possible to obtain airfoil characteristics for lift and drag coefficients as a function of the angle of attack.
Evaluation of different methods of determining the angle of attack on wind turbine blades under yawed inflow conditions

As part of the AVATAR and Mexnext projects, this study compares several methods used to derive lifting line variables from CFD simulations of the MEXICO rotor in yawed inflow. The results from six partners within the AVATAR/Mexnext consortium using five different methods of extraction were compared. Overall comparison of the induced velocities at the mid and tip parts of blade shows fairly good agreement between the tested methods, where the derived angle of attack differs within 1°, within the linear range this accounts to < 10% uncertainty on the aerodynamic forces. The presented comparison shows inadequate agreement between the methods for application towards the root.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, ECN, University of Oldenburg, University of Malta, Delft University of Technology, University of Stuttgart
Authors: Vimalakanthan, K. (Ekstern), Schepers, J. (Ekstern), Shen, W. Z. (Intern), Rahimi, H. (Ekstern), Micallef, D. (Ekstern), Simao Ferreira, C. (Ekstern), Jost, E. (Ekstern), Klein, L. (Ekstern)
Number of pages: 10
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Main Research Area: Technical/natural sciences

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BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
Evaluation of the Effect of Spar Cap Fiber Angle of Bending-Torsion Coupled Blades on the Aero-Structural Performance of Wind Turbines

This paper presents a comprehensive study of the evaluation of the effect of spar cap fiber orientation angle of composite blades with induced bending-torsion coupling (IBTC) on the aero-structural performance wind turbines. Aero-structural performance of wind turbines with IBTC blades is evaluated with the fatigue load mitigation in the whole wind turbine system, tower clearances, peak stresses in the blades, and power generation of wind turbines. For this purpose, a full E-glass/epoxy reference blade has been designed, following the inverse design methodology for a 5-MW wind turbine. An E-glass/epoxy blade with IBTC and novel, hybrid E-glass/carbon/epoxy blades with IBTC have been designed and aeroelastic time-marching multibody simulations of the 5-MW turbine systems, with the reference blade and the blades with IBTC, have been carried out using six different randomly generated turbulent wind profiles. Fatigue-equivalent loads (FELs) in the wind turbine have been determined as an average of the results obtained from the time response of six different simulations. The results reveal that certain hybrid blade designs with IBTC are more effective in fatigue load mitigation than the E-glass-epoxy blade with IBTC, and besides the fiber orientation angle, sectional properties of hybrid blades must be adjusted accordingly using proper number of carbon/epoxy layers in the sections of the blade with IBTC, in order to simultaneously reduce generator power losses and the FEL.

Bibliographical note
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General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control, Middle East Technical University
Authors: Sener, O. (Ekstern), Farsadi, T. (Ekstern), Gozc, M. O. (Intern), Kayran, A. (Ekstern)
Publication date: 2018
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Solar Energy Engineering
Volume: 140
Issue number: 4
Article number: 041004
ISSN (Print): 0199-6231
Ratings:
Evaluation of the LINCOM wind field reconstruction method with simulations and full-scale measurements

The LINCOM method is a set of linearised flow equations that enables the reconstruction of a 3D wind field from a large set of non-parallel radial wind speed measurements. An evaluation of the model is performed with both simulated and full-scale boundary layer wind field measurements. The model is first tested on deterministic wind fields to evaluate its performance under simple conditions. Afterwards, line-of-sight measurements are extracted from a virtual SpinnerLidar placed in an LES wind field and then the LINCOM method is applied and compared to it. Finally, the methodology is experimentally evaluated with lidar measurements from the IRPWIND joint experiment SCANFLOW campaign, where SpinnerLidar line-of-sight inflow measurements from the nacelle of a test turbine were used to reconstruct 3D wind fields. These reconstructed wind fields are then compared with simultaneously measured independent full-scale 3D short-range WindScanner data. It was seen that the LINCOM model is able to accurately reconstruct the deterministic wind fields. For the analysis with the LES wind fields, the LINCOM model is able to obtain an R² coefficient of 0.72 with no significant correlation found for the v- and w-components. The cosine de-projection of the line-of-sight speeds onto the main direction yields R² = 0.834. For the full field measurements, the LINCOM model was able to predict the longitudinal component with a low standard error, but the v- and w-components deviate significantly. The results suggest the suitability of the model to reconstruct only the mean characteristics of 3D fields under low turbulent conditions, and give a reasonable estimate of the fluctuations of the u-component.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, University of Oldenburg
Authors: Sekar, A. P. K. (Ekstern), van Dooren, M. F. (Ekstern), Mikkelsen, T. K. (Intern), Sjöholm, M. (Intern), Astrup, P. (Intern), Kühn, M. (Ekstern)
Number of pages: 10
Publication date: 2018
Conference: Torque 2018, Milan, Italy, 20/06/2018 - 20/06/2018
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Journal: Journal of Physics: Conference Series
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Article number: 052008
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Ratings:
BFI (2018): BFI-level 1
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Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Experimental and numerical validation of active flaps for wind turbine blades

An industrial active flap concept for wind turbine rotor blades is validated numerically by means of CFD, as well as experimentally in a wind tunnel environment. This paper presents the numerical and experimental results, as well as a discussion regarding the testing of airfoils equipped with active flaps with a highly loaded aft portion. A conceptual implementation for an offshore wind turbine and the potential for load reduction is shown by means of aeroelastic calculations. The work presented herein is conducted within the frame of the Induflap2 project and is partially funded by the Danish funding board EUDP.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design, Siemens Gamesa Renewable Energy
Authors: Gomez Gonzalez, A. (Ekstern), Enevoldsen, P. B. (Ekstern), Akay, B. (Ekstern), Barlas, T. K. (Intern), Fischer, A. (Intern), Aa Madsen, H. (Intern)
Number of pages: 10
Publication date: 2018
Conference: Torque 2018, Milan, Italy, 20/06/2018 - 20/06/2018
Main Research Area: Technical/natural sciences

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Journal: Journal of Physics: Conference Series
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BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Experimental investigation of process induced strain during cure of epoxy using optical fibre bragg grating and dielectric analysis

In order to investigate how cure cycles for composites can be optimized for improved fatigue life of composites, an experimental set-up which measures temperature, process induced strain and level of cure, is presented. The experimental set-up measures strain in a neat epoxy sample using optical Fibre Bragg Grating sensors in a single glass fibre, combined with a thermo-couple used to compensate for thermal effects. The degree of cure in the neat epoxy sample is measured in the same sample using a dielectric sensor working simultaneously with the temperature and strain measurements. The combined measurements allows for quantification of a number of important parameters required for understanding how the temperature profiles used in processing of composites affects the level of process induced strains in the neat polymer material and thereby the level of residual stresses in the final composite materials.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Mortensen, U. A. (Intern), Løgstrup Andersen, T. (Intern), Christensen, J. (Intern), Miranda Maduro, M. A. (Intern)
Number of pages: 8
Publication date: 2018
Main Research Area: Technical/natural sciences
Experimental Investigation of Static Stall Hysteresis and 3-Dimensional Flow Structures for an NREL S826 Wing Section of Finite Span

Flow characteristics of an S826 airfoil at different Reynolds numbers, ranging from 40,000–400,000 (based on airfoil chord length) and angles of attack from −10–25 degrees are thoroughly investigated in a low-speed wind tunnel. The airfoil's lift and drag polars are first measured, and with a focus on pitching the airfoil in upstroke and downstroke orders, static stall hysteresis is identified in selected experiments at Reynolds numbers below 100,000 near the stall angle and subsequently investigated. Experiments using wire-generated free stream turbulence are conducted, and the hysteresis effects are shown to disappear when introducing a free stream turbulence of less than 2.5%. Further, spanwise flow is detected by comparing lift and drag values measured using both surface pressure integration at one cross section as well as integral force gauge measurement, and the surface oil flow visualization technique is subsequently used to study the 3D flow topologies formed on the airfoil. The formation of distinct stall cells on the suction side of the airfoil is observed at Reynolds numbers above 100,000 near the stall angle. By repeating the experiments, stall cells are proven to be reproducible, although the identical geometries are necessarily not retained in absence of surface impurities such as tapes. The effect of disturbances on the stall cells is investigated by utilizing roughness elements on the airfoil surface, and it is found that while such disturbances tend to change the shape of the stall cells, they do not contribute to the creation, nor destruction of the cells. Polar and visualization measurements are also used to study flow separation, and it is observed that the separation location, as well as the laminar separation bubble, moves towards the leading edge when increasing the angle of attack.
Experimental investigation of Surface Roughness effects and Transition on Wind Turbine performance

Aerodynamic experiments have been executed in the wind tunnel and on a wind turbine blade to measure the impact of roughness on the airfoil characteristics and the associated effect on rotor performance and to establish the transition location on a rotating blade. The wind tunnel tests have been performed in the low-speed, low-turbulence wind tunnel of TUDelft. The wind turbine tests were carried out at ECN’s Wind Turbine Test Site. Roughness simulation material has been installed on the airfoil leading edge to measure the impact on airfoil performance. Microphones were mounted on the airfoil surface to detect the boundary layer laminar to turbulent transition position both on the wind tunnel model and on the wind turbine blade.

General information

State: Published
Organisations: Department of Wind Energy, Aerodynamic design, Centro Nacional de Energias Renovables, Energy research Centre of the Netherlands - ECN, Delft University of Technology
Authors: Pires, O. (Ekstern), Munduate, X. (Ekstern), Boorsma, K. (Ekstern), Ceyhan Yilmaz, O. (Ekstern), Aa Madsen, H. (Intern), Timmer, W. (Ekstern)
Number of pages: 10
Publication date: 2018
Conference: Torque 2018, Milan, Italy, 20/06/2018 - 20/06/2018
Main Research Area: Technical/natural sciences

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Ratings:
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
This paper presents two methods for frequency control of onshore AC grids from offshore wind power plants (OWPPs) connected to a multi-terminal DC (MTDC) grid. The first method is based on communicating the onshore frequency to the OWPP and the other voltage source converters (VSCs) in the MTDC grid. The second method is based on a coordinated strategy between the VSCs in the MTDC grid, where the onshore frequency is replicated at the offshore grid using additional control blocks implemented locally at the VSCs of the MTDC grid. The proposed control methods are first verified through simulations on a test set up with an OWPP connected to a three-terminal DC grid using DiStILENT PowerFactory and then validated experimentally on a laboratory scaled three-terminal DC grid. The simulation and experimental results prove that, with the proposed control strategies, OWPPs and the VSCs in the MTDC grid can participate in frequency control and support the onshore grid frequency stability.
Extension of EllipSys to compressible flows - Implementation and verifications
This report gives a brief overview of the main implementation details necessary to account for compressibility in the EllipSys code. The additional input parameters required to activate and configure the compressible formulation are presented. A series of test-cases are defined and comparisons with measurement data and solutions from existing validated compressible codes are conducted. It is shown that the code behaves as expected, although it typically requires longer computational times than for the incompressible case. Furthermore, the quantitative results appear to validate this compressible version of the code.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design
Authors: Bertagnolio, F. (Intern), Sørensen, N. N. (Intern)
Number of pages: 23
Publication date: 2018

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Original language: English
Series: DTU Wind Energy E
Number: 170
Main Research Area: Technical/natural sciences
Electronic versions: E_0170.pdf
Source: PublicationPreSubmission
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Publication: Research › Report – Annual report year: 2018

Fabrication of a Scaled MgB2 Racetrack Demonstrator Pole for a 10-MW Direct-Drive Wind Turbine Generator
Field windings made of MgB2 wires or tapes are considered for their potential to reduce volume, weight, and cost of large offshore wind turbine generators. To gain experience of how to use this relatively new material in full-scale generators, tests of different winding methodologies and techniques are needed. In this paper, we describe in detail the steps used to wind a racetrack coil with a length of 1 m and a width of 0.5 m out of 4.5 km of MgB2 superconducting tape. The width corresponds to a full-scale pole of a 10-MW generator, whereas the length of the straight section is shorter than the corresponding full-scale pole. The coil was built up of ten double pancake coils. Each double pancake coil was wet wound using a semiautomatic winding process, where Stycast 2850 was applied directly to the MgB2 tape without any other dedicated electrical insulation. The strengths and weaknesses of the winding process are discussed and compared to the dry-winding method.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design, SINTEF, Norwegian University of Science and Technology
Authors: Magnusson, N. (Ekstern), Eliassen, J. C. (Ekstern), Abrahamsen, A. B. (Intern), Helleso, S. M. (Ekstern), Runde, M. (Ekstern), Nysveen, A. (Ekstern), Moslatt, L. (Ekstern), Bjerkli, J. (Ekstern), King, P. (Ekstern)
Number of pages: 5
Publication date: 2018
Main Research Area: Technical/natural sciences

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Journal: IEEE Transactions on Applied Superconductivity
Volume: 28
Issue number: 4
Article number: 5207105
ISSN (Print): 1051-8223
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
Far-wake meandering induced by atmospheric eddies in flow past a wind turbine

A novel algorithm is developed to calculate the nonlinear optimal boundary perturbations in three-dimensional incompressible flow. An optimal step length in the optimization loop is calculated without any additional calls to the Navier-
Stokes equations. The algorithm is applied to compute the optimal inflow eddies for the flow around a wind turbine to clarify the mechanisms behind wake meandering, a phenomenon usually observed in wind farms. The turbine is modelled as an actuator disc using an immersed boundary method with the loading prescribed as a body force. At Reynolds number (based on free-stream velocity and turbine radius) Re = 1000, the most energetic inflow perturbation has a frequency omega = 0.8-2, and is in the form of an azimuthal wave with wavenumber m = 1 and the same radius as the actuator disc. The inflow perturbation is amplified by the strong shear downstream of the edge of the disc and then tilts the rolling-up vortex rings to induce wake meandering. This mechanism is verified by studying randomly perturbed flow at Re
Electronic versions:
farwake_meandering_induced_by_atmospheric_eddies_in_flow_past_a_wind_turbine.pdf

DOIs:
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Publication: Research - peer-review › Journal article – Annual report year: 2018

Fast trailed and bound vorticity modeling of swept wind turbine blades
Passive load alleviation can be achieved through geometric bend-twist coupling, for example, by sweeping the blade backwards. The influence of the blade sweep on the trailing vorticity and bound vorticity is not modelled in the current fast aerelastic wind turbine codes suitable for certification. A near wake trailed vorticity model which was coupled with a blade element momentum theory based aerodynamic model has been modified to take into account the blade sweep. The extended model is compared with the original near wake model, a blade element momentum (BEM) model and full rotor computational fluid dynamics (CFD) results for the modified IEA 10MW reference wind turbines. The steady-state loadings calculated from the extended model are in better agreements with CFD compared to the original model and the BEM for four different swept blades. It is also shown that the influence of the blade sweep on normal loading is not correctly modelled by BEM and this error will be inherited to the near wake model results. Thus, further modification to BEM will likely improve the predicted normal loading for swept blades, even if no near wake model is used.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design, Wind turbine loads & control
Authors: Li, A. (Intern), Pirrung, G. (Intern), Madsen, H. A. (Intern), Gaunaa, M. (Intern), Zahle, F. (Intern)
Number of pages: 11
Publication date: 2018
Conference: Torque 2018, Milan, Italy, 20/06/2018 - 20/06/2018
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Physics: Conference Series
Volume: 1037
Issue number: 6
Article number: 062012
ISSN (Print): 1742-6596
Ratings:
BFI (2018): BFI-level 1
Fatigue strength of composite wind turbine blade structures

Wind turbines are normally designed to withstand 20-30 years of life. During this period, the blades, which are the main rotating structures of a wind turbine, are subjected to high fluctuating load conditions as a result of a combination of gravity, inertia, and aeroelastic forces. For this reason, fatigue is one of the foremost concerns during the design of these structures. However, current standard fatigue methods used for designing wind turbine blades seem not to be completely appropriate for these structures because they are still based on methods developed for metals and not for composite materials from which the blades are made. In this sense, the aim of this work is to develop more accurate and reliable fatigue-life prediction models for composite wind turbine blades. In this project, two types of fatigue models are implemented: fatigue-life models and damage mechanics models. In the first part of the project, a probabilistic multiaxial fatigue-life model for composite materials, which takes the variability in the material properties into account, is proposed. In this model, novel probabilistic constant life diagrams are developed, which can efficiently estimate probabilistic *-N
curves at any load level and stress ratio. However, due to the low accuracy level of current multiaxial macroscopic fatigue failure criteria and damage accumulation theories for predicting the fatigue-life of composite materials under multiaxial and variable cycle load conditions, the proposed probabilistic fatigue-life model seems unsuitable for wind turbine blades. Based on this limitation, in the second part of the project, a damage mechanics-based multiscale approach using a 2D finite-element-based cross-section model for analyzing wind turbine blades under fatigue is proposed. By using this approach, reliable predictions about the effect of off-axis matrix cracks on the structural response of the blades are obtained. These results establish a basis for the development of an extended model that allows predicting the off-axis crack evolution in the blades and includes other types of damage, such as delaminations, fiber-related damage, etc. Furthermore, and following the framework of the proposed multiscale approach, a microscale fiber-related damage evolution study for on-axis UD glass/epoxy laminates under fatigue loading conditions is also presented. This study provides significant information for developing future fatigue models that allow predicting the catastrophic failure of multidirectional composite laminates and, therefore, possible failures in wind turbine blades.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Ardila, O. G. C. (Intern)
Number of pages: 174
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Publisher: DTU Wind Energy
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Main Research Area: Technical/natural sciences
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Relations
Projects:
Fatigue strength of composite wind turbine blade structures
Publication: Research › Ph.D. thesis – Annual report year: 2018

Final results from the EU project AVATAR: aerodynamic modelling of 10 MW wind turbines
This paper presents final results from the EU project AVATAR in which aerodynamic models are improved and validated for wind turbines on a scale of 10 MW and more. Special attention is paid to the improvement of low fidelity engineering (BEM based) models with higher fidelity (CFD) models but also with intermediate fidelity free vortex wake (FVW) models. The latter methods were found to be a good basis for improvement of induction modelling in engineering methods amongst others for the prediction of yawed cases, which in AVATAR was found to be one of the most challenging subjects to model. FVW methods also helped to improve the prediction of tip losses. Aero-elastic calculations with BEM based and FVW based models showed that fatigue loads for normal production cases were over predicted with approximately 15% or even more. It should then be realised that the outcome of BEM based models does not only depend on the choice of engineering add-ons (as is often assumed) but it is also heavily dependent on the way the induced velocities are solved. To this end an annulus and element approach are discussed which are assessed with the aid of FVW methods. For the prediction of fatigue loads the so-called element approach is recommended but the derived yaw models rely on an annulus approach which pleads for a generalised solution method for the induced velocities.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design, Energy research Centre of the Netherlands - ECN, National Technical University of Athens, ForWind, University of Stuttgart, GE, Centro Nacional de Energias Renovables, Delft University of Technology, Fraunhofer Institute for Wind Energy and Energy System Technology (I Wes), University of Glasgow, Centre for Renewable Energy Sources, POLIMI, LM Wind Power
Number of pages: 17
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Main Research Area: Technical/natural sciences

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Journal: Journal of Physics: Conference Series
Volume: 1037
Issue number: 2
Article number: 022013
Fine (Cr,Fe)\(_2\)B borides on grain boundaries in a 10Cr–0.01B martensitic steel

A 10Cr creep resistant martensitic steel with 108 ppm B was normalized at 1100 °C for 1 h and air cooled. Fine (Cr,Fe)\(_2\)B borides were observed on the majority of prior austenite grain boundaries, all of which were high angle boundaries, as revealed by EBSD-based reconstruction of parent austenite grains. Some high angle boundaries including twin boundaries were boride-free. Segregation of boron to austenite grain boundaries during slow cooling from 1100 °C led to boride nucleation and growth. Their size increased with decreasing cooling rate. Borides were verified by atom probe tomography, auger spectroscopy, transmission and scanning electron microscopy.
Flow in complex terrain - a Large Eddy Simulation comparison study

We present Large-Eddy Simulation (LES) results of flow over the double ridge complex site at Perdigão in Portugal. The focus is to compare simulated flow features from two LES codes with different discretization techniques. We compare a finite volume discretization with a pseudo spectral approach in two different terrains. Mean wind properties and turbulent kinetic energy from the two codes are to a large degree in agreement. The largest discrepancy we observe is attributed to the different effective resolution in the two codes which results from the numerical discretizations. Comparison with measured data from three installed meteorological masts inside the simulated domain show that many of the main flow features have been captured by the LES simulations despite its relatively simple setup.

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling, Aerodynamic design, Meteorology & Remote Sensing, National Center for Atmospheric Research
Authors: Berg, J. (Intern), Troldborg, N. (Intern), Menke, R. (Intern), Patton, E. G. (Ekstern), Sullivan, P. P. (Ekstern), Mann, J. (Intern), Sørensen, N. (Intern)
Number of pages: 10
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Journal: Journal of Physics: Conference Series
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Article number: 072015
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BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Fluoropolymer coated alanine films treated by atmospheric pressure plasmas – In comparison with gamma irradiation

Fluoropolymer coated alanine films are treated by a dielectric barrier discharge and a gliding arc at atmospheric pressure as well as with gamma irradiation. The film surfaces and the underlying bulk materials are characterized before and after each treatment. The fluorine content decreases and the oxygen content increases at the fluoropolymer surfaces, while deposition of specific plasma energies in the alanine films is detected by electron paramagnetic resonance spectroscopy, indicating that not only the fluoropolymer surfaces but also the bulk alanine materials are modified. Differences of surface and bulk modification effects between the two plasma treatments are discussed in detail.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics, Danish Technological Institute, University of Southern Denmark
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Number of pages: 10
Publication date: 2018
Main Research Area: Technical/natural sciences

Publication information
Journal: Plasma Processes and Polymers
Volume: 15
Issue number: 3
Article number: e1700131
ISSN (Print): 1612-8850
Ratings:
Flywheel Calibration of Coherent Doppler Wind Lidar

General information
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Flywheel Calibration of Coherent Doppler Wind Lidar
Within the field of lidar measurement it is often debated why it is necessary to calibrate lidars given that they are ‘absolute’ instruments. By this is meant that, given two parameters; the laser wavelength and the frequency at which we sample the backscattered light, we are able to calculate the measured radial speed through the well-known equation $V_r = \frac{\lambda}{2} \Delta f$. Unlike for example, a cup anemometer or even an LDA, there are no empirical constants that have to be found through a calibration.

Why then do we claim that lidar calibration is necessary anyhow? Probably the most direct answer is that without a calibration (comparison to a reference with known uncertainty) we cannot know that the lidar is getting it right. There could be wrong constants or some (maybe subtle) errors in the algorithm (frequency analysis is not trivial). Only by comparing to a known ‘truth’ can we be completely sure that the lidar gives the correct speed. More formally, since the uncertainty of the reference is known and, by implication, the reference is traceable to international measurement prototypes, we can assign an uncertainty to the lidar radial speed and claim traceability. In commercial measurements where the outcome can have financial consequences, it will usually be a requirement that the measurements are traceable.
Fracture mechanics approach to optimize inspection planning of offshore welds for wind turbines

General information
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Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design, Department of Mechanical Engineering, Solid Mechanics, Technical University of Denmark
Authors: Ruiz-Munoz, G. (Ekstern), Stolpe, M. (Intern), Sørensen, J. D. (Intern), Niordson, C. F. (Intern), Eder, M. A. (Intern), Østergaard, T. (Ekstern)
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Fracture of wind turbine blades in operation-Part I: A comprehensive forensic investigation
The structural integrity of rotor blades is crucial to ensuring continuous power production of wind turbines. Catastrophic blade fracture can cause significant economic loss and social impact and thereby should be prevented. It is important to understand the structural failure of rotor blades particularly during their normal operation. This study presents a comprehensive forensic investigation into fracture of 2 rotor blades in the field. The investigation is carried out synthetically taking into account interactive aspects associated with operational loads, materials, manufacturing processes, and structural design. The supervisory control and data acquisition data are analyzed to understand the turbine response with damaged blades. A detailed post-mortem investigation is carried out at structural, sub-component, and material levels both in field and in laboratory from a forensic perspective. Different manufacturing-induced defects are examined using X-ray computed tomography, and they are discussed in the context of the current manufacturing and design practices. Evidences from macroscopic failure features and microscopic fractographic morphologies are collected, analyzed, and correlated in order to identify the underlying mechanisms of blade fracture. Practices are recommended to improve structural integrity of rotor blades during their entire life cycles.

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Free flow wind speed from a blade-mounted flow sensor

This paper presents a method for obtaining the free-inflow velocities from a 3-D flow sensor mounted on the blade of a wind turbine. From its position on the rotating blade, e.g. one-third from the tip, a blade-mounted flow sensor (BMFS) is able to provide valuable information about the turbulent sheared inflow in different regions of the rotor. At the rotor, however, the inflow is affected by the wind turbine, and in most cases the wind of interest is the inflow that the wind turbine is exposed to, i.e. the free-inflow velocities. The current method applies a combination of aerodynamic models and procedures to estimate the induced velocities, i.e. the disturbance of the flow field caused by the wind turbine. These
velocities are subtracted from the flow velocities measured by the BMFS to obtain the free-inflow velocities. Aeroelastic codes, like HAWC2, typically use a similar approach to calculate the induction, but they use it for the reversed process, i.e. they add the induction to the free inflow to get the flow velocities at the blades, which are required to calculate the resulting aerodynamic forces. The aerodynamic models included in the current method comprise models based on blade element momentum (BEM) for axial and tangential induction, a radial induction model and tip loss correction, and models for skew and dynamic inflow. It is shown that the method is able to calculate the free-inflow velocities with high accuracy when applied to aeroelastic HAWC2 simulations with a stiff structural model while some deviations are seen in simulations with a flexible structure. Furthermore, the method is tested on simulations performed by a flexible structural model coupled with a large-eddy simulation (LES) flow solver. The results of this higher-fidelity verification confirm the HAWC2-based conclusion.

From lidar scans to roughness maps for wind resource modelling in forested areas
Applying erroneous roughness lengths can have a large impact on the estimated performance of wind turbines, particularly in forested areas. In this study, a new method called the objective roughness approach (ORA), which converts tree height maps created using airborne lidar scans to roughness maps suitable for wind modelling, is evaluated via cross predictions among different anemometers at a complex forested site with seven tall meteorological masts using the Wind Atlas Analysis and Application Program (WAsP). The cross predictions were made using ORA maps created at four spatial resolutions and from four freely available roughness maps based on land use classifications. The validation showed that the use of ORA maps resulted in a closer agreement with observational data for all investigated resolutions compared to the land use maps. Further, when using the ORA maps, the risk of making large errors (>25%) in predicted power density was reduced by 40–50% compared to satellite-based products with the same resolution. The results could be further improved for high-resolution ORA maps by adding the displacement height. The improvements when using the ORA maps were both due to a higher roughness length and due to the higher resolution.
Generic dynamic wind turbine models for power system stability analysis: A comprehensive review

In recent years, international working groups, mainly from the International Electrotechnical Commission (IEC) and the Western Electricity Coordinating Council (WECC), have made a major effort to develop generic —also known as simplified or standard— dynamic wind turbine models to be used for power system stability analysis. These models are required by power system operators to conduct the planning and operation activities of their networks since the use of detailed manufacturer models is not practical. This paper presents a comprehensive review of the work done in this field, based on the results obtained by IEC and WECC working groups in the course of their research, which have motivated the publication of the IEC 61400-27 in February 2015. The final published versions of the generic models developed according to the existing four wind turbine technology types are detailed, highlighting the subsequent changes made during the development phase. The main differences between IEC and WECC generic models are also analyzed. Not only is the final model structure presented but we also provide a complete description of the physical behavior of wind turbines facing power system stability problems. Results are thus of great interest to grid operators, software developers, wind farm owners and researchers focused on the integration of wind energy into power systems.
Voltage source converter (VSC) based High Voltage Direct Current (HVDC) Technologies have attracted more and more attention for integration of offshore wind power due to its good controllability. Coordinated control strategies shall be developed to utilize ancillary services from combined alternating current (AC)/DC grids and wind power plants, maintain good voltages, and mitigate the potential resonance problem. Besides, the fault current situation in DC grids depends on the control strategy and the interaction between the DC and AC grids. It is important to investigate the fault current situation considering both factors and design protection schemes.

This Special Issue on Coordinated Control and Protection of Offshore Wind and Combined AC/DC Grid contains 17 high quality papers that are relevant to this topic, including frequency control, voltage control, optimal operation, fault analysis and protection of wind power and AC/DC grids, and HVDC technologies.

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Organisations: Department of Electrical Engineering, Center for Electric Power and Energy, Electric Power Systems, Department of Wind Energy, Integration & Planning, Tsinghua University, State Grid Electric Power System Research Institute
Authors: Wu, Q. (Intern), Cutululis, N. A. (Intern), Wu, W. (Ekstern), Gomis-Bellmunt, O. (Ekstern), Xue, Y. (Ekstern), Ponci, F. (Ekstern), Liu, J. (Ekstern), Muljadi, E. (Ekstern)
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Hall-Petch strengthening in Fe-34.5Mn-0.04C steel cold-rolled, partially recrystallized and fully recrystallized

An Fe-34.5Mn-0.04C steel has been processed by cold rolling and annealing to prepare samples with a lamellar structure, a recrystallized grain structure and a composite structure of layers of recovered and recrystallized structures. For the recrystallized grain structure and the lamellar structure, the flow stress has been analyzed by applying Hall-Petch formulations. For the composite structure, the rule of mixture has been applied to calculate the flow stress, revealing an extra strengthening from a constraint effect. An excellent combination of strength and ductility has been found in a composite with 10% hard lamellae in a recrystallized grain structure.

General information
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Organisations: Department of Mechanical Engineering, Materials and Surface Engineering, Materials science and characterization, Yanshan University
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High dimensional dependence in power systems: A review

Weather-driven renewable generation is characterized by being uncertain and geographically dependent. In this regard, the recent deployment of wind and solar power has had a significant impact on the operation and planning of modern electricity grids; justifying the need to model high dimensional dependence. It is a relevant topic which is starting to have a significant importance in power systems. This paper presents a general overview on different multivariate dependence modeling techniques, namely parametric, non-parametric and copula functions. In addition, approximated methods based on limited information e.g. some statistical measures or a predefined dependence structure are presented. Autoregressive moving average (ARMA) and Markov models are discussed as general frameworks to reproduce spatio-temporal processes. Moreover, different applications in power systems are discussed in detail, along with a case study exemplifying the importance of a correct dependence modeling of wind generation.
High-resolution periodic mode shapes identification for wind turbines

The stability analysis of in-operation wind turbines is a very important topic, that has received considerable attention in the last years. Many identification algorithms have been developed to estimate frequencies and damping ratios, but very few papers have been dedicated to the mode shapes. The knowledge of high-resolution mode shapes could be exploited for several applications including model validation, accurate description of the vibratory content of a machine and spatially-accurate damage detection. In this work, we will present a procedure to compute the high-resolution periodic mode shapes of a wind turbine, and apply it to a high-fidelity wind turbine model. The results show that this methodology is able to identify the first low-damped modes of the system with good accuracy.
Hybrid metallic nanocomposites for extra wear-resistant diamond machining tools

The applicability of metallic nanocomposites as binder for diamond machining tools is demonstrated. The various nanoreinforcements (carbon nanotubes, boron nitride hBN, nanoparticles of tungsten carbide/WC) and their combinations are embedded into metallic matrices and their mechanical properties are determined in experiments. The wear resistance of diamond tools with metallic binders modified by various nanoreinforcements was estimated. 3D hierarchical computational finite element model of the tool binder with hybrid nanoscale reinforcements is developed, and applied for the structure-properties analysis of the binder. It is shown that the metallic nanocomposites with hybrid reinforcements ensure the highest mechanical properties and also the highest wear-resistance of the machining tools, with the nanocomposites used as binder.

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Publication information
ICT Based Performance Evaluation of Primary Frequency Control Support from Renewable Power Plants in Smart Grids

The increased penetration of Renewable Energy Generation (ReGen) plants in future power systems poses several challenges to the stability of the entire system. In future green energy rich power system, the responsibility for providing ancillary services will be shifted from conventional power plants towards ReGen plants, such as wind and photovoltaic power plants. Frequency control support from the Wind Power Plants (WPPs) is one of the crucial ancillary services in order to preserve operational stability in case of grid disturbances. Among other requirements, the ability to provide fast frequency control support from ReGen plants will highly depend on the underlying communication infrastructure that allows an exchange of information between different ReGen plants and the control centers. This paper, therefore, focuses on the impact of communication and the related aspects to provide online frequency control support from ReGen (with special focus on WPP). The study is conducted with an aggregated WPP model, integrated into a generic power system model, specifically designed to assess the ancillary services in a relatively simple yet relevant environment. Various case studies with different wind speeds at a particular wind-power penetration level and communication scenarios are considered to evaluate the performance of power system frequency response. The article provides the Transmission System Operator (TSO) and other communication engineers insights into the importance and various aspects of communication infrastructure for general service coordination between WPPs and specifically primary frequency control coordination from WPPs in future power systems.

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IEA Wind Task 32: Wind lidar identifying and mitigating barriers to the adoption of wind lidar

IEA Wind Task 32 exists to identify and mitigate barriers to the adoption of lidar for wind energy applications. It leverages ongoing international research and development activities in academia and industry to investigate site assessment, power performance testing, controls and loads, and complex flows. Since its initiation in 2011, Task 32 has been responsible for
several recommended practices and expert reports that have contributed to the adoption of ground-based, nacelle-based, and floating lidar by the wind industry. Future challenges include the development of lidar uncertainty models, best practices for data management, and developing community-based tools for data analysis, planning of lidar measurements and lidar configuration. This paper describes the barriers that Task 32 identified to the deployment of wind lidar in each of these application areas, and the steps that have been taken to confirm or mitigate the barriers. Task 32 will continue to be a meeting point for the international wind lidar community until at least 2020 and welcomes old and new participants.

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Authors: Clifton, A. (Ekstern), Clive, P. (Ekstern), Gottschall, J. (Ekstern), Schlipf, D. (Ekstern), Simley, E. (Ekstern), Simmons, L. (Ekstern), Stein, D. (Ekstern), Trabucchi, D. (Ekstern), Vasiljevic, N. (Intern), Würth, I. (Ekstern)
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Impact damage reduction by structured surface geometry
Repeated impacts can cause damage to not only a surface but also inside the material. Mechanisms include stress-wave propagation into the material, reflection of the waves at the back surface, and subsequent repeated reflections in the vicinity of the impact and the back surface. Impact damage performance was observed for polyurethane-coated fibre composites with structured geometries at the back surfaces. Repeated impacts by rubber balls on the coated side caused damage and delamination of the coating. The laminates with structured back surfaces showed longer durability than those
with a flat back surface. The in-situ acoustic measurement indicates that the acoustic power within the pulse duration was 25–40% lower using the structured back surfaces. The observed effect can be attributed to scattered reflection at the back surface to reduce the high intensity duration of the acoustic waves.
Impact fatigue damage of coated glass fibre reinforced polymer laminate

Impact fatigue caused by rain droplets, also called rain erosion, is a severe problem for wind turbine blades and aircraft. In this work, an assessment of impact fatigue on a glass fibre reinforced polymer laminate with a gelcoat is presented and the damage mechanisms are investigated. A single point impact fatigue tester is developed to generate impact fatigue damage and SN data. Rubber balls are repeatedly impacted on a single location of the coated laminate. Each impact induces transient stresses in the coated laminate. After repeated impacts, these stresses generate cracks, leading to the removal of the coating and damage to the laminate. High-resolution digital imaging is used to determine the incubation time until the onset of coating damage, and generate an SN curve. An acoustic emission sensor placed at the back of the laminate monitors changes in acoustic response as damage develops in the coated laminate. The subsurface cracks are studied and mapped by 3D X-ray computed tomography. A finite element method model of the impact shows the impact stresses in the coating and the laminate. The stresses seen in the model are compared to cracks found by 3D tomography. The damage is also evaluated by ultrasonic scanning.
Impact of turbulence induced loads and wave kinematic models on fatigue reliability estimates of offshore wind turbine monopiles

The cost of offshore wind turbine substructures has a significant impact on competitiveness of the wind energy market and is affected by conservative safety margins adopted in the design phase. This implies that an accurate design load prediction, especially of those resulting in fatigue damage accumulation, may help achieve more cost-effective solutions. In this article, the impact of turbulence and wave loads on fatigue reliability of pile foundations is investigated for a 5-MW offshore wind turbine. Loads obtained by varying turbulence percentiles are compared with those obtained from the full joint probability distribution of wind speed and turbulence through Monte Carlo (MC) simulations, and from the equivalent turbulence level currently adopted by IEC standards. The analyses demonstrate that a lower equivalent turbulence percentile leads to a more realistic and less conservative estimation of fatigue loads. Subsequently, the research focuses on studying the effects of uncertain marine environments on the fatigue load distribution, showing that the latter is insensitive to the random variability of the hydrodynamic coefficients. With respect to the wave kinematic model, a comparison between nonlinear and linear waves clearly suggests that hydrodynamic forces depend significantly on the kinematic model adopted and the operational conditions of the turbine. Furthermore, a term is derived to correct the error introduced by Wheeler stretching at finite water depths. The respective model uncertainties that originate from the nonlinear irregular wave model and Wheeler correction are quantified and employed in a reliability analysis. In a case study, the results are finally compared in terms of estimated probability of failure, with the aim to quantify the influence of environmental models on monopile reliability.
Implementation of large-scale average geostrophic wind shear in WAsP12.1

The vertical extrapolation model described in the European Wind Atlas Troen and Petersen (1989) is modified to take into account large-scale average geostrophic wind shear to describe the effect of horizontal temperature gradients on the geostrophic wind. The method is implemented by extracting the average geostrophic wind shear from Climate Forecast System Reanalysis (CFSR) data and the values of nearest grid point are automatically used in the WAsP 12.1 user interface to provide better AEP predictions.

Improved modelling of fatigue loads in wind farms under non-neutral ABL stability conditions

The purpose of this study is improve the predictive capability of the Dynamic Wake Meandering (DWM) model generalized to non-neutral atmospheric boundary layer (ABL) conditions in general and under stable ABL stratification in particular. The emphasis is on rotating wind turbine components, and the model improvement in focus is intimately linked to a newly developed refinement of the classic Monin-Obukhov theory, which, for stable ABL stratification, primary results in less pronounced mean wind shear outside the surface layer, where most modern wind turbines are operating. The model improvements are validated against a huge set of full-scale data, which allows for a one-to-one comparison of wind turbine load simulations and measurements conditioned on ABL stability conditions.
Inflow characterization using measurements from the SpinnerLidar: the ScanFlow experiment

We present a preliminary analysis of inflow measurements performed with a SpinnerLidar on a turbine’s nacelle and those from three grounded-based short-range continuous-wave lidars (WindScanners) during the ScanFlow experiment. After proper filtering for blade contamination and hub/nacelle shading of the beam, the SpinnerLidar measurements capture the structure of the inflow in detail. The WindScanners’ 3D measurements provide estimations of the three wind speed components without any flow assumptions. These 3D wind field measurements are used as reference to evaluate SpinnerLidar reconstructed winds. A wind reconstruction methodology for the SpinnerLidar measurements is evaluated against a numerical wind inflow simulation successfully. An intercomparison between reconstructed longitudinal velocity
components from the WindScanners and the Spinnerlidar shows good agreement (no bias and high correlation) at hub height and close to zero biases for all vertical levels measured by the SpinnerLidar.
Inflow measurements from blade-mounted flow sensors: Flow analysis, application and aeroelastic response

The power and load performance of wind turbines are both crucial for the development and expansion of wind energy. The power and loads are highly dependent on the inflow conditions, which can be measured using different types of sensors mounted on nearby met masts, on the nacelle, at the spinner or at the blade. Each combination of sensor type and mounting position has advantages and shortcomings. To characterise the inflow that results in high and low fatigue loads, information about the temporal and spatial variations within the rotor area is required. This information can be obtained from a blade-mounted flow sensor, BMFS, e.g. a five-hole pitot tube, which has been used in several research experiments over the last 30 years. The BMFS measured flow velocity is, however, located inside the induction zone and thereby influenced by the aerodynamic properties, the control strategy and the operational status of the turbine. In this project, a method to estimate the free-inflow velocity from the BMFS measured flow velocity has been developed and implemented. The method is based on the aerodynamic engineering models that are used in well-established aeroelastic codes to describe the relation between the free-inflow and the velocity at the blades. Before these models can be applied, the measured local flow must be compensated for flow deflection and change of flow speed near the airfoil. Furthermore, the sensor velocity must be subtracted and the resulting absolute flow must be mapped into fixed ground coordinates. In these steps, uncertainty is introduced because the actual velocity and orientation of the BMFS are unknown due to the deflection and torsion of the blade. The introduced uncertainties have been investigated using HAWC2 simulations and simulations performed by Flex5 coupled with the LES flow solver, EllipSys3D. The uncertainties should, however, be considered in relation to the advantages of measuring the flow at the blade: a BMFS yaws with the turbine, measures the inflow at the rotor plane and sweeps different parts of the rotor. It is thereby exposed to exactly the same inflow conditions as the turbine (including wake effects from upstream turbines) and able to provide valuable information about the instant inflow velocity as well as variations within the rotor plane, and that goes for all wind directions. From the BMFS measurements, estimates of the local aerodynamic forces, the angle-of-attack and relative flow speed, the rotor-plane velocity and the free-inflow velocity can be obtained. Applications of these measures have been investigated. It is concluded that a BMFS provides valuable information about the inflow, which can be used for the control of load alleviating concepts like individual pitch and trailing edge flaps, to investigate the complex relation between the inflow and the power and loads, to characterise the inflow conditions that yield high loads, and as input for aeroelastic simulations to improve the correlation between the measured and simulated loads.
NACA 63-418 airfoil profile, were used. Typical operating condition Reynolds numbers, turbulence grid and boundary layer control devices on the surface were implemented. The results indicate a high dependency of the transition process on these parameters. The analyses show that the critical height of the leading edge roughness (LER) is to be met in order to have a bypass transition to turbulent flow at the angle of attacks, where the stagnation point is upstream of the LER location. The transition location moves closer to the leading edge with increasing Reynolds number when the roughness height is smaller than the critical height. Inflow turbulence is observed to have a larger effect on the transition location than the predicted numerical results.

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Organisations: Department of Wind Energy, Aerodynamic design, Fluid Mechanics
Authors: Özçakmak, O. S. (Intern), Madsen, H. A. (Intern), Sørensen, N. N. (Intern), Sørensen, J. N. (Intern), Fischer, A. (Intern), Bak, C. (Intern)
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Scopus rating (2008): SJR 0.264 SNIP 0.301
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.258 SNIP 0.399
Web of Science (2007): Indexed yes
Influence of system level parameters on the Fatigue life of jacket substructure fro 10 MW and 20 MW Wind Turbines

This paper investigates the influence of system-level innovations on the fatigue life of jacket substructures for offshore wind turbines. The innovations consist of active control strategies as individual pitch control and individual flap control. Further the effect of a magnetic pseudo direct-drive generator (PDD) mounted upfront the rotor is investigated. Fully-coupled aeroelastic simulations are performed for 10 MW and 20 MW wind turbines, with the selected innovations, supported by jacket structures under specific met-ocean conditions at 50 m of water depth. Fatigue limit states at the jacket' welded joints are evaluated based on S-N curves and Miner's rule according to DNV-RP-C203 guideline. Results show the potential of advanced control systems to reduce stresses at jacket members. Few design challenges characterize PDD models, as increased tower base torsional loads and excitation of global bending modes may be critical for jacket’s members. Altogether, this study indicates the benefit of an integrated-iterative design approach for jacket substructures, where system-level parameters are iterated along with the jacket design parameters using fully-coupled models.

Instabilities in the Wake of an Inclined Prolate Spheroid

We investigate the instabilities, bifurcations and transition in the wake behind a 45-degree inclined 6:1 prolate spheroid, through a series of direct numerical simulations (DNS) over a wide range of Reynolds numbers (Re) from 10 to 3000. We provide a detailed picture of how the originally symmetric and steady laminar wake at low Re gradually looses its symmetry and turns unsteady as Re is gradually increased. Several fascinating flow features have first been revealed and subsequently analysed, e.g. an asymmetric time-averaged flow field, a surprisingly strong side force etc. As the wake partially becomes turbulent, we investigate a dominating coherent wake structure, namely a helical vortex tube, inside of which a helical symmetry alteration scenario was recovered in the intermediate wake, together with self-similarity in the far wake.

General information

State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Conti, D. (Intern), Natarajan, A. (Intern), Abrahamsen, A. B. (Intern)
Number of pages: 10
Publication date: 2018
Instantaneous Response and Mutual Interaction between Wind Turbine and Flow

The mutual fluid-structure interaction between wind turbine(s) and the highly turbulent flow deep inside a large wind farm is investigated in order to elucidate on how to implement and perform dynamic wind farm control. The study employs a fully coupled LES and aeroelastic framework, which provide time resolved flow and turbine response governed by a controller. The results show a large correlation between incoming flow and turbine response, which extends several radii upstream and could be utilized for turbine control by e.g. installing a lidar on top of the wind turbine. Similarly, the results are valuable for utilizing nacelle mounted lidars for power curve assessments in large wind farms. However, the correlations between turbine and wake flow as well as the dynamic wake position are low, which is potentially discouraging for attempts to do instantaneous yaw steering.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics
Authors: Andersen, S. J. (Intern), Sørensen, J. N. (Intern)
Number of pages: 10
Publication date: 2018
Conference: Torque 2018, Milan, Italy, 20/06/2018 - 20/06/2018
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Physics: Conference Series
Volume: 1037
Issue number: 7
Article number: 072011
ISSN (Print): 1742-6596
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
Integrated optimal design of jackets and foundations

The article proposes a method for integrated design of jackets and foundations using numerical structural optimization. Both piles and suction caissons are examined in both clayey and sandy soil, and several design procedures are taken into account. The optimal design problem enables an automatic design process which minimizes the primary steel mass of the jacket and the foundations. Both leg distance and soil stiffness are found to have a significant influence on the total mass as well as the first natural frequency of the full offshore wind turbine structure. The results indicate that an integrated design approach is valuable in the conceptual design phase. Firstly, the soil characteristics and foundation type have a significant influence on the optimal leg distance for the jacket. Secondly, the jacket mass has a significant influence on the optimal foundation type and foundation design.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design, Department of Civil Engineering, Section for Geotechnics and Geology, Geotechnics and Geology
Authors: Sandal, K. (Intern), Latini, C. (Intern), Zania, V. (Intern), Stolpe, M. (Intern)
Number of pages: 21
Pages: 398-418
Publication date: 2018
Main Research Area: Technical/natural sciences

Publication information
Journal: Marine Structures
Volume: 61
ISSN (Print): 0951-8339
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.35 SJR 2.049 SNIP 2.936
International experiences with opposition to wind energy siting decisions: Lessons for environmental and social appraisal

The planning of renewable energy infrastructure has proven highly controversial across many countries. We critically examine the lessons that can be learned from research investigating the causes of controversy over wind turbines. The review focuses on a specific, but often highly controversial, component of planning practice: environmental and social appraisal. The review advances understandings of the reasons for contestation over the social impacts of wind turbines; the basis and legitimacy of plurality and contestation; and, the biases that tend to underpin understandings of the role and functioning of participation in appraisal. A typology of actors’ attitudes to wind energy is employed to elucidate the implications of our review for appraisal practices. We conclude that a broader understanding of the societal purposes of public participation needs to be integrated into appraisal theory and practice, including an acceptance of the legitimacy of antagonism and dissent and its value in fostering social learning.

Investigation of droplet path in a rain erosion tester

Erosion of the leading edges of wind turbine blades due to the repeated impact of rain droplets at high speed over time can wear down the blade surfaces to the extent that power production is significantly reduced for the wind turbines. Therefore a rain erosion tester, which is a test bench for accelerated test of leading erosion due to rain impact, can be used to assess the durability of different leading edge materials and coatings. Since the droplet relative speed and size at impact is of key importance to the erosion process, it is important to know how these are affected by the complex flow disturbances stemming from the rain erosion tester itself. This is investigated in the present work using high speed camera recordings and CFD. The high speed camera recordings reveal that the droplets do not break up before impact at the surface, and that the path of the droplets is relatively undisturbed by the flow induced by the rain erosion tester. The comparison with droplet paths simulated in CFD is in good agreement with this result. The CFD simulations further indicate that an inaccurately set pitch angle of the blades can result in a very different flowfield in the RET, which can significantly alter the droplet trajectories.
Laminated Fe-34.5Mn-0.04C composite with high strength and ductility

To obtain a good combination of strength and ductility, a laminated composite structure composed of recovered hard lamellae and soft recrystallized lamellae has been produced in a single phase austenitic Fe-34.5 Mn-0.04C steel by cold
rolling and partial recrystallization. Enhanced mechanical properties in both strength and ductility have been obtained in the composite structure compared to a fully recrystallized coarse grain structure. A further increase in strength with only minor loss in total elongation has been achieved by a slight cold rolling of the composite structure, which also removes the small yield drop and Lüders elongation observed in the composite structure.

**General information**

State: Accepted/In press
Organisations: Department of Wind Energy, Department of Mechanical Engineering, Materials and Surface Engineering, Materials science and characterization, Yanshan University
Authors: Wang, Y. (Ekstern), Kang, J. (Ekstern), Peng, Y. (Ekstern), Wang, T. (Ekstern), Hansen, N. (Intern), Huang, X. (Intern)
Publication date: 2018
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Journal of Materials Science & Technology
ISSN (Print): 1005-0302
Ratings:
- BFI (2018): BFI-level 1
- Web of Science (2018): Indexed yes
- BFI (2017): BFI-level 1
- Scopus rating (2017): CiteScore 3.5 SJR 1.138 SNIP 1.462
- Web of Science (2017): Indexed Yes
- BFI (2016): BFI-level 1
- Scopus rating (2016): CiteScore 3.02 SJR 0.977 SNIP 1.407
- BFI (2015): BFI-level 1
- Scopus rating (2015): SJR 0.829 SNIP 1.265 CiteScore 2.38
- BFI (2014): BFI-level 1
- Scopus rating (2014): SJR 0.961 SNIP 1.615 CiteScore 2.23
- BFI (2013): BFI-level 1
- Scopus rating (2013): SJR 0.845 SNIP 1.39 CiteScore 1.89
- ISI indexed (2013): ISI indexed yes
- BFI (2012): BFI-level 1
- Scopus rating (2012): SJR 0.658 SNIP 1.113 CiteScore 1.21
- ISI indexed (2012): ISI indexed yes
- BFI (2011): BFI-level 1
- Scopus rating (2011): SJR 0.455 SNIP 0.89 CiteScore 0.94
- ISI indexed (2011): ISI indexed yes
- BFI (2010): BFI-level 1
- Scopus rating (2010): SJR 0.465 SNIP 0.797
- BFI (2009): BFI-level 1
- Scopus rating (2009): SJR 0.413 SNIP 0.68
- BFI (2008): BFI-level 1
- Scopus rating (2008): SJR 0.315 SNIP 0.56
- Scopus rating (2007): SJR 0.256 SNIP 0.424
- Scopus rating (2006): SJR 0.234 SNIP 0.442
- Web of Science (2006): Indexed yes
- Scopus rating (2005): SJR 0.183 SNIP 0.39
- Scopus rating (2004): SJR 0.247 SNIP 0.471
- Scopus rating (2003): SJR 0.231 SNIP 0.535
- Scopus rating (2002): SJR 0.243 SNIP 0.407
- Scopus rating (2001): SJR 0.185 SNIP 0.387
- Scopus rating (2000): SJR 0.189 SNIP 0.351
- Scopus rating (1999): SJR 0.209 SNIP 0.322

Original language: English
Constraint effect, Ductility, Laminated composite structure, Partial recrystallization, Strength

**DOIs:**
Large Scale Offshore Wake Impact on the Danish Power System

This poster gives an overview of the ongoing Danish ForskEL/EUDP project “OffshoreWake” (2017 - 2020). The focal point of this project is to develop a calculation system that adds the large scale offshore wind farm wake (WFW) to the power system. There are five components in this calculation system, as shown in FIG 1, with 0, 1 and 2 already existing. OffshoreWake adds components 3 and 4, namely the WFW and surface wave conditions.

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Publication date: 2018
Main Research Area: Technical/natural sciences
Electronic versions:
EGU2018_Poster_OffshoreWake_20180405
Publication: Research › Poster – Annual report year: 2018

Large Scale Offshore Wake Impact on the Danish Power System (OffshoreWake)

The project OffshoreWake will investigate and solve new issues in offshore wind resource estimation and the conversion to power calculation, arising from wake effects of wind farms as the number and size of offshore wind farms grow. The focal point of OffshoreWake is to develop a calculation system that adds the large scale offshore wind farm wake (WFW) to wind-to-power calculation system. At the same time it is essential to consider the effects from a series of external factors, including varying weather conditions, stability and wave conditions. The product of OffshoreWake will be a calculation system that contains five dynamically interacting components, the wind, the wake, the sea surface conditions, the wind-to-power conversion and the power system. The corresponding models for these components, with Weather Research and Forecasting (WRF) model for wind, Explicit Wake Parameterization (the EWP module in WRF) for wind farm wake, Spectral Wave model Nearshore (SWAN) for sea surface conditions, Corwind for the wind-to-power and Simba for power system. The novelty of OffshoreWake is the implementation of EWP and SWAN to the existing modeling system and improvement of the power conversion calculation. The development of the calculation system is calibrated, verified and validated with measurements, including offshore masts, SCADA and satellite data. The system will eventually be applied to existing and future offshore wind farm layouts, resource and wind power assessment.

General information
State: Published
Authors: Larsén, X. G. (Intern), Volker, P. (Intern), Sørensen, P. E. (Intern), Nissen, J. (Ekster), Du, J. (Intern), Giebel, G. (Intern), Hasager, C. B. (Intern), Maule, P. (Intern), Hahmann, A. N. (Intern), Badger, J. (Intern)
Publication date: 2018
Main Research Area: Technical/natural sciences
Electronic versions:
EGU2018_OffshoreWake.pdf
Publication: Research › Conference abstract for conference – Annual report year: 2018

Leading edge erosion of wind turbine blades

General information
State: Published
LES simulation and experimental validation of the unsteady aerodynamics of blunt wind turbine airfoils

In order to investigate the unsteady performance of blunt wind turbine airfoils caused by boundary layer separation and wake eddies, this paper studies the aerodynamic performance by large eddy simulation (LES) and wind tunnel experiment at a Reynolds number of $2.62 \times 10^5$. The blunt airfoils are obtained by enlarging the trailing edge of the DU 91-W2-250 airfoil to 6% and 10% chords symmetrically on both pressure and suction sides of the airfoil. The simulation was carried out with the incompressible finite-volume Navier-Stokes code EllipSys3D; and, the experiment was done in a wind tunnel with a cross-section of $0.5m \times 0.5m$ by measuring the surface pressure and wake velocities using ESP-64HD pressure scanner and TSI hot-wire anemometer. The unsteady wake was captured by hot-wire in the wind tunnel, and LES with EllipSys3D. Both experiment and LES show that the spectrum of aerodynamic forces has a broadband nature which is in coincidence with the wake eddies, implying that the unsteady Kármán vortex sheet is the driving mechanism of the force fluctuation. Moreover, the trailing edge size affects the separation bubbles and transition process in the boundary layer. It shows that the boundary layer near the leading edge is unstable in the spanwise direction, which is characterized by low frequency waves.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Liaoning University of Petroleum and Chemical Technology, Chinese Academy of Sciences
Authors: Wang, G. (Ekstern), Zhang, L. (Ekstern), Shen, W. Z. (Intern)
Number of pages: 13
Pages: 911-923
Publication date: 2018
Main Research Area: Technical/natural sciences

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Volume: 158
ISSN (Print): 0360-5442
Ratings:
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 5.6 SJR 1.99 SNIP 1.923
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.17 SJR 1.974 SNIP 1.823
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.22 SNIP 2.037 CiteScore 5.03
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.575 SNIP 2.602 CiteScore 5.7
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.458 SNIP 2.556 CiteScore 5.02
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Load validation of aero-elastic simulations with measurements performed on a 850kW horizontal-axis wind turbine

In this work, aero-elastic solver predictions with HAWC2 are compared with measured data from a VESTAS V52 wind turbine situated at DTU campus Risø. Nearly one year of several measured wind conditions were considered for selection of loads and performance simulations. A new methodology for adjusting strain gauge (SG) calibrations originally from blade pull testing over time is presented. As a result, we show and discuss the different predictions on power performance and compare results with measured blade loads, under the condition of adjusting blade SG pull test calibration for temperature and time degradation effects.

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control, University of Padua
Authors: Paulsen, U. S. (Intern), Gomiero, M. (Ekstern), Larsen, T. J. (Intern), Benini, E. (Ekstern)
Number of pages: 10
Publication date: 2018
Conference: Torque 2018, Milan, Italy, 20/06/2018 - 20/06/2018
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Physics: Conference Series
Volume: 1037
Issue number: 6
Long-term exposure to wind turbine noise at night and risk for diabetes: A nationwide cohort study

Focus on renewable energy sources and reduced unit costs has led to increased number of wind turbines (WTs). WT noise (WTN) is reported to be highly annoying at levels from 30 to 35dB and up, whereas for traffic noise people report to be highly annoyed from 40 to 45dB and up. This has raised concerns as to whether WTN may increase risk for major diseases, as exposure to traffic noise has consistently been associated with increased risk of cardiovascular disease and diabetes. We identified all Danish dwellings within a radius of 20 WT heights and 25% of all dwellings within 20-40 WT
heights from a WT. Using detailed data on WT type and hourly wind data at each WT position and height, we estimated hourly outdoor and low frequency indoor WTN for all dwellings, aggregated as nighttime 1- and 5-year running means. Using nationwide registries, we identified a study population of 614,731 persons living in these dwellings in the period from 1996 to 2012, of whom 25,148 developed diabetes. Data were analysed using Poisson regression with adjustment for individual and area-levels covariates. We found no associations between long-term exposure to WTN during night and diabetes risk, with incidence rate ratios (IRRs) of 0.90 (95% confidence intervals (CI): 0.79-1.02) and 0.92 (95% CI: 0.68-1.24) for 5-year mean nighttime outdoor WTN of 36-42 and ≥42dB, respectively, compared to

**General information**

State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling, Danish Cancer Society Research Center, Aarhus University, Roskilde University
Authors: Poulsen, A. H. (Ekstern), Raaschou-Nielsen, O. (Ekstern), Pena Diaz, A. (Intern), Hahmann, A. N. (Intern), Nordsborg, R. B. (Ekstern), Ketzel, M. (Ekstern), Brandt, J. (Ekstern), Sørensen, M. (Ekstern)
Pages: 40-45
Publication date: 2018
Main Research Area: Technical/natural sciences

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Journal: Environmental Research
Volume: 165
ISSN (Print): 0013-9351
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4.59 SJR 1.605 SNIP 1.413
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4.12 SJR 1.413 SNIP 1.326
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.424 SNIP 1.317 CiteScore 3.71
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.794 SNIP 1.76 CiteScore 4.32
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.569 SNIP 1.597 CiteScore 3.75
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.541 SNIP 1.362 CiteScore 3.31
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.703 SNIP 1.53 CiteScore 3.7
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.664 SNIP 1.474
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.506 SNIP 1.384
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.372 SNIP 1.39
Scopus rating (2007): SJR 1.318 SNIP 1.601
Scopus rating (2006): SJR 1.198 SNIP 1.506
Scopus rating (2005): SJR 1.094 SNIP 1.341
Scopus rating (2004): SJR 0.824 SNIP 0.973
Scopus rating (2003): SJR 0.752 SNIP 1.195
Scopus rating (2002): SJR 0.928 SNIP 1.263
The magnetic phase diagram of the quaternary borocarbide TbNi$_2$B$_2$C is investigated by direct means and by studying magnetically induced modifications of the crystal structure. Detailed superconducting quantum interference device measurements reveal a complex phase diagram with five distinct magnetic phases. The phase boundaries are mapped out comprehensively. Synchrotron hard x-ray measurements in applied magnetic fields are employed to probe the magnetoelastic distortions throughout the phase diagram. The determination of the wave vectors of these field-induced lattice deformations suggests a range of commensurate spin-slip-type magnetic structures at low temperatures with wave vectors of the form $(q,0,0)$ with $q = 6/11$ and $5/9$. The proposed magnetic structures yield values of magnetization well in-line with observations. The scattering intensity due to the magnetoelastic deformations exhibits a drastic jump at the phase boundary at 1.3 T and low temperatures.

**General information**

State: Published
Organisations: Department of Physics, Neutrons and X-rays for Materials Physics, Department of Energy Conversion and Storage, Electrofunctional materials, Department of Wind Energy, Wind Turbine Structures and Component Design, Technical University of Denmark, University of Copenhagen, Deutsches Elektronen-Synchrotron, Helmholtz–Zentrum Berlin für Materialien und Energie, Ochanomizu University, National Institute for Materials Science
Number of pages: 8
Publication date: 2018
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Physical Review B
Volume: 97
Issue number: 22
Article number: 224417
ISSN (Print): 1098-0121
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.34 SJR 1.604 SNIP 1.04
Web of Science (2017): Indexed yes
Scopus rating (2016): CiteScore 3.16 SJR 2.339 SNIP 1.151
Web of Science (2016): Indexed yes
Scopus rating (2015): SJR 2.377 SNIP 1.13 CiteScore 2.8
Web of Science (2015): Indexed yes
Scopus rating (2014): SJR 2.762 SNIP 1.316 CiteScore 3.3
Web of Science (2014): Indexed yes
Scopus rating (2013): SJR 2.813 SNIP 1.326 CiteScore 3.55
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
Scopus rating (2012): SJR 3.173 SNIP 1.378 CiteScore 3.57
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Scopus rating (2011): SJR 3.326 SNIP 1.423 CiteScore 3.61
Mass detection, localization and estimation for wind turbine blades based on statistical pattern recognition

A method for mass change detection on wind turbine blades using natural frequencies is presented. The approach is based on two statistical tests. The first test decides if there is a significant mass change and the second test is a statistical group classification based on Linear Discriminant Analysis. The frequencies are identified by means of Operational Modal Analysis using natural excitation. Based on the assumption of Gaussianity of the frequencies, a multi-class statistical model is developed by combining finite element model sensitivities in 10 classes of change location on the blade, the smallest area being 1/5 of the span. The method is experimentally validated for a full scale wind turbine blade in a test setup and loaded by natural wind. Mass change from natural causes was imitated with sand bags and the algorithm was observed to perform well with an experimental detection rate of 1, localization rate of 0.88 and mass estimation rate of 0.72.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design, Department of Civil Engineering, Section for Structural Engineering, Centre for oil and gas – DTU, Vestas Wind Systems AS, Aarhus University
Authors: Colone, L. (Intern), Hovgaard, K. (Ekstern), Glavind, L. (Forskerdatabase), Brincker, R. (Intern)
Pages: 266-277
Publication date: 2018
Main Research Area: Technical/natural sciences

Publication information
Journal: Mechanical Systems and Signal Processing
Volume: 107
ISSN (Print): 0888-3270
Measured aerodynamic forces on a full scale 2MW turbine in comparison with EllipSys3D and HAWC2 simulations

Design loads on turbines are normally simulated with an aeroelastic model using an engineering BEM type model with the turbulent inflow generated with a turbulence model like the Mann model. There are several fundamental uncertainties in this approach, e.g., how well the unsteady induction in response to the turbulent flow is computed. However, within the last few years full 3D CFD rotor computations with turbulent inflow have been performed which can provide detailed insight into this complex load response. In the present work we present computations with the EllipSys3D solver on the 80m diameter NM80 turbine used in the DANAERO project where surface pressure measurements at four radial positions were conducted. The aerodynamic loads integrated from the pressure distributions have been derived and compared with computations by the aeroelastic code HAWC2. Overall a very good correlation is found by comparing PSD spectra of the measured sectional blade forces with HAWC2 simulations using specific flow input from the meteorology mast at six
heights. In another comparison using purely turbulent inflow for the simulations on the NM80 rotor some deviations between the force spectra are found between EllipSys3D results and HAWC2 simulations at the inboard part of the blade and at high frequencies.

**General information**

State: Published
Organisations: Department of Wind Energy, Aerodynamic design, Wind turbine loads & control
Authors: Madsen, H. A. (Intern), Sørensen, N. N. (Intern), Bak, C. (Intern), Troldborg, N. (Intern), Pirrung, G. (Intern)
Number of pages: 10
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BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.351
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.259 SNIP 0.346
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.264 SNIP 0.301
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.258 SNIP 0.399
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.272 SNIP 0.311
Web of Science (2006): Indexed yes
Original language: English
Electronic versions:
Madsen_2018_J._Phys._3A_Conf._Ser._1037_022011.pdf
MEDOW - Multi-terminal DC Grid for Offshore Wind, Final report

A DC grid based on multi-terminal voltage-source converter is a newly emerging technology, which is particularly suitable for the connection of offshore wind farms. Multi-terminal DC grids will be the key technology for the European offshore Super Grid. In the project, DC power flow, DC relaying protection, steady state operation, dynamic stability, fault-ride through capability, and impacts of DC grids on the operation of AC grids and power market were studied. Systematic comparison of DC grid topologies and stability control strategies was carried out, and DC grids for offshore wind power transmission and onshore AC grid interconnection were investigated. Operation and control were evaluated using various simulation platforms and experimental test rigs. The outcomes of the project are expected to contribute to integrating offshore wind power into the onshore AC grids in European countries and for the European Super Grid.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning
Authors: Cutululis, N. A. (ed.) (Intern)
Number of pages: 139
Publication date: 2018

Publication information
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Original language: English
Series: DTU Wind Energy E
Number: 317221
Main Research Area: Technical/natural sciences
Electronic versions:
MEDOW_Final_Report_April2018.pdf

Relations
Projects:
MEDOW - Multi-terminal DC Grid for Offshore Wind, Final report
Source: PublicationPreSubmission
Source-ID: 146558251
Publication: Research › Report – Annual report year: 2018

Mesoscale to microscale coupling for determining site conditions in complex terrain

Accurate estimation of local site conditions, i.e. wind power resources and the turbulence impacting wind turbines, is an important part of wind farm planning. In complex terrain, non-linear microscale models that account for atmospheric stability effects are needed for accurate site assessment, but by themselves they are unable to account for the changing large-scale weather conditions. Therefore, coupling to a mesoscale model, which can provide these variations to the microscale models, is required. This thesis describes, implements and validates with observed tall mast measurements a novel coupling strategy using the Weather Research and Forecasting (WRF) mesoscale model and the EllipSys3D URANS microscale model for wind downscaling. The coupling strategy is based on forcing the microscale model with momentum and temperature source terms extracted from the time-evolving mesoscale model simulation. These terms are included as source terms instead of the usual lateral boundary conditions. Two cases are presented for sites in simple and complex terrain. First, results from simple terrain cases are presented. It is shown that a Single-Column Model (SCM) version of microscale model forced by tendencies from WRF results in long-term wind statistics of comparable statistical accuracy to results using the WRF model itself. Using different Planetary Boundary Layer and Surface Layer schemes in the WRF model simulations shows that the SCM results tend to follow the WRF model results, while maintaining a statistically similar response near the surface. Second, the coupling method was used at the complex double hill site Perdigão. It was shown that for a simulation using 80 m grid spacing and a first-order accurate discretisation scheme, the coupled approach results in large improvements in wind statistics compared to downscaling with the WRF model with an innermost domain of 333 m grid spacing. At four masts situated on top of the two ridge tops, the mean biases in wind speed for a 32-day period were less than 3% at the top most anemometer on each mast, compared to mean errors of 8–12% and 17–25% for WRF domains of 1 km and 333 m grid spacing, respectively. Despite the encouraging results, a clear dependence on grid spacing and numerical methods was seen in the coupled model results. Uncertainties remain
about possible double-counting of turbulent fluxes, and its impact on the simulated wind speed, when RANS turbulence closures are used for transient atmospheric modeling at fine resolution.

**General information**
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling
Authors: Olsen, B. T. (Intern)
Number of pages: 192
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Original language: English
Main Research Area: Technical/natural sciences
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Projects:
Mesoscale to microscale coupling for determining site conditions in complex terrain
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**Microscale modelling and validation**

**General information**
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling, Integration & Planning
Authors: Mortensen, N. G. (Intern), Hahmann, A. N. (Intern), Hansen, J. C. (Intern)
Number of pages: 22
Publication date: 2018

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Main Research Area: Technical/natural sciences
Electronic versions:
WASA_2_Microscale_modelling_and_validation.pdf
Source: PublicationPreSubmission
Source-ID: 149771029
Publication: Research - peer-review › Sound/Visual production (digital) – Annual report year: 2018

**New European wind atlas offshore**
The New European Wind Atlas (NEWA) is a joint research effort from eight European countries, co-funded under the ERANET Plus Program. The final aim is the creation and publication of an electronic European wind atlas. An offshore wind atlas extending 100 km from the European coasts is foreseen within the project, based on mesoscale modelling and various observational datasets. Satellite wind retrievals from scatterometers and Synthetic Aperture Radar (SAR) instruments are used to validate offshore modelled wind fields and identify the optimal model set-up parameters. The aim of this study is to present the initial outputs from the offshore wind atlas produced by the Weather & Research Forecasting (WRF) model, still in pre-operational phase, the METOP-A/B Advanced Scatterometer (ASCAT) and SAR derived winds. Different experiments were set-up to evaluate the model sensitivity for the various domains covered by the NEWA offshore atlas. ASCAT winds are utilised to assess the performance of the WRF offshore atlases. In addition, ASCAT winds were used to create an offshore atlas covering the years 2007 to 2016, where various spatial wind characteristics, such as channelling and lee effects from complex coastal topographical features, were visualised.

**General information**
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling
Authors: Karagali, I. (Intern), Hahmann, A. N. (Intern), Badger, M. (Intern), Hasager, C. B. (Intern), Mann, J. (Intern)
Number of pages: 10
Publication date: 2018

**Host publication information**
Title of host publication: Journal of Physics: Conference Series
Volume: 1037
New European Wind Atlas: The Østerild balconies experiment

One of the main objectives of the New European Wind Atlas (NEWA) project is to carry out large scale field experiments at a high spatial and temporal resolution, and provide a significant upgrade to the experimental databases currently available. The Østerild balconies experiment aimed at collecting measurements over a relatively flat and semi-forested terrain to quantify the effect of various terrain features on the mean wind field. The experiment was performed at the Østerild test station for large wind turbines in Northern Denmark, from April to August 2016. The two 250 m meteorological towers available at the test site were equipped with balconies, first at 50 m above local ground level, later raised to 200 m. Scanning lidars were placed on each of the balconies, performing horizontal scans over 90° arcs with an east or west orientation depending on the incoming wind direction. The purpose of this study is to describe i) the new filtering method applied to the data, ii) the wind field reconstruction and the iii) utilisation of the derived wind fields to examine the imprint of surface heterogeneity on the mean wind flow. Cloud point data from aerial lidar scans were used to accurately derive the terrain and tree height. The mean wind flow patterns appeared to be heavily influenced by the terrain characteristics at the height of 50 m above ground level.

Noise emission from wind turbines in wake - Measurement and modeling

The influence of the wake of an upstream turbine impinging another one located further downstream is studied focusing on the latter’s noise emission. Measurement data are investigated in the form of surface pressure fluctuations acquired using microphones flush-mounted in a wind turbine blade near its tip, characterizing the noise sources. Numerical results from a wind turbine noise model are also included in the analysis. The wind speed deficit and increased turbulence levels of the wake flow are clearly observed. Surface pressure measurements strongly support the fact that turbulent inflow noise is increased. However, numerical results show that the wake velocity deficit reduces noise in certain circumstances. This can compensate, or even sometime more than compensate, the additional noise emission expected as a result of the wake turbulence. Furthermore, noise amplitude modulation appears to increase when the turbine is impacted by the wake flow.
**Noise Quantification with Beamforming Deconvolution: Effects of Regularization and Boundary Conditions**

Delay-and-sum (DAS) beamforming can be described as a linear convolution of an unknown sound source distribution and the microphone array response to a point source, i.e., point-spread function. Deconvolution tries to compensate for the influence of the array response and reveal the true source distribution. Deconvolution is an inverse problem in which measurement noise can become dominant and yield meaningless solutions if the problem is not regularized (typically with Tikhonov regularization or a sparsity constraint). Therefore, the obtained solution estimate depends on the choice of regularization parameter, which in turn is highly problem dependent. Additionally, if sound sources are located near the edges of the computational domain, a discontinuity of sound power occurs that can result in a “ringing” effect in the deconvolved image. To remedy this, various boundary conditions can be assumed to model the sound field behaviour outside the computational domain. In this paper, noise quantification from deconvolution is investigated to better understand the derived effect on absolute noise levels. Using benchmark test cases from the aero-acoustic community, absolute noise levels is obtained from deconvolution and compared to that of the test cases. The effects of regularization and boundary conditions are discussed and practical usage scenarios are given.

**General information**

State: Published
Organisations: Acoustic Technology, Department of Wind Energy, Aerodynamic design, Department of Electrical Engineering
Authors: Lylloff, O. A. (Intern), Fernandez Grande, E. (Intern)
Number of pages: 18
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Event: Paper presented at 7th Berlin Beamforming Conference 2018 (BeBeC), Berlin, Germany.
Main Research Area: Technical/natural sciences

**Numerical Fluid-Structure Interaction Study on the NREL 5MW HAWT**

The development of reliable Fluid-Structure Interaction (FSI) simulation tools and models for the wind turbines is a critical step in the design procedure towards achieving optimized large wind turbine structures. Such approach will mitigate the aeroelastic instabilities like: torsional flutter, stall flutter and edgewise instability that introduce extra stresses to the turbine structure leading to reduced life time and substantial failures. In this study, FSI simulations were held using the commercial package Ansys v18.2 solvers as a preliminary step towards our on-going development of a reliable Open-Source solver. These simulations were applied to the full-scale rotor blades of the NREL 5MW reference horizontal axis wind turbine. The aerodynamic loads and structural responses computations were carried out using a steady-state FSI analysis. The computations were run on the Kyushu University multi-core Linux cluster using the public domain openMPI implementation of the standard message passing interface (MPI). Finally, the results were validated against the Technical University of Denmark’s (DTU) MIRAS aeroelastic code results as well as the widely used FLEX5-Q3UIC and FAST codes in different cases showing reasonable agreement.

**General information**

State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Kyushu University
Authors: Halawa, A. M. (Ekstern), Sessarego, M. (Intern), Shen, W. Z. (Intern), Yoshida, S. (Ekstern)
Number of pages: 9
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Conference: Torque 2018, Milan, Italy, 20/06/2018 - 20/06/2018
Main Research Area: Technical/natural sciences

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Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
In the presented study, it has been studied how tensile/tensile fatigue damage will develop in quasi-unidirectional non-crimp fabric based glass fibre epoxy matrix composites. A material system conventionally used as the load carrying laminates in wind turbine blades. It will be demonstrated by stopping a tensile/tensile fatigue test before the final material failure, how 3D X-ray computer tomography (x-ray CT) can be used for determining fibre failure inside the composite material. Due to the rather coarse bundle-structure of the non-crimp fabrics investigated, a relative large cross section area of the test-sample is necessary in order for testing a representative material volume. Therefore, the x-ray CT technique is used in a scout and zoom test-setup where a scout scan of the 15 mm large cross-section is used for identifying the damage region, while the subsequently zoom scan of a 2-3 mm field of view region is used for determine the fibre failures. This scan-setup is non-destructive, and it is therefore possible to obtain a number of scans during the fatigue damage development. Thereby, it is found that the fibre failure are mainly occurring close to points where the load carrying uni-directional fibre bundles are in close contact with the crossing points of secondary oriented fibre bundles, the so-called backing bundles.
Extreme wind is a required design parameter to be estimated for offshore and coastal structures such as wind turbines and platforms and floating objects, to avoid structures obtaining damages from severe wind conditions. Mid-latitude storms contribute to offshore extreme wind over the North Sea. It is often understood that offshore winds are relatively homogenous over space and the water surface can be described through the roughness length through the Charnock formulation. Though knowledge was gained that the Charnock formulation is not valid during storm conditions or in coastal regions where surface waves are breaking. In the last decades, researchers have been trying to introduce the wave impact to the atmospheric modeling through parameterization of derived wave parameters such as significant wave height, wave length and steepness, however all for open sea conditions.

It is shown in this study that during extreme wind storms over the North Sea, the wind field can be far from spatially homogeneous. About half of the time, open cellular structures are present, corresponding to strong and highly fluctuating (spatially and temporally) wind. It is also shown that for light to moderate winds, the many parameterization schemes in the literature give similar wave effect on the offshore wind, however, the differences between these schemes increase with increasing wind speed and become significant for winds greater than about 20 m/s. A wave boundary layer model (WBLM) was developed here to act as the interface between the atmospheric and wave modeling. WBLM uses one consistent set of equations, namely the momentum and kinetic energy conservations, to link the calculation in the wave model (here Spectral Wave model Nearshore SWAN) and that in the atmospheric model (here the Weather Research and Forecasting model WRF), thus avoiding the inconsistency that often occurs in parameterization schemes of the roughness length. The modeling system WRF-WBLM-SWAN has been used to model 429 storms from 1994 to 2016 that contributed to the calculation of the extreme wind over Denmark and surrounding waters. The WRF model was setup with consideration of...
climatological storm path and wind variability, which helped the decision of the domain size and position, simulation length and resolution. The extreme wind was obtained using the selective dynamical downscaling method in Larsén et al. (2013). Case studies show that WBLM outperforms the parameterization schemes for coastal areas and storm winds. Validation with measurements from several offshore sites in the North Sea suggests that WRF-WBLM-SWAN model system reproduces better offshore extreme winds over Denmark than using WRF alone.

General information
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Organisations: Department of Wind Energy, Resource Assessment Modelling, Meteorology & Remote Sensing, DHI Hørsholm
Authors: Larsén, X. G. (Intern), Du, J. (Intern), Bolanos, R. (Ekstern), Imberger, M. (Intern), Badger, M. (Intern)
Publication date: 2018
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Offshore Extreme Wind Atlas Using Wind-Wave Coupled Modeling

General information
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Organisations: Department of Wind Energy, Resource Assessment Modelling, Meteorology & Remote Sensing, DHI Hørsholm
Authors: Larsén, X. G. (Intern), Du, J. (Intern), Bolanos, R. (Ekstern), Imberger, M. (Intern), Badger, M. (Intern)
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Source-ID: 149534383
Publication: Research › Sound/Visual production (digital) – Annual report year: 2018

On gradient-based optimization of jacket structures for offshore wind turbines
During the bidding or very early design phases of jacket structures for offshore wind turbines, there may be very limited information available on meteorological conditions, soil conditions, turbine specifications, etc. However, it is still important to quickly produce near-optimal designs with production costs similar to that of the final support structure. Numerical optimization methods can be used to this purpose. This paper investigates three gradient-based optimization methods, where preliminary designs are produced by mass optimization. The mass is reduced by changing tube diameter and thickness of the structural members, and the optimization considers both frequency and fatigue constraints. The three methods are based on (1) damage equivalent loads, (2) quasi-static analysis, and (3) dynamic analysis. The optimizations are conducted using in-house software JADOP (jacket design optimization), and the optimized designs are evaluated using state-of-the-art integrated time-domain simulation software FEDEM Windpower. The findings show that each analysis can be applied with success. However, if excitations of structural frequencies contribute significantly to the overall damage, special care must be taken with quasi-static and static modeling. It is observed that wave loading does not contribute considerably to the fatigue damage. Additionally, the aerodynamic loading does not change significantly with changes of tube geometry within the optimization ranges. The optimized designs are partly driven by reducing stress concentration factors, which can be achieved by reducing the chord diameter to thickness ratio. Thus, the optimized designs resemble each other to a certain extent.

General information
State: Accepted/In press
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design, Norwegian University of Science and Technology, Aalborg University
Authors: Oest, J. (Ekstern), Sandal, K. (Intern), Schafhirt, S. (Ekstern), Stieng, L. E. S. (Ekstern), Muskulus, M. (Ekstern)
Number of pages: 15
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Main Research Area: Technical/natural sciences

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BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.18 SJR 1.051 SNIP 1.834
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.37 SJR 1.079 SNIP 2.316
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.201 SNIP 2.165 CiteScore 3.06
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.209 SNIP 3.688 CiteScore 3.42
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.235 SNIP 2.486 CiteScore 2.75
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.062 SNIP 2.297 CiteScore 2.36
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.892 SNIP 2.582 CiteScore 2.49
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.364 SNIP 2.026
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 0.885 SNIP 1.439
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.743 SNIP 1.555
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.942 SNIP 1.42
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.586 SNIP 1.653
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.273 SNIP 0.827
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.525 SNIP 0.845
Web of Science (2004): Indexed yes
Web of Science (2003): Indexed yes
Web of Science (2002): Indexed yes
Web of Science (2001): Indexed yes
Web of Science (2000): Indexed yes

Original language: English
Analytical sensitivities, Fatigue, Jacket support structures, Offshore wind, Optimization
On the simulation of aggregated solar PV forecast errors
The uncertainty arising from high levels of solar photovoltaic (PV) penetration can have a substantial impact on power system operation. Therefore, there is a need to develop models capable of representing PV generation in a rigorous manner. This paper introduces a novel transformation-based methodology to generate stochastic solar area power forecast scenarios; easy to apply to new locations. We present a simulation study comparing day-ahead solar forecast errors covering regions with different geographical sizes, total installed capacities and climatic characteristics. The results show that our model can capture the spatio-temporal properties and match the long-term statistical properties of actual data. Hence, it can be used to characterize the PV input uncertainty in power system studies.

General information
State: Accepted/In press
Organisations: Department of Wind Energy, Integration & Planning, Department of Energy Engineering, Wind energy, Technical University of Denmark, Roskilde Denmark 4000 (e-mail: e.nunno@gmail.com), Wind Energy, Danmarks Tekniske Universitet, 5205 Roskilde Denmark 4000 (e-mail: mkoiv@dtu.dk), Wind Energy, Technical University of Denmark, Rosksilde Denmark 4000 (e-mail: niaic@dtu.dk), Wind Energy, DTU, Roskilde Denmark 4000 (e-mail: posq@dtu.dk)
Authors: Nuño Martinez, E. (Intern), Koivisto, M. J. (Intern), Cutululis, N. A. (Intern), Sorensen, P. (Intern)
Number of pages: 10
Publication date: 2018
Main Research Area: Technical/natural sciences

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Journal: IEEE Transactions on Sustainable Energy
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BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 7.42 SJR 2.318 SNIP 2.452
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 7.8 SJR 2.368 SNIP 2.967
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.717 SNIP 3.22 CiteScore 7.09
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 2.554 SNIP 3.898 CiteScore 7.03
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 2.043 SNIP 3.712 CiteScore 7.03
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
Scopus rating (2012): SJR 1.243 SNIP 3.744 CiteScore 6.58
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.73 SNIP 3.01 CiteScore 5.13
ISI indexed (2011): ISI indexed no
Original language: English
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Source: FindIt
Source-ID: 2434684845
On wind turbine down-regulation control strategies and rotor speed set-point

The use of down-regulation or curtailment control strategies for wind turbines offers means of supporting the stability of the power grid and also improving the efficiency of a wind farm. Typically, wind turbine derating is performed by modifying the power set-point and subsequently, the turbine control input, namely generator torque and blade pitch, are acted on to such changes in the power reference. Nonetheless, in addition to changes in the power reference, derating can be also performed by modifying the rotor speed set-point. Thus, in this work, we investigate the performance of derating strategies with different rotor speed set-point, and in particular, their effect on the turbine structural fatigue and thrust coefficient were evaluated. The numerical results obtained from the high-fidelity turbine simulations showed that compared to the typical derating strategy, the derated turbines might perform better with lower rotor speed set-point but it is crucial to ensure such a set-point does not drive the turbine into stalled operations.

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control, Department of Applied Mathematics and Computer Science
Authors: Lio, W. H. (Intern), Mirzaei, M. (Intern), Larsen, G. C. (Intern)
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Journal: Journal of Physics: Conference Series
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Article number: 032040
ISSN (Print): 1742-6596
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BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.351
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.259 SNIP 0.346
Optimal Aero-Elastic Design of a Rotor with Bend-Twist Coupling

Passive Bend-Twist Coupling (BTC) can be used in blades to alleviate loads and generate more Annual Energy Production (AEP). However, BTC is inherently aero-elastic, thus difficult to incorporate into the design with sequential design process. Multi-disciplinary Design Optimization (MDO) is an attractive approach for overcoming these challenges. This paper presents the re-design of a 100kW BTC rotor using the MDO rotor design package HAWTOpt2. In the preliminary design phase, MDO was used to assess the differences between elastic BTC (i.e. off-axis fibers) and geometric BTC (i.e. sweep). This work found that aero-elastic design optimization without BTC was able to achieve a 16% improvement, then with sweep a 18% improvement and with material coupling a 17% improvement. Due to the reduced stiffness of off-axis fibers, material coupled designs had more difficulty satisfying the tip deflection constraint. The geometric BTC concept was chosen for the final design. The design optimization was repeated with additional manufacturing constraints. The final design achieved a 12% improvement.

Optimal Aero-Elastic Design of a Rotor with Bend-Twist Coupling

Passive Bend-Twist Coupling (BTC) can be used in blades to alleviate loads and generate more Annual Energy Production (AEP). However, BTC is inherently aero-elastic, thus difficult to incorporate into the design with sequential design process. Multi-disciplinary Design Optimization (MDO) is an attractive approach for overcoming these challenges. This paper presents the re-design of a 100kW BTC rotor using the MDO rotor design package HAWTOpt2. In the preliminary design phase, MDO was used to assess the differences between elastic BTC (i.e. off-axis fibers) and geometric BTC (i.e. sweep). This work found that aero-elastic design optimization without BTC was able to achieve a 16% improvement, then with sweep a 18% improvement and with material coupling a 17% improvement. Due to the reduced stiffness of off-axis fibers, material coupled designs had more difficulty satisfying the tip deflection constraint. The geometric BTC concept was chosen for the final design. The design optimization was repeated with additional manufacturing constraints. The final design achieved a 12% improvement.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design, Wind turbine loads & control, Fluid Mechanics
Authors: McWilliam, M. K. (Intern), Zahle, F. (Intern), Dicholkar, A. C. (Intern), Verelst, D. R. (Intern), Kim, T. (Intern)
Number of pages: 13
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Optimal design of galvanic corrosion protection systems for offshore wind turbine support structures

The current work addresses a mass/cost optimization procedure for galvanic anode cathodic protection (GACP) systems based on both cathodic protection (CP) standards and numerical simulation. An approach is developed for optimizing the number and dimensions of the galvanic anodes, distributing the optimized anodes on the support structure, and finally evaluating the protective potential on the structure during the lifetime by calling the finite element (FE) software COMSOL. An algorithm based on Sequential Quadratic Programming (SQP) is used for optimizing the number and dimensions of the anodes. Both simplified and detailed models are suggested for calculating the protective potential on the structure. The simplified model is selected based on its advantages in terms of calculation time and compatibility with DNV standard data. A time-dependent FE model is employed to take into account the electrical isolation degradation of the structure coating as well as the mass reduction of the anodes during the CP lifetime.

The performance of the proposed optimization process is examined on a mono bucket inspired (with some simplifications) by the Dogger Bank metrological mast in England. The optimized designs for different coating and anode types are compared and the best designs in terms of both cost and protective potential during the lifetime are suggested. The achieved results show that the proposed optimization procedure can reduce the cost of the CP system around 70% compared to the original non-optimized CP design of the Dogger Bank metrological mast. Furthermore, evaluating the time-evolution performance of the CP systems can reduce their lifetime uncertainty.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Sarhadi, A. (Intern), Abrahamsen, A. B. (Intern), Stolpe, M. (Intern)
Pages: 829-841
Publication date: 2018
Optimization of morphing flaps based on fluid structure interaction modeling

This article describes the design optimization of morphing trailing edge flaps for wind turbines with ‘smart blades’. A high fidelity Fluid Structure Interaction (FSI) simulation framework is utilized, comprised of 2D Finite Element Analysis (FEA)
and Computational Fluid Dynamics (CFD) models. A coupled aero-structural simulation of a 10% chordwise length morphing trailing edge flap for a 4 MW wind turbine rotor is carried out and response surfaces are produced with respect to the flap internal geometry design parameters for the design conditions. Surrogate model based optimization is applied in order to converge to a flap design, which maximizes aerodynamic lift control performance while minimizing drag penalty, subject to material strength and manufacturing constraints. The purely structural optimization of the flap response is compared to the coupled aerostructural optimization.

**General information**

- **State**: Published
- **Organisations**: Department of Wind Energy, Aerodynamic design, Siemens Gamesa Renewable Energy
- **Authors**: Barlas, A. (Intern), Akay, B. (Ekstern)
- **Number of pages**: 15
- **Publication date**: 2018

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- **Source-ID**: 142728818
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**Optimization of Short-term Overproduction Response of Variable Speed Wind Turbines**

Emphasis in this article is on the optimization of the short-term overproduction response of variable speed wind turbines for synthetic inertia provision or fast frequency control. The short-term overproduction response of wind turbines plays a crucial role in the enhancement of the resilience of future power systems with low inertia especially during large frequency disturbances. Novel optimization approaches employing the genetic algorithm are proposed to maximize the released energy from the wind turbine during its overproduction period considering the electrical and mechanical constraints. Based on the optimization results, the article identifies and analyses a set of relevant aspects to be taken into account by power system operators and wind turbine developers in the process of designing the synthetic inertia provision or the fast frequency control. Additionally, the impact of the short-term over production response on the wind turbine structural loading is analyzed through a set of aeroelastic simulations to further investigate aerodynamic limitations.

**General information**

- **State**: Accepted/In press
- **Organisations**: Department of Wind Energy, Integration & Planning, ABB HVDC, Technical University of Denmark
- **Authors**: Altin, M. (Intern), Hansen, A. D. (Intern), Barlas, T. K. (Ekstern), Das, K. (Intern), Sakamuri, J. N. (Ekstern)
- **Number of pages**: 8
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**Publication information**

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- **Volume**: PP
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  - Web of Science (2017): Indexed yes
  - BFI (2016): BFI-level 1
  - Scopus rating (2016): CiteScore 7.8 SJR 2.368 SNIP 2.967
  - Web of Science (2016): Indexed yes
  - BFI (2015): BFI-level 1
  - Scopus rating (2015): SJR 2.717 SNIP 3.22 CiteScore 7.09
  - Web of Science (2015): Indexed yes
  - BFI (2014): BFI-level 1
  - Scopus rating (2014): SJR 2.554 SNIP 3.898 CiteScore 7.03
In this paper the emphasis is on the optimization of synthetic inertial response of wind power plants (WPPs) for power systems with high wind power penetration levels, considering different wind speed operating conditions. The synthetic inertial response of wind power plants can play an important role in the resilience of future power systems with low inertia during large frequency disturbances. In order to investigate this role, a generic optimization methodology employing the genetic algorithm is proposed, taking into consideration the frequency nadir, second frequency dip, and time to reach the quasi-steady-state frequency. This optimization methodology comprehends the inertial response capability of WPPs and the frequency control dynamics of the power system. Accordingly, offline parameter tuning of synthetic inertial response is performed at the power system level with the proposed methodology. Based on the optimization results, the relevant aspects to be considered by transmission system operators and wind power plant developers in the process of designing and planning synthetic inertia are identified and analyzed. Additionally, sensitivity analyses are carried out to assess the impact of synthetic inertial response parameters on power system frequency control performance under different contingencies and wind power penetration levels.
Power curve measurement uncertainty – follow up comparative exercise for IEA Task 32: Paper

A comparative exercise for estimating the uncertainty associated with new methods for power performance measurements was coordinated by the International Energy Agency (IEA) Wind Task 32. Both IEA Task 32 and the Power Curve Working Group (PCWG) have identified the application of the new uncertainty guidelines as a problem area. One time series dataset from a wind turbine, hub height mast and vertical profiling lidar was provided to calculate the power curve using three different wind speed definitions. For each wind speed definition, participants had to estimate the wind speed measurement uncertainty based on the guidance provided by the June 2016 Final Draft International Standard (FDIS) of IEC 61400-12-1 Edition 2. The comparative exercise included three iterations over the course of one year to incrementally harmonize the calculations and assumptions. The exercise showed significant variability among participants reflecting difficulty with the interpretation and application of the informative guidance. It also demonstrated that when using current technology and the available calibration techniques the use of a standalone lidar with a short met mast resulted in a significantly higher uncertainty compared to only using a hub height mast (with some measurements of wind shear and wind veer in the lower rotor).
Pragmatic approach to cure profile enhancement for improved fatigue performance of thermoset matrix composites: Paper

The current paper proposes a low cost scheme for enhancement of the fatigue life properties of fibre reinforced composites through minimization of residual stresses induced from the composite cure cycle. The enhancement scheme works on the presumptions that a low processing temperature at the event of resin gelation causes reduced residual stresses. The requirements for material characterization and numerical implementation of the scheme is low compared to optimization schemes available in the literature. The enhancement scheme is implemented and used to produce enhanced two stage cure cycles for a commercially available epoxy resin.
Predicting the Influence of Surface Protuberance on the Aerodynamic Characteristics of a NACA 633-418: Paper

Leading Edge Roughness (LER) has become a critical challenge for wind turbine operators, often reducing the energy production of their turbines. LER has not yet been systematically categorized, and the transfer function between height/extent of roughness and the aerodynamic performance has not been established. A common method for emulating LER is to use zigzag tape or distributed sand grain roughness in a wind tunnel. This paper contains 2D and 3D CFD simulations and wind tunnel tests with zigzag tape on a NACA 633-418 airfoil, to evaluate the changes in aerodynamic characteristics. Because 3D CFD requires a vast amount of computing power, it is investigated if 2D simulation gives a sufficient level of accuracy.

General information
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Organisations: Department of Wind Energy, Composites and Materials Mechanics, Department of Applied Mathematics and Computer Science
Authors: Mortensen, U. A. (Intern), Løgstrup Andersen, T. (Intern), Mikkelsen, L. P. (Intern)
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Prediction of fatigue limit for unidirectional carbon fibre/epoxy composites

A micromechanics model is used for the prediction of the fatigue limit of unidirectional carbon fibre/epoxy composite materials. The model is based on the hypothesis that failure of a fibre will result in fibre/matrix debonding of the broken fibre. The associated debond crack tip stress fields will raise the stress in the neighbour fibres as the debond crack tips...
move along the broken fibre and can thus cause failure of the neighbouring fibres. The fatigue limit is defined from the maximum applied cyclic stress that does not induce failure of any neighbour fibres. Effects of microscale mechanical properties are investigated. The model predicts that the fatigue limit, expressed in terms of stress, increases with fibre volume fraction until 50-60 %, whereafter the fatigue limit decreases with increasing fibre volume fraction. With other parameters held fixed, the fatigue limit increases with increasing interfacial frictional sliding shear stress and with decreasing interfacial fracture energy.

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Scopus rating (2016): CiteScore 0.39 SJR 0.197 SNIP 0.535
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Preliminary Numerical Study on the Influence of a Wind Field on Wave-induced Load on a Circular Cylinder
The design load for offshore structures can be established from experimental and numerical investigations. When these are conducted, only the indirect effect of wind is taken into account, i.e. the wave spectrum is defined from fetch and wind speed. Nevertheless, the wind can have a direct effect on steep waves if airflow separation and vortexes develop above the waves. This could potentially cause increased waveinduced loads or change the breaking probability for waves and thereby the load statistics. This paper presents preliminary results from numerical simulations on how a local wind field affects wave kinematics and wave-induced loads on a cylinder. The waves are generated as spatio-temporal focused wave train. The wave field, including surface elevation and kinematics, is computed with the fully nonlinear potential solver program, OceanWave3D. The wave-induced load on the cylinder is computed from the output of the kinematics and the FNV force model. The wind forcing term is modelled by means of Jeffrey’s sheltering mechanism. Wave field and wave-induced loads are compared for different wind velocities and configurations of a focused wave. The presence of wind above a steep non-breaking wave increases the surface elevation until breaking is initiated for high wind velocity. The maximal wave-induced load for an initial non-breaking wave is obtained for the highest wind velocities due to the sudden initiation of breaking. The capability of the wind to increase surface elevation and load for wind above initially
breaking waves is more questionable. The numerical model simply exchanges the energy transfer between breaking dissipation and wind energy differently depending on wind velocity and wave field; nevertheless, no significant increase in surface elevation or load is discovered in this case. The highest wind velocity can, on the contrary, lead to a second breaking wave, which increases the line force. Finally, the numerical simulations are validated successfully against experimental investigations without wind.

Probing the structure and mechanical properties of the graphite nodules in ductile cast irons via nano-indentation

Little is known today about the mechanical properties of the graphite nodules, despite the key influence these particles have on the performance of ductile cast irons. To address this issue, nano-indentation tests were performed on the cross-section of a nodule whose sub-surface morphology was characterized via 3D computed tomography. From the recorded load vs. penetration curves, the spatial variation of the maximum indenter penetration $h_{\text{max}}$ and of the reduced Young's modulus $E^*$ was determined. It was observed that the pattern of $h_{\text{max}}$ presents features which, statistically, cannot be explained with the experimental error. Conversely, they can be justified by a model which takes into account the geometrical interaction between the indenter and the local orientation of the graphite platelets forming the nodule. To the authors' best knowledge, this result constitutes the first direct proof of a clear link between internal structure and mechanical properties of the nodules. The existence of a non-negligible mechanical anisotropy implies that the calculated mean value of $E^*$ can only be seen as indicative of a sort of "averaged" elastic stiffness. Caution should then be used when assessing the elastic response of the entire nodule just on the basis of this parameter, as complex anisotropic effects associated with the non-random orientation of the graphite platelets can be foreseen.
This paper presents an open-source tool that can be used to simulate turbulence boxes constrained by measured data, which is useful for wind turbine model validation. The tool, called PyConTurb for “Python Constrained Turbulence”, uses a novel algorithm based on the Kaimal Spectrum with Exponential Coherence method, and the algorithm can efficiently generate turbulence boxes under a wide variety of measurement constraints. The theoretical background for the technique is presented along with a few notes on its implementation in Python. The utility of PyConTurb is demonstrated using real data measured using three-dimensional sonic anemometers at the Denmark Technical University Risø campus. The presented results demonstrate that PyConTurb can successfully generate turbulence boxes from real measured data, including recreating the desired spatial coherence relationships between the simulated and measured time series. PyConTurb is shown to be a promising tool for investigating new spatial coherence models and for future one-to-one wind turbine validation studies.
Quantification of local mobilities
A new method for quantification of mobilities of local recrystallization boundary segments is presented. The quantification is based on microstructures characterized using electron microscopy and on determination of migration velocities and driving forces for local boundary segments. Pure aluminium is investigated and the results show that even for a single recrystallization boundary, different boundary segments migrate differently, and the differences can be understood based on variations in mobilities and local deformed microstructures. The present work has important implications for understanding of recrystallization boundary migration, and suggests an experimental way forward for how to determine boundary mobilities during recrystallization.
Remaining Life Assessment of Offshore Wind Turbines subject to Curtailment

The fatigue damage reduction versus energy production loss trade-off analysis is demonstrated on a Vestas V-52 turbine by de-rating the turbine power over a specific period corresponding to high measured turbulence using a spinner mounted anemometer. Based on the measured blade root and tower base loads, the benefit of curtailment under high turbulence on lowering the fatigue damage is quantified. A cut-off mean turbulence intensity level of 16% at 15m/s or class-A conditions is chosen as the turbulence level to impact tower base fatigue damage reduction. The turbulence is measured using a spinner anemometer mounted on the V-52. It is shown that the tower base foreaft damage equivalent moments can at some mean wind speeds be reduced by as much as 30%. The reduction in the blade root damage equivalent moment is not significant for power set point based curtailment. The learnings from this power curtailment strategy based on measured turbulence are extended to an offshore wind farm study case to demonstrate its benefit to life extension or CAPEX reduction of offshore sub structures.
Risk-based approach for rational categorization of damage observations from wind turbine blade inspections
This study provides a risk-based assessment procedure for wind turbine blade damages observed during visual inspections. A decision model is presented which identifies the cost-optimal intervention based on assessed damage severity. This is achieved by defining procedures for model-based estimation of probability of consequences for specific failure modes, and by analysing the costs associated with different scenarios for intervention. In addition, the procedure provides a risk-based, quantitative interpretation of damage severity categories used in wind turbine blade inspection practices. In the present paper, the workflow and example categorization are demonstrated on two specific faults in wind turbine blades: leading edge erosion damage, and trailing edge crack.

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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed no
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BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.351
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.259 SNIP 0.346
BFI (2008): BFI-level 1
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Web of Science (2008): Indexed yes
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SAR Wind Maps and Derived Products: New Possibilities for Offshore Wind Energy Exploitation

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing
Authors: Badger, M. (Intern), Ahsbahs, T. T. (Intern), Karagali, I. (Intern), Hasager, C. B. (Intern)
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Short-term nighttime wind turbine noise and cardiovascular events: A nationwide case-crossover study from Denmark

Aims: The number of people exposed to wind turbine noise (WTN) is increasing. WTN is reported as more annoying than traffic noise at similar levels. Long-term exposure to traffic noise has consistently been associated with cardiovascular disease, whereas effects of short-term exposure are much less investigated due to little day-to-day variation of e.g. road traffic noise. WTN varies considerably due to changing weather conditions allowing investigation of short-term effects of WTN on cardiovascular events. Methods and results: We identified all hospitalisations and deaths from stroke (16,913 cases) and myocardial infarction (MI) (17,559 cases) among Danes exposed to WTN between 1982 and 2013. We applied a time-stratified, case-crossover design. Using detailed data on wind turbine type and hourly wind data at each wind turbine, we simulated mean nighttime outdoor (10–10,000 Hz) and nighttime low frequency (LF) indoor WTN (10–160 Hz) over the 4 days preceding diagnosis and reference days. For indoor LF WTN between 10 and 15 dB(A) and above 15 dB(A), odds ratios (ORs) for MI were 1.27 (95% confidence interval (CI): 0.97–1.67; cases = 198) and 1.62 (95% CI: 0.76–3.45; cases = 21), respectively, when compared to indoor LF WTN below 5 dB(A). For stroke, corresponding ORs were 1.17 (95% CI: 0.95–1.69; cases = 166) and 2.30 (95% CI: 0.96–5.50; cases = 15). The elevated ORs above 15 dB(A) persisted across sensitivity analyses. When looking at specific lag times, noise exposure one day before MI events and three days before stroke events were associated with the highest ORs. For outdoor WTN at night, we observed both increased and decreased risk estimates. Conclusion: This study did not provide conclusive evidence of an association between WTN and MI or stroke. It does however suggest that indoor LF WTN at night may trigger cardiovascular events, whereas these events seemed largely unaffected by nighttime outdoor WTN. These findings need reproduction, as they were based on few cases and may be due to chance.

General information
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Organisations: Department of Wind Energy, Resource Assessment Modelling, Meteorology & Remote Sensing, Danish Cancer Society, Aarhus University
Authors: Poulsen, A. H. (Ekstern), Raaschou-Nielsen, O. (Ekstern), Pena Diaz, A. (Intern), Hahmann, A. N. (Intern), Nordsborg, R. B. (Ekstern), Ketzel, M. (Ekstern), Brandt, J. (Ekstern), Sørensen, M. (Ekstern)
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Simplification and Validation of a Spectral-Tensor Model for Turbulence Including Atmospheric Stability

A spectral-tensor model of non-neutral, atmospheric-boundary-layer turbulence is evaluated using Eulerian statistics from single-point measurements of the wind speed and temperature at heights up to 100 m, assuming constant vertical gradients of mean wind speed and temperature. The model has been previously described in terms of the dissipation rate \( \varepsilon \), the length scale of energy-containing eddies \( L \), a turbulence anisotropy parameter \( \Gamma \), the Richardson number \( R_i \), and the normalized rate of destruction of temperature variance \( \eta(\theta) \) equivalent to \( \varepsilon(\theta)/\varepsilon \). Here, the latter two parameters are collapsed into a single atmospheric stability parameter \( z/L \) using Monin-Obukhov similarity theory, where \( z \) is the height above the Earth's surface, and \( L \) is the Obukhov length corresponding to \( (R_i, \eta(\theta)) \). Model outputs of the one-dimensional velocity spectra, as well as cospectra of the streamwise and/or vertical velocity components, and/or temperature, and cross-spectra for the spatial separation of all three velocity components and temperature, are compared with measurements. As a function of the four model parameters, spectra and cospectra are reproduced quite well, but horizontal temperature fluxes are slightly underestimated in stable conditions. In moderately unstable stratification, our model reproduces spectra only up to a scale similar to 1 km. The model also overestimates coherences for vertical separations, but is less severe in unstable than in stable cases.

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling, Wind turbine loads & control, University of Agder
Authors: Chougule, A. (Ekstern), Mann, J. (Intern), Kelly, M. C. (Intern), Larsen, G. C. (Intern)
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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.854 SNIP 1.279 CiteScore 2.32
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.802 SNIP 1.785 CiteScore 2.74
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
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ISI indexed (2013): ISI indexed yes
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ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
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Simulation of transcontinental wind and solar PV generation time series

The deployment of Renewable Energy Sources (RES) is driving modern power systems towards a fundamental green transition. In this regard, there is a need to develop models to accurately capture the variability of wind and solar photovoltaic (PV) power, at different geographical and temporal scales. This paper presents a general methodology based on meteorological reanalysis techniques allowing to simulate aggregated RES time series over large geographical areas. It also introduces a novel PV conversion approach based on aggregated power curves in order to capture the uncertainty associated to the technical characteristics of individual installations spread across large regions. The proposed methodology is validated using actual power data in Europe and can be applied to represent intermittent generation in network development plans, reliability and market studies, as well as operational guidelines.

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Organisations: Department of Wind Energy, Integration & Planning, Resource Assessment Modelling, Meteorology & Remote Sensing
Authors: Nuño Martínez, E. (Intern), Maule, P. (Intern), Hahmann, A. N. (Intern), Cutululis, N. A. (Intern), Sørensen, P. E. (Intern), Karagali, I. (Intern)
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Specimen for cyclic delamination crack growth rates from ply-drops: Paper
The cyclic growth rate of delaminations initiated from ply-drops under tensile cyclic load was experimentally measured using a test specimen geometry, with internal ply-drops, that allows stable crack growth. It is found that the fatigue delaminations grow at a constant rate.

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Web of Science (2016): Indexed yes
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Spinner anemometer - best practice
Spinner anemometry is used to measure traceable and calibrated wind speed, yaw misalignment and inflow angle. Free wind speed may be measured by application of a spinner wind speed transfer function. Spinner anemometer free wind speed measurements are used in power performance measurements according to the standard IEC61400-12-2 on use of nacelle anemometry. An improved procedure, developed specifically for power performance measurements with spinner anemometry, without considering the use of nacelle anemometry, is the aim of this document. The best practice description for spinner anemometry provides procedures for mounting, calibrations, measurements and uncertainty calculation. As such it could provide input to a separate IEC standard on wind speed, yaw misalignment and inflow angle measurements with spinner anemometry. This best practice procedure for wind measurements is used in the PTP demo project for power performance measurements on 90 wind turbines. The experience from the measurements will be used to demonstrate and support the further development of the best practice procedures.

General information
Stability analysis of wind turbines with bend-twist coupled blades

Over the last years, bend-twist coupling (BTC) has become one of the most important passive load reduction techniques in wind turbine blades. The kind and amount of BTC is often decided on the basis of the load reduction, often forgetting the related stability implications. In this work we perform the stability analysis of a very large wind turbine, where the BTC is obtained by rotating the fibers of the spar caps. The study focuses first on the isolated blade, and then on the complete wind turbine. The findings show that this BTC leaves some modes unaffected, but reduces the damping of the collective edgewise mode.
Here we provide statistical low-order characterization of noise propagation from a single wind turbine, as affected by mutually interacting turbine wake and environmental conditions. This is accomplished via a probabilistic model, applied to an ensemble of atmospheric conditions based upon atmospheric stability; the latter follows from the basic form for stability distributions established by Kelly and Gryning [Boundary-Layer Meteorol. 136, 377–390 (2010)]. For each condition, a parabolic-equation acoustic propagation model is driven by an atmospheric boundary-layer (“ABL”) flow model; the latter solves Reynolds-Averaged Navier-Stokes equations of momentum and temperature, including the effects of stability and the ABL depth, along with the drag due to the wind turbine. Sound levels are found to be highest downwind for modestly stable conditions not atypical of mid-latitude climates, and noise levels are less elevated for very stable conditions, depending on ABL depth. The probabilistic modelling gives both the long-term (ensemble-mean) noise level and the variability as a function of distance, per site-specific atmospheric stability statistics. The variability increases with the distance; for distances beyond 3 km downwind, this variability is the highest for stability distributions that are modestly dominated by stable conditions. However, mean noise levels depend on the widths of the stable and unstable parts of the stability distribution, with more stably-dominated climates leading to higher mean levels.
Imaging with X-ray computed tomography (CT) enables non-destructive 3D characterisations of the micro-structure inside fibre composites. In this paper we validate the use of X-ray CT coupled with image analysis for characterising unidirectional (UD) fibre composites. We compare X-ray CT at different resolutions to optical microscopy (OM) and scanning electron microscopy (SEM), where we characterise fibres by their diameters and positions. In addition to comparing individual fibre diameters, we also model their spatial distribution, and compare the obtained model parameters. Our study shows that X-ray CT is a high precision technique for characterising fibre composites and, with our suggested image analysis method for fibre detection, high precision is also obtained at low resolutions. This has great potential, since it allows larger fields of view to be analysed. Besides analysing representative volumes with high precision, we demonstrate that based on our methodology for individual fibre segmentation it is now possible to study complete bundles at the fibre scale and reveal inhomogeneities in the physical sample.
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Scopus rating (2014): SJR 1.751 SNIP 2.435 CiteScore 4.62
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BFI (2010): BFI-level 2
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Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.408 SNIP 2.212
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.826 SNIP 2.696
Scopus rating (2005): SJR 1.629 SNIP 2.221
Scopus rating (2004): SJR 1.616 SNIP 1.956
Scopus rating (2003): SJR 1.333 SNIP 1.683
Web of Science (2003): Indexed yes
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Scopus rating (2001): SJR 1.397 SNIP 1.423
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Steady and Unsteady Analysis of NACA 0018 Airfoil in Vertical-Axis Wind Turbine

Numerical results are presented for aerodynamic unsteady and steady airfoil characteristics of the NACA 0018 airfoil of a two-dimensional vertical-axis wind turbine. A geometrical model of the Darrieus-type wind turbine and the rotor operating parameters used for numerical simulation are taken from the literature. Airfoil characteristics are investigated using the same mesh distribution around the airfoil edges and two turbulence models: the RNG k-a and the SST Transition. Computed results for the SST Transition model are in good agreement with the experiment, especially for static airfoil characteristics.

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Authors: Rogowski, K. (Ekstern), Hansen, M. O. L. (Intern), Maronski, R. (Ekstern)
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- Scopus rating (2015): SJR 0.399 SNIP 0.966 CiteScore 0.88
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- Scopus rating (2014): SJR 0.444 SNIP 1.066 CiteScore 0.88
- BFI (2013): BFI-level 1
- Scopus rating (2013): SJR 0.346 SNIP 0.959 CiteScore 0.71
- ISI indexed (2013): ISI indexed yes
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- Scopus rating (2012): SJR 0.254 SNIP 0.671 CiteScore 0.48
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- ISI indexed (2011): ISI indexed no
- Scopus rating (2010): SJR 0.186 SNIP 0.53
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Steady State Comparisons HAWC2 v12.5 vs HAWCStab2 v2.14: Integrated and distributed aerodynamic performance

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Authors: Verelst, D. R. (Intern), Hansen, M. H. (Intern), Pirrung, G. (Intern)
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Original language: English

Stiffening effect of fatigue and creep loading in unidirectional flax fibre/epoxy composites
A study related to the fatigue behaviour of natural fibre composites was conducted to expand their industrial applications. Unidirectional flax/epoxy composites were fabricated, and their fatigue and creep behaviour was investigated by applying a range of different testing conditions. Stiffness was found to increase during fatigue loading, and this was accompanied by accumulation of residual strain. By arranging the results in a stiffness-strain diagram, a linear trend was established with a positive slope representing the stiffening effect. A similar linear trend was obtained for creep loading, however, with a larger stiffening effect. For fatigue loading, the stiffening effect was found to be changed by the applied cycle frequency. The combined findings in the study suggest that stiffness change in the composites is reflecting a balance between stiffening due to residual strain, and softening due to fatigue damaging.

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Organisations: Department of Wind Energy, Composites and Materials Mechanics, Hitachi Ltd.
Authors: Ueki, Y. (Ekstern), Lilholt, H. (Intern), Madsen, B. (Intern)
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Web of Science (2016): Indexed yes
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ISI indexed (2013): ISI indexed no
An ultrafine grained Al-0.3wt. %Cu has been produced by cold rolling to a thickness reduction of 98% (εvM=4.5). The deformed structure is a typical lamellar structure with a boundary spacing of 200nm as characterized by transmission electron microscopy (TEM) and electron backscatter diffraction (EBSD). Coarsening of the deformed structure to recrystallization is achieved by heat treatment in the range of 100∼300°C. Good thermal stability has been observed up to 175°C with some segregation of Cu to the boundaries as observed by 3D atom probe characterization. Tensile tests have shown a flow stress (0.2% offset) of 198MPa with continuous flow with no yield drop and Lüders elongation. To quantify the contribution of boundary strengthening to the flow stress, dislocation strengthening and solid solution hardening have been calculated and subtracted from the flow stress. It has been found that boundary strengthening can be expressed by a Hall-Petch relationship and that these constants in this equation are in very good agreement with precious observation of recrystallized pure polycrystalline aluminium with a grain size in the tens of micrometer range. Thereby the Hall-Petch relationship of aluminium can be extended an order of magnitude from the micrometer to the sub-micrometer range, which is of both scientific and technical importance.

**General information**

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Authors: Huang, T. (Ekstern), Shuai, L. (Ekstern), Wakeel, A. (Ekstern), Wu, G. (Ekstern), Hansen, N. (Intern), Huang, X. (Intern)
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- Scopus rating (2016): CiteScore 5.67 SJR 3.21 SNIP 2.702
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 2
- Scopus rating (2015): SJR 3.417 SNIP 2.831 CiteScore 5.22
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 2
- Scopus rating (2014): SJR 3.885 SNIP 3.166 CiteScore 5.16
- Web of Science (2014): Indexed yes
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- Scopus rating (2013): SJR 3.238 SNIP 2.674 CiteScore 4.37
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Natural fibre composites are being utilized increasingly in high-performance, structurally demanding applications, in part because of their material properties and in part because they are a more sustainable choice compared to other engineering materials. However, there is a current lack in understanding of best practices for strength modelling of natural fibre composites. This study aims to understand how well common failure criteria predict strength in multidirectional flax fibre composite laminates. Four failure criteria are compared to experimental data from tension and compression tests of flax composite laminates with five different layups. Parametric optimization is performed on each criterion in order to determine the optimal strength, stiffness, and interaction parameters. In conclusion, the Hashin and Puck failure theories are recommended because they have the smallest error compared to experimental data. Values for parallel-to-fibre shear strength are also presented, and they are found to be comparable to the shear strength of conventional glass fibre composites with similar matrix materials.
Structural optimization with several discrete design variables per part by outer approximation
The article proposes an optimal design approach to minimize the mass of load carrying structures with discrete design variables. The design variables are chosen from catalogues, and several variables are assigned to each part of the structure. This allows for more design freedom than only choosing parts from a catalogue. The problems are modelled as mixed 0–1 nonlinear problems with nonconvex continuous relaxations. An algorithm based on outer approximation is proposed to find optimized designs. The capabilities of the approach are demonstrated by optimal design of a space frame (jacket) structure for offshore wind turbines, with requirements on natural frequencies, strength, and fatigue lifetime.
Structure and strength of sub-100 nm lamellar structures in cold-drawn pearlitic steel wire

Pearlitic steel wire, with a representative sub-100nm lamellar structure, is the strongest mass-produced steel with an excellent combination of formability and strength. This overview summarises investigations of cold-drawn pearlitic steel wire in the last decades, covering the microstructural evolution and strengthening mechanisms. Based on quantitative structural parameters, this overview covers a quantitative and extensive analysis of structure–strength relationships. By focusing on the structure, challenges and future strategy are outlined to further improve the mechanical behaviour and performance of pearlitic steel wire to widen its use in society.
The amine:epoxide ratio at the interface of a glass bre/epoxy matrix system and its in uence on the interfacial shear strength

The interfacial shear strength (IFSS) is commonly used for evaluating the adhesion at the interface between fibre and matrix. A glass fibre/epoxy matrix system was investigated. The surface coatings applied to glass fibres may result in a discrepancy in the amine:epoxide group ratio between the interface and the bulk matrix, consequently moving the ratio away from the optimum stoichiometric ratio most often used. The amine:epoxide group ratio in the matrix was varied to obtain the optimum ratio at the interface. The study found that the amine:epoxide ratio influenced the IFSS with an optimum just below the stoichiometric ratio. The microbond test was conducted in a thermal mechanical analyser (TMA) to determine the IFSS thus revealing an inverse dependency on the testing temperature: an increased testing temperature yields a decrease of IFSS. IFSS determined at temperatures below the glass transition temperature displays a decreasing trend at high amine:epoxide ratio whereas IFSS measured at testing temperatures above the glass transition temperature steadily increases as the amine:epoxide ratio increases. The microbond test was conducted using both a tensile tester and a TMA setup. The two microbond test setups yielded results with same behaviour of the IFSS as a function of the amine:epoxide ratio.
The effect of buffer-layer on the steady-state energy release rate of a tunneling crack in a wind turbine blade joint

The effect of a buffer-layer on the steady-state energy release rate of a tunneling crack in the adhesive layer of a wind turbine blade joint, loaded in tension, is investigated using a parametric 2D tri-material finite element model. The idea of embedding a buffer-layer in-between the adhesive and the basis glass fiber laminate to improve the existing joint design is novel, but the implications hereof need to be addressed. The results show that it is advantageous to embed a buffer-layer near the adhesive with controllable thickness-and stiffness properties in order to improve the joint design against propagation of tunneling cracks. However, for wind turbine blade relevant material combinations it is found more effective to reduce the thickness of the adhesive layer since the stiffness mismatch between the existing laminate and the adhesive is already high. The effect of material orthotropy was found to be relatively small for the blade relevant materials.
The induction zone/factor and sheared inflow: A linear connection?

Sheared inflow causes significant periodic load variations in wind turbine blades, but has only limited impact on the mean wake deficit. Following these findings the wind speed reduction upstream of the turbine - referred to as the induction zone - might also show little difference to uniform inflow. Using the local free-stream velocity to normalise the upstream flowfield should then render uniform and sheared inflow induced velocity profiles indiscernible, hinting towards wind shear acting solely as a linear addition. This has great implications in BEM methods for determining the velocity at the blades and also for near-rotor lidar measurements. The latter being applied in for power/loads assessment and turbine control.
LES simulations with an actuator line representation of the rotor confirm the linearity assumption for moderate wind shear. To estimate the normal velocities at the disc the annularly averaged thrust coefficient is best suited, when the induction is imposed on the inflow profile. A strictly local relationship breaks down in strongly sheared flow. A simple induction zone model devised for uniform inflow estimates the velocity upstream within ±0.5% even at extreme shear in the upper half of the rotor and at least three rotor radii away from the turbine.

**General information**
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Organisations: Department of Wind Energy, Aerodynamic design
Authors: Meyer Forsting, A. (Intern), van der Laan, M. (Intern), Trolldborg, N. (Intern)
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Web of Science (2010): Indexed yes
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Web of Science (2008): Indexed yes
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Web of Science (2006): Indexed yes
The influence of wing twist on pressure distribution and flow topology

Empirical data serve as the foundation to computational modeling in the initial stages of the wind turbine design process. In case of aerodynamic simulations, the empirical input is comprised of lift and drag data obtained in quasi two-dimensional wind tunnel tests. In the simulations, the global flow over an entire blade is finally approximated as a spatial summation of the obtained 2-D data, which stands in strong contrast to the true operation of a wind turbine and consequently leads to a higher level of uncertainty. Especially, the near-root region of the blade experiences highly three-dimensional flow conditions, particularly in regions of the blade where the flow separates from the airfoil. This study aims to accentuate the difference between airfoil data obtained in quasi two-dimensional wind tunnel tests compared to airfoil data from a wing with an imposed three-dimensional spanwise pressure gradient. For this, a geometrically altered wing section with a spanwise twist is tested in a wind tunnel and compared to CFD computations.

General information

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Organisations: Department of Wind Energy, Fluid Mechanics, Aerodynamic design, Princeton University
Authors: Kiefer, J. (Intern), Sørensen, N. N. (Intern), Hultmark, M. (Ekstern), Hansen, M. O. L. (Intern)
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Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
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ISI indexed (2012): ISI indexed no
The microstructural origin of work hardening stages

The strain evolution of the flow stress and work hardening rate in stages III and IV is explored by utilizing a fully described deformation microstructure. Extensive measurements by transmission electron microscopy reveal a hierarchical subdivision of grains by low angle incidental dislocation boundaries (IDBs) and medium to high angle geometrically necessary boundaries (GNBs). This universal evolution is demonstrated for nickel, copper, and aluminum deformed by cold rolling from strains of 0.05-5.5. Microstructural morphology evolves with increasing strain through a transition resulting in a lamellar cell-block structure aligned with the deformation. This transition is caused by the emergence of new slip systems and a stable texture. Four parameters describe the microstructure, the misorientation angle across each boundary type and their respective spacing. Universal scaling characterizes the normalized distributions of three separate parameters. A new scaling law connects the strain evolution of two strength parameters: the dislocation density of IDBs and the spacing between GNBs. Strengthening mechanisms and strength contributions for those two parameters are expressed respectively as a linear addition of the classical Taylor and Hall-Petch formulations. Model predictions agree closely with experimental values of flow stress and work hardening rate in stages III and IV. Strong connections between the evolutionary stages of the deformation microstructure and work hardening rates create a new (modern) basis for the classic problem of work hardening in metals and alloys. These connections lead the way for the future development of ultra high strength ductile metals produced via plastic deformation.(c) 2018 Acta Materialia Inc. Published by Elsevier Ltd. All rights reserved.
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Scopus rating (2016): CiteScore 5.67 SJR 3.21 SNIP 2.702
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Scopus rating (2015): SJR 3.417 SNIP 2.831 CiteScore 5.22
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 3.885 SNIP 3.166 CiteScore 5.16
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BFI (2013): BFI-level 2
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ISI indexed (2013): ISI indexed yes
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BFI (2012): BFI-level 2
Scopus rating (2012): SJR 3.37 SNIP 2.875 CiteScore 4.28
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BFI (2011): BFI-level 2
Scopus rating (2011): SJR 3.215 SNIP 2.768 CiteScore 4.27
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 3.709 SNIP 2.698
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Scopus rating (2009): SJR 3.663 SNIP 2.625
Web of Science (2009): Indexed yes
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Scopus rating (2008): SJR 3.82 SNIP 2.774
Web of Science (2008): Indexed yes
Web of Science (2007): Indexed yes
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Web of Science (2006): Indexed yes
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Scopus rating (2004): SJR 3.308 SNIP 3.073
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 3.852 SNIP 3.258
Web of Science (2003): Indexed yes
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Web of Science (2001): Indexed yes
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The North Sea Offshore Wind Service Industry: Status, perspectives and a joint action plan

The Offshore Wind Service sector is about to established itself as an industrial sector with its own identity, own organisation, and with large future challenges. The article introduces this new sector, including assessment of present and future market sizes. The overall aim of the research reported in this article was to increase the innovation capacity of the European offshore wind servicing (OWS) sector by establishing cross-regional cooperation and intensifying the relationship between research and the offshore wind industry. The article uses the concept of innovation system foresight (ISF). The linking of the two concepts of foresight and innovation systems has been explored by several studies, but ISF takes a further integration of the two concepts. The article presents a set of concrete actions at multiple levels to support the development of the offshore wind service sector. The findings provides an input for a concerted effort for supporting both the offshore wind development and the emerging clusters of offshore wind services around the North Sea. In addition, the article addresses the value of the ISF approach to such policy development.
The Park2 Wake Model - Documentation and Validation
This report describes the revised Park-model, Park2, and the validation and calibration of it. The Park2 model is implemented the WAsP 12 software package.

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Authors: Rathmann, O. S. (Intern), Hansen, B. O. (Intern), Hansen, K. S. (Intern), Mortensen, N. G. (Intern), Murcia Leon, J. P. (Ekstern)
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The role of laboratory testing in the development of rotor aerodynamics (review)
The aim of the review is to assess the value of model experimental studies for the development of classical rotor aerodynamics as well as to describe the most significant recent results stimulated by intense development of wind power.

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Authors: Okulov, V. (Intern)
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Publication information
The turbulence scales of a wind turbine wake: A revisit of extended k-epsilon models

The turbulence time and length scales of a single wind turbine wake subjected to atmospheric turbulence are calculated from two large eddy simulations that differ in ambient turbulence intensity. The smallest turbulence length scale in the wake is about half the rotor radius and it increases for higher ambient turbulence levels. The large eddy simulations are compared with Reynolds-averaged Navier-Stokes simulations employing the standard and three extended k-ε models: the k-ε-fP model of van der Laan, the k-ε model of Shih and k-ε model of Durbin. It is shown that all three extended k-ε models can be written in a similar form. All Reynolds-averaged Navier-Stokes based turbulence models predict turbulence time scales that are comparable to the turbulence time scales of the large eddy simulations. The standard k-ε model underpredicts the velocity deficit because the turbulence length scale is overpredicted compared to the large eddy simulations. The performance of the k-ε model of Durbin shows to be very dependent on the ambient turbulence level and it is therefore less suited for wind turbine wake simulations. The k-ε model of Shih and the k-ε-fP model of van der Laan are recommended to be used for wind turbine wake simulations because their results are similar and compare well with results of large eddy simulations for both a low and high ambient turbulence intensity due to a limitation of the turbulence length scale in the near wake.

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Organisations: Department of Wind Energy, Aerodynamic design, Fluid Mechanics
Authors: van der Laan, M. P. (Intern), Andersen, S. J. (Intern)
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Towards the understanding of vertical-axis wind turbines in double-rotor configuration

Vertical-axis wind turbines (VAWTs) in double-rotor configuration, meaning two rotors in close proximity, have the ability to enhance the power performance. In this study, we work towards the understanding of vertical-axis wind turbines in double-rotor configuration. Numerical simulations are performed to gain insight in the physics behind the double-rotor concept. Furthermore, a parametric study is performed to explore the effect of the double-rotor lay-out, rotor loading, rotor spacing and wind direction on the flow characteristics and the power generation.
Tunneling cracks in full scale wind turbine blade joints

A novel approach is presented and used in a generic tunneling crack tool for the prediction of crack growth rates for tunneling cracks propagating across a bond-line in a wind turbine blade under high cyclic loadings. In order to test and demonstrate the applicability of the tool, model predictions are compared with measured crack growth rates from a full scale blade fatigue test. The crack growth rates, measured for a several metre long section along the blade trailing-edge joint during the fatigue test, are found to be in-between the upper- and lower-bound predictions.
Two level undercut-profile substrate-based filamentary coated conductors produced using metal organic chemical vapor deposition

The two level undercut-profile substrate (2LUPS) has been introduced as a concept for subdividing rare-earth-Ba$_2$Cu$_3$O$_7$ (REBCO) coated conductors (CC) into narrow filaments which reduces the AC losses and improves field stability for DC magnets. The 2LUPS consists of two levels of plateaus connected by a wall with an undercut-profile, which enables a physical separation of the superconducting layer between the plateaus without reducing the effective width of the superconducting layer. In this study we report for the first time the results of fabrication and characterization of a filamentary CC produced in an industrial setup by SuperPower Inc. using ion beam assisted deposition and metal organic chemical vapor deposition (IBAD-MOCVD) on a 2LUPS substrate realized at the Technical University of Denmark (DTU), whereas previous studies discussed the fabrication using alternating beam assisted deposition and pulsed laser deposition (ABAD-PLD). We also present Hall probe scanning measurements performed using a standard TAPESTAR® XL machine that is routinely employed for industrial critical current characterization of long length CCs. It clear that additional analysis of the measured field profiles are required when characterizing filamentary 2LUPS CC using a standard TAPESTAR® setting. Using FEM we calculated the expected magnetization response and we find a good agreement.

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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
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Scopus rating (2015): SJR 0.403 SNIP 1.06 CiteScore 1.27
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.478 SNIP 1.13 CiteScore 0.83
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.443 SNIP 1.156 CiteScore 1.32
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.555 SNIP 1.274 CiteScore 1.11
ISI indexed (2012): ISI indexed yes
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Scopus rating (2011): SJR 0.368 SNIP 1.062 CiteScore 1.16
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.473 SNIP 1.065
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.447 SNIP 1.021
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Scopus rating (2008): SJR 0.884 SNIP 0.981
Scopus rating (2007): SJR 0.629 SNIP 1.093
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Scopus rating (2003): SJR 0.51 SNIP 1.054
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.226 SNIP 1.024
Scopus rating (2001): SJR 0.552 SNIP 1.368
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.498 SNIP 0.998
Web of Science (2000): Indexed yes
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Multifilamentary superconductors, hightemperature superconductors, magnetic variables measurement, finite element analysis
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UNAFLOW project: UNsteady Aerodynamics of FLOating Wind turbines
UNAFLOW (UNsteady Aerodynamics for Floating Wind) is a joint EU-IRPWIND founded experiment on wind turbine rotor unsteady aerodynamics. It brings together four different academic contributors: Energy research Centre of the Netherlands (ECN), DTU Wind Energy, University of Stuttgart (USTUTT) and Politecnico di Milano (PoliMi) sharing knowledge both in numerical modelling and in experimental tests design, allowing direct numerical and experimental comparison. The experimental tests carried out for UNAFLOW are of the same type of the ones carried out during the ongoing EU H2020 project LIFES50+ [1], regarding both the unsteady behaviour of the 2d blade section and the entire turbine rotor, although with improved setup and wider test matrix. The project partners are already currently jointly collaborating in the AVATAR project [2], developing and validating numerical models of different accuracy level. The numerical models used in the UNAFLOW project range from engineering tool (eg. BEM) to high fidelity CFD methods. Numerical simulations are used both in the design of experiment phase and in the results analysis allowing for an in depth understanding of the experimental findings through advanced modelling approach. The UNAFLOW project, together with a new understanding of the unsteady behaviour of the turbine rotor aerodynamics, will provide also an open database to be shared among the scientific community for future analysis and new models validation.

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Organisations: Department of Wind Energy, Fluid Mechanics, Politecnico di Milano, Energy research Centre of the Netherlands - ECN, University of Stuttgart
Authors: Bayati, I. (Ekstern), Belloli, M. (Ekstern), Bernini, L. (Ekstern), Boldrin, D. (Ekstern), Boorsma, K. (Ekstern), Caboni, M. (Ekstern), Cormier, M. (Ekstern), Mikkelsen, R. (Intern), Lutz, T. (Ekstern), Zasso, A. (Ekstern)
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BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
ISI indexed (2011): ISI indexed no
similar to the conventional power plants, the wind farms are expected to contribute to the grid stability and communicate with the system operators regarding the potential power production on much shorter time scales than AEP or even 10-min. Additionally, increasing interest to aerodynamic control of wind farms, both in the research community and in the industry, necessitates the wake models to be more accurate and reliable at shorter intervals. In this study, we discuss the uncertainties attached to an engineering wake model derived for 1-sec turbine data, and investigate the methods for reducing the uncertainty of such an application via further training the model for the wind farm and the time period in question using the historical data.

Uncertainties and Wakes for Short-term Power Production of a Wind Farm

Polynomial surrogates are used to characterize the energy production and lifetime equivalent fatigue loads for different components of the DTU 10 MW reference wind turbine under realistic atmospheric conditions. The variability caused by different turbulent inflow fields are captured by creating independent surrogates for the mean and standard deviation of each output with respect to the inflow realizations. A global sensitivity analysis shows that the turbulent inflow realization has a bigger impact on the total distribution of equivalent fatigue loads than the shear coefficient or yaw miss-alignment. The methodology presented extends the deterministic power and thrust coefficient curves to uncertainty models and adds new variables like damage equivalent fatigue loads in different components of the turbine. These surrogate models can then be implemented inside other work-flows such as: estimation of the uncertainty in annual energy production due to...
wind resource variability and/or robust wind power plant layout optimization. It can be concluded that it is possible to capture the global behavior of a modern wind turbine and its uncertainty under realistic inflow conditions using polynomial response surfaces. The surrogates are a way to obtain power and load estimation under site specific characteristics without sharing the proprietary aeroelastic design.

**General information**

State: Published  
Authors: Murcia Leon, J. P. (Intern), Réthoré, P. (Intern), Dimitrov, N. K. (Intern), Natarajan, A. (Intern), Sørensen, J. D. (Intern), Graf, P. (Ekstern), Kim, T. (Intern)  
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Web of Science (2017): Indexed yes  
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Scopus rating (2015): SJR 1.767 SNIP 2.085 CiteScore 4.51  
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BFI (2014): BFI-level 1  
Scopus rating (2014): SJR 1.925 SNIP 2.621 CiteScore 4.51  
Web of Science (2014): Indexed yes  
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Scopus rating (2013): SJR 1.989 SNIP 2.719 CiteScore 4.63  
ISI indexed (2013): ISI indexed yes  
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BFI (2012): BFI-level 1  
Scopus rating (2012): SJR 1.787 SNIP 2.699 CiteScore 3.97  
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Web of Science (2012): Indexed yes  
BFI (2011): BFI-level 1  
Scopus rating (2011): SJR 1.634 SNIP 2.349 CiteScore 3.9  
ISI indexed (2011): ISI indexed yes  
Web of Science (2011): Indexed yes  
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Web of Science (2010): Indexed yes  
BFI (2009): BFI-level 1  
Scopus rating (2009): SJR 1.272 SNIP 1.963  
Web of Science (2009): Indexed yes  
BFI (2008): BFI-level 2  
Scopus rating (2008): SJR 1.436 SNIP 1.891  
Web of Science (2008): Indexed yes  
Scopus rating (2007): SJR 1.194 SNIP 1.63  
Web of Science (2007): Indexed yes
Uncovering the fatigue damage initiation and progression in uni-directional non-crimp fabric reinforced polyester composite

The current work studies the fatigue damage initiation and progression in a quasi-unidirectional non-crimp fabric based fibre composite used for wind turbine blades. This is done by combining in situ transilluminated white light imaging (TWLI) with ex-situ X-ray computed tomography (CT) experiments along with tension clamp X-ray CT experiments. TWLI is used to monitor the off-axis cracks in the thin supporting backing fibre bundles present in quasi-UD composites, and a crack counting algorithm is applied to automatically count the cracks in images obtained in situ during fatigue testing. It is found that off-axis cracks not only initiate at the specimen edges but also at isolated locations inside the specimen, which could be related to the microstructural features. In addition, a clear effect of strain level on the measured off-axis crack density is observed. From the X-ray CT experiments, it is found that the UD fibre fractures initiate and progress from regions where the off-axis backing fibre bundles are 'in contact' with a UD fibre bundle. Damage is seen to first initiate at a cross-over region of the backing fibre bundles, and later at a region with only one backing fibre bundle. In addition, applying tension to the specimen during X-ray CT scanning is found to reveal additional UD fibre fractures that are not visible in scans performed the unloaded state. With load applied, a significant number of UD fibre fractures were observed earlier in the fatigue life than expected. Based on the observations of the study a damage progression scheme is presented for quasi-UD fibre composites.

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Organisations: Department of Wind Energy, Composites and Materials Mechanics, Department of Applied Mathematics and Computer Science, Aalborg University, LM Wind Power, Waseda University
Authors: Jespersen, K. M. (Intern), Glud, J. A. (Ekstern), Zangenberg, J. (Ekstern), Hosoi, A. (Ekstern), Kawada, H. (Ekstern), Mikkelsen, L. P. (Intern)
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4.82 SJR 1.478 SNIP 2.146
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.532 SNIP 2.219 CiteScore 4.09
Using SAR for Characterization of Offshore Wind Farm Wakes and Coastal Wind Speed Gradients

Offshore wind farms influence the atmosphere downwind for considerable distances and SAR has been used to demonstrate this effect in earlier studies. SAR has also been used to characterize winds in the coastal zone influenced by the proximity to the land. The novelty of the present study — focusing on the Anholt wind farm in the Kattegat Strait between Denmark and Sweden — is the interplay between the wind farm wake effect and a strong horizontal wind speed gradient from the coastline and further offshore. The wind farm was constructed after the Envisat ASAR mission ended and prior to the Sentinel-1 mission.

The study is based on the SAR wind archive available at https://satwinds.windenergy.dtu.dk. The SAR data are processed at DTU using CMOD5.N and wind directions from the Climate Forecast System Reanalysis (CFSR) from 2002 to 2010 and the Global Forecasting System (GFS) from 2011 to 2017. The pixel size is 500 m.

The offshore winds observed by Envisat are compared to Weather and Research and Forecasting (WRF) model results. More specifically, the variation in wind speed along the first (western) row of wind turbines (stretching 20 km from north to
south located closest to the Danish coastline) for winds coming from 265° (±15°) show good agreement between SAR and WRF. The wind speed variation along this row of turbines is also assessed based on the Supervisory Control And Data Acquisition (SCADA) data from the wind turbines kindly provided by Ørsted and Partners. The data are 10 minute values from January 2013 to June 2015. Interestingly, the average variation in wind speed along the western row for winds coming from 265° (±15°) show around 1 m/s higher winds at the northernmost turbines compared to the southernmost turbines. This difference is most likely caused by the varying distance to the coast. The fetch is up to 50 km in the north and down to 16 km in the south. Wind speeds relative to the center turbine from SAR and SCADA agree within 0.1% while WRF over-predicts around 1% as compared to SCADA. All data sets quantify a significant coastal wind speed variation.

The comparison of winds from SAR and SCADA (extrapolated from 81.6 m hub-height with logarithmic profile to 10 m) in non-waked and waked conditions give results of R2 of 0.97 with RMSE of 1.80 and 1.70 m/s and bias -0.12 and -0.52 m/s, respectively.

An investigation of the wind farm wake effects is completed using the Envisat data versus the Sentinel-1 data to provide the difference between free-stream and wind farm wake conditions. Various horizontal transects aligned with the wind direction and perpendicular to the wind direction are analysed. The uncertainty of the average wind speed is also assessed and significant variations are mapped (Ahsbahs et al. in review, Wind Energy Science).

The conclusions are that SAR enables quantification of spatial horizontal wind speed gradients and wind farm wakes. The large SAR wind archive can be used to explore complex cases providing a measurement independent of modelling results.

Variability of wind turbine noise over a diurnal cycle
The diurnal variation of atmospheric conditions over land has a significant effect on the wind and temperature distributions which greatly influence the generation and propagation of wind turbine aerodynamic sound. In this paper, a fully consistent unsteady approach is used to study wind turbine noise such that large eddy simulation with a rotational actuator disk wind turbine model is used to model the wind and temperature around a mega-watt scale wind turbine over a diurnal cycle, and time dependent flow and temperature fields are used as input to the coupled wind turbine noise generation-propagation model. Computations are carried out for four different 10 min datasets selected at certain periods of a day for a same hub height wind speed. It is observed that the time dependent as well as the time averaged sound pressure levels in near field do not show large variations during the day. However, as we move away from the turbine, the propagation effects take over and downwind of the turbine the night time levels exceed the day time levels (at 3600 m the averaged difference reaches 6.5 dBA).

General information
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Authors: Hasager, C. B. (Intern), Ahsbahs, T. T. (Intern), Badger, M. (Intern), Hansen, K. S. (Intern), Volker, P. (Intern)
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Authors: Barlas, E. (Intern), Wu, K. L. (Ekstern), Zhu, W. J. (Intern), Porté-Agel, F. (Ekstern), Shen, W. Z. (Intern)
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Variable pitch approach for performance improving of straight-bladed VAWT at rated tip speed ratio

This paper presents a new variable pitch (VP) approach to increase the peak power coefficient of the straight-bladed vertical-axis wind turbine (VAWT), by widening the azimuthal angle band of the blade with the highest aerodynamic
torque, instead of increasing the highest torque. The new VP-approach provides a curve of pitch angle designed for the blade operating at the rated tip speed ratio (TSR) corresponding to the peak power coefficient of the fixed pitch (FP)-VAWT. The effects of the new approach are exploited by using the double multiple stream tubes (DMST) model and Prandtl's mathematics to evaluate the blade tip loss. The research describes the effects from six aspects, including the lift, drag, angle of attack (AoA),resultant velocity, torque, and power output, through a comparison between VP-VAWTs and FP-VAWTs working at four TSRs: 4, 4.5, 5, and 5.5. Compared with the FP-blade, the VP-blade has a wider azimuthal zone with the maximum AoA, lift, drag, and torque in the upwind half-cycle, and yields the two new larger maximum values in the downwind half-cycle. The power distribution in the swept area of the turbine changes from an arched shape of the FP-VAWT into the rectangular shape of the VP-VAWT. The new VP-approach markedly widens the highest-performance zone of the blade in a revolution, and ultimately achieves an 18.9% growth of the peak power coefficient of the VAWT at the optimum TSR. Besides achieving this growth, the new pitching method will enhance the performance at TSRs that are higher than current optimal values, and an increase of torque is also generated.

General information
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Organisations: Department of Wind Energy, Fluid Mechanics, Hohai University, Nanjing University of Aeronautics and Astronautics
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Scopus rating (2014): SNIP 1.623 SJR 0.174
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Variation of boundary-layer wind spectra with height
This study revisits the height dependence of the wind speed power spectrum from the synoptic scale to the spectral gap. Measurements from cup anemometers and sonics at heights of 15 m to 244 m are used. The measurements are from one land site, one coastal land-based site and three offshore sites in the mid-latitudes. There are two new findings. The first finding addresses the diurnal peak in the power spectrum. Our analysis suggests that there are two sources that contribute to the diurnal peak. One is related to surface-driven processes and another one is related to pressure perturbation from the atmospheric tide. The second finding regards the height dependence of the general spectrum. We describe the dependence through a so-called effective roughness, which is calculated from wind spectra and represents the energy removal at different frequencies, and thus surface conditions in the footprint areas. The generalizable spectral properties of winds presented herein may prove useful for validating numerical models.

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Organisations: Department of Wind Energy, Resource Assessment Modelling
Authors: Larsén, X. G. (Intern), Petersen, E. L. (Intern), Larsen, S. E. (Intern)
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Vortex simulations of wind turbines operating in atmospheric conditions using a prescribed velocity-vorticity boundary layer model

A prescribed velocity-vorticity boundary layer model for the vorticity transport equation is proposed, which corrects the unphysical upward deflection of the wake seen in a simpler prescribed velocity shear approach. A Lagrangian implementation of the boundary layer model has been investigated using our in-house vortex solver MIRAS. The MIRAS code contains both an aerodynamic part and a structural-mechanical part taking into account aeroelastic phenomena. The solver is employed to simulate flows around wind turbines and uses a combination of filaments and particles in order to mimic the vorticity released by the wind turbine blades. The vorticity is interpolated onto a uniform Cartesian mesh, where the interaction is efficiently calculated by a fast Fourier transform-based method. Simulations of wind turbines operating in an atmospheric boundary layer flow are carried out and analysed in detail for a range of scenarios. The manuscript focuses on studying the influence of wind shear and turbulence, which is varied to mimic natural atmospheric conditions. A traverse virtual probe up to 30 diameters downstream of the rotor plane is used to investigate the properties of the turbulent wake flow for the different cases. This includes mean and standard deviation of the streamwise velocity component, wake deficit, Reynolds stresses, and power spectral density of the velocity signal. The results show that combining a prescribed boundary layer approach with a vortex method gives consistent and physically correct results if properly implemented.

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Authors: Ramos García, N. (Intern), Spietz, H. J. (Intern), Sørensen, J. N. (Intern), Walther, J. H. (Intern)
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  Web of Science (2016): Indexed yes
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  Scopus rating (2015): SJR 1.201 SNIP 2.165 CiteScore 3.06
  Web of Science (2015): Indexed yes
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  Scopus rating (2014): SJR 1.209 SNIP 3.688 CiteScore 3.42
  Web of Science (2014): Indexed yes
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  Scopus rating (2013): SJR 1.235 SNIP 2.486 CiteScore 2.75
  ISI indexed (2013): ISI indexed yes
  Web of Science (2013): Indexed yes
  BFI (2012): BFI-level 2
  Scopus rating (2012): SJR 1.062 SNIP 2.297 CiteScore 2.36
  ISI indexed (2012): ISI indexed yes
  Web of Science (2012): Indexed yes
  BFI (2011): BFI-level 2
  Scopus rating (2011): SJR 0.892 SNIP 2.582 CiteScore 2.49
  ISI indexed (2011): ISI indexed yes
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  Scopus rating (2010): SJR 1.364 SNIP 2.026
  Web of Science (2010): Indexed yes
Wind and solar resource data sets

The range of resource data sets spans from static cartography showing the mean annual wind speed or solar irradiance across a region to high temporal and high spatial resolution products that provide detailed information at a potential wind or solar energy facility. These data sets are used to support continental-scale, national, or regional renewable energy development; facilitate prospecting by developers; and enable grid integration studies. This review first provides an introduction to the wind and solar resource data sets, then provides an overview of the common methods used for their creation and validation. A brief history of wind and solar resource data sets is then presented, followed by areas for future research.

For further resources related to this article, please visit the WIREs website.

General information
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Organisations: Department of Wind Energy, Resource Assessment Modelling, National Renewable Energy Laboratory
Authors: Clifton, A. (Ekstern), Hodge, B. (Ekstern), Draxl, C. (Ekstern), Badger, J. (Intern), Habte, A. (Ekstern)
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.32 SJR 0.951 SNIP 1.325
Wind power support during overfrequency emergency events
This article concentrates on designing of frequency control and protection strategies for wind turbines during overfrequency emergencies. Critical overfrequency event on North-Eastern part of the UCTE network on 4th November 2006 is considered as a base case for investigation. A single bus power system model is developed to analyse the protection settings for this case and then to propose and discuss the design and recommendations for overfrequency control settings for wind turbines. The results of the investigation show that modification of the protection settings alone may not be sufficient to prevent frequency instability especially when wind power penetration is high and system inertia is low. Robust overfrequency emergency control strategies from wind turbines can therefore be required. The article provides the design for control parameter settings for different degrees of wind power penetration. The performance of the proposed frequency control with the developed settings is validated by means of simulations with the large scale pan-European model.

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Organisations: Department of Wind Energy, Integration & Planning, University College Dublin, Energinet.dk
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Journal: CIGRE Science & Engineering
Volume: 9
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BFI (2016): BFI-level 1
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Electronic versions:
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Links:
https://e-cigre.org/publication/CSE009-cse-009
Publication: Research - peer-review › Conference article – Annual report year: 2018

Wind power within European grid codes: Evolution, status and outlook
Grid codes are technical specifications that define the requirements for any facility connected to electricity grids. Wind power plants are increasingly facing system stability support requirements similar to conventional power stations, which is to some extent unavoidable, as the share of wind power in the generation mix is growing. The adaptation process of grid codes for wind power plants is not yet complete, and grid codes are expected to evolve further in the future. ENTSO-E is the umbrella organization for European TSOs, seen by many as a leader in terms of requirements sophistication. A current development by ENTSO-E aims to develop a uniform grid code framework for Europe. The new European codes leave many key aspects unspecified, referring instead to regulation by the relevant TSO, but they do provide a positive and encouraging step in the right direction. The present document is largely based on the definitions and provisions set out by
ENTSO-E. The main European grid code requirements are outlined here, including also HVDC connections and DC-connected power park modules. The focus is on requirements that are considered particularly relevant for large wind power plants. Afterwards, an outlook and discussion on possible future requirements is provided. This review has been written by members of IEA Wind Task 25, but it does not represent an official viewpoint of the IEA. This article is categorized under: Wind Power > Systems and Infrastructure

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning, SINTEF. VTT - Technical Research Centre of Finland, University College Dublin, Universidad de Castilla-La Mancha, Planair, UVIG
Authors: Vrana, T. K. (Ekstern), Flynn, D. (Ekstern), Gomez-Lazaro, E. (Ekstern), Kiviluoma, J. (Ekstern), Marcel, D. (Ekstern), Cutululis, N. A. (Intern), Smith, J. C. (Ekstern)
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Scopus rating (2017): CiteScore 3.69 SJR 0.963 SNIP 1.264
Web of Science (2017): Indexed yes
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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.689 SNIP 1.035 CiteScore 2.46
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.451 SNIP 0.757 CiteScore 1.53
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Scopus rating (2013): SJR 0.214 SNIP 0.434 CiteScore 0.45
ISI indexed (2013): ISI indexed no
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Wind tunnel tests of an airfoil with 18% relative thickness equipped with vortex generators
Vortex generators have in recent years been used extensively on pitch regulated wind turbines. A new trend has been to use vortex generators on thinner airfoils on the outer part of the blades. However, not much data is available for thin airfoils with vortex generators. That is the reason to carry out wind tunnel tests on a NACA 633-418 airfoil with 18% relative thickness in the Stuttgart Laminar Wind Tunnel. The airfoil was tested in clean condition, but also with leading edge roughness and different heights and different positions of the vortex generators. Results of the airfoil performance in terms of polars, maximum lift and lift-drag ratio are shown with focus on how the vortex generators influence the performance of the airfoil.

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Organisations: Department of Wind Energy, Aerodynamic design, Power Curve ApS
Wind Turbine Acoustic Day 2018
The bi-annual event entitled Wind Turbine Acoustic Day dealing with wind turbine noise issues organized by DTU Wind Energy took place on May, 17th 2018 as its third edition. The abstracts and slides for the presentations are reported.

General information
State: Published
Authors: Mogensen, J. (Ekstern), Søndergaard, B. (Ekstern), Hünerbein, S. V. (Ekstern), Søndergaard, L. S. (Ekstern), Hansen, T. R. (Ekstern), Hurault, J. (Ekstern), Bertagnolio, F. (Intern), Kelly, M. C. (Intern), Shen, W. Z. (Intern), Bak, C. (Intern), Fischer, A. (Intern)
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Wind Turbine Acoustic Day 2018 - Summary of the 3rd edition
The bi-annual event entitled Wind Turbine Acoustic Day dealing with wind turbine noise issues organized by DTU Wind Energy took place on May, 17th 2018 as its third edition. The abstracts and slides for the presentations are reported.

General information
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Authors: Mogensen, J. (Ekstern), Søndergaard, B. (Ekstern), Hünerbein, S. V. (Ekstern), Søndergaard, L. S. (Ekstern), Hansen, T. R. (Ekstern), Hurault, J. (Ekstern), Bertagnolio, F. (Intern), Kelly, M. C. (Intern), Shen, W. Z. (Intern), Bak, C. (Intern), Fischer, A. (Intern)
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Main Research Area: Technical/natural sciences
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Source-ID: 148214782
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Wind turbine aerodynamic measurements using a scanning lidar
A method for measuring wake and aerodynamic properties of a wind turbine with reduced error based on simulated lidar measurements is proposed. A scanning lidar measures air velocity scalar projected onto its line of sight. However, line of sight is rarely parallel to the velocities of interest. The line of sight projection correction technique showed reduced axial velocity error for a simple wake model. Next, an analysis based on large-eddy simulations of a 27 m diameter wind turbine was used to more accurately assess the projection correction technique in a turbulent wake. During the simulation, flow behind the turbine is sampled with a nacelle mounted virtual lidar matching the scanning trajectory and sampling frequency of the DTU SpinnerLidar. The axial velocity, axial induction, freestream wind speed, thrust coefficient, and power coefficient are calculated from virtual lidar measurements using two different estimates of the flow: line of sight
velocity without correction, and line of sight with projection correction. The flow field is assumed to be constant during one complete scan of the lidar field of view, and the average wind direction is assumed to be equal to the instantaneous wind direction at the lidar measurement location for the projection correction. Despite these assumptions, results indicate that all wake and aerodynamic quantity error is reduced significantly by using the projection correction technique; axial velocity error is reduced on average from 7.4% to 2.8%.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Sandia National Laboratories NM, Sandia National Laboratories, NREL's National Wind Technology Center
Authors: Kelley, C. L. (Ekstern), Herges, T. G. (Ekstern), Martinez, L. A. (Ekstern), Mikkelsen, T. (Intern)
Number of pages: 10
Publication date: 2018
Conference: Torque 2018, Milan, Italy, 20/06/2018 - 20/06/2018
Main Research Area: Technical/natural sciences

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BFI (2018): BFI-level 1
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Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.351
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.259 SNIP 0.346
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.264 SNIP 0.301
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.258 SNIP 0.399
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.272 SNIP 0.311
Web of Science (2006): Indexed yes
Wind turbine noise generation and propagation modeling at DTU Wind Energy: A review

The present review paper provides a comprehensive overview of the research activities on wind turbine aeroacoustics at DTU over the last 20 years, as well as it gives the state-of-the-art of noise prediction models for wind turbines under complex inflow conditions. Various noise generation models developed at DTU are described and analyzed, including models based on the acoustic analogy, flow-acoustics splitting techniques, Amiet's model, and various engineering models. Some of the models are coupled to existing aero-elastic software and computational fluid mechanics models developed at DTU, and implemented in the simulation platform WindSTAR (Wind turbine Simulation Tool for Aerodynamic noise). This simulation platform consists of WindSTAR-Gen, dealing with models for generation of noise and design of low-noise wind turbines, and WindSTAR-Pro, which is developed to handle the modeling of long distance acoustic propagation. As specific features of the WindSTAR-Pro package, the rotation of the noise sources is modeled, the propagation simulations combine the so-called Parabolic Equations (PE) propagation model with numerical flow simulations to take into account effects from wind turbine wakes, atmospheric turbulence and wind shear.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Aerodynamic design
Authors: Zhu, W. J. (Intern), Shen, W. Z. (Intern), Barlas, E. (Intern), Bertagnolio, F. (Intern), Sørensen, J. N. (Intern)
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Main Research Area: Technical/natural sciences

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Scopus rating (2017): CiteScore 10.54 SJR 3.036 SNIP 3.594
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 9.52 SJR 2.998 SNIP 3.501
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.921 SNIP 3.368 CiteScore 8.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 3.03 SNIP 3.72 CiteScore 7.79
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 2.98 SNIP 3.893 CiteScore 7.88
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 2.734 SNIP 3.861 CiteScore 7.24
ISI indexed (2012): ISI indexed yes
Wind turbine site-specific load estimation using artificial neural networks calibrated by means of high-fidelity load simulations

Previous studies have suggested the use of reduced-order models calibrated by means of high-fidelity load simulations as means for computationally inexpensive wind turbine load assessments; the so far best performing surrogate modelling approach in terms of balance between accuracy and computational cost has been the polynomial chaos expansion (PCE). Regarding the growing interest in advanced machine learning applications, the potential of using Artificial Neural-Network (ANN) based surrogate models for improved simplified load assessment is investigated in this study. Different ANN model architectures have been evaluated and compared to other types of surrogate models (PCE and quadratic response surface). The results show that a feedforward neural network with two hidden layers and 11 neurons per layer, trained with the Levenberg Marquardt backpropagation algorithm is able to estimate blade root flapwise damage-equivalent loads (DEL) more accurately and faster than a PCE trained on the same data set. Further research will focus on further model improvements by applying different training techniques, as well as expanding the work with more load components.

General information
State: Published
Authors: Schröder, L. (Intern), Dimitrov, N. K. (Intern), Verelst, D. R. (Intern), Sørensen, J. A. (Intern)
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Main Research Area: Technical/natural sciences

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During the intensive period (May-June 2017) of the Perdigão experiment, three sets of Doppler lidar were operated to scan the wake of the wind turbine (WT) on the southwest ridge. CU operated a Doppler scanning lidar in the valley bottom approximately 1 km northeast of the WT and conducted multiple arc scans and two RHI scans every 10-minutes centred on the WT. DTU used a dual Doppler lidar system scanning almost horizontally from the northeast ridge. Two of the three DLR lidars were in-plane with the WT for the main wind direction, one in the valley and one on the distant mountain ridge. The third DLR lidar was on the southwest ridge. All three systems (CU, DTU and DLR) were operated such that in data processing vertical and/or horizontal profiles of the wake can be derived at different distances from the WT. The paper
describes the strategies used to scan the wake by the three groups and compares wake characteristics derived from the different systems.
X-ray tomography based finite element modelling of non-crimp fabric based fibre composite

The current study presents a workflow to import a fibre bundle structure of a non-crimp fabric based fibre composite obtained by X-ray CT to a solvable 3D model in the finite element software ABAQUS. The considered fibre composite is similar to that used for the load carrying parts of wind turbine blades, and each layer of the non-crimp fabric contains fibre bundles oriented in the 0°, 90°, and 45° directions. The 3D fibre bundle geometry is first segmented in the software AVIZO and then imported to Geomagic Wrap where the geometry is smoothened and converted into a nurbs surface that can be imported into ABAQUS. The resulting stress distribution is qualitatively compared to previous experimental observations and discussed.

The equivalent static loads method for structural optimization does not in general generate optimal designs

The Equivalent Static Loads Method (ESLM) is an algorithm intended for dynamic response structural optimization. The algorithm attempts to solve a sequence of static response structural optimization problems approximating the original problem. It is argued in several published articles that if the ESLM converges, then it finds a KKT point of the considered dynamic structural response optimization problem. The theoretical convergence properties of the ESLM are however not as strong as previously reported. We propose and analyze easily reproducible counter examples based on a two-bar truss illustrating that the ESLM in general fails in finding optimal designs to the considered dynamic response problem.
Design optimization of offshore wind farms with multiple types of wind turbines

Most studies on offshore wind farm design assume a uniform wind farm, which consists of an identical type of wind turbines. In order to further reduce the cost of energy, we investigate the design of non-uniform offshore wind farms, i.e., wind farms with multiple types of wind turbines and hub-heights. Given a set of different types of wind turbines with a different default hub height for each type, we can specify the design of a wind farm by the types of turbines, number of turbines for each type, and turbine locations. We consider the optimization of such design to minimize the levelized cost of energy, which is calculated using a capital cost model that covers the turbine cost and the balance of plant cost. An empirical wind turbine design cost and scaling model is utilized to model the cost of turbines with different sizes. Constraints on wind farm boundary, wind turbine proximity and total capacity are also included. We solve the problem with a newly developed extended random search algorithm and tested it in a realistic design optimization problem based on the Horns Rev 1 offshore wind farm in Denmark. The optimized non-uniform designs are compared with their uniform counterparts. We find that a non-uniform design can achieve a lower levelized cost of energy than its uniform counterparts, when the capital cost per MW is slightly lower for the smaller size turbine. Comparison with the mixed-discrete particle swarm optimization algorithm is also carried out for a non-uniform wind farm design problem with a fixed number of turbines, which shows the effectiveness and superiority of the proposed algorithm. Finally, the advantages and possible disadvantages of non-uniform design are also identified and discussed.
Validation of the actuator disc and actuator line techniques for yawed rotor flows using the New Mexico experimental data

Experimental data acquired in the New Mexico experiment on a yawed 4.5m diameter rotor model turbine are used here to validate the actuator line (AL) and actuator disc (AD) models implemented in the Large Eddy Simulation code EllipSys3D in terms of loading and velocity field. Even without modelling the geometry of the hub and nacelle, the AL and AD models produce similar results that are generally in good agreement with the experimental data under the various configurations considered. As expected, the AL model does better at capturing the induction effects from the individual blade tip vortices, while the AD model can reproduce the averaged features of the flow. The importance of using high quality airfoil data (including 3D corrections) as well as a fine grid resolution is highlighted by the results obtained. Overall, it is found that both models can satisfactorily predict the 3D velocity field and blade loading of the New Mexico rotor under yawed inflow.
The present invention relates to a method of determining the condition of a device comprising a rotor arrangement. The rotor arrangement comprising a rotational shaft and a number rotor blades each connected at the root to the rotational shaft and extending radially from the rotational shaft. Sensors are arranged to measure for each rotor blade corresponding values of one or more of the following parameters: azimuth angle ($\Phi$) (or a parameter related to the azimuth angle), root bending moment(s) ($q$), such as the edgewise and/or flapwise root bending moments. The method comprises, while the rotor arrangement rotates, recording corresponding values of azimuth angle and edgewise and flapwise root bending moments for a plurality of rotations of rotor arrangement, transforming by use of e.g. a multi blade coordinate transformation, a Park's transformation or similar transformation the recorded edgewise and flapwise root bending moments ($q$) into a coordinate system rotating with the rotational shaft, thereby obtaining transformed root bending moments ($q_f$). The method further comprising identifying periodicity in each of the transformed root bending moments, determining the condition of the rotor arrangement to be faulty, in case the one or more periodicities are identified in the transformed root bending moments.

**General information**

State: Published
Organisations: Department of Electrical Engineering, Automation and Control, Department of Applied Mathematics and Computer Science, Dynamical Systems, Department of Wind Energy, Wind turbine loads & control
Authors: Niemann, H. H. (Intern), Poulsen, N. K. (Intern), Mirzaei, M. (Intern), Henriksen, L. C. (Ekstern)
Publication date: 8 Jun 2017

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Original language: English
Main Research Area: Technical/natural sciences
Source: espacenet
Source-ID: WO2017093512
Publication: Research › Patent – Annual report year: 2017
A unified aggregation and relaxation approach for stress-constrained topology optimization

In this paper, we propose a unified aggregation and relaxation approach for topology optimization with stress constraints. Following this approach, we first reformulate the original optimization problem with a design-dependent set of constraints into an equivalent optimization problem with a fixed design-independent set of constraints. The next step is to perform constraint aggregation over the reformulated local constraints using a lower bound aggregation function. We demonstrate that this approach concurrently aggregates the constraints and relaxes the feasible domain, thereby making singular optima accessible. The main advantage is that no separate constraint relaxation techniques are necessary, which reduces the parameter dependence of the problem. Furthermore, there is a clear relationship between the original feasible domain and the perturbed feasible domain via this aggregation parameter.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design, Delft University of Technology
Authors: Verbart, A. (Intern), Langelaar, M. (Ekstern), Keulen, F. V. (Ekstern)
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Main Research Area: Technical/natural sciences

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BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.26
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.14
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.42
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 2.77
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.86
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.08
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 1.85
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Web of Science (2008): Indexed yes
Web of Science (2007): Indexed yes
Web of Science (2006): Indexed yes
Web of Science (2005): Indexed yes
A strain gauge

The invention relates to a strain gauge of a carrier layer and a meandering measurement grid (101) positioned on the carrier layer, wherein the measurement grid comprises a number of measurement grid sections placed side by side with gaps in between, and a number of end loops (106) interconnecting the measurement grid sections at their ends. The end loops at both ends of the measurement grid extend a length (L, 500) in the axial direction in millimetres of a factor times a ratio between a width of a grid section and the gap distance, wherein the factor is larger or equal to 1.5. The invention further relates to a method for manufacturing a strain gauge as mentioned above.

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Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Mikkelsen, L. P. (Intern), Gili, J. (Ekstern)
Publication date: 19 Jan 2017

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Main Research Area: Technical/natural sciences
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Source-ID: WO2017009365
Publication: Research › Patent – Annual report year: 2017

Ultrafine particle number flux over and in a deciduous forest

Ultrafine particles (UFP, particles with diameters (Dp) < 100 nm) play a key role in climate forcing; thus, there is interest in improved understanding of atmosphere-surface exchange of these particles. Long-term flux measurements from a deciduous forest in the Midwestern USA (taken during December 2012 to May 2014) show that although a substantial fraction of the data period indicates upward fluxes of UFP, on average, the forest is a net sink for UFP during both leaf-active and leaf-off periods. The overall mean above-canopy UFP number flux computed from this large data set is $-4.90 \times 10^6$ m$^{-2}$s$^{-1}$ which re-emphasizes the importance of these ecosystems to UFP removal from the atmosphere. Although there remain major challenges to accurate estimation of the UFP number flux and in drawing inferences regarding the actual surface exchange from measurements taken above the canopy, the above the canopy mean flux is shown to be downward throughout the day (except at 23.00) with largest-magnitude fluxes during the middle of the day. On average, nearly three quarters of the total UFP capture by this ecosystem occurs at the canopy. This fraction increases to 78% during the leaf-active period, but the over-storey remains dominant over the subcanopy even during the leaf-off period.

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State: Published
Organisations: Department of Wind Energy, Cornell University, Aarhus University
Authors: Pryor, S. (Ekstern), Barthelmie, R. (Ekstern), Larsen, S. E. (Intern), Sørensen, L. (Ekstern)
Pages: 405-522
Publication date: 11 Jan 2017
30-year mesoscale model simulations for the *Noise from wind turbines and risk of cardiovascular disease* project

**General information**

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling
Authors: Pena Diaz, A. (Intern), Hahmann, A. N. (Intern)
Publication date: 2017

**Publication information**

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Volume: 0055
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Electronic versions:

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**Publication: Research - peer-review › Report – Annual report year: 2017**

3d Finite Element Modelling of Non-Crimp Fabric Based Fibre Composite Based on X-Ray Ct Data

Due to the high number of fatigue load cycles during the life of a wind turbine blade, fatigue is one of the main design concerns. However, it is still not possible to realistically predict the fatigue life of the non-crimp fabric based fibre composites commonly used for the main load carrying parts of wind turbine blades. Existing modelling attempts generally consider the fibre bundle structure as a perfect pattern, however recent experimental X-ray CT studies [1,2] have shown that the local variations in the fibre bundle structure have a large influence on the observed fatigue damage initiation and progression in the material. In the current study, the real bundle structure inside a non-crimp fabric based fibre composite is extracted from 3D X-ray CT images and imported into ABAQUS for numerical modelling. The local stress concentrations when loaded in tension caused by the fibre bundle structure are examined and compared to experimental observations of the fatigue damage. In the current study the bundle structure is manually segmented, however the possibility of automatic segmentation in the future is also discussed. The study shows the potential of X-ray CT based modelling for increased understanding of the fatigue damage mechanisms, but also sets the stage for modelling across scales including the variations caused by manufacturing process.

**General information**

State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics, Department of Applied Mathematics and Computer Science, Chalmers University of Technology
Authors: Jespersen, K. M. (Intern), Asp, L. (Ekstern), Mikkelsen, L. P. (Intern)
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Conference: 30th Nordic Seminar on Computational Mechanics (NSCM-30), Copenhagen, 25/10/2017 - 25/10/2017
Non-crimp fabric based composite, X-ray CT based modelling, Finite element modelling, Fatigue damage
Electronic versions:
3D wake measurements from a scanning wind lidar in combination with a fast wind field reconstruction model

High-resolution lidar wake measurements are part of an ongoing field campaign being conducted at the Scaled Wind Farm Technology (SWiFT) facility by Sandia National Laboratories and the National Renewable Energy Laboratory using a customized scanning “DTU SpinnerLidar” from the Technical University of Denmark. The purpose of the SpinnerLidar measurements at SWIFT is to measure the response of a V27 turbine wake to varying inflow conditions and turbine operating states. Although our fast scanning SpinnerLidar is able to measure the line-of-sight projected wind speed at up to 400 points per second, a single lidar is in principle never able to measure all three wind components (u, v, w) in the scan plane at the same time. This limitation is often referred to as the “lidar cyclops syndrome”. However, by processing the scanned line-of-sight wind speed data via a fast linearized Navier-Stokes CFD code “Lincom Cyclop-buster model,” the corresponding 3D wind vector field (u, v, w) can be reconstructed under constraints for conservation of mass and momentum. The resulting model calculated line-of-sight projections of the 3D wind velocity vectors will become consistent with the line-of-sight wind speed measurements from the SpinnerLidar. In this way, SpinnerLidar measured line-of-sight wake data from the SWiFT site at a range of downwind distances were used to calculate the three wind components u(x, y), v(x, y) and w(x, y) in the turbine wake in a number of downwind crosswind scan planes. Fig.1 shows: a) the experimental setup, b) the line-of-sight measured wind field in a crosswind plane 66.2 m downwind, and c) the corresponding Lincom model reconstructed axial wind component u(x, y).

3D WindScanner lidar measurements of wind and turbulence around wind turbines, buildings and bridges: Paper

WindScanner is a distributed research infrastructure developed at DTU with the participation of a number of European countries. The research infrastructure consists of a mobile technically advanced facility for remote measurement of wind and turbulence in 3D. The WindScanners provide coordinated measurements of the entire wind and turbulence fields, of all three wind components scanned in 3D space. Although primarily developed for research related to on- and offshore wind turbines and wind farms, the facility is also well suited for scanning turbulent wind fields around buildings, bridges, aviation structures and of flow in urban environments. The mobile WindScanner facility enables 3D scanning of wind and turbulence fields in full scale within the atmospheric boundary layer at ranges from 10 meters to 5 (10) kilometers. Measurements of turbulent coherent structures are applied for investigation of flow pattern and dynamical loads from turbines, building structures and bridges and in relation to optimization of the location of, for example, wind farms and suspension bridges. This paper presents our achievements to date and reviews briefly the state-of-the-art of the WindScanner measurement technology with examples of uses for wind engineering applications.
4D Study of Grain Growth in Armco Iron Using Laboratory X-ray Diffraction Contrast Tomography: Paper

Using a novel laboratory diffraction contrast tomography (LabDCT) technique, a non-destructive 4D study was conducted to investigate the evolution in 3D of the grain structure during grain growth in an Armco iron sample. The 3D grain morphology and the crystallographic orientations of more than 300 grains were determined at three temporal states during annealing. The correlation between growth of grains and grain orientation is explored. The results demonstrate the capability of the LabDCT technique to allow detailed studies of grain growth, and thereby provide the necessary 4D experimental evidence required for further understanding of grain growth.

General information

State: Published
Authors: Sun, J. (Intern), Lyckegaard, A. (Ekstern), Zhang, Y. (Intern), Catherine, S. A. (Ekstern), Patterson, B. R. (Ekstern), Bachmann, F. (Ekstern), Gueninchault, N. (Ekstern), Bale, H. (Ekstern), Holzner, C. (Ekstern), Lauridsen, E. (Ekstern), Juul Jensen, D. (Intern)
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Publication information

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BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.39 SJR 0.197 SNIP 0.535
Web of Science (2016): Indexed yes
A 1D version of EllipSys

A one-dimensional version of EllipSys, labeled as EllipSys1D is presented. Three atmospheric boundary layer test cases are used to show that results of EllipSys1D are exactly the same or very similar as results of EllipSys3D, while EllipSys1D uses 3 to 4 orders of magnitude less CPU hours compared to EllipSys3D.

A Case Study of Offshore Advection of Boundary Layer Rolls over a Stably Stratified Sea Surface

Streaky structures of narrow (8-9 km) high wind belts have been observed from SAR images above the Baltic Sea during stably stratified conditions with offshore winds from the southern parts of Sweden. Case studies using the WRF model and in situ aircraft observations indicate that the streaks originate from boundary layer rolls generated over the convective air above Swedish mainland, also supported by visual satellite images showing the typical signature cloud streets. The simulations indicate that the rolls are advected and maintained at least 30–80 km off the coast, in agreement with the streaks observed by the SAR images. During evening when the convective conditions over land diminish, the streaky structures over the sea are still seen in the horizontal wind field; however, the vertical component is close to zero. Thus advected feature from a land surface can affect the wind field considerably for long times and over large areas in coastal regions. Although boundary layer rolls are a well-studied feature, no previous study has presented results concerning their persistence during situations with advection to a strongly stratified boundary layer. Such conditions are commonly encountered during spring in coastal regions at high latitudes.
Accuracy of dual-Doppler lidar retrievals of near-shore winds

Abstract: In this presentation the accuracy in retrieving horizontal wind speed and wind direction using a dual-Doppler lidar system will be described. First, the line of sight wind speed uncertainty is described followed by the detailed description of the various sources of errors in laser beam pointing with a particular focus on static errors. A methodology for assessing static pointing errors is presented accompanied with results from the method implementation. Afterwards, mathematical relations for the horizontal wind speed and wind direction uncertainties are derived. For the end, the derived mathematical relations are implemented for the uncertainty assessment of the dual-Doppler retrievals of near-shore winds that took place during the RUNE experiment.

A classical model wind turbine wake "blind test" revisited by remote sensing lidars

One of the classical model wind turbine wake "blind test" experiments conducted in the boundary-layer wind tunnel at NTNU in Trondheim and used for benchmarking of numerical flow models has been revisited by remote sensing lidars in a joint experiment called "Lidars For Wind Tunnels" (L4WT) under the auspices of the IRPWind initiative within the community of the European Energy Research Alliance (EERA) Joint Programme on Wind Energy. The wind tunnel has a test section that is 11 m long and a cross-section of 2 by 3 m with windows along one side of the tunnel allowing for optical access from outside of the tunnel. Two continuous-wave lidars developed at DTU Wind Energy, short-range WindScanners, with a minimum focus distance of about 8 m were placed outside the tunnel with the optical heads at the turbine hub height. The short-range WindScanners can address the measurement location by synchronized steering of two wedge-shaped prisms and a translational motor stage for the focusing of the light. In addition, a small telescope (Lidic) was placed inside the wind tunnel and connected to the WindScanner steering system allowing for synchronized measurements. The diameter of the model turbine studied was D=0.894 m and it was designed for a tip speed ratio (TSR) of 6. However, the TSRs used were 3, 6, and 10 at a free-stream velocity of 10 m/s. Due to geometrical constraints
imposed by for instance the locations of the wind tunnel windows, all measurements were performed in the very same vertical cross-section of the tunnel and the various down-stream distances of the wake, i.e. 1D, 3D, and 5D were achieved by re-positioning the turbine. The approach used allows for unique studies of the influence of the inherent lidar spatial filtering on previously both experimentally and numerically well characterized flow fields with various spatial flow gradients which is difficult to achieve in full-scale field experiments. As a consequence of the quadratic range dependence on the averaging length of a continuous-wave lidar, the results are of relevance also for full-scale wind turbine lidar measurement scenarios in terms of the averaging length relative to the wind turbine rotor size.

**General information**
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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Norwegian University of Science and Technology, SINTEF Energy Research
Authors: Sjöholm, M. (Intern), Angelou, N. (Intern), Nielsen, M. B. (Intern), Mühle, F. V. (Ekstern), Sætran, L. R. (Ekstern), Bolstad, H. C. (Ekstern), Mann, J. (Intern), Mikkelsen, T. K. (Intern)
Number of pages: 1
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A combined aeroelastic-aeroacoustic model for wind turbine noise: Verification and analysis of field measurements
In this paper, semi-empirical engineering models for the three main wind turbine aerodynamic noise sources, namely, turbulent inflow, trailing edge and stall noise, are introduced. They are implemented into the in-house aeroelastic code HAWC2 commonly used for wind turbine load calculations and design. The results of the combined aeroelastic and aeroacoustic model are compared with field noise measurements of a 500kW wind turbine. Model and experimental data are in fairly good agreement in terms of noise levels and directivity. The combined model allows separating the various noise sources and highlights a number of mechanisms that are difficult to differentiate when only the overall noise from a wind turbine is measured.

**General information**
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Organisations: Department of Wind Energy, Aerodynamic design
Authors: Bertagnolio, F. (Intern), Aagaard Madsen , H. (Intern), Fischer, A. (Intern)
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
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Scopus rating (2015): SJR 1.201 SNIP 2.165 CiteScore 3.06
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Scopus rating (2014): SJR 1.209 SNIP 3.688 CiteScore 3.42
A comparison of extreme structural responses and fatigue damage of semi-submersible type floating horizontal and vertical axis wind turbines

A comprehensive comparison of floating HAWTs and VAWTs with different blade number. Extreme structural responses and fatigue damage are studied. Both operational and parked conditions are considered. The merits and disadvantages of floating HAWTs and VAWTs are revealed and highlighted.

General information
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Organisations: Department of Wind Energy, Aerodynamic design, Norwegian University of Science and Technology
Authors: Cheng, Z. (Ekstern), Aagaard Madsen, H. (Intern), Chai, W. (Ekstern), Gao, Z. (Ekstern), Moan, T. (Ekstern)
Pages: 207-219
Publication date: 2017
Main Research Area: Technical/natural sciences
Adequacy of Frequency Reserves for High Wind Power Generation

In this article, a new methodology is developed to assess the adequacy of frequency reserves to handle power imbalances caused by wind power forecast errors. The goal of this methodology is to estimate the adequate volume and speed of activation of frequency reserves required to handle power imbalances caused due to high penetration of wind power. An algorithm is proposed and developed to estimate the power imbalances due to wind power forecast error following activation of different operating reserves. Frequency containment reserve requirements for mitigating these power imbalances are developed through this methodology. Furthermore, the probability of reducing this frequency containment reserve requirement is investigated through this methodology with activation of different volumes and speed of frequency restoration reserve. Wind power generation for 2020 and 2030 scenarios for Continental Europe network are investigated based on which recommendations are made for requirements of frequency reserves in these scenarios. It has been observed through simulations that frequency containment reserve requirements reduce exponentially with increase in volume of frequency restoration reserve and remains almost unaffected by increase activation speed of frequency restoration reserve.
Adhesive Joints in Wind Turbine Blades

The industrial goal of this PhD project is to enable manufacturing of larger wind turbine blades by improving the existing design methods for adhesive joints. This should improve the present joint design such that more efficient wind turbine blades can be produced. The main scientific goal of the project is to develop new- and to improve the existing design rules for adhesive joints in wind turbine blades. The first scientific studies of adhesive joints were based on stress analysis, which requires that the bond-line is free of defects, but this is rarely the case for a wind turbine blade. Instead linear-elastic fracture mechanics are used in this project since it is appropriate to assume that a crack can initiate and propagate from a pre-existing defect. The project was divided into three sub-projects. In the first sub-project, the effect of different parameters (e.g. laminate thickness, post curing and test temperatures) on the formation of transverse cracks in the adhesive were tested experimentally. It was assumed that the transverse cracks evolved due to a combination of mechanical- and residual stresses in the adhesive. A new approach was developed that allows the residual stress to be determined in several different ways. The accuracy of different ways of measuring residual stresses in the adhesive was tested by applying five different methods on a single sandwich test specimen (laminate/adhesive/laminate) that was instrumented with strain gauges and fiber Bragg gratings. Quasi-static tensile tests of sandwich specimens showed that higher post curing temperature and lower test temperature had a negative effect on the formation of transverse cracks in the adhesive. In the second sub-project, tunneling cracks in adhesive joints were analyzed numerically and experimentally. Simulations with a new tri-material finite element model showed that the energy release rate of the tunneling crack could be reduced by embedding a so-called buffer-layer with a well-chosen stiffness and thickness. However, it was found for adhesive joints in wind turbine blades that the laminates were already sufficiently stiff. Thus, the effect of a stiffer buffer-layer was small in comparison with the effect of reducing the thickness of the adhesive layer. A new approach was tested by embedding a generic tunneling crack tool used to predict the cyclic crack growth rate for tunneling cracks in the adhesive joint of a full scale wind turbine blade. The model predictions were tested on a full scale wind turbine blade that was loaded excessively in an edgewise fatigue test in a laboratory. It was demonstrated that the model predictions were in agreement with measurements on the full scale test blade. In the third sub-project crack deflection at interfaces in adhesive joints was investigated experimentally. Therefore, it was necessary to design a test specimen, where a crack could propagate stable and orthogonal towards a bi-material interface. A four-point single-edge-notch-beam (SENB) test specimen loaded in displacement control (fixed grip) was designed and manufactured for the purpose. In order to design the test specimen, new models were established to ensure stable crack growth and thus enable that crack deflection could be observed during loading (in-situ). A new analytical model of the four-point SENB specimen was derived, and together with numerical models it was found that the test specimen should be short and thick and the start-crack length relatively deep for the crack to propagate in a stable manner. Using the design from the developed models, crack deflection at interfaces for different material systems was tested successfully. For test specimens in selected test series it was observed that a new crack initiated at the interface before the main crack propagated and reached the interface. This cracking mechanism was used to develop a novel approach to determine the cohesive strength of the interface. The novel approach was applied to determine the cohesive strength of different material systems including an adhesive/laminate interface. It was found that the cohesive strength of the interfaces was small in comparison with the macroscopic strength of the adhesive.
Aeroelastic Analysis of Olsen Wings 14.3m Blade-Blatigue Project

HAWC2 model description and basic analysis of a 15 m rotor radius horizontal axis wind turbine (HAWT) based on 14.3m blade from Olsen Wings and the V27 wind turbine (WT) tower and nacelle properties. The subcomponents of the aeroelastic HAWC2 model have been created in previous projects. The aim of this analysis is to give an overview of the whole model properties and response through simulations. The blade structural and aerodynamic properties in HAWC2 format have been provided by Frederik Zahle and the HAWC2 model of the V27 structure by Morten H. Hansen of DTU Wind Energy Department. The current analysis is part of the Bladigue project (Blatigue, 2020).

Aeroelastic code validation - A mixed collection of examples

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control
Authors: Larsen, T. J. (Intern)
Number of pages: 10
Publication date: 2017
Aeroelastic multidisciplinary design optimization of a swept wind turbine blade

Mitigating loads on a wind turbine rotor can reduce the cost of energy. Sweeping blades produces a structural coupling between flapwise bending and torsion, which can be used for load alleviation purposes. A multidisciplinary design optimization (MDO) problem is formulated including the blade sweep as a design variable. A multifidelity approach is used to confront the crucial effects of structural coupling on the estimation of the loads. During the MDO, ultimate and damage equivalent loads are estimated using steady-state and frequency-domain–based models, respectively. The final designs are verified against time-domain full design load basis aeroelastic simulations to ensure that they comply with the constraints. A 10-MW wind turbine blade is optimized by minimizing a cost function that includes mass and blade root flapwise fatigue loading. The design space is subjected to constraints that represent all the necessary requirements for standard design of wind turbines. Simultaneous aerodynamic and structural optimization is performed with and without sweep as a design variable. When sweep is included in the MDO process, further minimization of the cost function can be obtained. To show this achievement, a set of optimized straight blade designs is compared to a set of optimized swept blade designs. Relative to the respective optimized straight designs, the blade mass of the swept blades is reduced of an extra 2% to 3% and the blade root flapwise fatigue damage equivalent load by a further 8%.

General information

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Organisations: Department of Wind Energy, Wind turbine loads & control, Aerodynamic design, Fluid Mechanics
Authors: Pavese, C. (Intern), Tibaldi, C. (Intern), Zahle, F. (Intern), Kim, T. (Intern)
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Web of Science (2017): Indexed yes
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Scopus rating (2015): SJR 1.201 SNIP 2.165 CiteScore 3.06
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.209 SNIP 3.688 CiteScore 3.42
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BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.235 SNIP 2.486 CiteScore 2.75
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.062 SNIP 2.297 CiteScore 2.36
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.892 SNIP 2.582 CiteScore 2.49
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.364 SNIP 2.026
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
A framework for medium-fidelity wake dynamics in moderately complex terrain

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Organisations: Department of Wind Energy, Wind turbine loads & control, Aerodynamic design, Resource Assessment Modelling
Authors: Larsen, G. C. (Intern), van der Laan, P. (Intern), Ott, S. (Intern)
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A fully coupled method for numerical modeling and dynamic analysis of floating vertical axis wind turbines

Aerodynamic modeling of floating VAWTs is established using the Actuator Cylinder (AC) flow method. A fully coupled aero-hydro-servo-elastic simulation tool, i.e. SIMO-RIFLEX-AC, is developed for floating VAWTs. The developed simulation tool is verified to be accurate by a series of code-to-code comparisons. This simulation tool can be used for design and response analysis of different floating VAWT concepts.

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Organisations: Department of Wind Energy, Aerodynamic design, Norwegian University of Science and Technology
Authors: Cheng, Z. (Ekstern), Aagaard Madsen, H. (Intern), Gao, Z. (Ekstern), Moan, T. (Ekstern)
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Floating vertical axis wind turbine, Fully coupled method, Aero-hydro-servo-elastic, Actuator cylinder flow model

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A gradient surface produced by combined electroplating and incremental frictional sliding

A Cu plate was first electroplated with a Ni layer, with a thickness controlled to be between 1 and 2 μm. The coated surface was then deformed by incremental frictional sliding with liquid nitrogen cooling. The combined treatment led to a multifunctional surface with a gradient in strain, chemical content, microstructure, and hardness. The chemical profile was measured by glow-discharge optical emission spectroscopy, showing diffusion of Ni into the heavily deformed Cu layer to a depth of about 40 μm. The microstructure and hardness were characterized and compared with a similarly processed Cu plate without Ni coating, showing a strong effect of the coated layer on the deformation. The experimental results are followed by an analysis of strengthening mechanisms and a discussion of the applicability of the new technique for increasing the durability and lifetime of components exposed to friction and wear, e.g. in wind turbines.

A method to characterize the roughness of 2-D line features: recrystallization boundaries

A method is presented, which allows quantification of the roughness of nonplanar boundaries of objects for which the neutral plane is not known. The method provides quantitative descriptions of both the local and global characteristics. How the method can be used to estimate the sizes of rough features and local curvatures is also presented. The potential of the method is illustrated by quantification of the roughness of two recrystallization boundaries in a pure Al specimen characterized by scanning electron microscopy.
A method to investigate the biomechanical alterations in Perthes' disease by hip joint contact modeling

Perthes' disease is a destructive hip joint disorder characterized by malformation of the femoral head in young children. While the morphological changes have been widely studied, the biomechanical effects of these changes still need to be further elucidated. The objective of this study was to develop a method to investigate the biomechanical alterations in Perthes' disease by finite element (FE) contact modeling using MRI. The MRI data of a unilateral Perthes' case was obtained to develop the three-dimensional FE model of the hip joint. The stress and contact pressure patterns in the unaffected hip were well distributed. Elevated concentrations of stress and contact pressure were found in the Perthes' hip. The highest femoral cartilage von Mises stress 3.9 MPa and contact pressure 5.3 MPa were found in the Perthes' hip, whereas 2.4 MPa and 4.9 MPa in the healthy hip, respectively. The healthy bone in the femoral head of the Perthes' hip carries additional loads as indicated by the increase of stress levels around the necrotic-healthy bone interface. Identifying the biomechanical changes, such as the location of stress and contact pressure concentrations, is a prerequisite for the preoperative planning to obtain stress relief for the highly stressed areas in the malformed hip. This single-patient study demonstrated that the biomechanical alterations in Perthes' disease can be evaluated individually by patient-specific finite element contact modeling using MRI. A multi-patient study is required to test the strength of the proposed method as a pre-surgery planning tool.
A multi-frequency fatigue testing method for wind turbine rotor blades

Rotor blades are among the most delicate components of modern wind turbines. Reliability is a crucial aspect, since blades shall ideally remain free of failure under ultra-high cycle loading conditions throughout their designated lifetime of 20–25 years. Full-scale blade tests are the most accurate means to experimentally simulate damage evolution under operating conditions, and are therefore used to demonstrate that a blade type fulfils the reliability requirements to an acceptable degree of confidence. The state-of-the-art testing method for rotor blades in industry is based on resonance excitation where typically a rotating mass excites the blade close to its first natural frequency. During operation the blade response due to external forcing is governed by a weighted combination of its eigenmodes. Current test methodologies which only utilise the lowest eigenfrequency induce a fictitious damage where additional tuning masses are required to recover the desired damage distribution. Even with the commonly adopted amplitude upscaling technique fatigue tests remain a time-consuming and costly endeavour. The application of tuning masses increases the complexity of the problem by lowering the natural frequency of the blade and therefore increasing the testing time. The novel method presented in this paper aims at shortening the duration of the state-of-the-art fatigue testing method by simultaneously exciting the blade with a combination of two or more eigenfrequencies. Taking advantage of the different shapes of the excited eigenmodes, the actual spatial damage distribution can be more realistically simulated in the tests by tuning the excitation force amplitudes rather than adding tuning masses. This implies that in portions of the blade the lowest mode is governing the damage whereas in others higher modes contribute more significantly due to their higher cycle count. A numerical feasibility study based on a publicly available large utility rotor blade is used to demonstrate the ability of the proposed approach to outperform the state-of-the-art testing method without compromising fatigue test requirements. It will be shown that the novel method shortens the testing time and renders the damage evolution with a higher degree of fidelity.
An advanced structural trailing edge modelling method for wind turbine blades

This study demonstrates an advanced blade modelling approach based on a combination of shell and solid elements which can enhance the reliability of structural predictions for wind turbine blades. The advanced blade modelling approach is based on a shell element model where the adhesive bondline in the trailing edge region is discretised by means of solid brick elements which are connected via Multi-Point-Constraint to the shell elements. The new approach overcome the drawbacks of pure shell element simulations and can reliably predict the response of wind turbine blade structures which are exposed to ultimate loads. The prediction accuracy of the numerical simulations was compared to a certification load case and a full-scale ultimate limit state test of a 34 m wind turbine rotor blade. The displacements, stresses and strains show reasonably good agreement and demonstrate the capabilities of the advanced blade modelling approach.
Analysis of Anholt offshore wind farm SCADA measurements

SCADA measurements from the Danish Anholt offshore wind farm (ANH) for a period of 2½ years have been qualified. ANH covers 12 km × 22 km and is located between Djursland and the island Anholt in Kattegat, Denmark. This qualification encompasses identification of curtailment and idling periods, start/stop events and a power curve control for each wind turbine in the wind farm. Data also include wind speed measurements from a nearby WindCube lidar and simulations from the WRF model for the same period as the SCADA. An equivalent wind speed (wsi) is derived from the combined power and pitch signals for each wind turbine. Furthermore, the local wind direction is derived for a number of wake-free turbine groups. By combining the wsi and wind direction, the undisturbed wind speed and direction inflow conditions of the wind farm (Upark and WDpark) are estimated for all 360 degrees.

The preliminary analysis reveals a significant wind gradient along the North-South direction for the western row of the wind farm – for westerly inflow, together with a distinct wind speed reduction caused by coastal effects. Figure 1 shows how the coast influences the wind speed gradient along the western row of turbines. Furthermore, a minor wind speed reduction is identified for easterly inflow, caused by the island Anholt. The internal wake effects are small, due to the large “variable” spacing based on the arch-based layout compared to other wind farms.

A comparison between simulated WRF and measured wind speeds shows good correlation. The power deficit along the rows of turbines demonstrates a significant difference between unstable and stable conditions.

General information
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Organisations: Department of Wind Energy, Fluid Mechanics, Resource Assessment Modelling, Meteorology & Remote Sensing, Aerodynamic design
Authors: Hansen, K. S. (Intern), Volker, P. (Intern), Pena Diaz, A. (Intern), van der Laan, P. (Intern), Ott, S. (Intern), Hasager, C. B. (Intern)
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Analysis of bearing steel exposed to rolling contact fatigue

The objective of this work is to characterize fatigue damage in roller bearings under conditions of high load and slippage. A test rig constructed for rolling contact fatigue tests of rings is described, and test results are presented for rings taken from two spherical roller bearings. The preparation of the rings and the loading situation are explained. Test conditions are chosen with the aim of achieving pitting formation at the contacting surfaces. During testing the contact pressure, torque and the rotational speed are monitored and recorded. After testing the tested rings have been characterized using X-ray tomography and scanning electron microscopy. The observations confirm that rolling contact fatigue testing at high loads leads to pitting failure at the contacting surfaces. The pitting mostly appears on one side of the contact, attributed to a non-uniform contact pressure in the axial direction.

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Organisations: Department of Wind Energy, Composites and Materials Mechanics, Materials science and characterization, Wind Turbine Structures and Component Design, Department of Mechanical Engineering, Solid Mechanics, Technical University of Denmark
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Conference: 38th Risø International Symposium on Materials Science, Roskilde, Denmark, 04/09/2017 - 04/09/2017
Analysis of experimental data: The average shape of extreme wave forces on monopile foundations and the NewForce model

Experiments with a stiff pile subjected to extreme wave forces typical of offshore wind farm storm conditions are considered. The exceedance probability curves of the nondimensional force peaks and crest heights are analysed. The average force time history normalised with their peak values are compared across the sea states. It is found that the force shapes show a clear similarity when grouped after the values of the normalised peak force, $F/(\rho g h R^2)$, normalised depth $h/(g T^2 p)$ and presented in a normalised time scale $t/T_a$. For the largest force events, slamming can be seen as a distinct ‘hat’ on top of the smoother underlying force curve. The force shapes are numerically reproduced using a design force model, NewForce, which is introduced here for the first time to both first and second order in wave steepness. For force shapes which are not asymmetric, the NewForce model compares well to the average shapes. For more nonlinear wave shapes, higher order terms has to be considered in order for the NewForce model to be able to predict the expected shapes.
Analysis of extreme wind events at Høvsøre and the effect on wind turbine loads

The IEC 61400-1 standards for wind turbines prescribe a set of requirements to ensure that wind turbines are designed to defined reliability levels. These standards take into consideration extreme wind conditions and various operational turbine load regimes, and specify the damage a wind turbine may withstand over its lifetime. The standards include an extreme turbulence model (ETM), which gives the 50-year extreme ten-minute standard deviation of wind speed as function of ten-minute wind speed at hub height. Herein observations of high wind speed variance events, where the variance exceed the ETM level are analysed.

Inspection of these specific events shows that the measurements often include a sharp increase in wind speed, a ramp or a coherent gust-like structure. These structures give rise to the observed high wind speed variance, which is not resulting from extreme turbulence. The aim of this analysis is to answer the questions:

1. How are the wind-turbine loads affected by these events?
2. What atmospheric parameters give rise to the highest loads?

The data used for the analysis is from a 160 m tall lighting tower in Høvsøre, which is a measurement site approximately 2 km from the west coast of Denmark. The data consists of wind speed measurements from cup anemometers and directional data from wind vanes at 60 m, 100 m and 160 m.

A ten-year period with measurements from the western sector is used to identify events of high wind speed variance that exceed the ETM for a given 10-minute mean wind speed. The events are analysed and factors that might possibly contribute to extreme wind turbine loads, like wind-velocity jump, directional change and wind shear, are identified and quantified.

The wind speed measurements are low pass filtered and simulated with HAWC2, which is an aeroelastic software used to simulate wind turbine response in time domain. The simulations are made for the DTU 10 MW reference wind turbine. Load analysis shows that the maximum tilt moment on the tower yaw bearing correlates well with the wind shear of the measurements. When these loads are compared with the extreme wind shear load case of the IEC standards, it is seen that they are of similar magnitude and in one case even higher.

General information
Analytical gradients of wind turbine towers fatigue loads

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control, Wind Turbine Structures and Component Design
Authors: Tibaldi, C. (Intern), Hansen, M. H. (Intern), Stolpe, M. (Intern)
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An electron microscopy study of microstructural evolution during in-situ annealing of heavily deformed nickel
The microstructure of heavily deformed pure nickel processed by accumulative roll bonding to a von Mises strain of 6.4 has been investigated using both transmission electron microscopy and transmission Kikuchi diffraction in a scanning electron microscope. By monitoring the microstructure in one region during in-situ annealing in a transmission electron microscope, it is found that 9% of all triple junctions present in this region have migrated over more than 40 nm. Junctions formed by three high angle boundaries are observed to be more prone to motion during recovery than any other junctions. The extent of triple junction motion in the Ni sample is compared to that in heavily deformed aluminum.

General information
State: Published
Organisations: Department of Wind Energy, Materials science and characterization
Authors: Zhang, Y. (Intern), Yu, T. (Intern), Mishin, O. (Intern)
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.51 SJR 0.754 SNIP 0.939
Web of Science (2016): Indexed yes
An emerging European Doppler lidar network for meteorological applications

General information
State: Published
Organisations: Department of Wind Energy, University of Reading, Icelandic Meteorological Office, Météo-France, Leibniz Institute for Tropospheric Research (TROPOS), Leipzig, Finnish Meteorological Institute, Deutscher Wetterdienst, University of Helsinki, University of Köln, Universitat Politecnica de Catalunya, Reykjavik University, Leosphere, Halo Photonics
Authors: O'Connor, E. (Ekstern), Hirsiikko, A. (Ekstern), Halios, C. (Ekstern), Gryning, S. (Intern), Leinweber, R. (Ekstern), Manninen, A. (Ekstern), Marke, T. (Ekstern), Petersen, N. (Ekstern), Preissler, J. (Ekstern), Päschke, E. (Ekstern), Saeed, U. (Ekstern), schween, J. (Ekstern), Shu, Y. (Ekstern), Suomi, I. (Ekstern), Tuononen, M. (Ekstern), Vakkari, V. (Ekstern), Thobois, L. (Ekstern), Pearson, G. (Ekstern), Dabas, A. (Ekstern), Buehl, J. (Ekstern)

Electron microscopy, Transmission Kikuchi diffraction (TKD), Nickel, Microstructure, Recovery, Triple junction motion

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A new k-epsilon model consistent with Monin-Obukhov similarity theory

A new k-" model is introduced that is consistent with Monin–Obukhov similarity theory (MOST). The proposed k-" model is compared with another k-" model that was developed in an attempt to maintain inlet profiles compatible with MOST. It is shown that the previous k-" model is not consistent with MOST for unstable conditions, while the proposed k-" model can maintain MOST inlet profiles over distances of 50 km.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design, Resource Assessment Modelling
Authors: van der Laan, P. (Intern), Kelly, M. C. (Intern), Sørensen, N. N. (Intern)
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Scopus rating (2017): CiteScore 3.18 SJR 1.051 SNIP 1.834
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.37 SJR 1.079 SNIP 2.316
Web of Science (2016): Indexed yes
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Scopus rating (2015): SJR 1.201 SNIP 2.165 CiteScore 3.06
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.209 SNIP 3.688 CiteScore 3.42
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.235 SNIP 2.486 CiteScore 2.75
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.062 SNIP 2.297 CiteScore 2.36
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
A New Volume-Of-Fluid Method in Openfoam

To realise the full potential of Computational Fluid Dynamics (CFD) within marine science and engineering, there is a need for continuous maturing as well as verification and validation of the numerical methods used for free surface and interfacial flows. One of the distinguishing features here is the existence of a water surface undergoing large deformations and topological changes during transient simulations e.g. of a breaking wave hitting an off-shore structure. To date, the most successful method for advecting the water surface in marine applications is the Volume-of-Fluid (VOF) method. While VOF methods have become quite advanced and accurate on structured meshes, there is still room for improvement when it comes to unstructured meshes of the type needed to simulate flows in and around complex geometric structures. We have recently developed a new geometric VOF algorithm called isoAdvector for general meshes and implemented it in the OpenFOAM interfacial flow solver called interFoam. We have previously shown the advantages of isoAdvector for simple pure advection test cases on various mesh types. Here we test the effect of replacing the existing interface advection method in interFoam, based on MULES limited interface compression, with the new isoAdvector method. Our test case is a steady 2D stream function wave propagating in a periodic domain. Based on a series of simulations with different numerical settings, we conclude that the introduction of isoAdvector has a significant effect on wave propagation with interFoam. There are several criteria of success: Preservation of water volume, of interface sharpness and shape, of crest kinematics and celerity, not to mention computational efficiency. We demonstrate how isoAdvector can improve on many of these parameters, but also that the success depends on the solver setup. Thus, we cautiously conclude that isoAdvector is a viable alternative to MULES when set up correctly, especially when interface sharpness, interface smoothness and calculation times are important. There is, however, still potential for improvement in the coupling of isoAdvector with interFoam's PISO based pressure-velocity solution algorithm.
Anholt offshore wind farm wake investigated from satellite data and wake models

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Original language: English
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Publication: Research › Sound/Visual production (digital) – Annual report year: 2017

Anholt offshore wind farm winds investigated from satellite images
The Anholt offshore wind farm in the Kattegat Strait has its centre position around 56.6°N and 11.2°E. The Sentinel-1 satellite carries a C-band Synthetic Aperture Radar (SAR). A SAR-based instantaneous wind speed map from May 5th, 2015 at 17:01 UTC is shown below (See1). The wind speed is low at this particular moment and the backscatter from the wind turbines is much higher than that from the sea. Therefore the wind turbines are contrasted clearly as yellow/orange dots at the Anholt wind farm. Along the Swedish coast several ships (red dots) are visible. The SAR-based wind speeds can be trusted at around 1 km distance from any coastline except in grid cells with wind turbines, ships and other hard targets. The grid resolution is 1 km by 1 km. The wind direction is from the south west.

The satellite SAR analysis is based on ~1.000 SAR images from Envisat ASAR recorded from August 2002 to April 2012, i.e. before the wind farm was constructed. Based on these data the wind resource is estimated. Concurrent Sentinel-1 SAR data and available SCADA and lidar data, kindly provided by DONG Energy and partners, for the period January 2013 to June 2015 account for ~70 images, while ~300 images are available for Sentinel-1 from July 2015 to February 2017. The Sentinel-1 wind maps are investigated for wind farm wake effects. Furthermore the results on wind resources and wakes are compared to the SCADA and model results from WRF, Park, Fuga and RANS models.

General information
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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling, Fluid Mechanics, Aerodynamic design
Authors: Hasager, C. B. (Intern), Badger, M. (Intern), Volker, P. (Intern), Hansen, K. S. (Intern), Pena Diaz, A. (Intern), van der Laan, P. (Intern)
Publication date: 2017
An influence of the different incoming wake-like flows on the rotor vibrations: Paper
The aim of the current investigation is the rotor vibrations generated by the disturbances caused by the different types of incoming wake-like flows. Those wakes arriving at the tested rotor were created by two ways: a passive wake generator (immobile disk) and an upstream rotating rotor as an active wake generator. The influence of both wakes on the tested rotor was studied in a water flume. A model of the tested three-bladed rotor designed using Glauert’s optimum theory at an optimal tip speed ratio $\lambda = 5$ was placed in both “passive” and “active” wakes to recognize dissimilarities on the vibrations of the tested rotor. The distance from the wake generators to the tested rotor varied from 4 to 8 rotor diameters. Also, the shift between the rotor axis and axis of the incoming wakes was changed to 0, 0.5, and 1 rotor diameters. The flow condition before rotor was measured with high temporal accuracy using LDA. The turbulent intensity of the incoming wake flows changed from 3 to 16% due to the types of the wake generators. Power and thrust characteristics and their pulsations of the tested rotor were measured by strain gauges. The dependences of power coefficients from tip speed ratios and positions of the wake generators were documented. The present study showed a strong influence of the initial flow from the two different wake generators on the rotor vibrations.

An interaction of impacting droplets with superhydrophobic coatings

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Kutateladze Institute of Thermophysics SB RAS
Authors: Naumov, I. V. (Ekstern), Kabardin, I. K. (Ekstern), Mikkelsen, R. F. (Intern), Okulov, V. (Intern), Sørensen, J. N. (Intern)
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General information
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Organisations: Department of Micro- and Nanotechnology, Polymer Micro & Nano Engineering, Department of Mechanical Engineering, Fluid Mechanics
Authors: Okulova, N. (Intern), Okulov, V. (Intern), Taboryski, R. J. (Intern)
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Source-ID: 138355021
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An intercomparison of mesoscale models at simple sites for wind energy applications

Understanding uncertainties in wind resource assessment associated with the use of the output from numerical weather prediction (NWP) models is important for wind energy applications. A better understanding of the sources of error reduces risk and lowers costs. Here, an intercomparison of the output from 25 NWP models is presented for three sites in northern Europe characterized by simple terrain. The models are evaluated using a number of statistical properties relevant to wind energy and verified with observations. On average, the models have small wind speed biases offshore and aloft ( < 4 %) and larger biases closer to the surface over land (> 7 %). A similar pattern is detected for the inter-model spread. Strongly stable and strongly unstable atmospheric stability conditions are associated with larger wind speed errors. Strong indications are found that using a grid spacing larger than 3 km decreases the accuracy of the models, but we found no evidence that using a grid spacing smaller than 3 km is necessary for these simple sites. Applying the models to a simple wind energy offshore wind farm highlights the importance of capturing the correct distributions of wind speed and direction.

Application of simulated lidar scanning patterns to constrained Gaussian turbulence fields for load validation

We demonstrate a method for incorporating wind velocity measurements from multiple-point scanning lidars into threedimensional wind turbulence time series serving as input to wind turbine load simulations. Simulated lidar scanning patterns are implemented by imposing constraints on randomly generated Gaussian turbulence fields in compliance with the Mann model for neutral stability. The expected efficiency of various scanning patterns is estimated by means of the explained variance associated with the constrained field. A numerical study is made using the HAWC2 aeroelastic software, whereby the constrained turbulence wind time series serves as input to load simulations on a 10 MW wind turbine model using scanning patterns simulating different lidar technologies—pulsed lidar with one or multiple beams—and continuous wave lidars scanning in three different revolving patterns. Based on the results of this study, we assess the influence of the proposed method on the statistical uncertainty in wind turbine extreme and fatigue loads. The main conclusion is that introducing lidar measurements as turbulence constraints in load simulations may bring significant reduction in load and energy production uncertainty, not accounting for any additional uncertainty from real measurements. The constrained turbulence method is most efficient for prediction of energy production and loads governed by the turbulence intensity and the thrust force, while for other load components such as tower base side-to-side moment, the achieved reduction in uncertainty is minimal.
A semi-empirical airfoil stall noise model based on surface pressure measurements

This work is concerned with the experimental study of airfoil stall and the modelling of stall noise. Using pressure taps and high-frequency surface pressure microphones flush-mounted on airfoils measured in wind tunnels and on an operating wind turbine blade, the characteristics of stall are analyzed. This study shows that the main quantities of interest, namely convection velocity, spatial correlation and surface pressure spectra, can be scaled highlighting the universal nature of stall independently of airfoil shapes and flow conditions, although within a certain range of experimental conditions. Two main regimes for the scaling of the correlation lengths and the surface pressure spectra, depending on the Reynolds number of the flow, can be distinguished. These results are used to develop a model for the surface pressure spectra within the detached flow region valid for Reynolds numbers ranging from $1 \times 10^6$ to $6 \times 10^6$. Subsequently, this model is used to derive a model for stall noise. Modelled noise spectra are compared with experimental data measured in anechoic wind tunnels with reasonably satisfactory agreement.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design
Authors: Bertagnolio, F. (Intern), Aagaard Madsen , H. (Intern), Fischer, A. (Intern), Bak, C. (Intern)
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BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.09 SJR 1.459 SNIP 2.236
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.31 SNIP 2.15 CiteScore 2.71
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.41 SNIP 2.308 CiteScore 2.54
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.32 SNIP 2.553 CiteScore 2.61
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.441 SNIP 2.939 CiteScore 2.3
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.383 SNIP 2.661 CiteScore 2.05
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Web of Science (2011): Indexed yes
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Scopus rating (2010): SJR 1.175 SNIP 2.039
A short numerical study on the optimization methods influence on topology optimization

Structural topology optimization problems are commonly defined using continuous design variables combined with material interpolation schemes. One of the challenges for density based topology optimization observed in the review article (Sigmund and Maute Struct Multidiscip Optim 48(6):1031â€“1055 2013) is the slow convergence that is often encountered in practice, when an almost solid-and-void design is found. The purpose of this forum article is to present some preliminary observations on how designs evolves during the optimization process for different choices of optimization methods. Additionally, the authors want to open a discussion on how to properly define and identify the boundary translation that is often observed in practice. The authors hope that these preliminary observations can open for fruitful discussions and stimulate further investigations concerning slowly moving boundaries. Although the discussion is centered on density based methods it may be equally relevant to level-set and phase-field approaches.
A simple model of the wind turbine induction zone derived from numerical simulations

The induction zone in front of different wind turbine rotors is studied by means of steady-state Navier-Stokes simulations combined with an actuator disk approach. It is shown that, for distances beyond 1 rotor radius upstream of the rotors, the induced velocity is self-similar and independent of the rotor geometry. On the basis of these findings, a simple analytical model of the induction zone of wind turbines is proposed.

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Organisations: Department of Wind Energy, Aerodynamic design
A Statistical Model for Hourly Large-Scale Wind and Photovoltaic Generation in New Locations

The analysis of large-scale wind and photovoltaic (PV) energy generation is of vital importance in power systems where their penetration is high. This paper presents a modular methodology to assess the power generation and volatility of a system consisting of both PV plants (PVPs) and wind power plants (WPPs) in new locations. The methodology is based on statistical modelling of PV and WPP locations with a vector autoregressive model, which takes into account both the temporal correlations in individual plants and the spatial correlations between the plants. The spatial correlations are linked through distances between the locations, which allows the methodology to be used to assess scenarios with PVPs and WPPs in multiple locations without actual measurement data. The methodology can be applied by the transmission and distribution system operators when analysing the effects and feasibility of new PVPs and WPPs in system planning. The model is verified against hourly measured wind speed and solar irradiance data from Finland. A case study assessing the impact of the geographical distribution of the PVPs and WPPs on aggregate power generation and its variability is presented.
A survey of modelling methods for high-fidelity wind farm simulations using large eddy simulation

Large eddy simulations (LES) of wind farms have the capability to provide valuable and detailed information about the dynamics of wind turbine wakes. For this reason, their use within the wind energy research community is on the rise, spurring the development of new models and methods. This review surveys the most common schemes available to model the rotor, atmospheric conditions and terrain effects within current state-of-the-art LES codes, of which an overview is provided. A summary of the experimental research data available for validation of LES codes within the context of single and multiple wake situations is also supplied. Some typical results for wind turbine and wind farm flows are presented to illustrate best practices for carrying out high-fidelity LES of wind farms under various atmospheric and terrain conditions. This article is part of the themed issue 'Wind energy in complex terrains'.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Uppsala University, Dawson College
Authors: Breton, S. (Ekstern), Sumner, J. (Ekstern), Sørensen, J. N. (Intern), Hansen, K. S. (Intern), Sarmast, S. (Ekstern), Ivanell, S. (Ekstern)
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Scopus rating (2017): SJR 0.907 SNIP 1.15
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BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.26 SJR 0.986 SNIP 1.193
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.865 SNIP 1.116 CiteScore 2.08
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.902 SNIP 1.36 CiteScore 2.39
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Scopus rating (2013): SJR 1.18 SNIP 1.601 CiteScore 3.12
ISI indexed (2013): ISI indexed yes
Asymmetrical Fault Analysis at the Offshore Network of HVDC connected Wind Power Plants

Short-circuit faults for HVDC connected Wind Power Plants (WPPs) have been studied mostly for dc link and onshore ac grid faults, while the offshore ac faults, especially asymmetrical faults, have been mostly omitted in the literature. Requirements related to the offshore asymmetrical faults have been kept as future development at national levels in the recent ENTSO-E HVDC network code. In this paper offshore ac faults are studied using the classical power system fault analysis methods. It is shown that suppression of negative sequence current flow is not applicable and negative sequence current has to flow during the asymmetrical offshore faults, which implies that the offshore WPP and the HVDC offshore converter are required to provide flow of negative sequence current. The steady-state fault analysis is verified with time-domain simulations.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning, Dong Energy Wind Power A/S
Authors: Goksu, O. (Intern), Cutululis, N. A. (Intern), Sorensen, P. (Intern), Zeni, L. (Ekstern)
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A temporal wind turbine model for low-frequency noise

In this study, a numerical method aiming at modeling wind turbine noise in the low frequency range is presented. It is based on the coupling of an existing time-domain aeroelastic code for wind turbine applications called HAWC2, and the so-called Formulation 1A by Farassat (1) which is designed to compute the thickness and loading noise generated by moving objects in the time-domain. The numerical results of this code are analyzed in detail. The influence of various numerical parameters on the quality of the results is evaluated. It is shown that the present model compares relatively well with Viterna's model (2) for the prediction of low frequency noise from rotors, and with the turbulent inflow noise theory for airfoils by Amiet (3) over a specific frequency range. Various atmospheric turbulence intensities and geometrical configurations are considered. Finally, the influence of the wake of an operating turbine located upstream of the noise generating turbine is investigated.

General information
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Organisations: Department of Wind Energy, Aerodynamic design
Authors: Bertagnolio, F. (Intern), Madsen, H. A. (Intern), Fischer, A. (Intern)
Publication date: 2017

Benchmarking (Code2Code) of the 1Hs 3-Bladed Onshore VAWT

This study is part of the Inflow project. In this report the Nenuphar’s onshore 3-bladed Vertical Axis Wind Turbine (VAWT) prototype (1HS) is modelled in HAWC2 aeroelastic code. In the first part the model properties are summarized. Then the analysis is focused on the rotor performance and various cases are simulated assuming rigid structure. Finally, a code two code comparison is presented based on the HAWC2 results (DTU) and a 2D/3D vortex simulations from IFPEN. From the code to code comparison, a very good agreement is found on aerodynamic performance when dynamic stall effects are not included on the blade. When these effects are added, HAWC2 and vortex simulation results differ. Looking in the overall rotor performance, aerodynamic power predictions also vary between the codes for the blade. The main reasons that have been identified from the analysis are the dynamic stall modelling, the Reynolds effects on the airfoil polars and the blade-wake interaction and the finite aspect ratio effects. Finally, by studying the blade performance within HAWC2 it was made clear that the airfoil polars which are the main input for the simulations, apart from the structural modelling, can lead to different results especially on the rotor power performance.

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control
Authors: Galinos, C. (Intern), Schmidt Paulsen, U. (Intern)
Number of pages: 52
Publication date: 2017

Block factorization of step response model predictive control problems

By introducing a stage-wise prediction formulation that enables the use of highly efficient quadratic programming (QP) solution methods, this paper expands the computational toolbox for solving step response MPC problems. We propose a novel MPC scheme that is able to incorporate step response data in a traditional manner and use the computationally efficient solution methods.
efficient block factorization facilities in QP solution methods. In order to solve the MPC problem efficiently, both tailored Riccati recursion and condensing algorithms are proposed and embedded into an interior-point method. The proposed algorithms were implemented in the HPMPC framework, and the performance is evaluated through simulation studies. The results confirm that a computationally fast controller is achieved, compared to the traditional step response MPC scheme that relies on an explicit prediction formulation. Moreover, the tailored condensing algorithm exhibits superior performance and produces solution times comparable to that achieved when using a condensing scheme for an equivalent (but much smaller) state-space model derived from first-principles. Implementation aspects necessary for high performance on embedded platforms are discussed, and results using a programmable logic controller are presented.

**General information**
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Department of Wind Energy, Norwegian University of Science and Technology
Authors: Kufoalor, D. K. (Ekstern), Frison, G. (Intern), Imsland, L. (Ekstern), Johansen, T. A. (Ekstern), Jørgensen, J. B. (Intern)
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Scopus rating (2012): SJR 1.435 SNIP 2.883 CiteScore 3.39
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BFI (2009): BFI-level 2
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Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.445 SNIP 2.593
Web of Science (2008): Indexed yes
Boundary migration in a 3D deformed microstructure inside an opaque sample

How boundaries surrounding recrystallization grains migrate through the 3D network of dislocation boundaries in deformed crystalline materials is unknown and critical for the resulting recrystallized crystalline materials. Using X-ray Laue diffraction microscopy, we show for the first time the migration pattern of a typical recrystallization boundary through a well-characterized deformation matrix. The data provide a unique possibility to investigate effects of both boundary misorientation and plane normal on the migration, information which cannot be accessed with any other techniques. The results show that neither of these two parameters can explain the observed migration behavior. Instead we suggest that the subdivision of the deformed microstructure ahead of the boundary plays the dominant role. The present experimental observations challenge the assumptions of existing recrystallization theories, and set the stage for determination of mobilities of recrystallization boundaries.

General information
State: Published
Organisations: Department of Wind Energy, Materials science and characterization, Risø National Laboratory for Sustainable Energy, Oak Ridge National Laboratory, Argonne National Laboratory, Brigham Young University
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Web of Science (2017): Indexed yes
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Web of Science (2015): Indexed yes
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Scopus rating (2014): SJR 2.163 SNIP 1.554 CiteScore 4.75
Calibration of Ground-based Lidar instrument
This report presents the result of the lidar calibration performed for the given Ground-based Lidar at DTU’s test site for large wind turbines at Høvsøre, Denmark. Calibration is here understood as the establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements. The comparison of the lidar measurements of the wind direction with that from wind vanes measurements are given for information only.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Fernandez Garcia, S. (Intern), Gómez Arranz, P. (Intern)
Number of pages: 33
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Bibliographical note
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Calibration of Ground-based Lidar instrument
This report presents the result of a test of a ground-based lidar of other type. The test was performed at DTU’s test site for large wind turbines at Høvsøre, Denmark. The result as an establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainty. The comparison of the lidar measurements of the wind direction with that from the wind vanes is also given.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Gómez Arranz, P. (Intern), Georgieva Yankova, G. (Intern)
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Publication information
Calibration of Ground-based Lidar instrument
This report presents the result of a test of a ground-based lidar of other type. The test was performed at DTU's test site for large wind turbines at Høvsøre, Denmark. The result as an establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The comparison of the lidar measurements of the wind direction with that from the wind vanes is also given.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
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Calibration of Ground-based Lidar instrument
This report presents the result of the lidar calibration performed for the given Ground-based Lidar at DTU's test site for large wind turbines at Høvsøre, Denmark. Calibration is here understood as the establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements. The comparison of the lidar measurements of the wind direction with that from wind vanes measurements are given for information only.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Villanueva, H. (Intern), Georgieva Yankova, G. (Intern)
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Publication: Research › Report – Annual report year: 2017
Calibration of Ground-based Lidar instrument
This report presents the result of a test of a ground-based lidar of other type. The test was performed at DTU’s test site for large wind turbines at Havsvære, Denmark. The result as an establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The comparison of the lidar measurements of the wind direction with that from the wind vanes is also given.

General information
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Organisations: Department of Wind Energy, Test and Measurements
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Bibliographical note
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Calibration of Ground-based Lidar instrument
This report presents the result of the lidar calibration performed for the given Ground-based Lidar at DTU’s test site for large wind turbines at Havsvære, Denmark. Calibration is here understood as the establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements. The comparison of the lidar measurements of the wind direction with that from wind vanes measurements are given for information only.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
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Calibration of Ground-based Lidar instrument
This report presents the result of the lidar calibration performed for the given Ground-based Lidar at DTU’s test site for large wind turbines at Havsvære, Denmark. Calibration is here understood as the establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements. The comparison of the lidar measurements of the wind direction with that from wind vanes measurements are given for information only.
Calibration of Ground-based Lidar instrument

This report presents the result of the lidar calibration performed for the given Ground-based Lidar at DTU's test site for large wind turbines at Høvsøre, Denmark. Calibration is here understood as the establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements. The comparison of the lidar measurements of the wind direction with that from wind vanes measurements are given for information only.
Calibration of Nacelle-based Lidar instrument

This report presents the result of the lidar calibration performed for a two-beam nacelle based lidar at DTU’s test site for large wind turbines at Høvsøre, Denmark. Calibration is here understood as the establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements.

General information
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Organisations: Department of Wind Energy, Test and Measurements
Authors: Georgieva Yankova, G. (Intern), Gómez Arranz, P. (Intern)
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Calibration of Nacelle-based Lidar instrument
This report presents the result of the lidar calibration performed for a two-beam nacelle based lidar at DTU’s test site for large wind turbines at Høvsøre, Denmark. Calibration is here understood as the establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
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Publication: Research › Report – Annual report year: 2017

Calibration of Nacelle-based Lidar instrument. Comparison
This report presents the result of the comparison of the calibrations performed for the same lidar at DTU’s test sites. Calibration is here understood as the establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements.

General information
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Organisations: Department of Wind Energy, Test and Measurements
Authors: Georgieva Yankova, G. (Intern), Gómez Arranz, P. (Intern)
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Main Research Area: Technical/natural sciences

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Publication: Research › Report – Annual report year: 2017

Calibration of Nacelle-based Lidar instrument. Comparison
This report presents the result of the comparison of the calibrations performed for the same lidar at DTU’s test sites. Calibration is here understood as the establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements.

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Publication: Research › Report – Annual report year: 2017
Calibration of Nacelle-based Lidar instrument. Comparison
This report presents the result of a test of a ground-based lidar of other type. The test was performed at DTU's test site for large wind turbines at Høvsøre, Denmark. The result as an establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The comparison of the lidar measurements of the wind direction with that from the wind vanes is also given.

Calibration of scanning Lidar
This report describes the tests carried out on a scanning lidar at the DTU Test Station for large wind turbines, Høvsøre. The tests were divided in two parts. In the first part, the purpose was to obtain wind speed calibrations at two heights against two cup anemometers mounted on a mast. Additionally, comparison of wind direction and wind shear measurements were made, for informative purposes, although they are not formally considered calibrations. In the second part, we performed the calibration of the inclinometers and the check of the positional accuracy of the scanner head.
Calibration of three Nacelle-based Lidars

This report presents the result of the lidar calibration performed for three two-beam, continuous wave, nacelle based lidars at DTU’s test site Risø, Denmark. Calibration is here understood as the establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements, Meteorology & Remote Sensing
Authors: Gómez Arranz, P. (Intern), Wagner, R. (Intern)
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Organisations: Department of Wind Energy, Aerodynamic design, Resource Assessment Modelling, University of Tartu
Authors: Sørensen, N. N. (Intern), Bechmann, A. (Intern), Boudreault, L. (Intern), Koblitz, T. (Intern), Sogachev, A. (Intern), Laan, M. (Ekstern)
Number of pages: 33
Publication date: 2017

Challenges in experimental fatigue testing of glassfibre reinforced polymer matrix composites for wind turbine industry

The wind turbine industry always strives to increase the performance of wind turbines. To design longer and lighter wind turbine blades, one of the key factors is the fatigue design limit of the composite materials used in the load carrying structures. The fatigue design limits are based on the variance of the fatigue test results on composite materials specimens. Options to improve the design limits of the composite materials are either to improve the material quality, or to decrease the variance of the fatigue test results by improving the fatigue test methods. In recent years, extensive work has been done to improve the quality of the composite materials used in wind turbine blades. This improvement has been achieved by incorporating high performance glass fibres with improved sizing and exploring new resin formulations. However, the current standardised fatigue test methods still show low reproducibility and high scatter (high variance). Therefore, in order to improve the design limits and to reflect the high performance of the composite materials, it is critical to develop improved fatigue test methods. There are three types of uniaxial fatigue test methods, tension-tension, compression-compression and tension-compression. Specific challenges exist for each test type regarding the
experimental set-up and specimen geometry. Issues for the experimental setup include alignment and load introduction into the specimen. Issues for the test specimen include a specimen geometry that leads to failure in the gauge section. An example of a geometry issue is the length of the specimen. For tension-tension testing, it is beneficial if the gauge length of the specimen is as long as possible to obtain a homogeneous stress state in the test area and to have a long gripping area to be able to introduce the load through shear stresses without getting high shear stress concentrations causing shear failure in the gripping region. In compression-compression testing, the load introduction also has to be considered to avoid failure in the gripping region e.g. by transferring part of the load through the specimen’s ends and partly through shear stresses. The gauge length of the specimen is limited by the Euler buckling limit. Work on optimizing the specimen geometry and the experimental setup has been done on tension-tension fatigue by Korkiakosky et al. (2016) and on compression-compression fatigue by Fraisse and Brandsted (2017) resulting in lower scatter. However, limited work has been done on uniaxial tension-compression fatigue test methods although recent demands for wind turbine-material qualification require mainly tension-compression fatigue testing. The current work presents the challenges in development of experimental tests, which give reproducible results in tension-compression fatigue. Considerations from the developed methods for tension-tension and compression-compression fatigue have been included, and it is found that compromises have to be made in order to be able to successfully test uniaxial composites in both tension-compression fatigue. Based on experiments and finite element simulations, the shape/geometry of test specimen as well as optimization of gripping and geometry of tabs are discussed. A presentation of the state of the art experimental methods and current test challenges will be given.

**General information**

State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Sjøgreen, F. N. (Intern), Goutianos, S. (Intern)
Publication date: 2017
Main Research Area: Technical/natural sciences
Electronic versions: ISMEM_freja.pdf
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2017

**Challenges in simulating coastal effects on an offshore wind farm: Paper**

The effect of a coastline on an offshore wind farm is investigated with a Reynolds-averaged Navier-Stokes (RANS) model. The trends of the RANS model compare relatively well with results from a mesoscale model and measurements of wind turbine power. In addition, challenges of modeling a large domain in RANS are discussed.

**General information**

State: Published
Authors: van der Laan, P. (Intern), Peña, A. (Intern), Volker, P. (Intern), Hansen, K. S. (Intern), Sørensen, N. N. (Intern), Ott, S. (Intern), Hasager, C. B. (Intern)
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**Characterization of a new open jet wind tunnel to optimize and test vertical axis wind turbines**

Based on the increasing interest in urban environmental technologies, the study of small scale vertical axis wind turbines shows motivating challenges. In this paper, we present the characteristics and potentials of a new open jet wind tunnel. It has a nozzle exit area of $1.5 \times 1.5 \text{ m}^2$, and it can be operated with exit velocities from 3 m/s to 17 m/s. The
characterization of the flow has been carried out with calibrated pitot tubes, cup anemometers, and hot wire anemometers. Two different configurations of the test area, with and without a ceiling, are considered. Measurements in the range of available exit velocities show that the cross section, where the velocity and turbulence intensities show an acceptable level of uniformity, has an area of $0.8 \times 0.8 \, \text{m}^2$ and a streamwise dimension of 2 m from the nozzle exit of the tunnel. In this working section, the maximum turbulence intensity is 4%. The detailed characterization of the flow carried out indicates that the wind tunnel can be used to test small scale models of wind turbines.

**Characterization of Cu Distribution in an Al-0.3%Cu Alloy Cold Rolled to 98%**

In this study, the distribution of Cu element in a Al (99.9996% purity)-0.3% Cu alloy cold rolled to 98% has been characterized in detail by using three-dimensional atom probe (3DAP) and ChemiSTEM techniques. The cold rolled structure is a typical high strain lamellar structure with an average boundary spacing of 200 nm, indicating a strong role of the small amount of Cu element in stabilizing the microstructure to form the fine scale structure. A heavy segregation of Cu element in the lamellar boundaries of high angles has been observed and the Cu concentration in the boundaries can be as high as 20 times of the nominal concentration of the alloy, which is considered as the main reason for a formation of...
a stable nanoscale lamellar structure.

**General information**

State: Published  
Organisations: Department of Wind Energy, Materials science and characterization, Chongqing University  
Authors: Shuai, L. F. (Ekstern), Huang, T. L. (Ekstern), Wu, G. L. (Ekstern), Hansen, N. (Intern), Huang, X. (Intern)  
Number of pages: 6  
Publication date: 2017  
Conference: 38th Risø International Symposium on Materials Science, Roskilde, Denmark, 04/09/2017 - 04/09/2017  
Main Research Area: Technical/natural sciences

Characterization of voids in shock-loaded Al single crystal by combining X-ray tomography and electron microscopy

A combination of X-ray tomography and electron backscatter diffraction (EBSD) was applied to investigate both the shape of voids and the plastic deformation around voids in an Al single crystal shock-loaded in the direction. The combination of these two techniques allows the addition of crystallographic information to X-ray tomography and allows the addition of three-dimensional information to EBSD data. It is found that the voids are octahedral with \{1 1 1\} faces and that regular patterns of lattice reorientation exist around individual voids. The results provide new insights to the process of void growth during shock loading, which is important for both civil and military applications.

**General information**

State: Published  
Organisations: Department of Wind Energy, Materials science and characterization, Composites and Materials Mechanics, Oak Ridge National Laboratory  
Authors: Hong, C. (Intern), Føster, S. (Intern), Hansen, N. (Intern), Huang, X. (Intern), Barabash, R. I. (Ekstern)  
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Main Research Area: Technical/natural sciences
Cohesive zone modelling of nucleation, growth and coalesce of cavities

The stress-deformation relation i.e. cohesive law representing the fracture process in an almost incompressible adhesive tape is measured using the double cantilever beam specimen. As in many ductile materials, the fracture process of the tape involves nucleation, growth and coalesce of cavities. This process is studied carefully by exploiting the transparency of the used materials and the inherent stability of the specimen configuration. Utilising the path independence of the J-integral, the cohesive law is measured. The law is compared to the results of butt-joint tests. The law contains two stress peaks-the first is associated with nucleation of cavities at a stress level conforming to predictions of void nucleation in rubber elasticity. The second stress peak is associated with fracture of stretched walls between fully-grown cavities. After this second peak, a macroscopic crack is formed. The tape suffers at this stage an engineering strain of about 800%. A numerical analysis with the determined cohesive law recreates the global specimen behaviour.
Combined pseudo-spectral / actuator line model for wind turbine applications

This work contains a development of a new large eddy simulation (LES) tool for wind farm computations. One of the main goals of the development part has been to produce a scalable and efficient flow solver using pseudo-spectral discretization. In the first part of the thesis, details of the developed code is presented and verifications are carried out. In the second part, by using the new LES code, a comprehensive investigation is made for the well-known actuator line model (ALM), which is cost-efficient for investigation of the loading estimations on wind turbine blades. In ALM, the body forces are first distributed on a line to represent a blade and then projected to the CFD domain by a smearing function to avoid oscillations in the solver. As a result of the smearing application, the vorticity from the airfoil sections become distributed in 3D space which then causes over estimations of the blade tip loadings. To avoid the effect, researchers either use Prandtl's tip correction, which is conceptually wrong under ALM framework, or employ extremely fine grid
resolutions which result is excessive computational load. In this thesis detailed investigation of the issue is made and a correction procedure is introduced to avoid the effect. First an investigation is held for a simple planar wing that is represented with ALM in the CFD domain and the correction is presented in detail. Furthermore, NREL 5MW and Phase VI rotors are used for rotor applications and it is concluded by various validation cases that the new tip correction greatly improves the loading distributions on the blades. Additionally, it is found that by using grid resolutions as coarse as 10 grid points per blade, comparable results can be obtained.

**General information**
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Organisations: Department of Wind Energy, Fluid Mechanics
Authors: Dag, K. O. (Intern)
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**Comparison of fatigue constraints in optimal design of jacket structures for offshore wind turbines**

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Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design, Aalborg University, Norwegian University of Science and Technology
Authors: Oest, J. (Ekstern), Sandal, K. (Intern), Schafhirt, S. (Ekstern), Stieng, L. E. (Ekstern), Muskulus, M. (Ekstern)
Number of pages: 2
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Main Research Area: Technical/natural sciences
Conference: 12th World Congress of Structural and Multidisciplinary Optimisation, Braunschweig, Germany, 05/06/2017 - 05/06/2017

**Comparison of fracture properties of cellulose nanopaper, printing paper and buckypaper**
Cellulose nanopaper consists of a dense fibrous self-binding network composed of cellulose nanofibres connected by physical entanglements, hydrogen bonding, etc. Compared with conventional printing paper, cellulose nanopaper has higher strength and modulus because of stronger fibres and inter-fibre bonding. The aim of this paper is to investigate the fracture properties of cellulose nanopaper using double edge notch tensile tests on samples with different notch lengths. It was found that strength is insensitive to notch length. A cohesive zone model was used to describe the fracture behaviour of notched cellulose nanopaper. Fracture energy was extracted from the cohesive zone model and divided into an energy component consumed by damage in the material and a component related to pull-out or bridging of nanofibres between crack surfaces which was not facilitated due to the limited fibre lengths for the case of nanopapers. For comparison, printing paper which has longer fibres than nanopaper was tested and modelled to demonstrate the importance of fibre length. Buckypaper, a fibrous network made of carbon nanotubes connected through van der Waals forces and physical
entanglements, was also investigated to elaborate on the influence of inter-fibre connections.

**General information**

State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics, Queen Mary University of London, Huazhong University of Science and Technology, Royal Institute of Technology
Authors: Mao, R. (Ekstern), Goutianos, S. (Intern), Tu, W. (Ekstern), Meng, N. (Ekstern), Yang, G. Y. (Ekstern), Berglund, L. A. (Ekstern), Peijis, T. (Ekstern)
Number of pages: 12
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- Web of Science (2018): Indexed yes
- BFI (2017): BFI-level 1
- Scopus rating (2017): CiteScore 2.83 SJR 0.807 SNIP 1.064
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 1
- Scopus rating (2016): CiteScore 2.49 SJR 0.769 SNIP 1.072
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 1
- Scopus rating (2015): SJR 0.792 SNIP 1.059 CiteScore 2.36
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 1
- Scopus rating (2014): SJR 0.963 SNIP 1.388 CiteScore 2.54
- Web of Science (2014): Indexed yes
- BFI (2013): BFI-level 1
- Scopus rating (2013): SJR 0.926 SNIP 1.451 CiteScore 2.36
- ISI indexed (2013): ISI indexed yes
- Web of Science (2013): Indexed yes
- BFI (2012): BFI-level 1
- Scopus rating (2012): SJR 0.988 SNIP 1.383 CiteScore 2.2
- ISI indexed (2012): ISI indexed yes
- Web of Science (2012): Indexed yes
- BFI (2011): BFI-level 1
- Scopus rating (2011): SJR 0.935 SNIP 1.377 CiteScore 2.05
- ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 1
- Scopus rating (2010): SJR 0.957 SNIP 1.091
- Web of Science (2010): Indexed yes
- BFI (2009): BFI-level 1
- Scopus rating (2009): SJR 0.844 SNIP 0.956
- Web of Science (2009): Indexed yes
- BFI (2008): BFI-level 1
- Scopus rating (2008): SJR 0.68 SNIP 0.773
- Web of Science (2008): Indexed yes
- Scopus rating (2007): SJR 0.622 SNIP 0.868
- Web of Science (2007): Indexed yes
- Scopus rating (2006): SJR 0.549 SNIP 0.798
Comparison of OpenFOAM and EllipSys3D actuator line methods with (NEW) MEXICO results: Paper

The Actuator Line Method exists for more than a decade and has become a well-established choice for simulating wind rotors in computational fluid dynamics. Numerous implementations exist and are used in the wind energy research community. These codes were verified by experimental data such as the MEXICO experiment. Often the verification against other codes were made on a very broad scale. Therefore this study attempts first a validation by comparing two different implementations, namely an adapted version of SOWFA/OpenFOAM and EllipSys3D and also a verification by comparing against experimental results from the MEXICO and NEW MEXICO experiments.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design, ETS
Authors: Nathan, J. (Ekstern), Meyer Forsting, A. R. (Intern), Troldborg, N. (Intern), Masson, C. (Ekstern)
Number of pages: 9
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Applied fluid mechanics, General fluid dynamics theory, simulation and other computational methods, Civil and mechanical engineering computing, Fluid mechanics and aerodynamics (mechanical engineering), Mechanical components, Mechanical engineering applications of IT, computational fluid dynamics, rotors (mechanical), wind, wind power, OpenFOAM, EllipSys3D actuator line methods, wind rotors, wind energy research community, SOWFA

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Source: FindIt
Source-ID: 2371467291
Publication: Research - peer-review › Article in proceedings – Annual report year: 2017

Complex terrain experiments in the New European Wind Atlas

The New European Wind Atlas project will create a freely accessible wind atlas covering Europe and Turkey, develop the model chain to create the atlas and perform a series of experiments on flow in many different kinds of complex terrain to validate the models. This paper describes the experiments of which some are nearly completed while others are in the planning stage. All experiments focus on the flow properties that are relevant for wind turbines, so the main focus is the
mean flow and the turbulence at heights between 40 and 300 m. Also extreme winds, wind shear and veer, and diurnal and seasonal variations of the wind are of interest. Common to all the experiments is the use of Doppler lidar systems to supplement and in some cases replace completely meteorological towers. Many of the lidars will be equipped with scan heads that will allow for arbitrary scan patterns by several synchronized systems. Two pilot experiments, one in Portugal and one in Germany, show the value of using multiple synchronized, scanning lidar, both in terms of the accuracy of the measurements and the atmospheric physical processes that can be studied. The experimental data will be used for validation of atmospheric flow models and will by the end of the project be freely available. This article is part of the themed issue ‘Wind energy in complex terrains’.

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Volume: 375
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): SJR 0.907 SNIP 1.15
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.26 SJR 0.986 SNIP 1.193
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.865 SNIP 1.116 CiteScore 2.08
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.902 SNIP 1.36 CiteScore 2.39
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.18 SNIP 1.601 CiteScore 3.12
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.151 SNIP 1.452 CiteScore 2.89
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.017 SNIP 1.341 CiteScore 2.65
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.145 SNIP 1.418
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.118 SNIP 1.397
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.922 SNIP 1.059
Compression fatigue of Wind Turbine Blade composites materials and damage mechanisms

According to the new IEC 61400-5-rev0 recommendation, which is under preparation it will be required to qualify wind turbine blade (WTB) composite materials in fatigue at $R=0.1$, $R=-1$, and $R=10$. As a minimum fatigue at $R=-1$ is required. This is a consequence of the ever-growing blades, where gravity driven edgewise bending introduces significant fully reversed cycling at the leading and trailing edges. Therefore, material manufacturer and WTB manufacturer demand test results of highest reliability and reproducibility. However, these requirements for compression-compression and tension-compression fatigue properties are a big challenge for the test institutes to meet. Tests are very difficult to perform, as it is nearly impossible to design an optimal test setup. This study shows a newly developed sample geometry and test method in order to obtain representative and reliable results. Two different laminate architectures have been tested in order to validate the test method. Damage mechanisms and damage progression in compression fatigue have been investigated using 3D X-Ray Tomography and a qualitative explanation of the damage mechanisms is presented.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Fraisse, A. (Intern), Brøndsted, P. (Intern)
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Event: Paper presented at 21st International Conference on Composite Materials (ICCM-21), Xi’an, China.
Main Research Area: Technical/natural sciences
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Source: PublicationPreSubmission
Source-ID: 134900563
Publication: Research - peer-review › Paper – Annual report year: 2017

Computational assessment of the DeepWind aerodynamic performance with different blade and airfoil configurations
An aerodynamic improvement of the DeepWind rotor is conducted adopting different rotor geometries and solutions with respect to the original configuration while keeping the comparison as fair as possible. The objective of this work is to find the most suitable configuration in order to maximize the power production and minimize the blade stress and the cost of energy. Different parameters are considered for the study. The DeepWind blade is characterized by a shape similar to the Troposkien geometry but asymmetric between the top and bottom parts. The blade shape is considered as a fixed parameter in the optimization process and, because of different blade element radii, it will experience different tip speed ratios in the same operational condition. This leads to a complex optimization problem, which must be carefully analyzed in order to find the most suitable parameter set. The number of blades in the analysis is varied from 1 to 4. In order to keep the comparison fair among the different configurations, the solidity is kept constant and, therefore, the chord length reduced. A second comparison is conducted by considering different blade profiles belonging to the symmetric NACA airfoil family. Finally, a chord optimization along the blade span is conducted, in order to find the optimal chord distribution to maximize the power production.
Computational Modelling of Materials for Wind Turbine Blades: Selected DTUWind Energy Activities

Computational and analytical studies of degradation of wind turbine blade materials at the macro-, micro-, and nanoscale carried out by the modelling team of the Section Composites and Materials Mechanics, Department of Wind Energy, DTU, are reviewed. Examples of the analysis of the microstructural effects on the strength and fatigue life of composites are shown. Computational studies of degradation mechanisms of wind blade composites under tensile and compressive loading are presented. The effect of hybrid and nanoengineered structures on the performance of the composite was studied in computational experiments as well.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Department of Wind Energy, Composites and Materials Mechanics
Authors: Mikkelsen, L. P. (Intern), Mishnaevsky, L. (Intern)
Number of pages: 15
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Main Research Area: Technical/natural sciences

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Volume: 10
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Article number: 1278
ISSN (Print): 1996-1944
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Scopus rating (2017): CiteScore 3.02 SJR 0.732 SNIP 1.285
Web of Science (2017): Indexed Yes
Scopus rating (2016): CiteScore 3.26 SJR 0.838 SNIP 1.495
Web of Science (2016): Indexed yes
Scopus rating (2015): SJR 0.83 SNIP 1.457 CiteScore 3.11
Scopus rating (2014): SJR 0.767 SNIP 1.229 CiteScore 2.69
Web of Science (2014): Indexed yes
Scopus rating (2013): SJR 1.001 SNIP 1.631 CiteScore 3.12
ISI indexed (2013): ISI indexed yes
Scopus rating (2012): SJR 0.841 SNIP 1.465
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.651 SNIP 1.212
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
Scopus rating (2010): SJR 0.392 SNIP 0.981
Original language: English
Electronic versions:
materials_10_01278_v2.pdf
Conceptual research of a downwind turbine, based on Suzlon 2.1MW onshore turbine

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control, Suzlon Blade Science Center, University of Southern Denmark
Authors: Wanke, G. (Ekstern), Larsen, T. J. (Intern), Hansen, M. (Ekstern), Buhl, T. (Ekstern), Madsen, J. I. (Ekstern), Bergami, L. (Ekstern)
Number of pages: 19
Publication date: 2017

Consistent modelling of wind turbine noise propagation from source to receiver

The unsteady nature of wind turbine noise is a major reason for annoyance. The variation of far-field sound pressure levels is not only caused by the continuous change in wind turbine noise source levels but also by the unsteady flow field and the ground characteristics between the turbine and receiver. To take these phenomena into account, a consistent numerical technique that models the sound propagation from the source to receiver is developed. Large eddy simulation with an actuator line technique is employed for the flow modelling and the corresponding flow fields are used to simulate sound generation and propagation. The local blade relative velocity, angle of attack, and turbulence characteristics are input to the sound generation model. Time-dependent blade locations and the velocity between the noise source and receiver are considered within a quasi-3D propagation model. Long-range noise propagation of a 5 MW wind turbine is investigated. Sound pressure level time series evaluated at the source time are studied for varying wind speeds, surface roughness, and ground impedances within a 2000m radius from the turbine.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Yangzhou University, NREL's National Wind Technology Center
Authors: Barlas, E. (Intern), Zhu, W. J. (Ekstern), Shen, W. Z. (Intern), Dag, K. O. (Intern), Moriarty, P. (Ekstern)
Publication date: 2017
Main Research Area: Technical/natural sciences
Coordinated control of wind power plants in offshore HVDC grids

During the recent years, there has been a significant penetration of offshore wind power into the power system and this trend is expected to continue in the future. The North Sea in Europe has higher potential for offshore wind power; therefore, the North Seas Countries’ Offshore Grid initiative was formed among nine North Sea countries. They agreed on
closer energy cooperation to enable development of an efficient and economic offshore grid infrastructure for advantages, interconnectors based on the voltage source converter based high voltage DC (HVDC) transmission system is being used to exchange power between different countries, and different synchronous areas. It is very likely that they will then be combined with offshore wind power plant (OWPP) connections in the North Sea, transforming it in a multi terminal DC (MTDC) grid and, therefore, in a fully meshed offshore DC grid in near future. However, increased penetration of offshore wind power into the power system poses several challenges to its security. This thesis deals with two main research challenges, (1) Develop, and analyze the coordinated control strategies for AC voltage and reactive power control in the cluster of OWPPs connected to common offshore HVDC station, (2). Develop, analyze, and test the control strategies for ancillary services from OWPPs to the AC grid, mainly fast primary frequency control from OWPPs. Moreover, the impact of wind speed on the frequency control from OWPPs is also studied in this thesis. The main results of this research show that the OWPPs in the HVDC grid can participate in fast primary frequency control of the power system by using the proposed frequency control methods. Also, wind speed has a significant impact on the frequency control, particularly at below rated wind speeds. The proposed methods for AC voltage and reactive power control can improve the steady state and dynamic AC voltage profile of the offshore AC grid with cluster of OWPPs connected to common HVDC station, while minimizing the active power losses in the offshore AC grid. The research work is carried at the Technical University of Denmark (DTU) in the Department of Wind Energy and it is funded by the People Programme (Marie Curie Actions) of the EU FP7/2007-2013/ under REA grants agreement no. 317221, project title MEDOW.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning
Authors: Sakamuri, J. N. (Intern), Cutululis, N. A. (Intern), Sørensen, P. E. (Intern), Hansen, A. D. (Intern)
Number of pages: 208
Publication date: 2017

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Publication: Research › Ph.D. thesis – Annual report year: 2017

Coordination frequency control from offshore wind power plants connected to multi terminal DC system considering wind speed variation
A coordinated fast primary frequency control scheme from offshore wind power plants (OWPPs) integrated to a three terminal high voltage DC (HVDC) system is proposed in this study. The impact of wind speed variation on the OWPP active power output and thus on the AC grid frequency and DC grid voltage is analysed. The removal of active power support from OWPP after the frequency control action may result in second frequency (and DC voltage) dips. Three different methods to mitigate these secondary effects are proposed, such as, (i) Varying the droop gains of the HVDC converter (ii) Releasing the active power support from OWPP with a ramp rate limiter and (iii) An alternative method for the wind turbine overloading considering rotor speed. The effectiveness of the proposed control scheme is demonstrated on a wind power plant integrated into a three terminal HVDC system developed in DiGSIENT PowerFactory. The results show that the proposed coordinated frequency control method performs effectively at different wind speeds and minimises the secondary effects on frequency and DC voltage.

General information
State: Published
Organisations: Integration & Planning, Department of Wind Energy
Authors: Sakamuri, J. N. (Intern), Altin, M. (Intern), Hansen, A. D. (Intern), Cutululis, N. A. (Intern)
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Volume: 11
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Coordinated voltage control in offshore HVDC connected cluster of wind power plants

This paper presents a coordinated voltage control scheme (CVCS) for a cluster of offshore wind power plants connected to a voltage-source converter-based high-voltage direct current system. The primary control point of the proposed voltage control scheme is the introduced Pilot bus, which is having the highest short-circuit capacity in the offshore AC grid. The developed CVCS comprehends an optimization algorithm, aiming for minimum active power losses in the offshore grid, to generate voltage reference to the Pilot bus. During the steady-state operation, the Pilot bus voltage is controlled by dispatching reactive power references to each wind turbine (WT) in the wind power plant cluster based on their available reactive power margin and network sensitivity-based participation factors, which are derived from the dV/dQ sensitivity of a WT bus w.r.t. the Pilot bus. This method leads to the minimization of the risk of undesired effects, particularly overvoltage at the terminals of the WT located far away from the AC collector substation, by dispatching lower reactive power references compared with the ones nearer to the substation. In addition, this paper proposes a control strategy for improved voltage ride through capability of WTs for faults in the offshore grid, thus leading to improved dynamic voltage profile in the offshore AC grid.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning, Indian Institute of Technology, Bombay, Elia Engineering
Authors: Sakamuri, J. N. (Intern), Rather, Z. H. (Ekstern), Rimez, J. (Ekstern), Altin, M. (Intern), Goksu, O. (Intern), Cutululis, N. A. (Intern)
Correlated thermal motion of two liquid Pb inclusions attached to a fixed dislocation in an Al matrix: Paper

Thermal motion of two liquid lead inclusions attached to the same fixed dislocation in an Al-0.65 at% Pb alloy is studied in situ at 447 °C using transmission electron microscopy. Observations of their motion are recorded on video and analyzed frame by frame. Random oscillatory motion of the inclusions on the dislocation line occurs as a result of their mutual repulsion and their repulsion from the fixed ends of the dislocation caused by the dislocation line tension. The oscillations of the inclusions can be considered as correlated thermal motion in coupled potential wells. The effective potentials, in which the inclusions move, and the effective potential of their interactions are evaluated. It is found that the spatial correlations of the positions of the inclusions on the dislocation depend strongly on the interaction potential. The observed correlations of the positions of the inclusions suggest that they move along their averaged trajectories in a synchronous-like manner.

General information
State: Published
Organisations: Department of Wind Energy, Russian Academy of Sciences
Authors: Prokofjev, S. I. (Ekstern), Johnson, E. (Intern)
Number of pages: 10
Publication date: 2017
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Publication: Research - peer-review › Journal article – Annual report year: 2017

Coupling atmospheric and ocean wave models for storm simulation
This thesis studies the wind-wave interactions through the coupling between the atmospheric model and ocean surface wave models. Special attention is put on storm simulations in the North Sea for wind energy applications in the coastal zones. The two aspects, namely storm conditions and coastal areas, are challenging for the wind-wave coupling system because: in storm cases, the wave field is constantly modified by the fast varying wind field; in coastal zones, the wave field is strongly influenced by the bathymetry and currents. Both conditions have complex, unsteady sea state varying with time and space that challenge the current coupled modeling system.

The conventional approach of estimating the momentum exchange is through parameterizing the aerodynamic roughness length (z0) with wave parameters such as wave age, steepness, significant wave height, etc. However, it is found in storm and coastal conditions, z0 parameterization method often fails in reproducing z0 because the complexity of the sea state cannot be represented by a few selected wave parameters. Different from the parameterization method, physics-based methods take the idea that the loss of momentum and kinetic energy from the atmosphere must, by conservation, result in the generation of the surface waves and currents. The physics-based methods are sensitive to
the choice of wind-input source function (Sin), parameterization of high-frequency wave spectra tail, and numerical cut-off frequencies. Unfortunately, literature survey shows that in most wind-wave coupling systems, either the Sin in the wave model is different from the one used for the momentum flux estimation in the atmospheric model, or the methods are too sensitive to the parameterization of high-frequency spectra tail and numerical cut-off frequencies.

To confront the above mentioned challenges, a wave boundary layer model (WBLM) is implemented in the wave model SWAN as a new Sin. The WBLM Sin is based on the momentum and kinetic energy conservation. The wave-induced mean wind profile changes at all vertical levels within the wave boundary layer, and the spectral sheltering effect at each frequency within the wave spectrum are explicitly considered. The WBLM Sin is used for both the calculation of the wave growth and the estimation of the air-sea momentum flux. Moreover, the WBLM Sin extended the model ability in high-frequency ranges so that the issue of high-frequency spectra tail and numerical cut-off frequencies are automatically solved. The new WBLM method is proved to be able to improve both the wave simulation and stress estimation in idealized fetch-limited wind-wave evolution studies.

To apply the WBLM method in real cases, proper setup of the dissipation source function, numerical stability and model efficiency are needed to be considered. Therefore, a revised dissipation source function for the wave model and a refinement of the numerical algorithm of WBLM Sin is done. The new pair of wind-input and dissipation source functions are evaluated with point measurements through wave simulations during offshore and onshore storms in the west coast of Denmark. The WBLM method is proved to provide significant wave height and mean wave period that outperforms the other approaches in SWAN when compared with measurements.

The WBLM method is further applied in the wind-wave coupling system during a number of North Sea storms. In comparison, six other coupling method have also been used for one of the storms. Results of wind, wave, and stress have been validated with point measurements at a coastal, shallow water site. In particular, the spatial distribution of z0 from WBLM is found to have similar spatial patterns as the Advanced Synthetic Aperture Radar (ASAR) radar backscatter; both show features of the bathymetry. Analysis of the wind field from the non-coupled and WBLM coupled experiments show that the wind-wave coupling is important in strong wind conditions, varying wind conditions (e.g. front system, open cellular convections during a storm), and coastal areas.

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling , DHI Hørsholm
Authors: Du, J. (Intern), Larsén, X. G. (Intern), Kelly, M. C. (Intern), Larsen, S. E. (Intern), Bolanos, R. (Ekstern)
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Relations
Projects:
Coupling atmospheric and ocean wave models for storm simulation
Publication: Research › Ph.D. thesis – Annual report year: 2017

Cross-Cutting Activities 2016 on Wind Turbine Noise, Summary Report
The goal of this report is to summarize activities that took place in year 2016 as part of the Cross-Cutting Activity on Wind Turbine Noise, self-financed by DTU Wind Energy. A short description of the background behind this project (in particular Cross-Cutting Activities conducted in year 2015), the main objectives of the various studies and scientific achievements are reported in the introduction. Then, each Work Packages constituting this project are described in more details in the following sections.

General information
State: Published
Grouted joints for offshore wind turbines forming the connection between the transition piece to the monopile and tower are one of the weakest links of the support structure. The grout being a reinforced concrete material is susceptible to cyclic loading comprising of tensile and compressive components. As offshore wind turbines reach 10 MW capacities, it is extremely important to determine the reliability of grouted joints and their design configurations so as to ensure integrity of the 10 MW support structure. This report investigates two types of grouted joint connections, the conventional cylindrical joint with shear keys and a conical joint without shear keys. In both cases, fully coupled load simulations are made to determine the fatigue resistance and ultimate load resistance of the joint. Key recommendations are made for the reliable design of grouted joints for 10 MW wind turbines on monopile substructures.
Deformation analysis of polymers composites: rheological model involving time-based fractional derivative

A modeling approach to time-dependent property of Glass Fiber Reinforced Polymers (GFRP) composites is of special interest for quantitative description of long-term behavior. An electronic creep machine is employed to investigate the time-dependent deformation of four specimens of dog-bond-shaped GFRP composites at various stress level. A negative exponent function based on structural changes is introduced to describe the damage evolution of material properties in the process of creep test. Accordingly, a new creep constitutive equation, referred to fractional derivative Maxwell model, is suggested to characterize the time-dependent behavior of GFRP composites by replacing Newtonian dashpot with the Abel dashpot in the classical Maxwell model. The analytic solution for the fractional derivative Maxwell model is given and the relative parameters are determined. The results estimated by the fractional derivative Maxwell model proposed in the paper are in a good agreement with the experimental data. It is shown that the new creep constitutive model proposed in the paper needs few parameters to represent various time-dependent behaviors.
Deformation Induced Martensitic Transformation and Its Initial Microstructure Dependence in a High Alloyed Duplex Stainless Steel

Deformation induced martensitic transformation (DIMT) usually occurs in metastable austenitic stainless steels. Recent studies have shown that DIMT may occur in the austenite phase of low alloyed duplex stainless steels. The present study demonstrates that DIMT can also take place in a high alloyed Fe-23Cr-8.5Ni duplex stainless steel, which exhibits an unexpectedly rapid transformation from γ-austenite into α′-martensite. However, an inhibited martensitic transformation has been observed by varying the initial microstructure from a coarse alternating austenite and ferrite band structure to a fine equiaxed microduplex structure.

General information
State: Published
Organisations: Department of Mechanical Engineering, Department of Wind Energy, Materials and Surface Engineering, Materials science and characterization, Chongqing University, Yanshan University, Kyoto University
Authors: Xie, L. (Ekstern), Huang, T. L. (Ekstern), Wang, Y. H. (Ekstern), Wu, G. L. (Ekstern), Tsuji, N. (Ekstern), Huang, X. (Intern)
Number of pages: 9
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Main Research Area: Technical/natural sciences

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Scopus rating (2017): SNIP 1.068 SJR 0.783 CiteScore 1.5
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.44 SJR 0.732 SNIP 1.051
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.503 SNIP 0.732 CiteScore 0.74
BFI (2014): BFI-level 1
Demonstration and uncertainty analysis of synchronised scanning lidar measurements of 2-D velocity fields in a boundary-layer wind tunnel

This paper combines the research methodologies of scaled wind turbine model experiments in wind tunnels with short-range WindScanner lidar measurement technology. The wind tunnel at the Politecnico di Milano was equipped with three wind turbine models and two short-range WindScanner lidars to demonstrate the benefits of synchronised scanning lidars in such experimental surroundings for the first time. The dual-lidar system can provide fully synchronised trajectory scans with sampling timescales ranging from seconds to minutes. First, staring mode measurements were compared to hot-wire probe measurements commonly used in wind tunnels. This yielded goodness of fit coefficients of 0.969 and 0.902 for the 1 Hz averaged u and v components of the wind speed, respectively, validating the 2-D measurement capability of the lidar scanners. Subsequently, the measurement of wake profiles on a line as well as wake area scans were executed to illustrate the applicability of lidar scanning to the measurement of small-scale wind flow effects. An extensive uncertainty analysis was executed to assess the accuracy of the method. The downsides of lidar with respect to the hotwire probes are the larger measurement probe volume, which compromises the ability to measure turbulence, and the possible loss of a small part of the measurements due to hard target beam reflection. In contrast, the benefits are the high flexibility in conducting both point measurements and area scanning and the fact that remote sensing techniques do not disturb the flow during measuring. The research campaign revealed a high potential for using short-range synchronised scanning lidars to measure the flow around wind turbines in a wind tunnel and increased the knowledge about the corresponding uncertainties.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Technical University of Munich, University of Oldenburg
Dependence of dislocation structure on orientation and slip systems in highly oriented nanotwinned Cu

To explore the correlation between orientation, active slip systems and dislocation structure, highly oriented nanotwinned Cu has been deformed in compression to 2% and 6% strain. The compression directions are 90°, 0° and 45° with respect to the twin boundaries (TBs) of the almost parallel twins. The dislocation structures are analyzed by the two-beam diffraction imaging in a transmission electron microscope and by a Schmid factor analysis. In structures deformed at 90° a high density of long straight dislocation lines with both slip plane and Burgers vectors inclined to the twin plane (slip Mode I) are observed; they transmit across multiple TBs at a strain of 2% and form a high density of dislocations on TBs at a strain of 6%. In structures deformed at 0° dislocations with Burgers vectors parallel to the twin plane (slip Mode II) are confined within Twin/Matrix lamellae and the analysis shows that both slip Mode I and II are active with dominance of Mode II. In structures deformed at 45° dislocations from slip Modes I, II and III are identified, where Mode III dislocations consist of partial dislocations moving along the TBs and full dislocations inside the twin lamellae gliding on the slip planes parallel to the twin plane. The analysis of the dislocation structures illustrate the strong correlation between active slip systems and the dislocation structure and the strong effect of slip mode anisotropy on both the flow stress and strain hardening rate of nanotwinned Cu.

General information
State: Published
Organisations: Department of Wind Energy, Materials science and characterization, Chinese Academy of Sciences
Authors: Lu, Q. (Ekstern), You, Z. (Ekstern), Huang, X. (Intern), Hansen, N. (Intern), Lu, L. (Ekstern)
Pages: 85-97
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Main Research Area: Technical/natural sciences

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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.18 SJR 3.263 SNIP 2.737
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.67 SJR 3.21 SNIP 2.702
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 3.417 SNIP 2.831 CiteScore 5.22
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 3.885 SNIP 3.166 CiteScore 5.16
Web of Science (2014): Indexed yes
Description of the Probabilistic Wind Atlas Methodology, Deliverable D3.1

A new ensemble method is explored for estimating the uncertainty of the wind resource within Weather Research and Forecasting (WRF) model simulations. The output of the ensemble simulations is processed to create a "map" showing the uncertainty in the wind resource estimate at each geographic location. This new method is demonstrated by performing a collection of 9 different WRF model simulations using combinations of 3 planetary boundary layer schemes, 2 simulation re-initialization strategies, and 2 methods for initializing the land surface state. The results of the simulations are validated against data from 10 meteorological masts in South Africa, part of the Wind Atlas of South Africa (WASA) project, where a long-term set of high-quality observations exist. The results of the ensemble simulations are encouraging, but further analysis is needed to quantify their utility. A key disadvantage of the ensemble simulation strategy employed herein, is that some members may tend to be highly similar to others, leading to overconfidence in the mean and spread of the simulations. Such overconfidence yields misleading estimates of the accuracy, value, and uncertainty of the wind
Design of a wind turbine swept blade through extensive load analysis

The main focus of this work is to offer an extensive investigation regarding the use of backward swept blades for passive load alleviation on wind turbines. Sweeping blades backward produces a structural coupling between flapwise bending towards the tower and torsion towards feathering. This coupling mitigates loads on the wind turbine structure due to a decrease in the angle of attack. The load alleviation can be achieved by changing the blade geometry according to three parameters: starting point for the change of shape along the blade span, blade tip sweep, and blade forward sweep. A parametric study is carried out on a 10 MW wind turbine with the purpose of outlining the relation between load variations and three geometric parameters used to introduce passive control on wind turbine blades. The objective is to estimate and analyze extreme and fatigue loads, formulating suggestions for the design of a wind turbine that employs backward swept blades. From the investigation, it is concluded that mildly and purely backward swept shapes are the best option because they allow the wind turbine to achieve load alleviations without a large increase of the blade root torsional extreme and lifetime equivalent fatigue moment. The efficacy of the design procedure provided with this work is proved through its application on a 5 MW wind turbine design.
Design of the OffWindChina 5 MW Wind Turbine Rotor

The current article describes the conceptual design of a rotor for a 5 MW machine situated at an offshore site in China (OffWindChina). The OffWindChina 5 MW rotor design work was divided into two parts between the Technical University of Denmark (DTU) and the Chong Qing University (CQU). The two parts consist of the aeroelastic and structural design phases. The aeroelastic part determines the optimal outer blade shape in terms of cost of energy (COE), while the structural part determines the internal laminate layup to achieve a minimum blade mass. Each part is performed sequentially using in-house optimization tools developed at DTU and CQU. The designed blade yields a high energy
Design optimization of jacket structures for mass production

This thesis presents models and applications for structural optimization of jacket structures for offshore wind turbines. The motivation is that automatic design procedures can be used to obtain more cost efficient designs, and thus reduce the levelized cost of energy from offshore wind.
A structural finite element model is developed specifically for the analysis and optimization of jacket structures. The model uses Timoshenko beam elements, and assumes thin walled tubular beams and a linear elastic structural response. The finite element model is implemented in a Matlab package called JADOP (Jacket Design Optimization), and the static and dynamic structural response is verified with the commercial finite element software Abaqus. A parametric mesh of the offshore wind turbine structure makes it relatively easy to represent various structures from the literature, as well as exploring conceptual designs. Stress concentrations in welds are modelled using design dependent stress concentration factors. Simplified models are also implemented for both piled foundations and suction caissons. Wind and wave loads are applied according to a realistic offshore environment.

An optimal design problem is formulated to optimize the design of the jacket structure using analytical gradients. The diameter and wall thickness of the jacket members are considered as design variables, making it a sizing optimization problem. Structural integrity constraints are implemented based on the relevant industrial design guidelines. These constraints include fatigue damage in the welded joints, shell buckling, and yield stress. The most challenging structural integrity constraint is fatigue, as it generally requires computationally expensive time-domain simulations. A simplified fatigue constraint based on damage equivalent loads is presented, and results indicate that the method gives realistic designs. The objective and constraint functions, including sensitivities, are implemented in JADOP, and this package is used throughout the thesis.

The devised framework is applied to the optimal design of jacket structures and foundations, with continuous and discrete design variables. Design criteria such as mass, fatigue, stress, and frequency are considered, and the validity of the modelling assumptions are investigated with aeroelastic simulations. The proposed framework can thus be applied to automate the design of jackets and foundations, and be a powerful tool in the whole design process of offshore wind turbine structures.

**General information**

State: Published  
Authors: Sandal, K. (Intern), Stolpe, M. (Intern), Bredmose, H. (Intern)  
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**Relations**

Projects:  
Design optimization of jacket structures for mass production  
Publication: Research › Ph.D. thesis – Annual report year: 2017

**Detecting wind turbine wakes with nacelle lidars: Paper**

Because the horizontal homogeneity assumption is violated in wakes flows, lidars face difficulties when reconstructing wind fields. Further, small-scale turbulence which is prevalent in wake flows causes Doppler spectrum widths to be broader than in the free stream. In this study the Doppler peak variance is used as a detection parameter for wakes. A one month long measurement campaign, where a continuous-wave lidar on a turbine has been exposed to multiple wake situations, is used to test the detection capabilities. The results show that it is possible to identify situation where a downstream turbine is in wake by comparing the peak widths. The used lidar is inexpensive and brings instalments on every turbine within economical reach. Thus, the information gathered by the lidars can be used for improved control at wind farm level.

**General information**

State: Published  
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Windar Photonics A/S  
Authors: Held, D. P. (Ekstern), Larvol, A. (Ekstern), Mann, J. (Intern)  
Number of pages: 5  
Publication date: 2017

**Host publication information**

Title of host publication: Wake Conference 2017
Development of a Mechanical Passive Pitch System for a 500W Horizontal Axis Wind Turbine

The goal of this paper is to design, analyze, manufacture, and test a mechanical passive pitch mechanism for a small horizontal axis wind turbine. Several pitching concepts were investigated in the wind industry and related fields before ultimately deciding on a centrifugal governor design concept in a pitch-to-stall configuration. Inertial and aerodynamic models were developed in order to predict steady-state performance and an optimization routine was created to optimize the pitch mechanism configuration subject to manufacturing constraints. Dynamic modeling in HAWC2 validated the steady-state design code, aeroelastic simulations were performed in turbulent wind conditions to simulate the pitch system dynamics. Physical testing of the full turbine was not completed, however the hub sub-assembly was tested on its own to validate the passive pitch characteristics and showed good agreement with the simulation tools developed.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Wind turbine loads & control, Siemens Wind Power
Authors: Poryzala, T. (Ekstern), Mikkelsen, R. F. (Intern), Kim, T. (Intern)
Number of pages: 16
Publication date: 2017
Development of an aeroelastic code based on three-dimensional viscous–inviscid method for wind turbine computations

Aerodynamic and structural dynamic performance analysis of modern wind turbines are routinely estimated in the wind energy field using computational tools known as aeroelastic codes. Most aeroelastic codes use the blade element momentum (BEM) technique to model the rotor aerodynamics and a modal, multi-body or the finite-element approach to model the turbine structural dynamics. The present work describes the development of a novel aeroelastic code that combines a three-dimensional viscous–inviscid interactive method, method for interactive rotor aerodynamic simulations (MIRAS), with the structural dynamics model used in the aeroelastic code FLEX5. The new code, called MIRAS-FLEX, is an improvement on standard aeroelastic codes because it uses a more advanced aerodynamic model than BEM. With the new aeroelastic code, more physical aerodynamic predictions than BEM can be obtained as BEM uses empirical relations, such as tip loss corrections, to determine the flow around a rotor. Although more costly than BEM, a small cluster is sufficient to run MIRAS-FLEX in a fast and easy way. MIRAS-FLEX is compared against the widely used FLEX5 and FAST, as well as the participant codes from the Offshore Code Comparison Collaboration Project. Simulation tests consist of steady wind inflow conditions with different combinations of yaw error, wind shear, tower shadow and turbine-elastic modeling. Turbulent inflow created by using a Mann box is also considered. MIRAS-FLEX results, such as blade tip deflections and root-bending moments, are generally in good agreement with the other codes.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics
Authors: Sessarego, M. (Intern), Ramos García, N. (Intern), Sørensen, J. N. (Intern), Shen, W. Z. (Intern)
Number of pages: 26
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BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.18 SJR 1.051 SNIP 1.834
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.37 SJR 1.079 SNIP 2.316
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.201 SNIP 2.165 CiteScore 3.06
Dielectric barrier discharge plasma treatment of cellulose nanofibre surfaces

Dielectric barrier discharge plasma treatment was applied to modify cellulose nanofibre (CNF) surfaces with and without ultrasonic irradiation. The plasma treatment improved the wetting by deionised water and glycerol, and increased the contents of oxygen, carbonyl group, and carboxyl group on the nanofibre surface. Ultrasonic irradiation further enhanced the wetting and oxidation of the nanofibre coating. Scanning electron microscopic observations showed skeleton-like features on the plasma-treated surface, indicating preferential etching of weaker domains, such as low-molecular weight domains and amorphous phases. Ultrasonic irradiation also improved the uniformity of the treatment. Altogether, it is demonstrated that atmospheric pressure plasma treatment is a promising technique to modify the CNF surface before composite processing.
Direct observation of nucleation in the bulk of an opaque sample

Remarkably little is known about the physical phenomena leading to nucleation of new perfect crystals within deformed metals during annealing, in particular how and where volumes with nearly perfect lattices evolve from structures filled with dislocations, and how local variations at the micrometer length scale affect this nucleation process. We present here the first experimental measurements that relate directly nucleation of recrystallization to the local deformation microstructure in the bulk of a sample of cold rolled aluminum, further deformed locally by a hardness indentation. White beam differential aperture X-ray microscopy is used for the measurements, allowing us to map a selected gauge volume in the bulk of the sample in the deformed state, then anneal the sample and map the exact same gauge volume in the annealed state. It is found that nuclei develop at sites of high stored energy and they have crystallographic orientations from those present in the deformed state. Accordingly we suggest that for each nucleus the embryonic volume arises from a structural element contained within the voxels identified with the same orientation. Possible nucleation mechanisms are discussed and the growth potentials of the nuclei are also analyzed and discussed.

General information
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Organisations: Department of Wind Energy, Materials science and characterization, Technical University of Denmark, Tsinghua University, Chongqing University, Argonne National Laboratory
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Main Research Area: Technical/natural sciences

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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 4.36 SJR 1.533 SNIP 1.245
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.63 SJR 1.692 SNIP 1.354
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.034 SNIP 1.597 CiteScore 5.3
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 2.163 SNIP 1.554 CiteScore 4.75
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.998 SNIP 1.57 CiteScore 4.06
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.531 SNIP 0.962 CiteScore 2.44
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Distance relay performance in future converter dominated power systems

Increasing penetration of converter-based generations in power system has led to new system challenges. Short circuit power response from converter-based generations is different from that of traditional synchronous generators. Power electronic converters can be designed for over-current only up to 1.1-1.25 times of its nominal value. Low availability of short circuit power can cause many challenges such as misoperation of distance relays. The aim of this paper is to investigate the effect of converter dominated systems on performance of distance relays. Backup functionality of the distance relay is major concern as miscoordination of backup relays in case of cascading faults can lead to severe stress in system, which can develop into blackout. In this paper, response of relays in traditional system is compared with response of relays in low short-circuit-current power systems. Impact of converter controls on fault current response of converter-based generations is also investigated. Index Terms—Converter control, distance relays, power system protection, system modelling.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning, Department of Electrical Engineering, Center for Electric Power and Energy, Electric Power Systems
Authors: Sarkar, M. (Intern), Jia, J. (Intern), Yang, G. (Intern)
Number of pages: 6
Publication date: 2017
Do regional weather models contribute to better wind power forecasts? A few Norwegian case studies.

In most operational wind power forecasting systems statistical methods are applied to map wind forecasts from numerical weather prediction (NWP) models into wind power forecasts. NWP models are complex mathematical models of the atmosphere that divide the earth’s surface into a grid. The spatial resolution of this grid determines how accurate meteorological processes can be modeled and thereby also limits forecast quality. In this study, two global and four regional operational NWP models with spatial horizontal resolutions ranging from 1 to 32 km were applied to make wind power forecasts up to 66 hours ahead for one offshore and two onshore Norwegian wind farms. A statistical meta-Gaussian method was applied to generate both probabilistic and deterministic wind power forecasts based on the NWP model wind forecasts. The experiments showed that the regional NWP models with higher resolution did not result in better wind power forecasts for these wind farms. In fact, the best wind power forecasts were obtained using one of the coarsest global NWP models.

EBSD characterization of deformed lath martensite in IF steel

Rolling deformation results in the transformation of a lath martensite structure to a lamellar structure characteristic to that of IF steel cold-rolled to medium and high strains. The structural transition takes place from low to medium strain, and electron backscatter diffraction analysis shows that the frequency of medium angle boundaries with misorientation angles of 5-10° decreases with increasing strain, while the frequencies of boundaries with angles in the ranges of 1-5° and 10-25° increase, resulting in the evolution of a bimodal misorientation angle distribution. The microstructural evolution and the strength are characterized for lath martensite rolled to a thickness reduction of 30%, showing that large changes in the misorientation take place, while the strain hardening rate is low.
Effective roughness and displacement height over forested areas, via reduced-dimension CFD

While extensive field campaigns as well as modern remote sensing methods based on airborne laser scans allow obtaining of detailed information about forest canopy structure, there is still a great need for simple and consistent description of vegetation roughness, as its parametrization differs significantly from one flow model to the other (e.g. CFD, mesoscale and linearized models). Here, we present a method to facilitate use of forest data, having an arbitrary level of detail, in flow models employing different types or levels of canopy drag-force prescription.

Effect of second-order and fully nonlinear wave kinematics on a tension-leg-platform wind turbine in extreme wave conditions

In this study, we assess the impact of different wave kinematics models on the dynamic response of a tension-leg-platform wind turbine. Aero-hydro-elastic simulations of the floating wind turbine are carried out employing linear, second-order, and fully nonlinear kinematics using the Morison equation for the hydrodynamic forcing. The wave kinematics are computed from either theoretical or measured signals of free-surface elevation. The numerical results from each model are compared to results from wave basin tests on a scaled prototype. The comparison shows that sub and superharmonic responses can be introduced by second-order and fully nonlinear wave kinematics. The response at the wave frequency
range is better reproduced when kinematics are generated from the measured surface elevation. In the future, the numerical response may be further improved by replacing the global, constant damping coefficients in the model by a more detailed, customizable definition of the user-defined numerical damping.

**General information**
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, National Renewable Energy Laboratory
Authors: Pegalajar Jurado, A. M. (Intern), Borg, M. (Intern), Robertson, A. (Ekstern), Jonkman, J. (Ekstern), Bredmose, H. (Intern)
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Source: FindIt
Source-ID: 2392652623
Publication: Research - peer-review › Article in proceedings – Annual report year: 2017

**Effect of shot peening on the residual stress and mechanical behaviour of low-temperature and high-temperature annealed martensitic gear steel 18CrNiMo7-6**

A martensitic gear steel (18CrNiMo7-6) was annealed at 180 degrees C for 2h and at similar to 750 degrees C for 1h to design two different starting microstructures for shot peening. One maintains the original as-transformed martensite while the other contains irregular-shaped sorbite together with ferrite. These two materials were shot peened using two different peening conditions. The softer sorbite + ferrite microstructure was shot peened using 0.6 mm conditioned cut steel shots at an average speed of 25 m/s in a conventional shot peening machine, while the harder tempered martensite steel was shot peened using 1.5 mm steel shots at a speed of 50 m/s in an in-house developed shot peening machine. The shot speeds in the conventional shot peening machine were measured using an in-house lidar set-up. The microstructure of each sample was characterized by optical and scanning electron microscopy, and the mechanical properties examined by microhardness and tensile testing. The residual stresses were measured using an Xstress 3000 G2R diffractometer equipped with a Cr K alpha x-ray source. The correspondence between the residual stress profile and the gradient structure produced by shot peening, and the relationship between the microstructure and strength, are analyzed and discussed.

**General information**
State: Published
Organisations: Department of Mechanical Engineering, Department of Wind Energy, Manufacturing Engineering, Materials science and characterization, Meteorology & Remote Sensing, Composites and Materials Mechanics, Materials and Surface Engineering, Chongqing University, Chalmers University of Technology, Nanjing University of Science and Technology
Authors: Yang, R. (Ekstern), Zhang, X. (Intern), Mallipeddi, D. (Ekstern), Angelou, N. (Intern), Toftegaard, H. L. (Intern), Li, Y. (Ekstern), Ahlstrom, J. (Ekstern), Lorentzen, L. (Intern), Wu, G. (Ekstern), Huang, X. (Intern)
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Effect of the number of blades on the dynamics of floating straight-bladed vertical axis wind turbines

Floating vertical axis wind turbines (VAWTs) are promising solutions for exploiting the wind energy resource in deep waters due to their potential cost-of-energy reduction. The number of blades is one of the main concerns when designing a VAWT for offshore application. In this paper, the effect of blade number on the performance of VAWTs and dynamic behavior of floating VAWTs was comprehensively studied in a fully coupled aero-hydro-servo-elastic way. Three VAWTs with straight and parallel blades, with identical solidity and with a blade number varying from two to four, were designed using the actuator cylinder method and adapted to a semi-submersible platform. A generator torque controller was also designed based on a PI control algorithm. Time domain simulations demonstrated that the aerodynamic loads and structural responses are strongly dependent on the number of blades. In particular, by increasing the number of blades from two to three reduces the variation in the tower base bending moment more significantly than increasing it from three to four. However, the blade number does not significantly affect the generator power production due to the control strategy employed, and the platform motions and tension in mooring lines because of the compliant catenary mooring system.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design, Norwegian University of Science and Technology
Authors: Cheng, Z. (Ekstern), Aagaard Madsen, H. (Intern), Gao, Z. (Ekstern), Moan, T. (Ekstern)
Number of pages: 14
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Scopus rating (2017): CiteScore 5.38 SJR 1.847 SNIP 2.008
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.83 SJR 1.661 SNIP 2.05
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Effects of Armature Winding Segmentation with Multiple Converters on the Short Circuit Torque of 10-MW Superconducting Wind Turbine Generators

Superconducting synchronous generators (SCSGs) are drawing more attention in large direct-drive wind turbine applications. Despite low weight and compactness, the short circuit torque of an SCSG may be too high for wind turbine constructions due to a large magnetic air gap of an SCSG. This paper aims at assessing the effects of armature winding segmentation on reducing the short circuit torque of 10-MW SCSGs. A concept of armature winding segmentation with multiple power electronic converters is presented. Four SCSG designs using different topologies are examined. Results show that armature winding segmentation effectively reduce the short circuit torque in all the four SCSG designs when

Original language: English
one segment is shorted at the terminal.
Effects of normal and extreme turbulence spectral parameters on wind turbine loads

 Loads simulations as performed to obtain design loads on wind turbines, requires wind turbulence as an input, characterized by parameters associated with the turbulence length scale, dissipation and anisotropy. The effect of variation in these turbulence spectral parameters on the magnitude of design loads is investigated with a focus on the commonly used Mann turbulence model. Quantification of the Mann model parameters is made through wind measurements acquired from the Høvsøre site. The parameters of the Mann model fitted to site specific observations can differ significantly from the recommended values in the IEC 61400-1 Ed.3 that is used for wind turbine design. The present paper investigates the impact of Mann turbulence model parameter variations on the design loads envelope for 5 MW and 10 MW reference wind turbines. Specific focus is made on the blade root loads, tower top moments and tower base loads under normal turbulence and extreme turbulence, whereby the change in operating extreme and fatigue design loads obtained through turbulence model parameter variations is compared with corresponding variations obtained from random seeds of turbulence. The investigations quantify the effects of turbulent length scale and anisotropy on the major wind turbine component extreme and fatigue loads.

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Authors: Dimitrov, N. K. (Intern), Natarajan, A. (Intern), Mann, J. (Intern)
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.83 SJR 1.661 SNIP 2.05
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.767 SNIP 2.085 CiteScore 4.51
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.925 SNIP 2.621 CiteScore 4.51
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.989 SNIP 2.719 CiteScore 4.63
ISI indexed (2013): ISI indexed yes
Effects of wind turbine wake on atmospheric sound propagation

In this paper, we investigate the sound propagation from a wind turbine considering the effects of wake-induced velocity deficit and turbulence. In order to address this issue, an advanced approach was developed in which both scalar and vector parabolic equations in two dimensions are solved. Flow field input was obtained using the actuator line (AL) technique with Large Eddy Simulation (LES) to model the wind turbine and its wake and from an analytical wake model. The effect of incoming wind speed and atmospheric stability was investigated with the analytical wake input using a single point source. Unsteady acoustic simulations were carried out with the AL/LES input for three cases with different incoming turbulence intensity, and a moving source approach to mimic the rotating turbine blades. The results show a non-negligible effect of the wake on far-field noise prediction. Particularly under stable atmospheric conditions, SPL amplification reaches up to 7.5dB at the wake centre. Furthermore, it was observed that when the turbulence intensity level of the incoming flow is higher, the SPL difference between the moving and the steady source is lower.

General information
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Organisations: Department of Wind Energy, Fluid Mechanics, Resource Assessment Modelling
Authors: Barlas, E. (Intern), Zhu, W. J. (Intern), Shen, W. Z. (Intern), Kelly, M. C. (Intern), Andersen, S. J. (Intern)
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.33 SJR 0.846 SNIP 1.669
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.668 SNIP 1.716 CiteScore 1.85
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.705 SNIP 1.885 CiteScore 1.67
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.778 SNIP 2.288 CiteScore 1.64
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 0.76 SNIP 2.191 CiteScore 1.66
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.772 SNIP 1.796 CiteScore 1.38
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.639 SNIP 1.542
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.793 SNIP 1.506
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.665 SNIP 1.761
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.642 SNIP 1.324
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.645 SNIP 1.314
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.614 SNIP 1.258
Scopus rating (2004): SJR 0.594 SNIP 1.071
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.794 SNIP 1.218
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.874 SNIP 0.959
Scopus rating (2001): SJR 0.62 SNIP 0.92
Scopus rating (2000): SJR 0.323 SNIP 0.874
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 0.322 SNIP 0.58
Efficiency of large wind farms: investigation of dependency on turbine technology and cluster layout

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling, Meteorology & Remote Sensing
Authors: Volker, P. (Intern), Badger, J. (Intern), Hahmann, A. N. (Intern), Ejsing Jørgensen, H. (Intern)
Number of pages: 2
Publication date: 2017
Main Research Area: Technical/natural sciences
Electronic versions: abstract_pvol.pdf
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2017

Efficient large-scale wind turbine deployment can meet global electricity generation needs

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling
Authors: Badger, J. (Intern), Volker, P. J. H. (Intern)
Pages: E8945-E8945
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
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Volume: 114
Issue number: 43
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Ratings:
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 8.59 SJR 6.092 SNIP 2.626
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 8.56 SJR 6.576 SNIP 2.642
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 6.814 SNIP 2.691 CiteScore 8.84
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 6.898 SNIP 2.734 CiteScore 8.86
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 7.073 SNIP 2.738 CiteScore 9.5
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 6.868 SNIP 2.697 CiteScore 9.49
ISI indexed (2012): ISI indexed yes
EIAplus - Subreport 3: Limitations and possibilities for social consequences in EIA

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning, Aalborg University
Authors: Larsen, S. V. (Ekstern), Nielsen, H. (Ekstern), Lyhne, I. (Ekstern), Rudolph, D. P. (Intern), Clausen, N. (Intern)
Publication date: 2017

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
VVMplus_Delrapport_3_Februar2017.pdf
Source: FindIt
Source-ID: 2353448326
Publication: Research - Report – Annual report year: 2017
Elastic deformations of floaters for offshore wind turbines: Dynamic modelling and sectional load calculations

To achieve economically and technically viable floating support structures for large 10MW+ wind turbines, structural flexibility may increase to the extent that becomes relevant to incorporate along with the corresponding physical effects within aero-hydro-servo-elastic simulation tools. Previous work described a method for the inclusion of substructural flexibility of large-volume substructures, including wave-structure interactions through linear radiation-diffraction theory. Through an implementation in the HAWC2 simulation tool, it was shown that one may incorporate the effects of additional modes on substructure and wind turbine response as well as predict the excitation of substructure flexible modes. This work goes one step further and describes a method to calculate internal substructural stresses that includes dynamic effects. In dynamic calculations, the substructure flexibility is considered through a reduced set of modes, selected based on their relevance to the external load frequency range, and represented with a superelement. The implementation of this method in aeroelastic simulation tool HAWC2 and wavestructure analysis program WAMIT is described, highlighting the practical challenges. A case study of the DTU 10MW Reference Wind Turbine installed on the Triple Spar concept is presented to illustrate the method. The results show that the substructure flexible modes, global platform motion and wind turbine loads can influence sectional loads within the substructure.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Wind turbine loads & control
Authors: Borg, M. (Intern), Bredmose, H. (Intern), Hansen, A. M. (Intern)
Number of pages: 10
Publication date: 2017

Energy Yield Potential Estimation Using Marine Current Turbine Simulations for the Bosphorus

In this work, several simulations and analyses are carried out to investigate the feasibility of generating electricity from sea underwater currents at Istanbul Bosphorus Strait. Bosphorus is a natural canal which forms a border between Europe and Asia by connecting Black Sea and Marmara Sea. The differences in elevation and salinity ratios between these two seas cause strong underwater currents. Depending on the morphology of the canal the speed of the flow varies and at some specific locations the energy intensity reaches to sufficient levels where electricity generation by marine current turbines becomes economically feasible. In this study, several simulations are performed for a 10 MW marine turbine farm/cluster whose location is selected by taking into account several factors such as the canal morphology, current speed and passage of vessels. 360 different simulations are performed for 15 different virtual sea states (for 5 significant wave heights and 3 peak periods). Similarly, 8 different configurations are analyzed in order to find the optimum spacing between the turbines. Considering that the complicated morphology of the strait may cause some spatial variations in the current speed within the selected region, the analyses are performed for three different flow speeds corresponding to 10 % increase and decrease in the average value. For each simulation the annual energy yield and cluster efficiency are calculated.

General information
State: Published
Organisations: Department of Wind Energy, Istanbul Bilgi University
Authors: Yazicioglu, H. (Intern), Tunc, K. M. M. (Ekstern), Ozbek, M. (Ekstern), Kara, T. (Ekstern)
Pages: 65-71
Publication date: 2017
Layered structures are susceptible to delamination because they often exhibit low interlaminar fracture resistance. Through-thickness stresses e.g. due to manufacturing defects or geometric discontinuities, can result in growing interlaminar cracks which may lead to loss of structural integrity [1]. As a result, a number of techniques have been developed to improve the through-thickness fracture resistance of layered structures e.g. fibre reinforced composites. In the field of composite materials, two directions to develop damage tolerant composites can be identified: a) material improvements (e.g. tougher matrices and interleaves) and b) modifications of the fibre architecture (e.g. stitching, z-pinning, knitting and braiding). These techniques aim to increase the fracture resistance by making the damage prone areas stronger.

In the present work, a third approach is explored. It is shown, through cohesive zone modelling, that the fracture resistance can be improved by introducing weak layers that result in multiple delaminations next to the damage prone areas. Our model is motivated by the experimental results of Rask and Sørensen [2] who observed that by changing the ply thicknesses of composite beams bonded together with a thermoset adhesive, more delamination cracks could be developed next to the main/primary adhesive/laminate crack. An analytical model, based on the J integral, was developed for multiple delaminations [3]. It is shown that the maximum possible increase (upper limit) of the steady-state fracture resistance, JR,ss, scales linearly with the number of delaminations in agreement with the observations of Rask and Sørensen.
Evolution of microstructure and texture in copper during repetitive extrusion-upsetting and subsequent annealing

The evolution of the microstructure and texture in copper has been studied during repetitive extrusion-upsetting (REU) to a total von Mises strain of 4.7 and during subsequent annealing at different temperatures. It is found that the texture is significantly altered by each deformation pass. A duplex 001 + 111 fiber texture with an increased 111 component is observed after each extrusion pass, whereas the 110 fiber component dominates the texture after each upsetting pass. During REU, the microstructure is refined by deformation-induced boundaries. The average cell size after a total strain of 4.7 is measured to be ~0.3μm. This refined microstructure is unstable at room temperature as is evident from the presence of a small number of recrystallized grains in the deformed matrix. Pronounced recrystallization took place during annealing at 200 °C for 1 h with recrystallized grains developing predominantly in high misorientation regions. At 350 °C the microstructure is fully recrystallized with an average grain size of only 2.3 μm and a very weak crystallographic texture. This REU-processed and subsequently annealed material is considered to be potentially suitable for using as a material for sputtering targets.
Examples of Applications of Vortex Methods to Wind Energy

The current chapter presents wind-energy simulations obtained with the vortex code OmniVor (described in Chap. 44) and compared to BEM, CFD and measurements. The chapter begins by comparing rotor loads obtained with vortex methods, BEM and actuator-line simulations of wind turbines under uniform and yawed inflows. The second section compares wakes and flow fields obtained by actuator-disk simulations and a free-wake vortex code that uses vortex segments and vortex particles. The third section compares different implementations of viscous diffusion models and investigate their effects on the determination of wake deficits. The last section compares the wake deficits obtained from vortex code and CFD simulations under turbulent conditions with results from lidar measurements.
Experimental and numerical statistics of storm wave forces on a monopile in uni- and multidirectional seas

Experiments with both uni- and multidirectional wave realizations with a stiff pile subjected to extreme wave forces are considered. Differences in crest heights and force peaks resulting from directional spread waves are analysed. The wave realizations are reproduced numerically in the fully nonlinear wave model OceanWave3D. The numerical reproductions compare well to the experiments. Only for the largest forces significant differences are seen, which is due to a very simple breaking filter applied in OceanWave3D. In the wave spectra, the higher harmonics occur for smaller frequencies than the straight multiples of the peak frequency. Further, the higher harmonics of the multidirectional wave spectra contain less energy. Both effects can be explained by the second order wave theory. Finally, the computed wave kinematics are used to investigate the dynamic response of an offshore wind turbine. The excitation of the first natural frequency is largest for the unidirectional wave realizations, as the higher harmonics are largest for these realizations.

Ex-situ X-ray computed tomography data for a non-crimp fabric based glass fibre composite under fatigue loading

The data published with this article are high resolution X-ray computed tomography (CT) data obtained during an ex-situ fatigue test of a coupon test specimen made from a non-crimp fabric based glass fibre composite similar to those used for wind turbine blades. The fatigue test was interrupted four times for X-ray CT examination during the fatigue life of the considered specimen. All the X-ray CT experiments were performed in the region where unidirectional fibre fractures first became visible, and thereby include the damage progression in 3D in this specific region during fatigue loading of the specimen.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Jespersen, K. M. (Intern), Mikkelsen, L. P. (Intern)
Pages: 1003-1005
Publication date: 2017
Main Research Area: Technical/natural sciences
Extreme variance vs. turbulence: What can the IEC cover?

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling, Wind Turbine Structures and Component Design
Authors: Hannesdóttir, Á. (Intern), Kelly, M. C. (Intern), Dimitrov, N. K. (Intern)
Publication date: 2017
Event: Poster session presented at WIND ENERGY DENMARK 2017, Herning, Denmark.
Main Research Area: Technical/natural sciences
Electronic versions:
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Poster
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Source-ID: 141912722
Publication: Research - peer-review » Poster – Annual report year: 2017

Extreme wave impacts on monopiles: Re-analysis of experimental data by a coupled CFD solver
Two different numerical models, OceanWave3D and a coupled solver, OceanWave3D-OpenFOAM (Waves2Foam), are used to reproduce extreme events in one sea state. The events are chosen as, the measured event that generates the largest peak moment (exceedance probability of 0.05%) and one event with a slightly smaller peak moment (exceedance probability of 0.3%). Time series of free surface elevation, depth integrated forces, bending moment at the sea bed and pressure time series at 5 different heights on the cylinder are compared for two events between the measurements and the numerical models. The numerical pressure field on the monopile at impact is analyzed and stagnation pressures at the back side of the cylinder, in addition to the main impact pressure at the front side are observed. There is a good agreement between the OceanWave3D results and the measurements in the reproduction of the first selected event. However, for the larger selected event, OceanWave3D results in the peaks of time series are smaller than the measurements. This illustrates the sensitivity of the strong impact loads to the state of wave breaking. For small values of the inline force, the OpenFOAM results provided good agreement with the measurements. The secondary load cycles are observed in the measured force and bending moment time series and the reproduced time series using OpenFOAM.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, DHI Denmark
Authors: Ghadirian, A. (Intern), Bredmose, H. (Intern), Schloer, S. (Intern), Dixen, M. (Ekstern)
Number of pages: 10
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Title of host publication: Proceedings of ASME 2017 36th International Conference on Ocean, Offshore and Arctic Engineering: Offshore Technology
Volume: 1
Publisher: American Society of Mechanical Engineers
Extreme winds and waves for offshore turbines: Coupling atmosphere and wave modeling for design and operation in coastal zones

The X-WiWa project was motivated by Denmark's long term vision for off-shore wind energy and the many technical and scientific challenges in existing methodologies for assessing the design parameters, for both winds and waves. X-WiWa succeeded in developing a most up-to-date modeling system for wind modeling for offshore wind farms. This modeling system consists of the atmospheric Weather Research and Forecasting (WRF) model, the wave model SWAN and an interface the Wave Boundary Layer Model WBLM, within the framework of coupled-ocean-atmosphere-wave-sediment transport modeling system COAWST (Hereinafter the WRF-WBLM-SWAN model). WBLM is implemented in SWAN, and it calculates stress and kinetic energy budgets in the lowest atmospheric layer where the wave-induced stress is introduced to the atmospheric modeling. WBLM ensures consistent calculation of stress for both the atmospheric and wave modeling, which was considered a major improvement to previous attempts in the literature. This methodology thus provides an option to avoid the parametrization of an often used interface parameter, the roughness length. Many parametrization schemes for the roughness length have brought diverse estimates and associated uncertainties to the modelled wind speed. Data validation using measurements from the Baltic Sea and North Sea around Denmark suggests that the coupled modeling system WRF-WBLM-SWAN outperforms the non-coupled, no-wave, WRF modeling of wind; an improvement by 10% or more is present at strong winds, which can affect the choice of the off-shore wind turbine type.

X-WiWa examined various methodologies for wave modeling. The offline coupling system using atmospheric data such as WRF or global reanalysis wind field to the MIKE 21 SW model has been improved with considerations of stability, air density, currents and new wind drag relations. X-WiWa suggests that, implementation of an online coupling technology does not necessarily provide better estimation of the waves, if the physics have not been properly described. This is supported by the comparisons of the modeled wave data between offline MIKE 21 SW modeling and the WRF-WBLM-SWAN modeling. The two provide comparably good wave calculations for coastal areas but the latter underestimates the wave height for far offshore areas, which is speculated to be related to the dissipation description in the wave source functions, where further improvement is seen necessary. X-WiWa puts modeling efforts on storms that are defined to be contributors to the extreme wind and extreme significant wave height through the annual maximum method. Thus for 23 years from 1994 to 2016, 429 storm days are simulated for the extreme wind, and for 1994 to 2014, 932 storm days are simulated for the extreme significant wave height. The 50-year winds at 10 m, 50 m and 100 m over the waters around Denmark are calculated and validated and agreement is satisfactory. The 50-year significant wave height for the Danish waters and surrounding North Sea and Baltic Sea are presented from the online and offline systems. The modeling systems, data, analysis, results and publications are introduced and provided on www.xwiwa.dk. These outputs are expected to be useful for general offshore wind and wave applications such as Operation and Maintenance, Forecasting, and Design.

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling, Meteorology & Remote Sensing, DHI Denmark, Uni Research AS, DHI Harsholm, Danish Hydraulic Institute
Authors: Larsen, X. G. (Intern), Bolanos, R. (Ekstern), Du, J. (Intern), Kelly, M. C. (Intern), Kofod-Hansen, H. (Ekstern), Larsen, S. E. (Intern), Karagali, I. (Intern), Badger, M. (Intern), Hahmann, A. N. (Intern), Imberger, M. (Intern), Tomfeldt Sørensen, J. (Ekstern), Jackson, S. (Ekstern), Volker, P. (Intern), Svenstrup Petersen, O. (Ekstern), Jenkins, A. (Ekstern), Graham, A. (Forskerdatabase)
Number of pages: 113
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Series: DTU Wind Energy E
Volume: 154
Main Research Area: Technical/natural sciences
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Fabricating interstitial-free steel with simultaneous high strength and good ductility with homogeneous layer and lamella structure

Annealed interstitial-free steel (IF steel) and deformed IF steel sheets were stacked alternatively into multi-layers to produce laminated IF steel through thermal-mechanical processing. After proper processing, a yield strength of 500 MPa, an ultimate tensile strength of 600 MPa (comparable to cold rolled one) and a uniform elongation around 17% can be realized. Microstructural observation by electron back-scatter diffraction revealed a characteristic hierarchical layer + heterogeneous lamella structure, namely L2 structure. The reasons for the good mechanical properties were discussed.

General information

State: Published
Organisations: Department of Chemistry, NanoChemistry, Department of Wind Energy, Materials science and characterization, Chongqing University, Yanshan University
Authors: Zhang, L. (Intern), Chen, Z. (Ekstern), Wang, Y. (Ekstern), Ma, G. (Ekstern), Huang, T. (Ekstern), Wu, G. (Ekstern), Juul Jensen, D. (Intern)
Pages: 111-114
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Publication information

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BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4.19 SJR 1.923 SNIP 1.855
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.71 SJR 1.884 SNIP 1.737
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.259 SNIP 1.841 CiteScore 3.54
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.65 SNIP 2.035 CiteScore 3.55
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.323 SNIP 1.946 CiteScore 3.19
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.292 SNIP 1.996 CiteScore 3.01
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.314 SNIP 2.082 CiteScore 3.21
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.427 SNIP 2.117
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Facing the challenges of distribution systems operation with high wind power penetration

This paper addresses the challenges associated with the operation of a distribution system with high penetration of wind power. The paper presents some preliminary investigations of an ongoing Danish research work, which has as main objective to reduce the network losses by optimizing the reactive power flow in 60kV distribution networks through controlling the ability of wind power plants (WPPs) to generate or absorb reactive power. This paper aims to understand the characteristics of a distribution network with high penetration of distributed generation. A detailed analysis of the active and reactive power flows in a real distribution network under different wind and load conditions based on actual measurements is performed in order to understand the correlation between the consumption, wind power production, and the network losses. Conclusive remarks are presented, briefly expressing the track for the future work.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning, Eniig
Authors: Das, K. (Intern), Altin, M. (Intern), Hansen, A. D. (Intern), Nuño Martinez, E. (Intern), Sørensen, P. E. (Intern), Thybo, G. W. (Ekstern), Rangård , M. (Ekstern), Skytte, K. M. (Ekstern)
Number of pages: 6
Publication date: 2017

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Publisher: IEEE
Main Research Area: Technical/natural sciences
Conference: 12th IEEE Power and Energy Society PowerTech Conference, Manchester, United Kingdom, 18/06/2017 - 18/06/2017
Electronic versions:
Facing the challenges of distribution systems_PowerTech2017.pdf
DOIs:
10.1109/PTC.2017.7981136
Source: PublicationPreSubmission
Source-ID: 133324392
Fatigue behaviors and damage mechanism of a Cr-Mn-N austenitic steel
Four-point bending fatigue tests were conducted on a Cr-Mn-N austenitic steel at room temperature, at frequency of 20 Hz and the stress ratio of R = 0.1, in air. The fatigue strength of this Cr-Mn-N austenitic steel was measured to be 503 MPa in the maximum stress from the S-N curve obtained. It was found that multi-site crack nucleation took place on the surface of the steel during fatigue, and that the crack population (i.e., fatigue weak-links) was found to be a Weibull function of the applied stress. Usually only one or two of the initiated cracks could lead to the final failure of the samples. Most of the cracks were initiated at the(111) primary slip bands, especially within coarse grains. The cracks were deflected at grain boundaries, which effectively resisted short crack growth and arrested most of the short cracks in the alloy. It can be anticipated that grain refinement could further enhance the fatigue properties of the alloy. (C) 2016 Elsevier B.V. All rights reserved.
Fatigue crack growth in mode II of adhesively joined composites

The structure of a wind turbine is exposed to a complex multi-axial cyclic loading. The blades are commonly manufactured of adhesively joined composites. Adhesive joints are usually strongest if loaded in shear and accordingly fatigue properties in shear are important. In the current paper, experiments are performed to derive material data for a crack propagation in shear i.e. in mode II. The shear loading of the crack is achieved by use of double cantilever beam specimens loaded with uneven bending moments. The experiments are performed under a constant cyclic displacement. An initial mode I loading is used to make the crack start in the adhesive. The crack length is measured using a load synchronized camera. Due to the shear loading the crack deviates from the adhesive layer into the laminate. A stable crack propagation is detected in the laminate. No influence have been detected due to an increasing crack length. It is also observed that the crack is trapped in the laminate; if the loading is changed to mode I the crack continues to propagate in the laminate.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Biel, A. (Intern), Toftegaard, H. L. (Intern)
Publication date: 2017

Host publication information
Title of host publication: ECCM17 - Proceedings of the 17th European Conference on Composite Materials 2016
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Main Research Area: Technical/natural sciences
Conference: 17th European Conference on Composite Materials, Munich, Germany, 26/06/2016 - 26/06/2016
Source: FindIt
Source-ID: 2370837239
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2017

Fatigue Damage Evolution in Fibre Composites for Wind Turbine Blades
One of the largest challenges in wind turbine design, is realistically predicting the lifetime of the blades. Wind turbine blades experience a high number of fatigue load cycles during their life-time, and the fatigue damage mechanisms of the non-crimp fabric based glass fibre composites used for the load carrying parts of wind turbine blades are not well
understood. This PhD project establishes experimental methods making it possible to monitor the damage initiation and progression of fibre composites in 3D using X-ray CT. To overcome the resolution challenges of X-ray CT, a tension clamp solution that applies load to the specimen during X-ray CT examination is presented, and the advantage of combining X-ray CT with other techniques such as transilluminated white light imaging is demonstrated. The established methods are used to monitor the damage initiation and progression of fatigue damage on the micro-scale in the non-crimp fabric based composites used for wind turbine blades.

The results show that fibre fractures in the unidirectional (UD) load carrying fibre bundles initiate from off-axis cracks in the thin supporting backing fibre bundles. With an increasing number of fatigue load cycles, the UD fibre fractures progress gradually into the thickness direction of the UD fibre bundles, which eventually results in final fracture of the fibre composite. It is also found that the UD fibre fracture regions generally grow larger and initiate earlier at cross-over regions of the backing fibre bundles than at single backing fibre bundle regions. Furthermore, UD Fibre fractures are only observed to initiate at locations where the backing fibre bundles are 'in contact' with a UD fibre bundle. By observing the damage progression in 3D, it is also clear that the UD fibre fractures initiated and progressed as local 3D phenomena rather than being homogeneously distributed within the UD fibre bundles. Hence, the results show the importance of considering the problem in 3D.

The knowledge obtained on the fatigue damage mechanisms during the project can not only be used to improve the materials, but also sets the stage for X-ray CT based modelling. This is a step towards more realistic fatigue life-time modelling of fibre composites used for wind turbine blades, which will make it possible to push the design limits of wind turbine blades and thereby decrease the cost of energy for the wind energy production. In addition, the methods established during the PhD project can be applied to other problems, material systems, and load conditions in the future, which opens up for many new opportunities.

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General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics, Department of Applied Mathematics and Computer Science, LM Wind Power
Authors: Jespersen, K. M. (Intern), Mikkelsen, L. P. (Intern), Zangenberg Hansen, J. (Ekstern), Mishnaevsky, L. (Intern)
Number of pages: 196
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Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy PhD
Volume: 75
Main Research Area: Technical/natural sciences
Electronic versions:
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Projects:
Fatigue Damage Evolution in Fibre Composites for Wind Turbine Blades
Fatigue Damage Evolution in Fibre Composites for Wind Turbine Blades
Publication: Research › Ph.D. thesis – Annual report year: 2017

Fatigue damage evolution in quasi-unidirectional non-crimp fabric based composite materials for wind turbine blades
The fatigue failure of wind turbine blades is controlled by failure mechanisms on multiple scales spanning single fiber fatigue failure at the sub-micron scale, over the fiber bundle structure on the millimeter scale to the quasi-unidirectional non-crimp fabric on the meter scale. At the smaller scales, the 3D x-ray computer tomography technique is used non-destructive to observe the fatigue damage evolution on the fiber and bundle scale. These observations are then linked to the larger scales through mechanical testing of representative volumes of the non-crimp fabric bundle structure. Numerically, those non-crimp fabric bundle structures extracted from the 3D x-ray scans can be used in a multi-scale based finite element models used for understanding the parameters controlling the fatigue damage evolutions. During tensiontension fatigue testing, the damage mechanism is shown to be controlled by local architecture of the so-called backing bundle structure present in the non-crimp fabric. This mechanism is demonstrated to be highly dependent on the presence of curing induced residual stresses. Residual stresses which for an epoxy matrix system can be controlled by the chosen cure profile and thereby the mold time during wind turbine blade manufacture.

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General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics
Fatigue damage in non-crimp fabric composites subjected to cyclic bending load

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Mortensen, U. A. (Intern)
Number of pages: 11
Publication date: 2017
Main Research Area: Technical/natural sciences
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UlrichAMortensen_DTU_ISMEM2017.pdf
Source: PublicationPreSubmission
Source-ID: 143334519
Publication: Research - peer-review › Paper – Annual report year: 2018

Fatigue Reliability Analysis of Wind Turbine Cast Components
The fatigue life of wind turbine cast components, such as the main shaft in a drivetrain, is generally determined by defects from the casting process. These defects may reduce the fatigue life and they are generally distributed randomly in components. The foundries, cutting facilities and test facilities can affect the verification of properties by testing. Hence, it is important to have a tool to identify which foundry, cutting and/or test facility produces components which, based on the relevant uncertainties, have the largest expected fatigue life or, alternatively, have the largest reliability to be used for decision-making if additional cost considerations are added. In this paper, a statistical approach is presented based on statistical hypothesis testing and analysis of covariance (ANCOVA) which can be applied to compare different groups (manufacturers, suppliers, test facilities, etc.) and to quantify the relevant uncertainties using available fatigue tests. Illustrative results are presented as obtained by statistical analysis of a large set of fatigue data for casted test components typically used for wind turbines. Furthermore, the SN curves (fatigue life curves based on applied stress) for fatigue assessment are estimated based on the statistical analyses and by introduction of physical, model and statistical uncertainties used for the illustration of reliability assessment.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics, Aalborg University, Vestas
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Fault diagnosis and condition monitoring of wind turbines

This paper describes a model-free method for the fault diagnosis and condition monitoring of rotor systems in wind turbines. Both fault diagnosis and monitoring can be achieved without using a model for the wind turbine, applied controller, or wind profiles. The method is based on measurements from standard sensors on modern wind turbines, including moment sensors and rotor angle sensors. This approach will allow the method to be applied to existing wind turbines without any modifications. The method is based on the detection of asymmetries in the rotor system caused by changes or faults in the rotor system. A multiblade coordinate transformation is used directly on the measured flap-wise and edge-wise moments followed by signal modulation. Changes or faults in the rotor system will result in unique signatures in the set of modulation signals. These signatures are described through the amplitudes and phase information of the modulation signals. It is possible to detect and isolate which blade is faulty or has been changed based on these signatures. Furthermore, the faulty component can be isolated, ie, the actuator, sensor or blade, and the type of fault can be determined. The method can be used both on- and off-line.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, Department of Applied Mathematics and Computer Science, Dynamical Systems, Department of Wind Energy, Wind turbine loads & control, AF Consult
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Pages: 586-613
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Feasibility of wind power integration in weak grids in non-coastal areas of Sub-Saharan Africa: the case of Mali

Installed wind capacity in Africa has grown rapidly in recent years, and by late 2016 had reached about 4.8 GW. However, so far few investments have been made in inland localities due to the generally lower wind potential. This paper therefore explores if and to what extent it is possible to establish economically feasible wind-power plants in countries with lower wind potential. To address this question, the paper provides a combined wind resource mapping and a pre-feasibility
study for grid integration of wind power at four specific sites in Mali. The study finds that Mali has generally poor wind conditions, with average wind speeds of below 5 m/s at 50 m above ground level in the south, while there are larger areas in the northern part with average wind speeds of above 7 m/s at 50 m above ground level. Overall the research shows that in countries with generally poor wind conditions, such as in the southern part of Mali, it is possible to identify a limited number of sites with local speed-up effects situated close to the existing grid, at which there are options for undertaking medium-size wind-power projects that would be economically feasible at current crude oil prices of 50 USD/barrel.

**General information**
State: Published
Organisations: Department of Management Engineering, UNEP DTU Partnership, Department of Electrical Engineering, Center for Electric Power and Energy, Energy System Management, Department of Wind Energy, Resource Assessment Modelling, Agence d’Energie Renouvelable, 3E
Authors: Nygaard, I. (Intern), Kamissoko, F. (Ekstern), Nørgård, P. B. (Intern), Badger, J. (Intern), Dewilde, L. (Ekstern)
Pages: 557-584
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**Flap controllers applied on the OffshoreWindChina (OWC) 5MW reference wind turbine for Chinese typhoon conditions**
The report describes the development of flap controllers applied on the OffshoreWindChina (OWC) 5MW reference wind turbine for Chinese typhoon conditions. Optimal flap controllers are designed and tuned based on linear aeroelastic models from HawcStab2. The controllers are evaluated in normal, parked and storm conditions, targeting the alleviation of fatigue and extreme loads.

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Organisations: Department of Wind Energy, Aerodynamic design
Authors: Barlas, A. (Intern)
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**Flexibility: It’s More Than an Engineering Challenge [In My View]**
Flexibility is key for a power system under strain. When the city metro breaks down, you require other means of transportation. Before a big conference, you might need staff to work outside regular office hours. And when the production of electricity is dependent on how the wind blows or the sun shines, something or someone has to adapt. One of the best ways to increase your flexibility is to use the entire portfolio of available resources. The metro is down? Walk;
take the bus, the train, your bike, or your car. Short on staff for next week’s conference? Ask HR, communication, planning, or someone else if you can use some of their people; you’ll pay it back later. Are we getting too much electricity from wind? Use it for heating or get people to turn on appliances or change to electric cars. Flexibility is largely about systems, so it’s no surprise that, in recent years, there’s been increasing interest in applying systems thinking to energy research. As a policy adviser, I’ve been involved first hand in the transition toward a renewable-based energy system with its large share of intermittent energy sources, such as wind and solar.
Flow field and load characteristics of the whole MEXICO wind turbine

CFD (Computational Fluid Dynamics) method was used to perform steady numerical simulation investigation on the flow field and load characteristics of MEXICO (Model EXperiment In Controlled cOnditions) wind turbine under non-yawed condition. Circumferentially-Averaged method was used to extract the calculated axial, radial and tangential components of velocity along the axial direction, then these components were compared with the experimental data, the compared results show that the computational components agree well with the experimental data and the computational results are reliable. The flow characteristics around the blade was analyzed and the points of flow separation were found along the blade, the results show that the points of flow separation move towards trailing edge with the increase of radius. The distribution of vorticity in the wake of MEXICO rotor was also analyzed. The distribution of vorticity in the wake of three blade passages is symmetrical approximately. The value of vorticity decreases gradually along the axial direction behind the rotor and the tower has limited effects on the wake when the CFD simulation is steady. Besides, the load distribution along the radial direction of rotor blades was analyzed and the distribution law of load along the blade was obtained. The obtained load characteristic can provide the basis for the analysis of aeroelasticity of wind turbines.

General information
State: Published
Organisations: Department of Wind Energy, Technical University of Denmark, Fluid Mechanics, Yangzhou University, School of Hydraulic Energy and Power Engineering
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Flow induced by a skewed vortex cylinder

The velocity field induced by a skewed vortex cylinder of longitudinal and tangential vorticity is derived in this chapter by direct integration of the Biot-Savart law. The derivation steps are provided in details. The results of Castles and Durham for the skewed semi-infinite cylinder of tangential vorticity are presented first. The results are then extended so that all the velocity components induced by the tangential vorticity are expressed. The derivation of Coleman et al. which focused on the velocity induced on the base axis is then detailed. The result of Coleman is relevant for the implementation of yaw-models in BEM codes (see e.g. Chap. 21, Sects. 6.1 and 10.3.3). A Matlab source code to evaluate the induced velocity field in the entire domain is provided. Results for semi-infinite and infinite skewed cylinders with longitudinal vorticity are provided in the next section of the articles. Properties for the infinite cylinder of longitudinal vorticity are essential for the understanding of the properties of the semi-finite cylinder. In particular, it is shown that the velocity is zero inside of the infinite cylinder, and the stream-lines are confocal ellipse outside of the cylinder. The content of this chapter is
based on the publication of the author entitled "Cylindrical vortex wake model: skewed cylinder, application to yawed or tilted rotors" [1]. Results from this chapter are applied: in Chap. 21 to model a wind turbine (or rotor) in yaw, in Chap. 22 to derive a new yaw-model applicable to a BEM code and in Chap. 24 to study the induction zone in front of a yawed wind turbine (or rotor).

Flux footprints for a tall tower in a land–water mosaic area: A case study of the area around the Risø tower
The understanding of scalar fluxes observed in the lower atmosphere is a challenging task, when the underlying surface is non-uniform. In this paper, we apply a micro-scale flow model with a two-equation closure scheme to analyse the influence of the surface heterogeneity on a flux measurement in the area surrounding the 122-m tower at Risø (Denmark), which is a mosaic of water, agricultural areas and forests. These heterogeneities are clearly reflected in the tower-based observations of the turbulence statistics from a profile of six sonic anemometers and are also reproduced by the flow model. Using the two-dimensional mode of the model, in combination with the footprint estimator, we calculate the scalar flux footprints for the 122m eddy-covariance location and compare these results to analytical footprint estimators, which are only valid for homogeneous terrain, but are commonly applied also for heterogeneous terrain. Whereas the results by the analytical footprint estimator indicate smooth source areas regardless of the surface heterogeneities, the footprint estimator based on the micro-scale model indicates source hotspots, which have a stronger weight in the footprint. The hotspots coincide with areas, where the mean vertical velocity is positive. The positive mean vertical velocity is, in turn, related to topography and forest edge effects on the flow. Relative to the surface roughness estimated from a sonic anemometer, a higher value of the surface roughness was needed for the analytical footprint estimator in order to coarsely match the flow model-based footprint result. Although neither footprint model can be directly verified, the difference in the results underlines that the analytical model should be used with caution in heterogeneous areas. We also estimate the effect of the surface flux source-strength on the observed CO2 flux. This step demonstrates a novel way of evaluating the CO2 exchange with the surface, which is useful for constraining models of the surface source or sink.
For wind turbines in complex terrain, the devil is in the detail

The cost of energy produced by onshore wind turbines is among the lowest available; however, onshore wind turbines are often positioned in a complex terrain, where the wind resources and wind conditions are quite uncertain due to the...
surrounding topography and/or vegetation. In this study, we use a scale model in a three-dimensional wind-testing chamber to show how minor changes in the terrain can result in significant differences in the flow at turbine height. These differences affect not only the power performance but also the life-time and maintenance costs of wind turbines, and hence, the economy and feasibility of wind turbine projects. We find that the mean wind, wind shear and turbulence level are extremely sensitive to the exact details of the terrain: a small modification of the edge of our scale model, results in a reduction of the estimated annual energy production by at least 50% and an increase in the turbulence level by a factor of five in the worst-case scenario with the most unfavorable wind direction. Wind farm developers should be aware that near escarpments destructive flows can occur and their extent is uncertain thus warranting on-site field measurements.

General information
State: Published
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BFI (2016): BFI-level 1
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Scopus rating (2014): SJR 2.177 SNIP 1.446 CiteScore 3.91
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Web of Science (2013): Indexed yes
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Scopus rating (2012): SJR 2.122 SNIP 1.541 CiteScore 3.65
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.897 SNIP 1.503 CiteScore 3.51
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.732 SNIP 1.299
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.854 SNIP 1.274
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.73 SNIP 1.208
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.402 SNIP 0.197
Frequency Support from OWPPs connected to HVDC via Diode Rectifiers

This paper presents a study assessing the actual capability of an offshore wind power plant (offshore WPP, OWPP) to provide frequency support (FS) to an onshore network, when connected through a high-voltage direct-current (HVDC) link having a diode rectifier (DR) offshore terminal and a voltage source converter (VSC) onshore terminal. Both primary and fast frequency response (PFR and FFR, respectively) are studied, and both the power reserves from preventive curtailment and the kinetic energy stored in the rotating masses of the wind turbines (WTs) are considered as sources of additional power during onshore under-frequency events. Three methods are considered for overloading the WTs, including the proposed External Reference method, in which the base active power reference can be set externally. The performance of the controls is studied by means of electromagnetic transient (EMT) simulations, for which an aggregated model of the OWPP is used. The results suggest that such OWPPs can in principle provide onshore FS by means of plant-level active power control strategies already developed for OWPPs connected to HVDC via VSCs. Some of the results also suggest that it may be unnecessary to overload the WTs if active power reserves from curtailed operation are available when providing both PFR and FFR.

Full-scale observation of the flow downstream of a suspension bridge deck

The paper presents a full-scale observation of the flow conditions downstream of a suspension bridge by a system of synchronized short-range dual-Doppler wind lidars. The lidar units were deployed directly on the bridge walkway during a four-day pilot experiment. The wind velocity was monitored at every meter along a 111 m long vertical line segment 40 m downstream of the deck, with a sampling period of one second. The lidar wind data are studied in terms of the mean wind velocity deficit and turbulence intensity downstream of the bridge deck. They provided a full-scale characterization of the wake of a bridge box girder not previously seen in the literature. This includes an observation of the vortex shedding process, consistent with a Strouhal number of 0.11. The drag coefficient, deduced from the mean velocity deficit, is found to be comparable to the value available from the wind tunnel tests. Challenges in the estimation of the wind velocity data related to the variable measurement noise of the individual lidars, as a function of the wind direction, are highlighted. Suggestions for future applications of a similar measurement set-up, based on this unique study performed during a single day only, are also provided.
Fundamental aeroelastic properties of a bend–twist coupled blade section
The effects of bend–twist coupling on the aeroelastic modal properties and stability limits of a two-dimensional blade section in attached flow are investigated. Bend–twist coupling is introduced in the stiffness matrix of the structural blade section model. The structural model is coupled with an unsteady aerodynamic model in a linearised state–space formulation. A numerical study is performed using structural and aerodynamic parameters representative for wind turbine blades. It is shown that damping of the edgewise mode is primarily influenced by the work of the lift which is close to antiphase, making the stability of the mode sensitive to changes in the stiffness matrix. The aerodynamic forces increase the stiffness of the flapwise mode for flap–twist coupling to feather for downwind deflections. The stiffness reduces and damping increases for flap–twist to stall. Edge–twist coupling is prone to an edgetwist flutter instability at much lower inflow speeds than the uncoupled blade section. Flap–twist coupling results in a moderate reduction of the flutter speed for twist to feather and divergence for twist to stall.

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control
Authors: Stäblein, A. R. (Intern), Hansen, M. H. (Intern), Pirrung, G. (Intern)
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.62 SJR 1.308 SNIP 2.065
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.361 SNIP 1.834 CiteScore 2.33
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.375 SNIP 2.649 CiteScore 2.69
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.497 SNIP 2.734 CiteScore 2.96
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.094 SNIP 2.3 CiteScore 2.14
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.287 SNIP 2.35 CiteScore 2.16
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.459 SNIP 2.601
BFI (2009): BFI-level 1
Future defence plan requirements with high penetration of renewable generation

The contribution of solar photovoltaic (PV) power to the generation is becoming more relevant in modern power system. Therefore, there is a need to model the variability large-scale PV generation accurately. This paper presents a novel methodology to generate regional PV scenarios based on aggregated power curves rather than traditional physical PV conversion models. Our approach is based on hourly mesoscale reanalysis irradiation data and power measurements and do not require additional variables such as ambient temperature or wind speed. It was used to simulate the PV generation on the German system between 2012 and 2015 showing high levels of correlation with actual measurements (93.02–97.60%) and small deviations from the expected capacity factors (0.02–1.80%). Therefore, we are confident about the ability of the proposed model to accurately generate realistic large-scale PV scenarios.

Generation of large-scale PV scenarios using aggregated power curves

The contribution of solar photovoltaic (PV) power to the generation is becoming more relevant in modern power system. Therefore, there is a need to model the variability large-scale PV generation accurately. This paper presents a novel methodology to generate regional PV scenarios based on aggregated power curves rather than traditional physical PV conversion models. Our approach is based on hourly mesoscale reanalysis irradiation data and power measurements and do not require additional variables such as ambient temperature or wind speed. It was used to simulate the PV generation on the German system between 2012 and 2015 showing high levels of correlation with actual measurements (93.02–97.60%) and small deviations from the expected capacity factors (0.02–1.80%). Therefore, we are confident about the ability of the proposed model to accurately generate realistic large-scale PV scenarios.
Global Wind Atlas – validation and uncertainty

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling
Authors: Mortensen, N. G. (Intern), Davis, N. (Intern), Badger, J. (Intern), Hahmann, A. N. (Intern)
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Gradient microstructure and microhardness in a nitrided 18CrNiMo7-6 gear steel: Paper
A commercial gear steel (18CrNiMo7-6) containing a tempered martensite structure was nitrided using a pressurized gas nitriding process under a pressure of 5 atm at 530 °C for 5 hours. The mechanical properties and microstructure of the nitrided sample were characterized by Vickers hardness measurements, X-ray diffraction, and backscatter electron imaging in a scanning electron microscope. A micro-hardness gradient was identified over a distance of 500 μm with hardness values of 900 HV at the top surface and 300 HV in the core. This micro-hardness gradient corresponds to a gradient in the microstructure that changes from a nitride compound layer at the top surface (∼ 20 μm thick) to a diffusion zone with a decreasing nitrogen concentration and precipitate density with distance from the surface, finally reaching the core matrix layer with a recovered martensite structure.

General information
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Organisations: Department of Wind Energy, Materials science and characterization, Chongqing University, Yanshan University
Authors: Yang, R. (Ekstern), Wu, G. L. (Ekstern), Zhang, X. (Intern), Fu, W. T. (Ekstern), Huang, X. (Intern)
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Grain orientation mapping in gradient nanostructured metals produced by surface plastic deformation

Surface gradient nanostructured metals characterized by grain size and grain orientation variations from the surface to the interior can be produced by surface plastic deformation. Grain orientation mapping allows a quantitative characterization of both the microstructural and textural gradients that determine the properties and performance of such surface deformed metals. Two-dimensional (2D) orientation mapping techniques in a scanning electron microscope and a transmission electron microscope are typically used to generate grain orientation maps in surface gradient nanostructured metals. In this paper, examples of such grain orientation maps are given to show the advantages and limitations of 2D grain orientation mapping. The challenges associated with the indexing of superimposed electron diffraction patterns are discussed in particular, leading to the conclusion that solving this problem can ultimately only be achieved by 3D orientation mapping.

Graphite nodules in fatigue-tested cast iron characterized in 2D and 3D

Thick-walled ductile iron casts have been studied by applying (i) cooling rate calculations by FVM, (ii) microstructural characterization by 2D SEM and 3D X-ray tomography techniques and (iii) fatigue testing of samples drawn from components cast in sand molds and metal molds. An analysis has shown correlations between cooling rate, structure and fatigue strengths demonstrating the benefit of 3D structural characterization to identify possible causes of premature fatigue failure of ductile cast iron.
Growth of InAs Wurtzite Nanocrosses from Hexagonal and Cubic Basis

Epitaxially connected nanowires allow for the design of electron transport experiments and applications beyond the standard two terminal device geometries. In this Letter, we present growth methods of three distinct types of wurtzite structured InAs nanocrosses via the vapor-liquid-solid mechanism. Two methods use conventional wurtzite nanowire arrays as a 6-fold hexagonal basis for growing single crystal wurtzite nanocrosses. A third method uses the 2-fold cubic symmetry of (100) substrates to form well-defined coherent inclusions of zinc blende in the center of the nanocrosses. We show that all three types of nanocrosses can be transferred undamaged to arbitrary substrates, which allows for structural, compositional, and electrical characterization. We further demonstrate the potential for synthesis of as-grown nanowire networks and for using nanowires as shadow masks for in situ fabricated junctions in radial nanowire heterostructures.
In the last decade, renewable energy, in particular wind and solar energy, has experienced one of the most substantial growths of any power generation source. At present, in many areas across the world, wind and solar energy are providing substantial proportions of the total electrical demand, rising to over 50% in certain regions. However, many renewable energy sources, e.g. modern variable speed wind turbines and photovoltaic systems, are significantly different from conventional thermal and hydropower generating technologies, since they synchronize to the electricity grid via power electronics converters, and so are not directly responsive to system frequency transients. As a result, there are significant challenges for maintaining a reliable and secure power system, particularly in areas with high penetration of wind/solar energy. On the other hand, flexible control strategies can give modern wind turbines and solar generation units, as well as large scale wind/solar farms, the ability to provide active power support to the grid during frequency transients over a wide timeframe. This Special Issue brings together papers focused on the recent advances and breakthroughs in the technology of active power control (APC) from wind and solar (including photovoltaic and solar thermal) energy generation systems, ranging from individual wind turbines and solar generation units to large wind/solar farms. 135 manuscripts were submitted to this Special Issue, and underwent a formal review process, after which only 24 papers were accepted for publication. The accepted papers are broadly classified into four themes: (I) inertia and primary frequency control of wind turbines; (II) grid integration of photovoltaic generations; (III) power system operation and stability with renewable energy generations; and (IV) Wind power predictions and other issues. A brief discussion of each paper and the authors’ contributions are presented below.
Hierarchical Structure and Strengthening Mechanisms in Pearlitic Steel Wire

Microstructure evolution and strengthening mechanisms have been analyzed in a cold-drawn pearlitic steel wire (the strongest engineering materials in the world) with a nanostructure down to 10 nm and a flow stress up to 5.4 GPa. The interlamellar spacing and the cementite lamellae thickness are reduced during drawing in accordance with the change in wire diameter up to a strain of 2.5. At a higher strain enhanced thinning of cementite lamellae points to decomposition and carbon enrichment of the ferrite lamellae. Dislocations are stored as individual dislocations and in low angle boundaries. No saturation in the dislocation density is observed and it increases to 5E16 m-2 at a strain of 5.4. A high dislocation density at the ferrite/cementite(ferrite) interface is also observed. Boundary strengthening, dislocation strengthening and solid solution hardening are suggested and good agreement is found between the calculated flow stresses and experimental values.

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State: Published
Organisations: Department of Mechanical Engineering, Department of Wind Energy, Manufacturing Engineering, Materials science and characterization, Materials and Surface Engineering
Higher-order spectral modelling of the diffraction force around a vertical circular cylinder

The present paper is a continuation of the paper by the same authors at the workshop of 2016 (Bredmose & Andersen, 2016). While the 2016 paper outlined the concept for the proposed higher-order spectral force model, the present paper details the validation of its linear and nonlinear implementation.

High-fidelity linear time-invariant model of a smart rotor with adaptive trailing edge flaps

A high-fidelity linear time-invariant model of the aero-servo-elastic response of a wind turbine with trailing-edge flaps is presented and used for systematic tuning of an individual flap controller. The model includes the quasi-steady aerodynamic effects of trailing-edge flaps on wind turbine blades and is integrated in the linear aeroelastic code HAWCStab2. The dynamic response predicted by the linear model is validated against non-linear simulations, and the quasi-steady assumption does not cause any significant response bias for flap deflection with frequencies up to 2-3 Hz. The linear aero-servo-elastic model support the design, systematic tuning and model synthesis of smart rotor control systems. As an example application, the gains of an individual flap controller are tuned using the Ziegler-Nichols method for the full-order poles. The flap controller is based on feedback of inverse Coleman transformed and low-pass filtered flapwise blade root moments to the cyclic flap angles through two proportional-integral controllers. The load alleviation potential of the active flap control, anticipated by the frequency response of the linear closed-loop model, is also confirmed by non-linear time simulations. The simulations report reductions of lifetime fatigue damage up to 17% at the blade root and up to 4% at the tower bottom.
Renewable Energy, Sustainability and the Environment, Active fatigue damage load alleviation, Adaptive trailing edge flaps, Linear time-invariant (LTI) model, Linearized aero-servo-elastic modeling, Ziegler-Nichols tuning, Aerodynamics, Aeroelasticity, Control equipment, Control system synthesis, Fatigue damage, Flaps, Frequency response, Inverse problems, Linear control systems, Low pass filters, Time varying control systems, Turbomachine blades, Two term control systems, Wind turbines, Elastic modeling, Linear time invariant model, Load alleviation, Trailing edge flaps, Controllers

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Publication: Research - peer-review › Journal article – Annual report year: 2016
High-Order Numerical Simulations of Wind Turbine Wakes: Paper
Previous attempts to describe the structure of wind turbine wakes and their mutual interaction were mostly limited to large-eddy and Reynolds-averaged Navier–Stokes simulations using finite-volume solvers. We employ the higher-order spectral-element code Nek5000 to study the influence of numerical aspects on the prediction of the wind turbine wake structure and the wake interaction between two turbines. The spectral-element method enables an accurate representation of the vortical structures, with lower numerical dissipation than the more commonly used finite-volume codes. The wind-turbine blades are modeled as body forces using the actuator-line method (ACL) in the incompressible Navier–Stokes equations. Both tower and nacelle are represented with appropriate body forces. An inflow boundary condition is used which emulates homogeneous isotropic turbulence of wind-tunnel flows. We validate the implementation with results from experimental campaigns undertaken at the Norwegian University of Science and Technology (NTNU Blind Tests), investigate parametric influences and compare computational aspects with existing numerical simulations. In general the results show good agreement between the experiments and the numerical simulations both for a single-turbine setup as well as a two-turbine setup where the turbines are offset in the spanwise direction. A shift in the wake center caused by the tower wake is detected similar to experiments. The additional velocity deficit caused by the tower agrees well with the experimental data. The wake is captured well by Nek5000 in comparison with experiments both for the single wind turbine and in the two-turbine setup. The blade loading however shows large discrepancies for the high-turbulence, two-turbine case. While the experiments predicted higher thrust for the downstream turbine than for the upstream turbine, the opposite case was observed in Nek5000.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, KTH - Royal Institute of Technology
Authors: Kleusberg, E. (Ekstern), Mikkelsen, R. F. (Intern), Schlatter, P. (Ekstern), Ivanell, S. (Ekstern), Henningson, D. S. (Ekstern)
Number of pages: 10
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Volume: 854
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High resolution wind turbine wake measurements with a scanning lidar: Paper
High-resolution lidar wake measurements are part of an ongoing field campaign being conducted at the Scaled Wind Farm Technology facility by Sandia National Laboratories and the National Renewable Energy Laboratory using a customized scanning lidar from the Technical University of Denmark. One of the primary objectives is to collect experimental data to improve the predictive capability of wind plant computational models to represent the response of the turbine wake to varying inflow conditions and turbine operating states. The present work summarizes the experimental setup and illustrates several wake measurement example cases. The cases focus on demonstrating the impact of the atmospheric conditions on the wake shape and position, and exhibit a sample of the data that has been made public through the Department of Energy Atmosphere to Electrons Data Archive and Portal.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Sandia National Laboratories
Authors: Herges, T. G. (Ekstern), Maniaci, D. C. (Ekstern), Naughton, B. T. (Ekstern), Mikkelsen, T. K. (Intern), Sjöholm, M. (Intern)
Number of pages: 11
Publication date: 2017
Horns Rev 2 offshore wind farm photo case with wakes observed in 2016

Offshore wind farm wakes were photographed in foggy conditions at Horns Rev 2 on 25 January 2016 at 12:45 UTC (See1). The study examines the atmospheric conditions from satellite images, radiosonde, vertical profiling wind lidar located at the transformer platform and SCADA data. Furthermore results from atmospheric WRF meso-scale modelling, Park wake model and large eddy simulation wake model are prepared and analysed. At the time of the photos a humid and warm air mass was advected from the southwest over cold sea. The dew-point temperature was such that cold-water advection fog formed in a shallow layer. Most turbines produced at or near rated power. The wind speed was 13 m/s at hub height and wind direction was from the southwest. The flow was stably stratified. The photo shows long, narrow wakes that persisted several rotor diameters downwind of the wind turbines. The LES model included a temperature scheme, and the results indicate the pattern of fog in the wake. Due to stable stratification the wakes are long and narrow with a smooth appearance. The LES results are novel and for the first time ever compared to visually observed fog cones. In the far-field of the wind farm wake mixing of warm air from aloft dispersed the fog. This is noted in the photos and WRF model results. The physical processes are modelled from WRF without and with a parametrization for the wind farm included. The results indicate a difference in liquid water content showing that a drying effect appear downwind of the wind farms for more than 100 km. Thus the photos confirm this drying process. It is the first time this is visualized and modelled for an offshore wind farm. Interestingly, these new images show highly contrasting conditions regarding the wind speed, turbulence intensity, atmospheric stability, weather conditions and wind farm wake development as compared to the well-known Horns Rev 1 photographs from 12 February 2008.

How do PBL schemes in WRF describe summer and winter conditions at a high arctic site?

We compare 4 planetary boundary layer (PBL) schemes of Weather Research and Forecasting model for high Artic conditions, documented during summer and winter campaigns at Station Nord, Greenland. During March 2012, 22 radiosonds were launched at 00 and 12 UTC. During July-August 2011, 25 radiosondes were launched at 00, 06, 12, and 18 UTC. The chosen PBL schemes are 3 TKE schemes: MYJ, MYNN and QNSE and non-local YSU. Comparison is performed between data from radiosoundings and corresponding in time model results up to different height from 100 m to 8000 m. Sensitivity of model to vertical and spatial resolution is examined with MYJ through 4 configurations combining 26 or 42 vertical levels and 4 km or 1.33 km horizontal grid step. Sensitivity to the resolution tests showed that increasing horizontal resolution from 4 km to 1.33 km did not improve model performance. Increasing the number of vertical layers lead to closer to observed profiles and slightly improved statistics by layers. Sensitivity to the lead time (24 h or 48 h) is examined with MYJ at 1.33 km grid step and 42 vertical layers. Quality of forecast for day 1 and day 2 is similar for the summer. Temperature and wind speed (WS) biases for the winter are with 1 K and 1 ms-1 larger for 48 h compared to 24 h lead time. The lack of diurnal variability during both campaigns is correctly simulated by all PBL schemes. The performed tests show that TKE schemes outperform YSU and as a whole MYNN gives the highest scores.
Hybrid Simulation of Composite Structures

Hybrid simulation is a substructural method combining a numerical simulation with a physical experiment. A structure is thereby simulated under the assumption that a substructure’s response is well known and easily modelled while a given substructure is studied more accurately in a physical experiment. The technique has primarily been used within earthquake engineering but many other fields of engineering have utilized the method with benefit. However, these previous efforts have focused on structures with a simple boundary between the numerical and physical substructure i.e. few degrees of freedom. In this dissertation the main focus is to develop hybrid simulation for composite structures e.g. wind turbine blades where the boundary between the numerical model and the physical experiment is continues i.e. in principal infinite amount of degrees of freedom. This highly complicates the transfer system and the control and monitoring techniques in the shared boundary is therefore a key issue in this type of hybrid simulation. During the research, hybrid simulation platforms have been programmed capable of running on different time scales with advanced control and monitoring techniques at the shared boundary. The hybrid simulation programs have been tested on different simple composite structures and they have proven able to increase the accuracy in tests with a complex transfer system.

General information

State: Published
Organisations: Department of Mechanical Engineering, Solid Mechanics, Department of Wind Energy, Wind Turbine Structures and Component Design, Department of Civil Engineering, Section for Building Design, Section for Structural Engineering
Authors: Høgh, J. H. (Intern), Berggreen, C. (Intern), Branner, K. (Intern), Schmidt, J. W. (Intern), Stang, H. (Intern)
Number of pages: 136
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Publication information

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ISSN: 0903-1685
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Electronic versions:
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Relations

Projects:

Hybrid Simulation of Composite Structures
Publication: Research › Ph.D. thesis – Annual report year: 2017

Hybrid vortex simulations of wind turbines using a three-dimensional viscous-inviscid panel method

A hybrid filament-mesh vortex method is proposed and validated to predict the aerodynamic performance of wind turbinerotors and to simulate the resulting wake. Its novelty consists of using a hybrid method to accurately simulate the wakedownstream of the wind turbine while reducing the computational time used by the method. The proposed method
uses a hybrid approach, where the near wake is resolved by using vortex filaments, which carry the vorticity shed by the trailing edge of the blades. The interaction of the vortex filaments in the near vicinity of the wind turbine is evaluated using a direct calculation, whereas the contribution from the large downstream wake is calculated using a mesh-based method. The hybrid method is first validated in detail against the well-known MEXICO experiment, using the direct filament method as a comparison. The second part of the validation includes a study of the influence of the time-integration scheme used for evolving the wake in time, aeroelastic simulations of the National Renewable Energy Laboratory 5 MW wind turbine and an analysis of the central processing unit time showing the gains of using the hybrid filament-mesh method.

**General information**

State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Department of Mechanical Engineering, Fluid Mechanics, Coastal and Maritime Engineering
Authors: Ramos García, N. (Intern), Hejlesen, M. M. (Intern), Sørensen, J. N. (Intern), Walther, J. H. (Intern)
Pages: 1871-1889
Publication date: 2017
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Wind Energy
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ISSN (Print): 1095-4244
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- BFI (2018): BFI-level 2
- Web of Science (2018): Indexed yes
- BFI (2017): BFI-level 2
- Scopus rating (2017): CiteScore 3.18 SJR 1.051 SNIP 1.834
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 2
- Scopus rating (2016): CiteScore 3.37 SJR 1.079 SNIP 2.316
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 2
- Scopus rating (2015): SJR 1.201 SNIP 2.165 CiteScore 3.06
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 2
- Scopus rating (2014): SJR 1.209 SNIP 3.688 CiteScore 3.42
- Web of Science (2014): Indexed yes
- BFI (2013): BFI-level 2
- Scopus rating (2013): SJR 1.235 SNIP 2.486 CiteScore 2.75
- ISI indexed (2013): ISI indexed yes
- Web of Science (2013): Indexed yes
- BFI (2012): BFI-level 2
- Scopus rating (2012): SJR 1.062 SNIP 2.297 CiteScore 2.36
- ISI indexed (2012): ISI indexed yes
- Web of Science (2012): Indexed yes
- BFI (2011): BFI-level 2
- Scopus rating (2011): SJR 0.892 SNIP 2.582 CiteScore 2.49
- ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 2
- Scopus rating (2010): SJR 1.364 SNIP 2.026
- Web of Science (2010): Indexed yes
- BFI (2009): BFI-level 2
- Scopus rating (2009): SJR 0.885 SNIP 1.439
- Web of Science (2009): Indexed yes
- BFI (2008): BFI-level 2
- Scopus rating (2008): SJR 0.743 SNIP 1.555
- Web of Science (2008): Indexed yes
Hydrogen Decrepitation Press-Less Process Recycling of NdFeB sintered magnets

A Hydrogen Decrepitation Press-Less Process (HD-PLP) recycling method for recycling of anisotropic NdFeB magnets is demonstrated. The method combines hydrogen decrepitation (HD) disintegration of the initial magnet, powder sieving and the Press-Less Process (PLP), where hydride powder is sintered in a graphite mold. Coercivities up to 534 kA/m were obtained in porous samples based on powder size \( d < 100 \mu m \). Adding a ball milling step resulted in full density isotropic magnets for \( d > 100 \mu m \). The coercivity reached \( H_{ci} = 957 \) kA/m being 86 % of the original N48M material without addition of rare earth elements.

General information

State: Published
Authors: Xia, M. (Intern), Abrahamsen, A. B. (Intern), Bahl, C. (Intern), Veluri, B. (Ekstern), Søegaard, A. I. (Ekstern), Bøjsøe, P. (Ekstern)
Pages: 55-61
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information

Journal: Journal of Magnetism and Magnetic Materials
Volume: 441
ISSN (Print): 0304-8853
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SJR 0.786 SNIP 1.349 CiteScore 2.97
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.41 SJR 0.699 SNIP 1.181
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.73 SNIP 1.296 CiteScore 2.33
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.815 SNIP 1.423 CiteScore 2.07
Web of Science (2014): Indexed yes
In order to reveal the effect of hydrogen on the room-temperature plasticity of the titanium alloys TC4 and TC21, compression tests have been carried out at room temperature. Results show that an appropriate amount of hydrogen can improve the room-temperature plasticity of both the TC4 and TC21 alloys. The ultimate compression strain of the TC4 alloy containing a hydrogen concentration of 0.5 wt.% increases by 39% compared to the untreated material. For the TC21 alloy the ultimate compression strain is increased by 33% at a hydrogen concentration of 0.6 wt.%. The main reason for the improvement of hydrogen-induced room-temperature plasticity of the TC4 and TC21 alloys is discussed.

**General information**

State: Published

Organisations: Department of Wind Energy, Materials science and characterization, Hefei University of Technology, Anhui University
Identification of critical design load cases for a jacket supported offshore wind turbine

This paper identifies the most critical design load cases of ultimate load analysis for an offshore wind jacket foundation from IEC 61400-3 to understand the relative severity among different operation situation. A comprehensive design load cases for ultimate load analysis were simulated using the DTU Wind Energy aero-elastic code HAWC2. The superelement modelling was used to speed up the simulation. The modified INNWIND.EU reference jacket and DTU 10MW wind turbine were used as the reference model. A variety of critical design load cases were identified from all the investigated cases considering the bending moments at tower bottom and jacket mudline as the key design parameters for wind turbine and jacket foundation, respectively. It is shown that the hydrodynamic loading in severe sea state is the design drive load for jacket foundation with respect to the ultimate bending moment at the mudline.

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control
Authors: Wang, S. (Intern), Larsen, T. J. (Intern)
Pages: 257-265
Publication date: 2017

Identification of loading conditions resulting in roller slippage in gearbox bearings of large wind turbines

The dynamic loads on the rollers inside the bearings of large wind turbine gearboxes operating under transient conditions are presented with a focus on identifying conditions leading to slippage of rollers. The methodology was developed using a multi-body model of the drivetrain coupled with aeroelastic simulations of the wind turbine system. A 5 MW reference wind turbine is considered for which a three-stage planetary gearbox is designed on the basis of upscaling of an actual 750 kW gearbox unit. Multi-body dynamic simulations are run using the ADAMS software using a detailed model of the gearbox planetary bearings to investigate transient loads inside the planet bearing. It was found that assembly and pre-loading conditions have significant influence on the bearing’s operation. Also, the load distribution in the gearbox bearings strongly depends on wind turbine operation. Wind turbine start-up and shut-down under normal conditions are shown to induce roller slippage, as characterized by loss of contacts and impacts between rollers and raceways. The roller impacts occur under reduced initial pre-load on opposite sides of the load zone followed by stress variation, which can be one of the potential reasons leading to wear and premature bearing failures.

General information
State: Published
Organisations: Wind Turbines, Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Dabrowski, D. (Intern), Natarajan, A. (Intern)
Pages: 1365-1387
Publication date: 2017
Main Research Area: Technical/natural sciences
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Original language: English

Loss of Contact, Multi-body model, Planet bearing failure, Transient Conditions, Wind turbine drivetrain

DOIs:
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Publication: Research - peer-review › Journal article – Annual report year: 2017
Imaging of Composites by Helical X-Ray Computed Tomography
Understanding the fatigue damage mechanisms of composite materials used in wind turbine rotor blades could potentially enhance the reliability and energy efficiency of wind turbines by improving the structure design. In this paper, the fatigue damage propagating mechanisms of unidirectional glass fibre composites was characterised by helical X-ray CT. The staining approach was used and it was effective to enhance the visibility of thin matrix cracks and partly closed fibre breaks instead of widely opened cracks. Fibre breaks in the centre UD bundle were found to occur locally, instead of being evenly distributed along the 0° fibre direction after 500,000 cycles. The locations of these damage sites were found to be correlated with intersecting points of +/-80° backing bundles. At higher number of cycles, edge effect becomes dominant with extensive fibre breaks in the edge UD bundles and matrix cracks in the resin-rich region.

Impact of Innovation and Places on Corporate Governance the Case of Wind Turbine Production
We examine how corporate governance changes over the industrial life cycle when places commit firms to certain governance structures. Focus is on industries where a significant part of the economic value is created by technological knowledge changing the conditions for corporate financing. The article extends this view to include knowledge needed to accumulate governance capabilities. The board is a crucial governance institution emphasized in the study. We find that changes in this institution depend on shareholders’ concern regarding innovation management. We also find that boards are changed over time to improve the conversational exchange, which is attained by extending the boards with directors holding degrees in engineering. The main finding is that the most successful firms recruit board members from the geographic setting in which they were founded at all stages of the industrial life cycle. The Danish wind turbine industry serves as empirical evidence.

Impact of renewable energy uncertainty on electric power system reliability
We examine how corporate governance changes over the industrial life cycle when places commit firms to certain governance structures. Focus is on industries where a significant part of the economic value is created by technological knowledge changing the conditions for corporate financing. The article extends this view to include knowledge needed to accumulate governance capabilities. The board is a crucial governance institution emphasized in the study. We find that changes in this institution depend on shareholders’ concern regarding innovation management. We also find that boards are changed over time to improve the conversational exchange, which is attained by extending the boards with directors holding degrees in engineering. The main finding is that the most successful firms recruit board members from the geographic setting in which they were founded at all stages of the industrial life cycle. The Danish wind turbine industry serves as empirical evidence.
Impact of the interfaces for wind and wave modeling - interpretation using COAWST, SAR and point measurements

Air and sea interacts, where winds generate waves and waves affect the winds. This topic is ever relevant for offshore functions such as shipping, portal routines, wind farm operation and maintenance. In a coupled modeling system, the atmospheric modeling and the wave modeling interfere with each other through an interface. In most modeling system the interface is described through the roughness length. The roughness length is parameterized with the basic idea of the Charnock formulation while the coefficients could be functions of simply wind speed, or wave parameters. More advanced interfaces use the stress directly, thus avoiding the uncertainties caused by parameterizations. This study examines the efficiency of the wave impact transfer to the atmospheric modeling through the two types of interfaces, roughness length and stress, through the coupled-ocean-atmosphere-wave-sediment-transport (COAWST) modeling system. The roughness length has been calculated using seven schemes (Charnock, Fan, Oost, Drennen, Liu, Andreas, Taylor-Yelland). The stress approach is applied through a wave boundary layer model in SWAN. The experiments are done to a case where the Synthetic Aperture Radar (SAR) image shows the wind field affected by the coastal wave field. Point measurements from Horns Rev are used for data analysis and validation.

Impact of wind power plants on voltage control of power system

High penetration of renewable energy sources poses numerous challenges on stability and security of power systems. Wind power plants (WPPs) of considerable size when connected to a weak grid by long transmission line results in low short circuit ratio at the point of connection. This may result in both transient voltage fluctuations and poor steady-state voltage profile at the point of connection. In this paper, transient and steady-state voltage support from WPPs are investigated. Low voltage ride through capability of WPP is studied for two different control modes namely, V control and Q control, during transient voltage dips. Steady-state analysis is performed for stressed system conditions. Results are validated through simulation in a detailed power system model.
Impacts of offshore grid developments in the North Sea region on market values by 2050: How will offshore wind farms and transmission lines pay?

Increasing the integration of renewable energy in Northern and Central Europe markets is greatly influenced by the development of electricity transmission grid infrastructure. On the background of the fast development of offshore wind energy and its connection to the onshore electricity systems, a coordinated grid development in the North Sea may not only save costs for individual wind farms, but also deliver additional benefits through the provision of increased interconnection of electricity markets. The previous studies do not include offshore wind development with high ambition in the long term perspective and do not focus on the assessment of the specific effects on the economic value of offshore wind farms connected to Belgium, Norway, the UK, the Netherlands, and Germany (North Sea Link, Cobra Cable, Viking Link, Nord Link, BritNed and Nemo Link). This paper tries to shed some lights on the substantial differences in the expected economic exposure of wind power plants and transmission lines to the development of the electricity grid in the North Sea. Since details of the prospective energy system around the North Sea region shape these revenue expectations, we further develop and apply the energy model Balmorel. The tool is used to quantify effects of the implementation of a meshed offshore grid compared to a radial grid that connects wind farms in a non-coordinated fashion to the countries by 2050. The model runs conducted for the present paper show substantial variation of expectable market values of wind farms on hub level due to impacts of different options for grid structures. The results aim to inform the discussion on possibilities for the allocation of grid expansion costs to the different connected countries including Belgium, Denmark, Germany, the Netherlands, Norway and Britain.

General information
State: Published
Organisations: Department of Management Engineering, Systems Analysis, Department of Wind Energy, Integration & Planning, Tallinn University of Technology
Authors: Traber, T. (Intern), Koduvere, H. (Ekstern), Koivisto, M. J. (Intern)
Number of pages: 6
Publication date: 2017

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ISBN (Print): 978-1-5090-5499-2
BFI conference series: International Conference on the European Energy Market (8782594)
Main Research Area: Technical/natural sciences
Conference: 14th International Conference on the European Energy Market, Dresden, Germany, 06/06/2017 - 06/06/2017
DOIs: 10.1109/EEM.2017.7981945

Relations
Projects:
Impacts of offshore grid developments in the North Sea region on market values by 2050: How will offshore wind farms and transmission lines pay?
Source: PublicationPreSubmission
Source-ID: 134005605
Publication: Research - peer-review › Article in proceedings – Annual report year: 2017

Improved fixed point iterative method for blade element momentum computations
The blade element momentum (BEM) theory is widely used in aerodynamic performance calculations and optimization applications for wind turbines. The fixed point iterative method is the most commonly utilized technique to solve the BEM equations. However, this method sometimes does not converge to the physical solution, especially for the locations near the blade tip and root where the failure rate of the iterative method is high. The stability and accuracy of aerodynamic calculations and optimizations are greatly reduced due to this problem. The intrinsic mechanisms leading to convergence problems are addressed through both theoretical analysis and numerical tests. A term from the BEM equations equals to zero at a critical inflow angle is the source of the convergence problems. When the initial inflow angle is set larger than the critical inflow angle and the relaxation methodology is adopted, the convergence ability of the iterative method will be greatly enhanced. Numerical tests have been performed under different combinations of local tip speed ratio, local solidity, local twist and airfoil aerodynamic data. Results show that the simple iterative methods have a good convergence ability which will improve the aerodynamic or structural design of wind turbines.

General information
State: Published
Improved Load Shedding Scheme considering Distributed Generation

With high penetration of distributed generation (DG), the conventional under-frequency load shedding (UFLS) face many challenges and may not perform as expected. This article proposes new UFLS schemes, which are designed to overcome the shortcomings of traditional load shedding scheme. These schemes utilize directional relays, power flow through feeders, wind and PV measurements to optimally select the feeders to be disconnected during load shedding such that DG disconnection is minimized while disconnecting required amount of consumption. These different UFLS schemes are compared in terms of frequency response, amount of consumption and DG disconnected during load shedding.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning
Authors: Das, K. (Intern), Nitsas, A. (Intern), Altin, M. (Intern), Hansen, A. D. (Intern), Sørensen, P. E. (Intern)
Number of pages: 10
Pages: 515-524
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: IEEE Transactions on Power Delivery
Volume: 32
Issue number: 1
ISSN (Print): 0885-8977
Ratings:
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Scopus rating (2017): SNIP 2.211 SJR 1.814 CiteScore 4.52
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.47 SJR 1.634 SNIP 2.536
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.788 SNIP 2.587 CiteScore 3.96
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.508 SNIP 2.631 CiteScore 3.4
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.412 SNIP 2.769 CiteScore 3.51
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.222 SNIP 2.577 CiteScore 3.28
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.99 SNIP 2.242 CiteScore 2.89
ISI indexed (2011): ISI indexed yes
Improvement of grid frequency dynamic characteristic with novel wind turbine based on electromagnetic coupler

A synchronous generator is directly coupled to grid in the novel wind turbine drive train concept based on electromagnetic coupler (WT-EMC). Similarly to conventional power plants, WT-EMC has inherent (inertial) grid frequency support capability, albeit rather limited due to its configuration. Additional power should be generated in response to a grid frequency drop in order to improve the dynamic characteristic of the grid frequency. In this paper, a novel control strategy for WT-EMC to improve the dynamic characteristic of grid frequency is proposed. The principle is to detect active power imbalance in the grid and then rapidly regulate the output power of WT-EMC. Based on the calculated electromagnetic torque of the synchronous generator in WT-EMC acquired faster than the calculated grid frequency, the synchronous generator mechanical torque is controlled to track its electromagnetic torque to stabilize the rotor speed, therefore directly improving the grid frequency. The proposed control strategy effectiveness is firstly tested through simulations and then validated on a specially built experimental platform.
Improvement of TNO type trailing edge noise models

The paper describes an improvement of the so-called TNO model to predict the noise emission from aerofoil sections due to the interaction of the boundary layer turbulence with the trailing edge. The surface pressure field close to the trailing edge acts as source of sound in the TNO model. It is computed by solving a Poisson equation which includes flow turbulence cross correlation terms. Previously published TNO type models used the assumption of Blake to simplify the Poisson equation. This paper shows that the simplification should not be used. We present a new model which fully models the turbulence cross correlation terms. The predictions of the new model are in better agreement with measurements of the surface pressure and far field sound spectra. The computational cost of the new model is only slightly higher than the one of the TNO model, because we derived an analytical solution for the turbulence cross correlation terms.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design
Authors: Fischer, A. (Intern), Bertagnolio, F. (Intern), Aagaard Madsen, H. (Intern)
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Journal: European Journal of Mechanics B - Fluids
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Scopus rating (2017): SNIP 1.36 SJR 0.726 CiteScore 2.14
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.808 SNIP 1.414 CiteScore 2.07
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.8 SNIP 1.444 CiteScore 1.75
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.788 SNIP 1.57 CiteScore 1.8
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.847 SNIP 1.538 CiteScore 1.79
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.934 SNIP 1.609 CiteScore 1.86
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.712 SNIP 1.475 CiteScore 1.61
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.925 SNIP 1.476
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.086 SNIP 1.496
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.902 SNIP 1.338
Scopus rating (2007): SJR 0.93 SNIP 1.082
Scopus rating (2006): SJR 1.206 SNIP 1.343
Scopus rating (2005): SJR 1.299 SNIP 1.431
Individual fibre segmentation from 3D X-ray computed tomography for characterising the fibre orientation in unidirectional composite materials

The aim of this paper is to characterise the fibre orientation in unidirectional fibre reinforced polymers, namely glass and carbon fibre composites. The compression strength of the composite is related to the orientation of the fibres. Thus the orientation is essential when designing materials for wind turbine blades. The calculation of the fibre orientation distribution is based on segmenting the individual fibres from volumes that have been acquired through X-ray tomography. The segmentation method presented in this study can accurately extract individual fibres from low contrast X-ray scans of composites with high fibre volume fraction. From the individual fibre orientations, it is possible to obtain results which are independent of the scanning quality. The compression strength for both composites is estimated from the average fibre orientations and is found to be of the same order of magnitude as the measured values.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Department of Wind Energy, Composites and Materials Mechanics
Authors: Emerson, M. J. (Intern), Jespersen, K. M. (Intern), Dahl, A. B. (Intern), Conradsen, K. (Intern), Mikkelsen, L. P. (Intern)
Pages: 83–92
Publication date: 2017
Main Research Area: Technical/natural sciences

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Volume: 97
ISSN (Print): 1359-835X
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4.82 SJR 1.478 SNIP 2.146
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.532 SNIP 2.219 CiteScore 4.09
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.703 SNIP 2.568 CiteScore 4.08
BFI (2013): BFI-level 2
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ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.582 SNIP 2.752 CiteScore 3.36
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
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Scopus rating (2011): SJR 1.48 SNIP 2.557 CiteScore 3.23
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.599 SNIP 2.313
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.561 SNIP 2.03
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.441 SNIP 1.924
Scopus rating (2007): SJR 1.267 SNIP 2.227
Web of Science (2007): Indexed yes
Scopus rating (2005): SJR 1.133 SNIP 2.121
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.244 SNIP 1.718
Scopus rating (2003): SJR 1.203 SNIP 1.435
Scopus rating (2002): SJR 1.244 SNIP 1.534
Scopus rating (2001): SJR 1.431 SNIP 1.361
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.808 SNIP 1.337
Scopus rating (1999): SJR 0.829 SNIP 1.117
Original language: English
Polymer-matrix composites (PMCs), Strength, Non-destructive testing Misalignment
DOIs:

Relations
Projects:
Individual fibre segmentation from 3D X-ray computed tomography for characterising the fibre orientation in unidirectional composite materials
Source: Findit
Source-ID: 2351025373
Publication: Research - peer-review › Journal article – Annual report year: 2017

Inflow conditions and wake effects for wind turbines in forested terrain

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling, Wind turbine loads & control, Technical University of Denmark, Uppsala University
Authors: Dellwik, E. (Intern), Papetta, A. (Ekstern), Arnqvist, J. (Ekstern), Nielsen, M. (Intern), Larsen, T. J. (Intern)
Number of pages: 1
Publication date: 2017
Main Research Area: Technical/natural sciences
Electronic versions:
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Relations
Activities:
Inflow conditions and wake effects for wind turbines in forested terrain
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2017

Inflow conditions and wake effects for wind turbines in forested terrain
Influence of curing profile and fibre architecture on the fatigue resistance of composite materials for wind turbine blades

The fatigue performance of unidirectional glass fibre reinforced epoxy is found to be highly dependent on the manufacturing conditions, where a low manufacturing temperature, for the investigated wind turbine relevant composite material system, is found to improve the tension/tension fatigue life-time with a factor of 10 if compared with a corresponding laminate manufactured at a high manufacturing temperature. It should be noted that a low manufacturing temperature will increase the required mould time significantly and thereby influence the cost of the manufactured wind turbine blade. In addition, the thick laminates typically used in the root section of the wind turbine blades will experience significant exothermically generated temperature raise during the curing process increasing the local manufacturing temperature. The tension/tension fatigue life-time has been investigated using 3D x-ray computer tomography. Thereby, it has been found during ex-situ fatigue studies, that the fatigue failure mechanism is highly influenced by transverse cracking in the so-called backing bundles which is present in order to ease the handling during the dry fabric layup during wind turbine blade manufacturing. It is a failure mechanism which is judged to be highly influenced by the magnitude of the residual stresses exhibit in the matrix material and therefore also in the secondary oriented backing bundles. Using fibre Bragg grated optical fibres; the build-up of the cure-induced strains in the fibre-reinforcement has been investigated during a variety of curing profiles of the used epoxy material system. Thereby, it is possible to observe that even though the overall chemical shrinkage of the epoxy material system is independent on the chosen curing profile, the location of the gel-point and thereby the amount of shrinkage occurring in the solid state is highly influenced. During the study, it is therefore documented that even though a short mould time may be beneficial lowering the manufacturing cost, it has a drawback on the fatigue life time. In addition, it can be expected that the internal part of the thick laminates used in the root sections of a wind turbine blade has a lower fatigue resistance compared with the composite materials used elsewhere.

In Search of the Wind Energy Potential

The worldwide advancement of wind energy is putting high demands on a number of underlying technologies such as wind turbine aerodynamics, structural dynamics, gearbox design, electrical grid connections, and so on. As wind is the only fuel for wind power plants, naturally, wind-meteorology and wind-climatology are essential for any utilization of wind energy. This is what we are concerned about here with a view on what has happened in wind energy potential assessments in the last 25 years where the utilization of wind turbines in national power supply has accelerated and what is the perspective for future improvements of the assessment methods. We take as the starting point the methodology of The European Wind Atlas [I. Troen and E. L. Petersen, European Wind Atlas (Rise National Laboratory, Roskilde, Denmark, 1989)]. From there to the global wind atlas methodology [J. Badger et al., The New Worldwide Microscale Wind Resource Assessment Data on IRENA’s Global Atlas (The EUDP Global Wind Atlas, 2015)], and finally, the perspective for the current work with the New European Wind Atlas [E. L. Petersen et al., Energy Bull. 17, 34–39 (2014); Environ. Res.
In-situ Calibration of Ground-based Lidar Instrument

This report presents the result of the lidar in-situ calibration performed at DTU’s test site for large wind turbine at Østerild, Denmark. Calibration is here understood as the establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements. The comparison of the lidar measurements of the wind direction with that from wind vanes measurements are given for information only.
Installation report - Lidar
The report describes the installation, configuration and data transfer for the ground-based lidar. The unit is provided by a customer but is installed and operated by DTU while in this project.

Interfaces between a fibre and its matrix
The interface between a fibre and its matrix represents an important element in the characterization and exploitation of composite materials. Both theoretical models and analyses of experimental data have been presented in the literature since modern composite were developed and many experiments have been performed. A large volume of results for a wide range of composite systems exists, but rather little comparison and potential consistency have been reached for fibres and/or for matrices. Recently a materials mechanics approach has been presented to describe the interface by three parameters, the interfacial energy [J/m²], the interfacial frictional shear stress [MPa] and the mismatch strain [-] between fibre and matrix. The model has been used for the different modes of fibre pull-out and fibre fragmentation. In this paper it is demonstrated that the governing equations for the experimental parameters (applied load, debond length and relative fibre/matrix displacement) are rather similar for these test modes. A simplified analysis allows the direct determination of the three interface parameters from two plots for the experimental data. The complete analysis is demonstrated for steel fibres in polyester matrix. The analysis of existing experimental literature data is demonstrated for steel fibres in epoxy matrix and for tungsten wires in copper matrix. These latter incomplete analyses show that some results can be obtained even if all three experimental parameters are not recorded.
Interim (5 km) High-Resolution Wind Resource Map for South Africa

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling, Integration & Planning
Authors: Mortensen, N. G. (Intern), Hahmann, A. N. (Intern), Hansen, J. C. (Intern)
Number of pages: 29
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Interim High-Resolution Wind Resource Map for South Africa

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling, Integration & Planning
Authors: Mortensen, N. G. (Intern), Hansen, J. C. (Intern), Hahmann, A. N. (Intern)
Publication date: 2017
International Requirements for Large Integration of Renewable Energy Sources

Most European countries have concerns about the integration of large amounts of renewable energy sources (RES) into electric power systems, and this is currently a topic of growing interest. In January 2008, the European Commission published the 2020 package, which proposes committing the European Union to a 20% reduction in greenhouse gas emissions, to achieve a target of deriving 20% of the European Union's final energy consumption from renewable sources, and to achieve 20% improvement in energy efficiency both by the year 2020 [1]. Member states have different individual goals to meet these overall objectives, and they each need to provide a detailed roadmap describing how they will meet these legally binding targets [2]. At this time, RES are an indispensable part of the global energy mix, which has been partially motivated by the continuous increases in hydropower as well as the rapid expansion of wind and solar photovoltaic (PV). The International Energy Agency's 2012 edition of the World Energy Outlook stated that the rapid increases in RES integration are underpinned by falling technology costs as well as rising fossilfuel prices and carbon pricing, but RES integration is also encouraged by continued subsidies: from $88 billion globally in 2011 (compared to $523 billion in fossil-fuel subsidies in 2012 [3], with a share of $131 billion for electricity generation) to an estimated $240 billion in 2035 [4]. According to [3], in 2015 RES accounted for 22% of electricity generation, which was approximately the same level as gas and about one-half the level of coal.

General information

State: Published
Organisations: Department of Wind Energy, Integration & Planning, National Renewable Energy Laboratory, REpower Systems, University of Castilla–La Mancha
Authors: Molina-Garcia, A. (Ekstern), Hansen, A. D. (Intern), Muljadi, E. (Ekstern), Gevorgian, V. (Ekstern), Fortmann, J. (Ekstern), Gomez-Lazaro, E. (Ekstern)
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ISBN (Electronic): 9781785611636
Chapter: 2
Main Research Area: Technical/natural sciences
DOIs:
10.1049/PBPO098E
Publication: Research - peer-review › Book chapter – Annual report year: 2017

Interpreting wind energy resource visualisations for South Africa

General information
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Organisations: Department of Wind Energy, Resource Assessment Modelling, Integration & Planning
Authors: Hahmann, A. N. (Intern), Mortensen, N. G. (Intern), Hansen, J. C. (Intern)
Publication date: 2017

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Media of output: Power Point Presentation
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
WindAC_2017_Hahmann.pdf
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Publication: Research › Sound/Visual production (digital) – Annual report year: 2018
Investigation of sizing - from glass fibre surface to composite interface

Composites are far from a new invention, and have through time taken many shapes. From a simple hay clay house to advanced nano particle containing composites for advanced material applications. Since the industrialisation in the late 1800’s the use of fibre reinforced composites have increased significantly. The usage span wide, from furniture and car components to construction materials. Even though, the concept of composites is well known and widely applied, the fundamental principles of the interaction of the constituents, in the composites are still not fully understood. This thesis is a part of Danish Center for Composite Structures and Materials for wind turbine blades who work towards improving composites. Since wind turbine blades are the basis of the DCCSM it is the materials used here that are the focus, explicitly glass fibres and epoxy matrix. Glass fibre composites greatly dominate the fibre reinforced composite industry due to the combination of their relatively high stiffness and low production cost. During manufacturing the glass fibres are applied a coating, called sizing, for protection of the fibres and for compatibility with the polymer matrix. The sizing is located at the interface between glass fibre and polymer matrix. Despite the importance of this interface, in regards to the stress transfer, which is responsible for the reinforcing effect of fibres, very little research address how the interface is affected and how it can be controlled. This thesis covers an analysis of the sizing from the glass fibre surface to the interface in composites. Through soxhlet extraction with acetone it was possible to remove a part of the sizing from the glass fibres for analysis. By burning off the sizing at 565 °C a higher mass loss was obtained than from the extraction, indicating that a part of the sizing might be covalently bonded to the glass fibre surface. The investigation of the sizing extract by ATR-FTIR and TGA-MS revealed the presence of a DGEBA film former as one of the components of the sizing. Glass plates were successfully coated with the organosilanes APTMS and GPTMS in order to mimic the surface of the glass fibres. The non-planar surface of glass fibres yields difficulties in some analysis e.g. determination of contact angle. The plates displayed a clear difference in contact angle after being coated towards a more polar surface. An investigation of the adhesion between fibre and matrix analysed by microbond testing and the determination of the IFSS was conducted varying the amine:epoxide group ratio in the matrix and the testing temperature. IFSS was found to be affected by both parameters. A maximum IFSS was observed around the stoichiometric ratio of amine:epoxide group (1:1). The presence of amine or epoxide groups in the sizing will affect the ratio at the interface and in all probability also the IFSS with a decrease in IFSS as the result. Furthermore, the testing temperature influenced the IFSS. The highest values were obtained at room temperature. Above the glass transition temperature the dependency of the amine:epoxide group ratio changed to become linear. Two different microbond setups were used for the determination of the IFSS and a difference was detected. It was explained by the difference in loading procedure; one had constant strain rate and the other constant load rate. Additionally the duration of the microbond test might also influence the determination of the IFSS. The influence on the mechanical properties stiffness, strength and J-integral by changes in the chemistry of the interface was investigated. The stiffness of single glass fibres increased after the removal of sizing by extraction but also when the sizing was removed by burning. This could partly be explained by the sizing being less dense than the glass fibres. For the burned glass fibres compactment of the glass structure also yields an increase in stiffness. The fibre strength was less affected by the extraction of sizing but burning drastically decreased the strength. The enlargement of surface flaws after the removal of the protective sizing is given as the cause of the decrease in strength. Coating of fibres after extraction of the original sizing by the organosilane GPTMS resulted only in insignificant changes of stiffness and strength of single glass fibres. However the effect on the adhesion measured by the J-integral was remarkable. Small scale specimens were successfully used for the DCB testing and the determination of the J-integral. The GPTMS modified fibres displayed significant higher interface adhesion in comparison to the fibres with the original sizing. From this it had been proved that the original sizing is far from the optimal when it comes to facilitating a strong adhesion between glass fibre and matrix.
Large Eddy Simulation of an SD7003 Airfoil: Effects of Reynolds number and Subgrid-scale modeling: Paper

This paper presents results of a series of numerical simulations in order to study aerodynamic characteristics of the low Reynolds number Selig-Donovan airfoil, SD7003. Large Eddy Simulation (LES) technique is used for all computations at chord-based Reynolds numbers 10,000, 24,000 and 60,000 and simulations have been performed to primarily investigate the role of sub-grid scale (SGS) modeling on the dynamics of flow generated over the airfoil, which has not been dealt with in great detail in the past. It is seen that simulations are increasingly getting influenced by SGS modeling with increasing the Reynolds number, and the effect is visible even at a relatively low chord-Reynolds number of 60,000. Among the tested models, the dynamic Smagorinsky gives the poorest predictions of the flow, with overprediction of lift and a larger separation on airfoils suction side. Among various models, the implicit LES offers closest pressure distribution predictions compared with literature.
Large-Eddy Simulation of turbine wake in complex terrain: Paper
We present Large-Eddy Simulation results of a turbine wake in realistic complex terrain with slopes above 0.5. By comparing simulations including and without the wind turbine we can estimate the induction factor, $a$, and we show how the presence of a strong recirculation zone in the terrain dictates the positioning of the wake. This last finding is in contrast to what would happen in gentle terrain with no substantial increase of turbulent kinetic energy in the terrain induced wakes.

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling , Aerodynamic design, National Center for Atmospheric Research
Authors: Berg, J. (Intern), Troldborg, N. (Intern), Sørensen, N. N. (Intern), Patton, E. G. (Ekstern), Sullivan, P. P. (Ekstern)
Publication date: 2017

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Volume: 854
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ISSN: 1742-6596
Main Research Area: Technical/natural sciences
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Source: FindIt
Source-ID: 2371467219
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LIDAR Correlation to Extreme Flapwise Moment : Gust Impact Prediction Time and Feedforward Control
A Conventional wind turbine controller uses feedback parameters reacting to wind disturbances after they have already impacted the rotor. LIDARs are able to measure the wind speed before it reaches the wind turbine rotor. These anticipated values can be used in control systems designed to reduce turbine loads. This report is focused on gust prediction events, based on nacelle mounted LIDAR measurements, which lead to large blade flapwise moments. The prediction could be used as a mitigation system decreasing the loading and extending the turbine lifetime. The data obtained from the UniTTe project (www.unitte.dk) is used in this task. The measurements come from three different acquisition systems: a met mast, an Avent 5 beam LIDAR and a series of sensors installed on a SWT-2.3MW-93. The turbine is owned by Vattenfall and is placed in Nørrekær Enge. The impact of wind gusts on the blade root bending moment will be studied. In this report, first the measurement data is synchronized and second a sub-set of cases are chosen based on the wind turbine status, mean wind direction and cause of the blade root bending moment peak. Then, the LIDAR measurements are compared to the met mast and wind turbine loads. Finally, a discussion of the prediction accuracy of the current LDIAR set-up and some aeroelastic simulations are performed.

General information
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Organisations: Department of Wind Energy, Wind turbine loads & control
Authors: Meseguer Urban, A. (Intern), Hansen, M. H. (Intern)
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Volume: 156
Main Research Area: Technical/natural sciences
Electronic versions:
LIDAR_Correlation_to_Extreme_Flapwise_Moment.pdf
Source: PublicationPreSubmission
Source-ID: 140345170
Lidars for Wind Tunnels - an IRPWind Joint Experiment Project
Measurement campaigns with continuous-wave Doppler Lidars (Light detection and ranging) developed at DTU Wind Energy in Denmark were performed in two very different wind tunnels. Firstly, a measurement campaign in a small icing wind tunnel chamber at VTT in Finland was performed with high frequency measurements for increasing the understanding of the effect of in-cloud icing conditions on Lidar signal dynamics. Secondly, a measurement campaign in the relatively large boundary-layer wind tunnel at NTNU in Norway was performed in the wake of a scaled test turbine in the same configuration as previously used in blind test comparisons for wind turbine wake modelers. These Lidar measurement activities constitute the Joint Experiment Project's L4WT - Lidars for Wind Tunnels, with applications to wakes and atmospheric icing in a prospective Nordic Network with the aim of gaining and sharing knowledge about possibilities and limitations with lidar instrumentation in wind tunnels, which was funded by the IRPWind project within the community of the European Energy Research Alliance (EERA) Joint Programme on Wind Energy.

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Test and Measurements, SINTEF Energy Research, Norwegian University of Science and Technology, VTT - Technical Research Centre of Finland
Authors: Sjöholm, M. (Intern), Vignaroli, A. (Intern), Angelou, N. (Intern), Nielsen, M. B. (Intern), Mann, J. (Intern), Mikkelsen, T. K. (Intern), Bolstad, H. C. (Ekstern), Merz, K. O. (Ekstern), Sætran, L. R. (Ekstern), Mühle, F. V. (Ekstern), Tiihonen, M. (Ekstern), Lehtomäki, V. (Ekstern)
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BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.44 SJR 0.495 SNIP 0.799
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.16 SJR 0.464 SNIP 0.598
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.359 SNIP 0.562 CiteScore 0.92
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.429 SNIP 0.807 CiteScore 1.09
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.42 SNIP 0.778 CiteScore 1.02
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
Scopus rating (2012): SJR 0.411 SNIP 0.55 CiteScore 1.08
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
Scopus rating (2011): SJR 0.877 SNIP 1.45 CiteScore 2.42
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.416 SNIP 0.91
Web of Science (2009): Indexed yes
Original language: English
Lidar, Lidic, WindScanner, Wind Tunnel, Icing Conditions, Wind Turbine Wake, Blind test
Electronic versions:
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DOIs:
10.1016/j.egypro.2017.10.358
Source: FindIt
Source-ID: 2394200561
Publication: Research - peer-review » Conference article – Annual report year: 2017
Load Measurements
The report describes load measurements carried out on a given wind turbine. The aim of the measurement program regarding the loads on the turbine is to verify the basic characteristics of the wind turbine and loads on the blades, the rotor and the tower, using [Ref 1], [Ref 2] and [Ref 3]. Regarding the fatigue loads, the rotor, blades and tower moments are presented. The fatigue loads are evaluated using rainflow counting described in detail in Ref. [1]. The 1Hz equivalent load ranges are calculated at different wind speeds. All information regarding the instrumentation is collected in [Ref 4] and [Ref 6].

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Authors: Federici, P. (Intern), Kock, C. W. (Intern)
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Publication: Research › Report – Annual report year: 2017
Load Measurements
The report describes Load measurements carried out on a given wind turbine. The aim of the measurement program regarding the loads on the turbine is to verify the basic characteristics of the wind turbine and loads on the blades, the rotor and the tower, using [Ref 1], [Ref2] and [Ref 3]. Regarding the fatigue loads, the rotor, blades and tower moments are presented. The fatigue loads are evaluated using rainflow counting described in detail in Ref. [1]. The 1Hz equivalent load ranges are calculated at different wind speeds. All information regarding the instrumentation is collected in [ref 4] and [ref 6].

General information
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Organisations: Department of Wind Energy, Test and Measurements
Authors: Federici, P. (Intern), Vesth, A. (Intern)
Number of pages: 218
Publication date: 2017

Loads in wind farms under non-neutral ABL stability conditions: A full-scale validation study of the DWM model.
The purpose of this study is twofold: To validate a generalized version of the DWM approach for load prediction under non-neutral atmospheric stability conditions, and to demonstrate the importance of atmospheric stability for wind turbines operating in wind farm conditions.

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control, Fluid Mechanics
Authors: Larsen, G. C. (Intern), Larsen, T. J. (Intern), Hansen, K. S. (Intern)
Number of pages: 2
Publication date: 2017
Event: Abstract from International Conference on Future Technologies for Wind Energy
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Main Research Area: Technical/natural sciences
Electronic versions:
AbstractTemplate_Boulder2017_final_2.pdf
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2017
Loads in wind farms under non-neutral ABL stability conditions: A full-scale validation study of the DWM model.
The purpose of this study is twofold: To validate a generalized version of the DWM approach for load prediction under non-neutral atmospheric stability conditions, and to demonstrate the importance of atmospheric stability for wind turbines operating in wind farm conditions.

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control, Resource Assessment Modelling , Fluid Mechanics
Authors: Larsen, G. C. (Intern), Larsen, T. J. (Intern), Ott, S. (Intern), Hansen, K. S. (Intern)
Publication date: 2017

Publication information
Media of output: Power Point Presentation
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
Presentation_final_3.pdf
Publication: Research › Sound/Visual production (digital) – Annual report year: 2017

Local microstructure and flow stress in deformed metals
The microstructure and flow stress of metals are related through many well-known strength-structure relationships based on structural parameters, where grain size and dislocation density are examples. In heterogeneous structures, the local stress and strain are important as they will affect the bulk properties. A microstructural method is presented which allows the local stress in a deformed metal to be estimated based on microstructural parameters determined by an EBSD analysis. These parameters are the average spacing of deformation introduced boundaries and the fraction of high angle boundaries. The method is demonstrated for two heterogeneous structures: (i) a gradient (sub)surface structure in steel deformed by shot peening; (ii) a heterogeneous structure introduced by friction between a tool and a workpiece of aluminum. Flow stress data are calculated based on the microstructural analysis, and validated by hardness measurement and 2D numerical simulations. A good agreement is found over a plastic strain range from ~1 to 5.

General information
State: Published
Organisations: Department of Wind Energy, Materials science and characterization, Department of Mechanical Engineering, Manufacturing Engineering
Authors: Zhang, X. (Intern), Hansen, N. (Intern), Nielsen, C. V. (Intern)
Number of pages: 7
Publication date: 2017
Conference: 38th Risø International Symposium on Materials Science, Roskilde, Denmark, 04/09/2017 - 04/09/2017
Main Research Area: Technical/natural sciences

Publication information
Journal: I O P Conference Series: Materials Science and Engineering
Volume: 219
Article number: 012053
ISSN (Print): 1757-8981
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.49 SJR 0.201 SNIP 0.573
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.39 SJR 0.197 SNIP 0.535
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.197 SNIP 0.361 CiteScore 0.22
Scopus rating (2014): SJR 0.206 SNIP 0.362 CiteScore 0.18
Scopus rating (2013): SJR 0.205 SNIP 0.287 CiteScore 0.16
ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 0.183 SNIP 0.257 CiteScore 0.14
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.23 SNIP 0.355 CiteScore 0.1
ISI indexed (2011): ISI indexed no
Loss of efficiency in a coaxial arrangement of a pair of wind rotors

The efficiency of a pair of wind turbines is experimentally investigated for the case when the model of the second rotor is coaxially located in the wake of the first one. This configuration implies the maximum level of losses in wind farms, as in the rotor wakes, the deceleration of the freestream is maximum. As a result of strain gauge measurements, the dependences of dimensionless power characteristics of both rotors on the distances between them were determined for different modes at different tip speed ratios. The obtained results are of interest for further development of aerodynamics of wind turbines, for optimizing the work of existing wind farms and reducing their power losses due to interactions with wakes of other wind turbines during design and calculation.
Marine wind profiles measured by a wind-lidar – ability of WRF predict marine wind profiles

General information
State: Published
Organisations: Department of Wind Energy, National Institute of Meteorology and Hydrology
Authors: Batchvarova, E. (Ekstern), Gryning, S. (Intern)
Publication date: 2017

Host publication information
Title of host publication: EMS Annual Meeting Abstracts
Volume: 14
Article number: 775
Main Research Area: Technical/natural sciences
Electronic versions:
EMS2017_775.pdf

Relations
Activities:
Marina wind profiles measured by a wind lidar - ability of WRF to predict marine wind profiles
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2017

Materials for Wind Turbine Blades: An Overview
A short overview of composite materials for wind turbine applications is presented here. Requirements toward the wind turbine materials, loads, as well as available materials are reviewed. Apart from the traditional composites for wind turbine blades (glass fibers/epoxy matrix composites), natural composites, hybrid and nanoengineered composites are discussed. Manufacturing technologies for wind turbine composites, as well their testing and modelling approaches are reviewed.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics, Wind Turbine Structures and Component Design
Authors: Mishnaevsky, L. (Intern), Branner, K. (Intern), Petersen, H. N. (Intern), Beauson, J. (Intern), McGugan, M. (Intern), Sørensen, B. F. (Intern)
Number of pages: 24
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Materials
Volume: 10
Issue number: 11
ISSN (Print): 1996-1944
Ratings:
Web of Science (2018): Indexed yes
Scopus rating (2017): CiteScore 3.02 SJR 0.732 SNIP 1.285
Web of Science (2017): Indexed Yes
Scopus rating (2016): CiteScore 3.26 SJR 0.838 SNIP 1.495
Web of Science (2016): Indexed yes
Scopus rating (2015): SJR 0.83 SNIP 1.457 CiteScore 3.11
Scopus rating (2014): SJR 0.767 SNIP 1.229 CiteScore 2.69
Web of Science (2014): Indexed yes
Scopus rating (2013): SJR 1.001 SNIP 1.631 CiteScore 3.12
ISI indexed (2013): ISI indexed yes
Scopus rating (2012): SJR 0.841 SNIP 1.465
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.651 SNIP 1.212
General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Test and Measurements, CNRM Centre National de Recherches Meteorologiques, Finnish Meteorological Institute
Number of pages: 28
Pages: 29-56
Publication date: 2017

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Title of host publication: Renewable Energy Forecasting: From Models to Applications
Publisher: Woodhead Publishing
Editor: Kariniotakis, G.
ISBN (Print): 978-0-08-100504-0
ISBN (Electronic): 978-0-08-100505-7
Chapter: 2
Series: Woodhead Publishing Series in Energy
Main Research Area: Technical/natural sciences
DOIs:
10.1016/B978-0-08-100504-0.00002-0
Publication: Research - peer-review › Book chapter – Annual report year: 2017

Measurements of surface-layer turbulence in a wide norwegian fjord using synchronized long-range doppler wind lidars
Three synchronized pulsed Doppler wind lidars were deployed from May 2016 to June 2016 on the shores of a wide Norwegian fjord called Bjørnafjord to study the wind characteristics at the proposed location of a planned bridge. The purpose was to investigate the potential of using lidars to gather information on turbulence characteristics in the middle of a wide fjord. The study includes the analysis of the single-point and two-point statistics of wind turbulence, which are of major interest to estimate dynamic wind loads on structures. The horizontal wind components were measured by the intersecting scanning beams, along a line located 25m above the sea surface, at scanning distances up to 4.6km. For a mean wind velocity above 8m·s⁻¹, the recorded turbulence intensity was below 0.06 on average. Even though the along-beam spatial averaging leads to an underestimated turbulence intensity, such a value indicates a roughness length much lower than provided in the European standard EN 1991-1-4:2005. The normalized spectrum of the along-wind component was compared to the one provided by the Norwegian Petroleum Industry Standard and the Norwegian Handbook for bridge design N400. A good overall agreement was observed for wave-numbers below 0.02m⁻¹. The along-beam spatial averaging in the adopted set-up prevented a more detailed comparison at larger wave-numbers, which challenges the study of wind turbulence at scanning distances of several kilometres. The results presented illustrate the need to complement lidar data with point-measurement to reduce the uncertainties linked to the atmospheric stability and the spatial averaging of the lidar probe volume. The measured lateral coherence was associated with a decay coefficient larger than expected for the along-wind component, with a value around 21 for a mean wind velocity bounded between 10m·s⁻¹ and 14m·s⁻¹, which may be related to a stable atmospheric stratification.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, University of Stavanger, Reykjavik University, Christian Michelsen Research AS
Authors: Cheynet, E. (Ekstern), Jakobsen, J. B. (Ekstern), Snæbjörnsson, J. (Ekstern), Mann, J. (Intern), Courtney, M. (Intern), Lea, G. (Intern), Svardal, B. (Ekstern)
Measurement System & Calibration report
This Measurement System & Calibration report is describing DTU's measurement system installed at a specific wind turbine. A part of the sensors has been installed by others, the rest of the sensors have been installed by DTU. The results of the measurements, described in this report, are only valid for the specific wind turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Federici, P. (Intern), Vesth, A. (Intern)
Number of pages: 260
Publication date: 2017

Bibliographical note
This is an internal report and therefore not available in full text. Please contact author's or director of author's department for further information.
Publication: Research › Report – Annual report year: 2017
Measurement System & Calibration report
This Measurement System & Calibration report is describing DTU's measurement system installed at a specific wind turbine. A part of the sensors has been installed by others, the rest of the sensors have been installed by DTU. The results of the measurements, described in this report, are only valid for the specific wind turbine

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Kock, C. W. (Intern), Federici, P. (Intern)
Number of pages: 183
Publication date: 2017

Publication information
Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy WTT I
Number: 1186
Main Research Area: Technical/natural sciences

Bibliographical note
This is an internal report and therefore not available in full text. Please contact author's or director of author's department for further information.
Publication: Research › Report – Annual report year: 2017
Measurement System & Calibration report
This Measurement System & Calibration report is describing DTU's measurement system installed at a specific wind turbine. A part of the sensors has been installed by others, the rest of the sensors have been installed by DTU. The results of the measurements, described in this report, are only valid for the specific wind turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Kock, C. W. (Intern), Federici, P. (Intern)
Number of pages: 167
Publication date: 2017

Publication information
Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy WTT I
Number: 1179
Main Research Area: Technical/natural sciences

Bibliographical note
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Publication: Research › Report – Annual report year: 2017

Measurement System & Calibration report
This Measurement System & Calibration report is describing DTU's measurement system installed at a specific wind turbine. A part of the sensors has been installed by others, the rest of the sensors have been installed by DTU. The results of the measurements, described in this report, are only valid for the specific wind turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Gómez Arranz, P. (Intern), Georgieva Yankova, G. (Intern)
Number of pages: 94
Publication date: 2017

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Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy WTT I
Number: 1186
Main Research Area: Technical/natural sciences

Bibliographical note
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Publication: Research › Report – Annual report year: 2017

Measurement System & Calibration report
This Measurement System & Calibration report is describing DTU's measurement system installed at a specific wind turbine. A part of the sensors has been installed by others, the rest of the sensors have been installed by DTU. The results of the measurements, described in this report, are only valid for the specific wind turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Kock, C. W. (Intern), Federici, P. (Intern)
Number of pages: 249
Publication date: 2017

Publication information
Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy WTT I
Number: 1215
Main Research Area: Technical/natural sciences

Bibliographical note
Mechanical properties of biaxially strained poly(L-lactide) tubes: Strain rate and temperature dependence

Poly(L-lactide) (PLLA) is a bioabsorbable polymer with high stiffness and strength compared to the other commercially available bioabsorbable polymers. The properties of PLLA can be improved by straining, causing deformation-mediated molecular orientation. PLLA tubes were biaxially strained above their T_g for improvement of their strength, in a two-step process (sequential straining). Mechanical properties and crystal morphology were investigated as a function of processing strain rate and temperature. DSC revealed that a low processing strain rate allows molecular chain relaxation in the direction of strain and the crystallization is suppressed. Faster strain rates on the other hand suppress chain relaxation, and results in crystalline tubes. The mechanical properties are influenced by both processing strain rate and temperature. Low strain rates allow chain relaxation resulting in the lowest strength and stiffness, whereas a larger stiffness and strength is achieved by increasing strain rate and temperature. Isotropic mechanical properties are only observed at high processing strain rates.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Amphiphilic Polymers in Biological Sensing, Department of Energy Conversion and Storage, Imaging and Structural Analysis, Department of Wind Energy, Composites and Materials Mechanics, Mixed Conductors
Number of pages: 6
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Applied Polymer Science
Volume: 134
Issue number: 33
Article number: 45192
ISSN (Print): 0021-8995
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.87 SJR 0.543 SNIP 0.742
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.73 SJR 0.588 SNIP 0.792
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.587 SNIP 0.846 CiteScore 1.74
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.664 SNIP 0.972 CiteScore 1.76
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.629 SNIP 1.085 CiteScore 1.71
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.657 SNIP 1.075 CiteScore 1.57
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.604 SNIP 0.969 CiteScore 1.45
ISI indexed (2011): ISI indexed yes
Medium fidelity modelling of loads in wind farms under non-neutral ABL stability conditions – a full-scale validation study: Paper

The aim of the present paper is to demonstrate the capability of medium fidelity modelling of wind turbine component fatigue loading, when the wind turbines are subjected to wake affected non-stationary flow fields under non-neutral atmospheric stability conditions. To accomplish this we combine the classical Dynamic Wake Meandering model with a fundamental conjecture stating: Atmospheric boundary layer stability affects primary wake meandering dynamics driven by large turbulent scales, whereas wake expansion in the meandering frame of reference is hardly affected. Inclusion of stability (i.e. buoyancy) in description of both large- and small scale atmospheric boundary layer turbulence is facilitated by a generalization of the classical Mann spectral tensor, which consistently includes buoyancy effects. With non-stationary wind turbine inflow fields modelled as described above, fatigue loads are obtained using the state-of-the art aeroelastic model HAWC2. The Lillgrund offshore wind farm (WF) constitute an interesting case study for wind farm model validation, because the WT interspacing is small, which in turn means that wake effects are significant. A huge data set, comprising 5 years of blade and tower load recordings, is available for model validation. For a multitude of wake situations this data set displays a considerable scatter, which to a large degree seems to be caused by atmospheric boundary layer stability effects. Notable is also that rotating wind turbine components predominantly experience high fatigue loading for stable stratification with significant shear, whereas high fatigue loading of non-rotating wind turbine components are associated with unstable atmospheric boundary layer stratification.

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control, University of Agder
Authors: Larsen, G. C. (Intern), Larsen, T. J. (Intern), Chougule, A. (Ekstern)
Number of pages: 10
Publication date: 2017
Mesoscale to microscale wind farm flow modeling and evaluation

The increasing size of wind turbines, with rotors already spanning more than 150m diameter and hub heights above 100m, requires proper modeling of the atmospheric boundary layer (ABL) from the surface to the free atmosphere. Furthermore, large wind farm arrays create their own boundary layer structure with unique physics. This poses significant challenges to traditional wind engineering models that rely on surface-layer theories and engineering wind farm models to simulate the flow in and around wind farms. However, adopting an ABL approach offers the opportunity to better integrate wind farm design tools and meteorological models. The challenge is how to build the bridge between atmospheric and wind engineering model communities and how to establish a comprehensive evaluation process that identifies relevant physical phenomena for wind energy applications with modeling and experimental requirements. A framework for model verification, validation, and uncertainty quantification is established to guide this process by a systematic evaluation of the modeling system at increasing levels of complexity. In terms of atmospheric physics, 'building the bridge' means developing models for the so-called 'terra incognita,' a term used to designate the turbulent scales that transition from mesoscale to microscale. This range of scales within atmospheric research deals with the transition from parameterized to resolved turbulence and the improvement of surface boundary-layer parameterizations. The coupling of meteorological and wind engineering flow models and the definition of a formal model evaluation methodology, is a strong area of research for the next generation of wind conditions assessment and wind farm and wind turbine design tools. Some fundamental challenges are identified in order to guide future research in this area.
Methodology for obtaining wind gusts using Doppler lidar
A new methodology is proposed for scaling Doppler lidar observations of wind gusts to make them comparable with those observed at a meteorological mast. Doppler lidars can then be used to measure wind gusts in regions and heights where traditional meteorological mast measurements are not available. This novel method also provides estimates for wind gusts at arbitrary gust durations, including those shorter than the temporal resolution of the Doppler lidar measurements. The input parameters for the scaling method are the measured wind-gust speed as well as the mean and standard deviation of the horizontal wind speed. The method was tested using WindCube V2 Doppler lidar measurements taken next to a 100 m high meteorological mast. It is shown that the method can provide realistic Doppler lidar estimates of the gust factor, i.e. the ratio of the wind-gust speed to the mean wind speed. The method reduced the bias in the Doppler lidar gust factors from 0.07 to 0.03 and can be improved further to reduce the bias by using a realistic estimate of turbulence. Wind gust measurements are often prone to outliers in the time series, because they represent the maximum of a (moving-averaged) horizontal wind speed. To assure the data quality in this study, we applied a filtering technique based on spike detection to remove possible outliers in the Doppler lidar data. We found that the spike detection-removal method clearly improved the wind-gust measurements, both with and without the scaling method. Spike detection also outperformed the traditional Doppler lidar quality assurance method based on carrier-to-noise ratio, by removing additional unrealistic outliers present in the time series.

General information
State: Published
Organisations: Department of Wind Energy, Finnish Meteorological Institute, University of Reading
Authors: Suomi, I. (Ekstern), Gryning, S. (Intern), O'Connor, E. J. (Ekstern), Vihma, T. (Ekstern)
Number of pages: 12
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Quarterly Journal of the Royal Meteorological Society
Volume: 143
Issue number: 705
ISSN (Print): 0035-9009
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 1.306 SJR 2.258 CiteScore 3.1
Micromechanical model of the single fiber fragmentation test
A shear-lag model is developed for the analysis of single fiber fragmentation tests for the characterization of the mechanical properties of the fiber/matrix interface in composite materials. The model utilizes the relation for the loss in potential energy of Budiansky, Hutchinson and Evans. The model characterizes the interface in terms of an interfacial fracture energy and a frictional sliding shear stress. Results are obtained in closed analytical form. An experimental approach is proposed for the determination of the interfacial fracture energy and the frictional shear stress from simultaneously obtained data for the applied strain, the opening of a broken fiber and the associated debond length. The residual stresses are obtained as a part of the approach and enables the determination of in-situ fiber strength.
Microstructural and hardness gradients in Cu processed by high pressure surface rolling

The surface of an annealed Cu plate was processed by a high pressure surface rolling (HPSR) process. It is found that the deformed surface layer in the Cu plate after HPSR can be as thick as 2 mm and is characterized by a gradient microstructure, with grain sizes varying from the nanoscale in the topmost surface to the microscale in the bulk. The hardness varies from 1.37 GPa at the topmost surface to about 0.6 GPa in the coarse-grained matrix. The results of the investigation demonstrate that the HPSR process shows good potential for the generation of thick gradient microstructures on the surface of bulk metallic materials.
Microstructure and mechanical strength of near- and sub-micrometre grain size copper prepared by spark plasma sintering

Spark plasma sintering (SPS) has been used to prepare fully dense samples of copper in a fully recrystallized condition with grain sizes in the near- and sub-micrometre regime. Two synthesis routes have been investigated to achieve grain size control: (i) SPS at different temperatures from 800 to 1000 °C, and (ii) SPS at 800 °C followed by annealing at temperatures from 950 to 1050 °C. By use of an initial spherical powder with an average particle diameter of ≈ 0.5 μm, samples with average grain sizes in the range from 0.5 to 3 μm have been prepared. Microstructural examination based on both transmission electron microscope, and on electron back-scatter diffraction studies, confirms the samples are in a nearly fully recrystallized condition, with grains that are dislocation-free, and have a random texture, with a high fraction of high angle boundaries. The mechanical strength of the samples has been probed using hardness measurements and tensile testing, revealing an enhanced strength for samples with grain sizes less than ≈ 1 μm.

General information
State: Published
Organisations: Department of Wind Energy, Materials science and characterization, Tsinghua University
Authors: Zhu, K. N. (Ekstern), Godfrey, A. (Ekstern), Hansen, N. (Intern), Zhang, X. (Intern)
Number of pages: 9
Pages: 95-103
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Materials & Design
Volume: 117
ISSN (Print): 0264-1275
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 5.16 SJR 1.82 SNIP 2.424
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.9 SJR 1.76 SNIP 2.547
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.844 SNIP 2.623 CiteScore 4.51
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 2.364 SNIP 3.403 CiteScore 4.36
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 2.024 SNIP 3.215 CiteScore 3.8
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.963 SNIP 3.171 CiteScore 3.31
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.387 SNIP 2.501 CiteScore 2.63
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.058 SNIP 1.845
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.931 SNIP 1.808
Modal Properties and Stability of Bend-Twist Coupled Wind Turbine Blades

Coupling between bending and twist has a significant influence on the aeroelastic response of wind turbine blades. The coupling can arise from the blade geometry (e.g. sweep, prebending or deflection under load) or from the anisotropic properties of the blade material. Bend-twist coupling can be utilised to reduce the fatigue loads of wind turbine blades. In this study the effect of material based coupling on the aeroelastic modal properties and stability limits of the DTU 10 MW Reference Wind Turbine are investigated. The modal properties are determined by means of eigenvalue analysis around a steady-state equilibrium using the aero-servo-elastic tool HAWCStab2 which has been extended by a beam element that allows for fully coupled cross-sectional properties. Bend-twist coupling is introduced in the cross-sectional stiffness matrix by means of coupling coefficients that introduce twist for flapwise (flap-twist coupling) or edgewise (edge-twist coupling) bending. Edge-twist coupling can increase or decrease the damping of the edgewise mode relative to the reference blade, depending on the operational condition of the turbine. Edge-twist to feather coupling for edgewise deflection towards the leading edge reduces the inflow speed at which the blade becomes unstable. Flap-twist to feather coupling for flapwise deflections towards the suction side increase the frequency and reduce damping of the flapwise mode. Flap-twist to stall reduces frequency and increases damping. The reduction of blade root flapwise and tower bottom fore-aft moments due to variations in mean wind speed of a flap-twist to feather blade are confirmed by frequency response functions.

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control
Authors: Stäblein, A. R. (Intern), Hansen, M. H. (Intern), Verelst, D. R. (Intern)
Pages: 343-360
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Wind Energy Science Discussions
Volume: 2
ISSN (Print): 2366-7621
Original language: English
Electronic versions:
wes_2_343_2017.pdf
DOIs:
10.5194/wes-2016-39
Source: PublicationPreSubmission
Source-ID: 127597193
Publication: Research - peer-review › Journal article – Annual report year: 2016
Modeling and Validation across Scales: Parametrizing the effect of the forested landscape

When validating the performance of a flow model in forested areas, it is important that the model accurately represents the forest effects. This presentation concerns the use of remote-sensing technology for describing forest effects, and more specifically, how positioning lidar data can be transferred into a parametrization of forests in wind models. The presentation covers three scales: the single tree, the forest edges and clearings, and the large-scale forested landscape in which the forest effects are parameterized with a roughness length. Flow modeling results and validation against observations are presented along with the different forest presentations for each of the cases. In a new research project called InnoWind, the use of satellite-based alternatives to airborne lidar campaigns are investigated, and examples of satellite products in wind power modeling are discussed.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling, Aerodynamic design
Authors: Dellwik, E. (Intern), Badger, M. (Intern), Angelou, N. (Intern), Mann, J. (Intern), Karagali, I. (Intern), Hahmann, A. N. (Intern), Cavar, D. (Intern), van der Laan, P. (Intern)
Published date: 2017
Event: Abstract from International Conference on Future Technologies for Wind Energy WindTech 2017
Main Research Area: Technical/natural sciences
Electronic versions:
AbstractTemplate_Boulder2017_final.pdf
Source: PublicationPreSubmission
Source-ID: 139141131
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2017

Modeling Atmospheric Turbulence via Rapid Distortion Theory: Spectral Tensor of Velocity and Buoyancy

A spectral tensor model is presented for turbulent fluctuations of wind velocity components and temperature, assuming uniform vertical gradients in mean temperature and mean wind speed. The model is built upon rapid distortion theory (RDT) following studies by Mann and by Hanazaki and Hunt, using the eddy lifetime parameterization of Mann to make the model stationary. The buoyant spectral tensor model is driven via five parameters: the viscous dissipation rate epsilon, length scale of energy-containing eddies L, a turbulence anisotropy parameter Gamma, gradient Richardson number (Ri) representing the local atmospheric stability, and the rate of destruction of temperature variance eta(eta). Model output includes velocity and temperature spectra and associated cospectra, including those of longitudinal and vertical temperature fluxes. The model also produces two-point statistics, such as coherences and phases of velocity components and temperature. The statistics of uniformly sheared and stratified turbulence from the model are compared with atmospheric observations taken from the Horizontal Array Turbulence Study (HATS) field program, and model results fit observed one-dimensional spectra quite well. For highly unstable stratification, however, the model has deficiencies at low wavenumbers that limit its prediction of longitudinal velocity component spectra at scales on the order of 0.6 km. The model predicts coherences well for horizontal separations but overestimates vertical coherence with increasing separation. Finally, it is shown that the RDT output can deviate from Monin-Obukhov similarity theory.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling, Wind turbine loads & control, University of Agder
Authors: Chougule, A. S. (Ekstern), Mann, J. (Intern), Kelly, M. C. (Intern), Larsen, G. C. (Intern)
Number of pages: 26
Pages: 949-974
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of the Atmospheric Sciences
Volume: 74
Issue number: 4
ISSN (Print): 0022-4928
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 1.285 SJR 2.672 CiteScore 3.13
Modeling of wind turbine vortex generators in considering the inter-effects between arrays

Vortex generators (VGs) are commonly placed on wind turbine blades to delay flow separation in the boundary layer. VGs can be parametrically modeled in computational fluid dynamics for effective and efficient simulations of wind blade flow fields. Many researchers have studied the vortex circulation created by VGs and created various parametric models used with the Navier-Stokes equations, but most of them are based on a single winglet of VGs and do not include the inter-effects between the winglets. This paper proposes a parameterized VG array model based on counter-rotating VGs, which properly takes into account the inter-effects between winglets. Two cases, i.e., a plate with a pair of VGs and a DU-W2-250 blade segment with five pairs of VGs, are investigated to validate this model; the array type parametric model is in closer agreement with experimental data than traditional models. Compared to the solid VG model, the array type model
has similar streamlines and surface pressure coefficients on the suction surface. The array type VG model can effectively reduce the number of grid points and yield highly accurate predictions of wind turbine blade aerodynamic characteristics.

**Modelling lidar volume-averaging and its significance to wind turbine wake measurements:** Paper

Lidar velocity measurements need to be interpreted differently than conventional in-situ readings. A commonly ignored factor is "volume-averaging", which refers to lidars not sampling in a single, distinct point but along its entire beam length. However, especially in regions with large velocity gradients, like the rotor wake, can it be detrimental. Hence, an efficient algorithm mimicking lidar flow sampling is presented, which considers both pulsed and continuous-wave lidar weighting functions. The flow-field around a 2.3 MW turbine is simulated using Detached Eddy Simulation in combination with an actuator line to test the algorithm and investigate the potential impact of volume-averaging. Even with very few points discretising the lidar beam is volume-averaging captured accurately. The difference in a lidar compared to a point measurement is greatest at the wake edges and increases from 30% one rotor diameter (D) downstream of the rotor to
60% at 3D.

**General information**
State: Published
Organisations: Department of Wind Energy, Aerodynamic design, Meteorology & Remote Sensing
Authors: Meyer Forsting, A. R. (Intern), Troldborg, N. (Intern), Borraccino, A. (Intern)
Number of pages: 10
Publication date: 2017

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Series: Journal of Physics: Conference Series
ISSN: 1742-6596
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Conference: Wake Conference 2017, Visby, Sweden, 30/05/2017 - 30/05/2017
Applied fluid mechanics, Wakes, General fluid dynamics theory, simulation and other computational methods, Wind power plants, Optical radar, Power and plant engineering (mechanical engineering), Fluid mechanics and aerodynamics (mechanical engineering), Mechanical components, Measurement, CW radar, flow simulation, optical radar, rotors (mechanical), velocity measurement, wakes, wind turbines, LiDAR volume-averaging modelling, wind turbine wake measurement, LiDAR velocity measurement, lidar flow sampling, pulsed lidar weighting functions, continuous-wave lidar weighting functions, detached eddy simulation, rotor diameter, power 2.3 MW

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Modelling lidar volume-averaging and its effect on wake measurements
Source: FindIt
Source-ID: 2371467250
Publication: Research - peer-review › Article in proceedings – Annual report year: 2017

**Modelling the elastic properties of cellulose nanopaper**
The elastic modulus of cellulose nanopaper was predicted using a two-dimensional (2D) micromechanical fibrous network model. The elastic modulus predicted by the network model was 12 GPa, which is well within the range of experimental data for cellulose nanopapers. The stress state in the network revealed both tensile and compressive stresses during elastic deformation of the model. The length, diameter, waviness and elastic modulus of the cellulose nanofibres were varied in the model and their effect on the elastic modulus of fibrous networks was studied. It was found that high values of elastic moduli of cellulose networks could be obtained for long, thin and straight nanofibres of high stiffness. The effect of inter-fibre bonding and network density was also investigated. Increasing fibre-fibre interactions facilitated stress transfer in cellulose networks and led to a higher elastic modulus of the nanopaper. Denser networks also resulted in a higher elastic modulus due to an increasing number of nanofibres and inter-fibre bonds.

**General information**
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics, Queen Mary University of London, Donghua University
Authors: Mao, R. (Ekstern), Goutianos, S. (Intern), Tu, W. (Ekstern), Meng, N. (Ekstern), Chen, S. (Ekstern), Peijs, T. (Ekstern)
Pages: 183-189
Publication date: 2017
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Materials & Design
Volume: 126
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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
Modelling the wind farm wake for the Horns Rev photo case 2016

General information
State: Published
Authors: Hasager, C. B. (Intern), Nygaard, N. (Ekstern), Volker, P. (Intern), Karagali, I. (Intern), Andersen, S. J. (Intern), Badger, J. (Intern)
Number of pages: 22
Modelling Wind Turbine Inflow: The Induction Zone

A wind turbine decelerates the wind in front of its rotor by extracting kinetic energy. The wind speed reduction is maximal at the rotor and negligible more than five rotor radii upfront. By measuring wind speed this far from the rotor, the turbine’s performance is determined without any rotor bias. However, the measured wind speed decorrelates from the one interacting with the rotor especially in wind farms and mountainous terrain. This is exacerbated by the ever growing rotors, as the physical distance to the measurement location grows equally. Decorrelation is mitigated by measuring closer to the rotor, but requires exact knowledge of the flow deceleration to estimate the available, undisturbed kinetic energy. Thus this thesis explores, mostly numerically, any wind turbine or environmental dependencies of this deceleration. The computational fluid dynamics model (CFD) employed is validated with velocity measurements from lidars upstream of an operational turbine. A new stochastic validation methodology in combination with extensive uncertainty quantification and propagation allows validating the CFD model under these realistic conditions for an area covering the majority of the decelerating flow upstream. This is the first validation of its kind and it demonstrates the advantage of including uncertainties in the process. The flow behaviour upstream of a single rotor is largely insensitive to specific rotor designs and operating conditions. In fact the rotor thrust coefficient is the single most significant parameter. Exploiting this singular dependency, a fast semi-empirical model is devised that accurately predicts the velocity deficit upstream of a single turbine. Near-rotor measurements in combination with this model are able to retrieve the kinetic energy available to the turbine in flat terrain. Complex terrain and multiple turbines are more demanding, though, as they enhance non-linear interactions.

Multi-fidelity optimization of horizontal axis wind turbines

This paper is concerned with the numerical design optimization of wind turbines. Many examples of wind turbine design optimization in literature rely on simplified analysis in some form. This may lead to sub-optimal design, because the optimizer does not see the full fidelity of the problem. To overcome these challenges, this research will explore the multi-fidelity Approximation and Model Management Framework (AMMF) optimization algorithm. AMMF is similar to conventional gradient based optimization, except in the search phase of the optimization, the analysis is replaced with a fast low-fidelity model that has been corrected to give C1 consistency with the high-fidelity model. AMMF was first explored with a simple preliminary investigation based on analytic equations. Second, it was applied to a single-discipline design optimization problem to find the internal structure with the least weight. Finally, AMMF was used in full aero-elastic wind turbine rotor design optimization problem based on the DTU 10 MW reference wind turbine design. Mixed results were achieved for the final study and further work is needed to find the best configuration for AMMF.
Multiscale characterization of White Etching Cracks (WEC) in a 100Cr6 bearing from a thrust bearing test rig
A common cause for premature bearing failures in wind turbine gearboxes are the so-called White Etching Cracks (WEC). These undirected, three-dimensional cracks are bordered by regions of altered microstructure and ultimately lead to a cracking or spalling of the raceway. An accelerated WEC test was carried out on a FE8 test rig using cylindrical roller thrust bearings made of martensitic 100Cr6 steel. The resulting WECs were investigated with several characterisation techniques. Ultrasonic measurements showed the WEC were mainly located in the region of the overrolled surface in which negative slip occurs, which agrees with hypotheses based on an energetic approach for a prognosis. SEM orientation contrast imaging of the area around WEC revealed an inhomogeneous structure with varied grain sizes and a large amount of defects. Microstructure characterization around the WEA using EBSD showed significant grain refinement. Atom probe tomography showed the microstructure in the undamaged zone has a plate-like martensitic structure with carbides, while no carbides were detected in the WEA where the microstructure consisted of equiaxed 10 nm grains. A three dimensional characterisation of WEC network was successfully demonstrated with X-ray computerized tomography, showing crack interaction with unidentified inclusion-like particles.
This paper proposes a method of installing phasor measurement units (PMU) in multiple stages. The scheme is developed on the concept of bus tier system and provides an optimal number of PMUs with a strategy to install them in a particular stage. The synchronized phasor measurements from the PMUs placed by the proposed method are used in developing a hybrid state estimator (HSE). The HSE estimates the voltage phasor at all the buses of a power system with a limited numbers of PMUs in steady state as well as in the presence of disturbances even in that part of network which is unobservable through PMUs. Performance of the proposed phased installation scheme for HSE is evaluated on the number of standard test system and the simulation results shows an improvement in the accuracy of the estimated states as compared to the existing methods in the literature.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning, IBM Research, National Institute of Technology Agartala, Indian Institute of Technology, Kharagpur
Authors: Hazra, J. (Ekstern), Das, K. (Intern), Roy, B. K. S. (Ekstern), Padmanaban, M. (Ekstern), Sinha, A. K. (Ekstern)
Number of pages: 5
Nacelle Transfer Function

The report describes measurements carried out on a given turbine. A comparison between wind speed on the met mast and Nacelle Wind speed are made and the results are presented on graphs and in a table. The data used for the comparison are the data that are same as used for the power curve report. The measurements have been performed using DTU's measurement equipment, the analysis and quality control has been performed by DTU.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Villanueva, H. (Intern), Gómez Arranz, P. (Intern)
Number of pages: 98
Publication date: 2017

Publication information
Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy WTT I
Number: 1170
Main Research Area: Technical/natural sciences

Bibliographical note
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Publication: Research › Report – Annual report year: 2017
Nacelle Transfer Function
The report describes measurements carried out on a given turbine. A comparison between wind speed on the met mast and Nacelle Wind speed are made and the results are presented on graphs and in a table. The data used for the comparison are the data that are same as used for the power curve report. The measurements have been performed using DTU's measurement equipment, the analysis and quality control has been performed by DTU.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Gómez Arranz, P. (Intern), Kock, C. W. (Intern)
Number of pages: 100
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Publication information
Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy WTT I
Number: 1183
Main Research Area: Technical/natural sciences

Bibliographical note
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Publication: Research › Report – Annual report year: 2017

Nanocomposites for Machining Tools
Machining tools are used in many areas of production. To a considerable extent, the performance characteristics of the tools determine the quality and cost of obtained products. The main materials used for producing machining tools are steel, cemented carbides, ceramics and superhard materials. A promising way to improve the performance characteristics of these materials is to design new nanocomposites based on them. The application of micromechanical modeling during the elaboration of composite materials for machining tools can reduce the financial and time costs for development of new tools, with enhanced performance. This article reviews the main groups of nanocomposites for machining tools and their performance.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics, National University of Science and Technology MISIS

Publication information
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Original language: English

Series: DTU Wind Energy WTT I
Number: 1204
Main Research Area: Technical/natural sciences

Bibliographical note
This is an internal report and therefore not available in full text. Please contact author's or director of author's department for further information.
Publication: Research › Report – Annual report year: 2017
Near-shore wind resource estimation using lidar measurements and modelling

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling, Meteorology & Remote Sensing
Authors: Floors, R. R. (Intern), Hahmann, A. N. (Intern), Pena Diaz, A. (Intern)
Publication date: 2017
Main Research Area: Technical/natural sciences
Electronic versions:
OWE17_RogierFloors_PO026.pdf

Needs for Flexibility Caused by the Variability and Uncertainty in Wind and Solar Generation in 2020, 2030 and 2050 Scenarios

The growing share of variable renewable energy sources (VRE) in Nordic and Baltic countries is expected to increase the need for flexibility in the energy systems. VRE generation is highly variable because it is determined by weather conditions, and it is uncertain due to forecasting errors. Both of these aspects will be considered for the analysed 2020, 2030 and 2050 scenarios. In addition to the variability in VRE generation, the variability in net load (electricity consumption subtracted by the VRE generation) is analysed. The results show that, compared to hourly ramp rates in consumption, the hourly ramp rates of the net load are not expected to increase significantly; however, there is a modest increase in 2050. The relative variability of the net load is expected to increase significantly when going from 2014 to 2050. Wind generation forecasting uncertainties are assessed for 5 minute, 15 minute and hour ahead forecasts. It is shown that the forecasting error probability distributions are fat-tailed, which means that the risk of experiencing a large forecasting error is higher than what one would expect.

The growing share of variable renewable energy (VRE) is expected to increase the need for flexibility in the energy systems in many countries. VRE generation is highly variable because it is determined by weather conditions. The geographical distribution of installed wind generation affects the probability distribution (PD) of the aggregate generation, including the probabilities of very low or high generation. A combined modelling of wind and solar power has been presented. Here, a combined analysis of wind and solar power in multiple Nordic and Baltic countries is presented. The analysed scenarios are the baseline scenarios from the CorWind tool developed at DTU Wind Energy. In addition to analysing VRE generation, the variability of net load (electricity consumption subtracted by VRE generation) is analysed. Compared to 2014, the relative variability in VRE generation decreases in the future scenarios, as the overall geographical dispersion of the installed VRE generation increases. The correlation between solar and wind generation is generally slightly negative, which can reduce the variability of the aggregate generation compared to only having wind generation in the VRE generation mix (however, the installed solar generation capacities in the analysed scenarios are low, so this effect is small).

Figure 1 shows the probability distribution functions (PDFs) of the aggregate net load in the different scenarios. The standard deviation (STD) of the hourly net load increases notably in 2050 (22% higher than in 2014). At the same time, the expected value of the net load decreases. Thus, there will be less energy to be generated by the other generation types, such as hydro power, while the need for flexibility increases. Alternatively, the variability in the net load can be managed by demand-side response, transmission of power to or from surrounding countries or by storing energy.

With more VRE generation installed, the probability of very high net load decreases (as some VRE generation is usually available during peak consumption). However, there is always some probability that the aggregate generation is zero, so the highest possible net load is determined by peak consumption. This may raise questions considering the incentives to hold enough other generation capacity to meet the rare peak net load.

Compared to the hourly ramp rates in consumption, the increasing VRE generation increases the ramp rates in the aggregate net load only moderately in the future scenarios; STD of the net load ramp rate in 2050 is expected to be 14% higher than in 2014. However, while ramp rates in consumption happen usually at well-known times (i.e., ramping up in working day mornings), the hourly changes in VRE generation are less predictable.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning, Department of Management Engineering, Systems Analysis
Authors: Koivisto, M. J. (Intern), Sørensen, P. E. (Intern), Maule, P. (Intern), Nuño Martinez, E. (Intern), Traber, T. (Intern)
Number of pages: 14
Publication date: 2017

New approach for validating the segmentation of 3D data applied to individual fibre extraction
We present two approaches for validating the segmentation of 3D data. The first approach consists on comparing the amount of estimated material to a value provided by the manufacturer. The second approach consists on comparing the segmented results to those obtained from imaging modalities that provide a better resolution and therefore a more accurate segmentation. The imaging modalities used for comparison are scanning electron microscopy, optical microscopy and synchrotron CT. The validation methods are applied to the asses the segmentation of individual fibres from X-ray microtomograms.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Statistics and Data Analysis, Department of Wind Energy, Composites and Materials Mechanics
Authors: Emerson, M. J. (Intern), Dahl, A. B. (Intern), Dahl, V. A. (Intern), Conradsen, K. (Intern), Mikkelsen, L. P. (Intern)
Number of pages: 2
Publication date: 2017

New methodologies to observe wind gusts: research aircraft and Doppler lidar measurements

General information
State: Published
Organisations: Department of Wind Energy, University of Reading, Alfred Wegener Institute for Polar and Marine Research, Finnish Meteorological Institute, Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI)
Authors: Suomi, I. (Ekstern), Vihma, T. (Ekstern), Gryning, S. (Intern), Lüpkes, C. (Ekstern), Hartmann, J. (Ekstern), O’Connor, E. (Ekstern), Fortelius, C. (Ekstern)
**New methodologies to observe wind gusts: research aircraft and Doppler lidar measurements**

**Publication Information**
- **State**: Published
- **Organisations**: Department of Wind Energy, Integration & Planning, HTW Berlin - University of Applied Sciences, Gamesa - Sarriguren I, DiGILENT Ibérica
- **Authors**: Sørensen, P. E. (Intern), Göksu, Ö. (Intern), Fortmann, J. (Ekstern), Buendia, F. J. (Ekstern), Morales, A. (Ekstern)
- **Number of pages**: 4
- **Publication date**: 2017
- **Event**: Paper presented at 1st International Conference on Large-Scale Grid Integration of Renewable Energy in India, New Delhi, India.
- **Main Research Area**: Technical/natural sciences
- **Source**: PublicationPreSubmission
- **Source-ID**: 140139695
- **Publication**: Research - peer-review › Conference abstract in proceedings – Annual report year: 2017

**Next Edition of IEC 61400-27: Electrical simulation models for wind power plants**

**General Information**
- **State**: Published
- **Organisations**: Department of Wind Energy, Fluid Mechanics, University of Calgary
- **Authors**: Wood, D. H. (Ekstern), Okulov, V. (Intern)
- **Pages**: 542-549
- **Publication date**: 2017
- **Main Research Area**: Technical/natural sciences
- **Publication information**
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  - **Volume**: 107
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    - BFI (2018): BFI-level 1
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    - Web of Science (2017): Indexed yes
    - BFI (2016): BFI-level 1
    - Scopus rating (2016): CiteScore 4.83 SJR 1.661 SNIP 2.05
    - Web of Science (2016): Indexed yes

**Nonlinear blade element-momentum analysis of Betz-Goldstein rotors**

• We analyze Betz-Goldstein (BG) rotors for maximum power at any tip speed ratio and number of blades. • We prove that Glauert's incorporation of tip loss in the blade torque and thrust equation are correct. • We show the nonlinear angular momentum terms can contribute 12% of the total torque.

**General Information**
- **State**: Published
- **Organisations**: Department of Wind Energy, Fluid Mechanics, University of Calgary
- **Authors**: Wood, D. H. (Ekstern), Okulov, V. (Intern)
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- **Main Research Area**: Technical/natural sciences
- **Publication information**
  - **Journal**: Renewable Energy
  - **Volume**: 107
  - **ISSN (Print)**: 0960-1481
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    - BFI (2018): BFI-level 1
    - Web of Science (2018): Indexed yes
    - BFI (2017): BFI-level 1
    - Scopus rating (2017): CiteScore 5.38 SJR 1.847 SNIP 2.008
    - Web of Science (2017): Indexed yes
    - BFI (2016): BFI-level 1
    - Scopus rating (2016): CiteScore 4.83 SJR 1.661 SNIP 2.05
    - Web of Science (2016): Indexed yes
Non-spherical voids and lattice reorientation patterning in a shock-loaded Al single crystal

An Al single crystal shock loaded in the <1 2 3> direction and captured at incipient spallation was examined by combining X-ray tomography, electron backscatter diffraction on a scanning electron microscope, and transmission electron microscopy (TEM). Octahedral voids with (1 1 1) faces were a characteristic feature in the spall region. Regular patterns of lattice reorientation were found around individual voids, with lattice rotation being up to 25–30°. Each reorientation pattern consists of a number of reoriented zones. The direction of lattice rotation varies systematically from one zone to another. Four groups of reorientation patterns were identified morphologically in the same metallographic section, which result from
different sectioning positions relative to the voids and thus provide equivalently a “serial sectioning” investigation of the deformed volume around the voids. An analysis of the observed reorientation patterns based on active slip systems rationalizes the key features observed and suggests that the systematic reorientation patterns result from the dominance of a single slip system in each individual zone. Microstructures revealed by TEM in the spall region show formation of dislocation cells and extended dislocation boundaries, illustrating the importance of plastic deformation during void growth.

**General information**
- **State:** Published
- **Organisations:** Department of Wind Energy, Materials science and characterization, Oak Ridge National Laboratory
- **Authors:** Hong, C. (Intern), Fæster, S. (Intern), Hansen, N. (Intern), Huang, X. (Intern), Barabash, R. I. (Ekstern)
- **Number of pages:** 15
- **Pages:** 16-30
- **Publication date:** 2017
- **Main Research Area:** Technical/natural sciences

**Publication information**
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- **Volume:** 134
- **ISSN (Print):** 1359-6454
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  - Web of Science (2018): Indexed yes
  - BFI (2017): BFI-level 2
  - Scopus rating (2017): CiteScore 6.18 SJR 3.263 SNIP 2.737
  - Web of Science (2017): Indexed yes
  - BFI (2016): BFI-level 2
  - Scopus rating (2016): CiteScore 5.67 SJR 3.21 SNIP 2.702
  - Web of Science (2016): Indexed yes
  - BFI (2015): BFI-level 2
  - Scopus rating (2015): SJR 3.417 SNIP 2.831 CiteScore 5.22
  - Web of Science (2015): Indexed yes
  - BFI (2014): BFI-level 2
  - Scopus rating (2014): SJR 3.885 SNIP 3.166 CiteScore 5.16
  - Web of Science (2014): Indexed yes
  - BFI (2013): BFI-level 2
  - Scopus rating (2013): SJR 3.238 SNIP 2.674 CiteScore 4.37
  - ISI indexed (2013): ISI indexed yes
  - Web of Science (2013): Indexed yes
  - BFI (2012): BFI-level 2
  - Scopus rating (2012): SJR 3.37 SNIP 2.875 CiteScore 4.28
  - ISI indexed (2012): ISI indexed yes
  - Web of Science (2012): Indexed yes
  - BFI (2011): BFI-level 2
  - Scopus rating (2011): SJR 3.215 SNIP 2.768 CiteScore 4.27
  - ISI indexed (2011): ISI indexed yes
  - Web of Science (2011): Indexed yes
  - BFI (2010): BFI-level 2
  - Scopus rating (2010): SJR 3.709 SNIP 2.698
  - Web of Science (2010): Indexed yes
  - BFI (2009): BFI-level 2
  - Scopus rating (2009): SJR 3.663 SNIP 2.625
  - Web of Science (2009): Indexed yes
  - BFI (2008): BFI-level 2
  - Scopus rating (2008): SJR 3.82 SNIP 2.774
  - Web of Science (2008): Indexed yes
  - Web of Science (2007): Indexed yes
This report introduces the set of basic data to define scenarios with realistic yet ambitious targets for offshore wind power development in the North Sea to be used in the NSON-DK project. The assumptions are in line with those of IEA for a two degree temperature increase scenario and correspond with a strong recovering of coal and crude oil prices, and a pronounced increase of CO2 prices from 2020. For the countries around the North Sea that are considered, the evolution of electricity demand is projected to be strongly impacted by aggressive energy efficiency policies that lead in total to stagnating consumption despite substantial electric vehicle up-take. To the contrary, Denmark is assumed to substantially increase its consumption, i.e. by 14% from 2020 to 2050. However, the Danish electricity system is looking forward to a decommissioning of the remaining coal fired power plants towards the mid of the century and replacing these capacities essentially with natural gas power plants. In Belgium, and Germany nuclear power plants are expected to be phased-out by 2035, with Sweden following this policy by 2050. Moreover, the economic outlook for nuclear in the other countries is also weak mainly due to pronounced competition from fluctuating renewable energies. In regard to wind energy, for Denmark it is suggested that onshore installations are not increased significantly after 2030. By contrast, a major increase in offshore wind energy is assumed. Corresponding with these offshore and onshore wind power developments, the proposed NSON-DK scenario projects at least 8 TWh higher expected annual wind generation for Denmark. Given the pronounced increases of offshore wind farms, the installations are expected to form significant clusters from 2030 onwards with particularly strong developments in the British Hornsea and on the Dogger Bank.
Numerical modelling of micro-plasto-hydrodynamic lubrication in plane strip drawing

This paper presents a new finite element model capable of predicting the onset of micro-plasto-hydrodynamic (MPH) lubrication and the amount of lubricant escaping from surface pockets in metal forming. The present approach is divided in two steps. First, a simulation at the macroscopic level is conducted. Then, a second simulation highlighting microscopic liquid lubrication mechanisms is achieved using boundary conditions provided by the first model. These fluid-structure interaction computations are made possible through the use of the Arbitrary Lagrangian Eulerian (ALE) formalism. The developed methodology is validated by comparison to experimental measurements conducted in plane strip drawing. The effect of physical parameters like the drawing speed, the die angle and the strip thickness reduction is investigated. The numerical results show good agreement with experiments.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics, University of Liège, ArcelorMittal Global R&D
Authors: Carretta, Y. (Ekstern), Bech, J. I. (Intern), Legrand, N. (Ekstern), Laugier, M. (Ekstern), Ponthot, J. P. (Ekstern), Boman, R. (Ekstern)
Pages: 378-391
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Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 2.013 SJR 1.52 CiteScore 3.55
Web of Science (2017): Indexed yes
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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.421 SNIP 2.067 CiteScore 2.61
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.564 SNIP 2.454 CiteScore 2.44
Web of Science (2014): Indexed yes
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Scopus rating (2013): SJR 1.459 SNIP 2.727 CiteScore 2.51
ISI indexed (2013): ISI indexed yes
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BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.405 SNIP 2.294 CiteScore 1.96
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.244 SNIP 2.241 CiteScore 1.89
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.376 SNIP 2.165
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Numerical modelling of microscopic lubricant flow in sheet metal forming. Application to plane strip drawing
This paper presents a numerical investigation of microscopic lubricant flows from the cavities to the plateaus of the surface roughness of metal sheets during forming processes. This phenomenon, called micro-plasto-hydrodynamic (MPH) lubrication, was observed experimentally in various situations such as compression sliding tests, strip drawing and cold rolling. It leads to local friction drop and wear reduction. It is therefore critical to achieve a good understanding of this phenomenon.
To move towards that goal, a multiscale fluid-structure interaction (FSI) model is developed to model lubricant flows at the microscopic scale. These simulations are made possible through the use of the Arbitrary Lagrangian Eulerian (ALE) formalism.
In this paper, this methodology is used to study plane strip drawing. The numerical model is able to predict the onset of lubricant escape and the amount of lubricant flowing on the plateaus. Numerical results exhibit good agreement with experimental measurements.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics, University of Liege, ArcelorMittal Global R&D
Authors: Carretta, Y. (Ekstern), Boman, R. (Ekstern), Bech, J. I. (Intern), Legrand, N. (Ekstern), Laugier, M. (Ekstern), Ponthot, J. (Ekstern)
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): SJR 1.623 SNIP 1.493 CiteScore 2.88
Web of Science (2017): Indexed yes
Numerical Study of Wind Turbine Wake Modeling Based on a Actuator Surface Model

In the Actuator Surface Model (ALM), the turbine blades are represented by porous surfaces of velocity and pressure discontinuities to model the action of lifting surfaces on the flow. The numerical simulation is implemented on FLUENT platform combined with N-S equations. This model is improved on the basis of actuator line model (ALM). By using ASM, the model of turbine can be simplified and the quantity of grids and computing time can be significantly reduced. A linear distribution model and a ASM Grid identification method are presented. This paper compares the ASM with ALM by computing both near and far wake of a Nibe A wind turbine, which combines wake velocity, turbulent intensity and vortex structure. Results show that ASM has better prediction accuracy and verify it's feasibility on numerical simulation of wind turbine wake.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Hohai University, Chinese Academy of Sciences
Authors: Zhou, H. (Ekstern), Xu, C. (Ekstern), Han, X. X. (Ekstern), Shen, W. Z. (Intern), Zhang, M. (Ekstern), Chen, X. Y. (Ekstern)
Number of pages: 6
Pages: 535-540
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Gongcheng Rewuli Xuebao
Volume: 38
Issue number: 3
ISSN (Print): 0253-231X
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Scopus rating (2017): CiteScore 0.23
Scopus rating (2016): CiteScore 0.2
Scopus rating (2015): CiteScore 0.28
Scopus rating (2014): CiteScore 0.26
Scopus rating (2013): CiteScore 0.25
Scopus rating (2012): CiteScore 0.23
Scopus rating (2011): CiteScore 0.25
Original language: English
Electronic versions: _-pdf
Source: FindIt
Source-ID: 2371424560
Publication: Research - peer-review › Journal article – Annual report year: 2017

Observation of simultaneous increase in strength and ductility by grain refinement in a Fe-34.5Mn-0.04C steel

Fine grained Fe-34.5Mn-0.04C steel samples with fully recrystallized grain sizes of 3.8 to 2.0 μm were prepared by cold rolling followed by annealing a temperatures of either 650 degrees C or 800 degrees C. It is found that a simultaneous increase in both strength and ductility can be obtained by grain refinement, leading to an observation that the best combination of strength and ductility occurs in the sample with the finest recrystallized grain size.

General information
State: Published
Organisations: Department of Wind Energy, Materials science and characterization, Yanshan University
Authors: Wang, Y. H. (Ekstern), Kang, J. M. (Ekstern), Peng, Y. (Ekstern), Zhang, H. W. (Ekstern), Wang, T. S. (Ekstern), Huang, X. (Intern)
Number of pages: 5
Publication date: 2017
Conference: 38th Risø International Symposium on Materials Science, Roskilde, Denmark, 04/09/2017 - 04/09/2017
Main Research Area: Technical/natural sciences

Publication information
Journal: I O P Conference Series: Materials Science and Engineering
Volume: 219
Issue number: 1
ISSN (Print): 1757-8981
Ratings:
This paper summarizes the findings from Phase II of the Offshore Code Comparison, Collaboration, Continued, with Correlation project. The project is run under the International Energy Agency Wind Research Task 30, and is focused on validating the tools used for modeling offshore wind systems through the comparison of simulated responses of select system designs to physical test data. Validation activities such as these lead to improvement of offshore wind modeling tools, which will enable the development of more innovative and cost-effective offshore wind designs.

**General information**

**State:** Published

**Organisations:** Department of Wind Energy, Wind turbine loads & control, Institute for Energy Technology, National Renewable Energy Laboratory, Fraunhofer Institute for Wind Energy and Energy System Technology (IWES), University of Maine, Maritime Research Institute Netherlands, 4subsea, Centro Nacional de Energías Renovables, CENTEC, European Centre of the Netherlands, TECLALIA Research & Innovation, DNV GL, IFP Energies nouvelles, PRINCIPIA, Politecnico di Milano, Siemens PLM, Universidad de Cantabria, University of Ulsan, University of Tokyo, Universitat Politècnica de Catalunya, WavEC – Offshore Renewables


**Pages:** 38-57

**Publication date:** 2017

**Main Research Area:** Technical/natural sciences

**Publication information**

**Journal:** Energy Procedia

**Volume:** 137

**ISSN (Print):** 1876-6102

**Ratings:**

- BFI (2018): BFI-level 1
- BFI (2017): BFI-level 1
- Scopus rating (2017): CiteScore 1.44 SJR 0.495 SNIP 0.799
- BFI (2016): BFI-level 1
- Scopus rating (2016): CiteScore 1.16 SJR 0.464 SNIP 0.598
Offshore Wind Farms and HVDC Grids Modeling as a Feedback Control System for Stability Analysis
The low impedance characteristics of DC transmission lines cause the voltage source converter (VSC) in HVDC networks to become electrically closer together and increase the risk of severe interactions between the converters. Such interactions, in turn, intensify the implementation of the grid control schemes and may lead the entire system to instability. Assessing the stability and adopting complex coordinated control schemes in an HVDC grid and wind farm turbines are challenging and require a precise model of the HVDC grid, wind farm, and the controllers. In this paper, a linear multivariable feedback control system (FCS) model is proposed to represent the dynamic characteristics of HVDC grids and their controllers. The FCS model can be used for different dynamic analyses in time and frequency domains. Moreover, using the FCS model the system stability is analyzed in both open- and closed-loop forms. The standard eigenanalysis identifies the modes of only the closed-loop system and detects the pertaining state variables. The open-loop model, in the frequency domain, is a complementary tool that helps to have more intuitive insight into the system stability. A four terminal HVDC grid with two OWPPs and two AC grids is used for simulations and verification of the proposed FCS model.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning
Authors: Bidadfar, A. (Intern), Saborío-Romano, O. (Intern), Altin, M. (Intern), Göksu, Ö. (Intern), Cutululis, N. A. (Intern), Sørensen, P. E. (Intern)
Number of pages: 5
Publication date: 2017
Event: Paper presented at 16th International Workshop on Large-Scale Integration of Wind Power into Power Systems as well as on Transmission Networks for Offshore Wind Power Plants, Berlin, Germany.
Main Research Area: Technical/natural sciences
Electronic versions:
Offshore_Wind_Farms_and_HVDC_Grids_Modeling_as_a_Feedback_Control_System_for_Stability_Analysis.pdf
Source: PublicationPreSubmission
Source-ID: 134900630
Publication: Research - peer-review › Paper – Annual report year: 2017
substation. The transformer in offshore AC substation steps up the voltage to 132-200 kV for further transmission. The stepping up of voltage is important to reduce the current flow through the cables. Reduced current flow decreases the copper/aluminium requirement for the cables as well reduce the power losses through them.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning
Authors: Das, K. (Intern), Antonios Cutululis, N. (Intern)
Number of pages: 66
Publication date: 2017

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
Technology_Catalogue_final.pdf
Publication: Research - peer-review › Report – Annual report year: 2018

Offshore winds from a new generation of European satellites
Offshore wind fields retrieved from satellite Synthetic Aperture Radar (SAR) observations can give valuable insight in the spatial wind variability over large areas. We can utilize this for mapping of wind farm wakes, wind resources, coastal wind speed gradients, storms, and other wind phenomena at sea. All are important for the planning, operation, and maintenance of offshore wind farms.

Typical shortcomings of SAR-based wind fields include a low sampling frequency and a need for advanced data processing in order to retrieve the wind speed at 10 m above sea level. A new generation of European satellites and services could lower these barriers for applications in wind energy significantly.

The Sentinel-1 A/B missions by the European Space Agency (ESA) deliver C-band SAR observations at an unprecedented coverage and spatial resolution. Over the seas of Europe, approximately 200 new acquisitions take place every day. DTU Wind Energy operates a system for processing of the raw SAR data to wind fields in near-real-time. The wind fields are available for download; for example by users in the wind energy community. Comparisons with mast and lidar observations have shown RMS errors of 1.3-1.5 m/s as close as 1 km from the coastline.

ESA's Copernicus programme offers an Ocean Wind and Wave product (OWI), which allows users to bypass the processing of raw SAR data to wind and wave fields. The coverage is limited to the Mediterranean Sea at present but we can expect an expansion to other seas of Europe over time. The accuracy of this new product is currently under investigation.

TerraSAR-X is an X-band SAR mission by the German Aerospace Center (DLR). It offers very high-resolution imagery, which may be used for detailed studies of e.g. wind farm wakes. TerraSAR-X imagery is acquired on-demand and this requires payment of a fee. Because the most widely used algorithms for SAR wind retrieval are for C-band, further validation of wind retrieval algorithms for X-band is needed before it can be used routinely. Comparisons with mast and lidar observations are in progress at present.

This presentation will address the availability, the spatial coverage, and the accuracy of different wind products retrieved from SAR. We investigate the possibility of combining all available SAR-based wind fields into a single data series for wind resource assessment, which requires careful calibration of all sensors by the space agencies as well as consistent processing of historical and current satellite observations. Examples of the use of SAR-based wind fields for offshore wind energy applications will be given to illustrate their value.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing
Authors: Badger, M. (Intern), Karagali, I. (Intern), Ahsbahs, T. T. (Intern), Hasager, C. B. (Intern)
Publication date: 2017
Main Research Area: Technical/natural sciences
Electronic versions:
Badger_et_al_Offshore_winds_from_a_new_generation_of_satellites.pdf
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2017

On AEP prediction and wake modelling at Anholt
The Anholt wind farm is not only one of the largest parks of the world but also has one of the highest capacity factors (CFs); in 2014 it was 45.85%. This is mainly due to the low wake effects within the wind farm. Using hub-height hourly simulated winds from the WRF model for the year 2014 at a position in the middle of the wind farm, without accounting for wake effects and assuming flow homogeneity within the wind farm, the CF is 45.07%. The difference between the model-estimated and the reported CFs are partly due to errors in the WRF model but it is also due to the gradients of wind speed and direction. We show that the WRF model is able to reproduce such gradients relatively well by comparison to the wind farm’s SCADA. About 1.5 yr of such SCADA, further quality controlled and filtered, reveals an average wake loss of 3.87%
only, whereas results from three wake models, Park, Larsen and FUGA, show average wake losses of 3.46%, 3.69%, and 3.38%, respectively. We employ a bootstrap method to estimate the uncertainty of the wake models. As this is performed with reference to the SCADA, the results provide an idea of the uncertainty of the AEP prediction. We find all wake models to underpredict the wake loss. The simpler models are as uncertain as the more sophisticated ones.

General information
State: Published
Authors: Pena Diaz, A. (Intern), Hansen, K. S. (Intern), Volker, P. (Intern), Ott, S. (Intern), Hasager, C. B. (Intern)
Publication date: 2017
Main Research Area: Technical/natural sciences
Electronic versions:
On_AEP_prediction_and_wake_modelling_at_Anholt.pdf
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2017

On the impact of wind on the development of wave field during storm Britta
The observation of extreme waves at FINO 1 during storm Britta on the 1st November 2006 has initiated a series of research studies regarding the mechanisms behind. The roles of stability and the presence of the open cell structures have been previously investigated but not conclusive. To improve our understanding of these processes, which are essential for a good forecast of similarly important events offshore, this study revisits the development of storm Britta using an atmospheric and wave coupled modeling system, wind and wave measurements from ten stations across the North Sea, cloud images and Synthetic Aperture Radar (SAR) data. It is found here that a standard state-of-the-art model is capable of capturing the important characteristics of a major storm like Britta, including the storm path, storm peak wind speed, the open cells, and peak significant wave height ($H_s$) for open sea. It was also demonstrated that the impact of the open cells has negligible contribution to the development of extreme $H_s$ observed at FINO 1. At the same time, stability alone is not sufficient in explaining the development of extreme $H_s$. The controlling conditions for the development of Britta extreme $H_s$ observed at FINO 1 are the persistent strong winds and a long and undisturbed fetch over a long period.

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling, Risø National Laboratory for Sustainable Energy, DHI
Authors: Larsén, X. G. (Intern), Du, J. (Intern), Bolaños, R. (Ekstern), Larsen, S. (Intern)
Pages: 1407-1427
Publication date: 2017
Main Research Area: Technical/natural sciences
Publication information
Journal: Ocean Dynamics
Volume: 67
Issue number: 11
ISSN (Print): 1616-7341
Ratings:
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.79 SJR 0.789 SNIP 0.849
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.74 SJR 1 SNIP 0.998
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.838 SNIP 0.955 CiteScore 1.74
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.041 SNIP 1.216 CiteScore 1.99
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.302 SNIP 1.25 CiteScore 1.94
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
On the spatial and temporal resolution of land cover products for applied use in wind resource mapping

The suitability of Copernicus Global Land Service products for wind assessment is investigated using two approaches. In the first approach the CORINE land cover database and the pan-European high-resolution products were considered as input to atmospheric flow models. The CORINE data were used as input for modelling the wind conditions over a Danish near-coastal region. The flow model results were compared to alternative use of USGS land cover. Significant variations in the wind speed were found between the two atmospheric flow model results. Furthermore the wind speed from the flow model was compared to meteorological observations taken in a tall mast and from ground based remote-sensing wind profiling lidars. It is shown that simulations using CORINE provide better wind flow results close to the surface as compared to those using USGS on the investigated site. The next step towards improvement of flow model inputs is to investigate in further detail applied use of satellite maps in forested areas. 75% of new land-based wind farms are planned in or near forests in Europe. In forested areas the near surface atmospheric flow is more challenging to calculate than in regions with low vegetation because the tall vegetation to a high degree influences the atmospheric flow. Also in many forests the variation in forest plant structure is high. The forest structure depends on the tree height, the tree density, the existence of clearings, the types of leaves and branches and their structure. So the method of assigning one typical roughness length for land cover type ‘forest’ is at many sites not sufficient. This method assumes that all land cover classes can be represented with one value each. In our second approach, we look at a forested area in Northern Denmark, where an aerial lidar data observing terrain height, tree height and derived plant parameters provided a novel input for atmospheric flow modelling in forested areas. The flow model results were compared to horizontally scanning wind lidar observations and the results are very promising. Since, aerial lidar data are not available everywhere, we discuss the possibility of using similar Copernicus Global Land Service products as input to the flow model.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling
Authors: Hasager, C. B. (Intern), Badger, M. (Intern), Dellwik, E. (Intern), Floors, R. R. (Intern), Hahmann, A. N. (Intern), Mann, J. (Intern)
Publication date: 2017
Event: Poster session presented at WorldCover 2017, Rome, Italy.
Main Research Area: Technical/natural sciences
Electronic versions:
On wake modeling, wind-farm gradients and AEP predictions at the Anholt wind farm

We investigate wake effects at the Anholt offshore wind farm in Denmark, which is a farm experiencing strong horizontal wind-speed gradients because of its size and proximity to land. Mesoscale model simulations are used to study the horizontal wind-speed gradients over the wind farm. From analysis of the mesoscale simulations and supervisory control and data acquisition (SCADA), we show that for westerly flow in particular, there is a clear horizontal wind-speed gradient over the wind farm. We also use the mesoscale simulations to derive the undisturbed inflow conditions that are coupled with three commonly used wake models: two engineering approaches (the Park and G. C. Larsen models) and a linearized Reynolds-averaged Navier–Stokes approach (Fuga). The effect of the horizontal wind-speed gradient on annual energy production estimates is not found to be critical compared to estimates from both the average undisturbed wind climate of all turbines’ positions and the undisturbed wind climate of a position in the middle of the wind farm. However, annual energy production estimates can largely differ when using wind climates at positions that are strongly influenced by the horizontal wind-speed gradient. When looking at westerly flow wake cases, where the impact of the horizontal wind-speed gradient on the power of the undisturbed turbines is largest, the wake models agree with the SCADA fairly well; when looking at a southerly flow case, where the wake losses are highest, the wake models tend to underestimate the wake loss. With the mesoscale-wake model setup, we are also able to estimate the capacity factor of the wind farm rather well compared to that derived from the SCADA. Finally, we estimate the uncertainty of the wake models by bootstrapping the SCADA. The models tend to underestimate the wake losses (the median relative model error is 8.75 %) and the engineering wake models are as uncertain as Fuga. These results are specific for this wind farm, the available dataset, and the derived inflow conditions.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Fluid Mechanics, Resource Assessment Modelling, Aerodynamic design
Authors: Pena Diaz, A. (Intern), Hansen, K. S. (Intern), Ott, S. (Intern), van der Laan, M. P. (Intern)
Pages: 191-202
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Wind Energy Science Discussions
Volume: 3
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Pen18_wes_3_191_2018.pdf
DOIs:
10.5194/wes-2017-37
Source: FindIt
Source-ID: 2390507884
Publication: Research - peer-review › Journal article – Annual report year: 2017

Operational modal analysis on a VAWT in a large wind tunnel using stereo vision technique

This paper is about development and use of a research based stereo vision system for vibration and operational modal analysis on a parked, 1-kW, 3-bladed vertical axis wind turbine (VAWT), tested in a wind tunnel at high wind. Vibrations were explored experimentally by tracking small deflections of the markers on the structure with two cameras, and also numerically, to study structural vibrations in an overall objective to investigate challenges and to prove the capability of using stereo vision. Two high speed cameras provided displacement measurements at no wind speed interference. The displacement time series were obtained using a robust image processing algorithm and analyzed with data-driven stochastic subspace identification (DD-SSI) method. In addition of exploring structural behaviour, the VAWT testing gave us the possibility to study aerodynamic effects at Reynolds number of approximately 2 x 10^{5}. VAWT dynamics were simulated using HAWC2. The stereo vision results and HAWC2 simulations agree within 4% except for mode 3 and 4. The high aerodynamic damping of one of the blades, in flatwise motion, would explain the gap between those two modes from simulation and stereo vision. A set of conventional sensors, such as accelerometers and strain gauges, are also measuring rotor vibration during the experiment. The spectral analysis of the output signals of the conventional sensors agrees the stereo vision results within 4% except for mode 4 which is due to the inaccuracy of spectral analysis in picking very closely spaced modes. Finally, the uncertainty of the 3D displacement measurement was evaluated by applying a generalized method based on the law of error propagation, for a linear camera model of the stereo vision system.

General information
State: Published
Optimisation of Data Acquisition in Wind Turbines with Data-Driven Conversion Functions for Sensor Measurements

Operation and Maintenance (O&M) is an important cost driver of modern wind turbines. Condition monitoring (CM) allows the implementation of predictive O&M strategies helping to reduce costs. In this work a novel approach for wind turbine condition monitoring is proposed focusing on synergistic effects of coexisting sensing technologies. The main objective is to understand the predictability of signals using information from other measurements recorded at different locations of the turbine. The approach is based on a multi-step procedure to pre-process data, train a set of conversion functions and evaluate their performance. A subsequent sensitivity analysis measuring the impact of the input variables on the predicted response reveals hidden relationships between signals. The concept feasibility is tested in a case study using Supervisory Control And Data Acquisition (SCADA) data from an offshore turbine.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design, Universidad de Zaragoza, Loughborough University
Authors: Colone, L. (Intern), Reder, M. (Ekstern), Tautz-Weinert, J. (Ekstern), Melero, J. J. (Ekstern), Natarajan, A. (Intern), Watson, S. J. (Ekstern)
Pages: 571-578
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Energy Procedia
Volume: 137
ISSN (Print): 1876-6102
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BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.44 SJR 0.495 SNIP 0.799
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.16 SJR 0.464 SNIP 0.598
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.359 SNIP 0.562 CiteScore 0.92
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.429 SNIP 0.807 CiteScore 1.09
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.42 SNIP 0.778 CiteScore 1.02
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
Scopus rating (2012): SJR 0.411 SNIP 0.55 CiteScore 1.08
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
Scopus rating (2011): SJR 0.877 SNIP 1.45 CiteScore 2.42
Optimization and comparison of superconducting generator topologies for a 10 MW wind turbine application

A direct-drive superconducting generator (DDSCG) is proposed for 10 MW wind turbines in the INNWIND.EU project. To fit the generator into the "king-pin" conceptual nacelle design, the generator structure with inner stationary superconducting (SC) field winding and outer rotating copper armature winding is investigated in the first research phase. Since the cost is an important performance indicator for this application, this paper presents a method to minimize the active material cost of the "king-pin" fitted DDSCG. In this method a relatively fast optimization program is developed with 2D non-linear finite element models. By implementing this method, three typical superconducting generator topologies are compared in terms of the active material cost and mass, the synchronous reactance and the phase resistance. The optimization method and the comparison results provide the DDSCG designers with a guideline for selecting a suitable machine topology.

General information
State: Published
Authors: Liu, D. (Ekstern), Polinder, H. (Ekstern), Abrahamsen, A. B. (Intern), Stehouwer, E. (Ekstern), Hendriks, B. (Ekstern), Magnusson, N. (Ekstern)
Pages: 191-202
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: The International Journal of Applied Electromagnetics and Mechanics
Volume: 53
Issue number: Suppl. 2
ISSN (Print): 1383-5416
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.95 SJR 0.304 SNIP 0.783
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.85 SJR 0.307 SNIP 0.872
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.293 SNIP 0.67 CiteScore 0.8
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.321 SNIP 0.848 CiteScore 0.81
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.279 SNIP 0.659 CiteScore 0.75
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.235 SNIP 0.654 CiteScore 0.54
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.186 SNIP 0.355 CiteScore 0.23
BFI (2010): BFI-level 1
Optimization of wind farm power production using innovative control strategies

Wind energy has experienced a very significant growth and cost reduction over the past decade, and is now able to compete with conventional power generation sources. New concepts are currently investigated to decrease costs of production of electricity even further. Wind farm coordinated control is one of them; it is aimed at increasing the efficiency of a wind farm and decreasing the fatigue loads faced by wind turbines by reducing aerodynamic interactions between them. These objectives are achieved considering two different strategies: curtailing an upwind turbine to reduce the wind speed deficit caused by the wake downstream, or yawing the turbine to deflect the wake away from the downwind turbine. Simulation results found in the literature indicate that an increase in overall power production can be obtained. However they underline the high sensitivity of these gains to incoming wind conditions. It is therefore not known to what extent these gains can be reproduced in a real wind farm where wind conditions are very fluctuating. The French national project SMARTÉOLE constitutes one of the first attempts of implementing these strategies on a full scale wind farm. A ten month measurement campaign was realized in 2016 in which different scenarios were tested. In this master thesis the experimental data from this field test are analyzed and used to calibrate two different models. An optimization process is then performed based on these models to find the maximum power production of two aligned wind turbines.

The experimental results show that the scenarios implemented during the first measurement campaign did not achieve an increase in overall power production, which confirms the difficulty to realize wind farm power optimization in real operating conditions. In the curtailment field test, the down-regulation of the upwind turbine was probably too high to expect the downstream wind turbine to compensate for that loss. Total losses were quite low though, meaning that a significant part of the upwind turbine lost energy is regained downstream by the second turbine. Regarding the yaw offset strategy, no wake deflection could be detected at the downstream turbine and therefore no conclusion be drawn about the impact of yaw misalignment of the upstream turbine. In both cases, unfavorable wind conditions and an incomplete knowledge of the wind turbine behavior in the farm considerably reduced the amount of usable data in the wake sector.

However the data recorded during this campaign could still be used to calibrate models. First a wake deficit model was obtained by re-calibrating the well known Jensen model. Contrary to the original Jensen model, where the wake expansion coefficient is assumed to be constant for the whole wind farm, in this new proposed model it is calculated at each wind turbine based on the local measurement of turbulence intensity. In that way the wake added turbulence intensity can be taken into account and thus the wind speed deficit caused by wind turbines in the wake of other turbines further upstream is not over-estimated. This model proved to be in very good agreement with the measured power deficit in the wind farm. Second, a Ct model giving variation of wind turbine thrust coefficient during down-regulation could be derived from the analysis of guaranteed power curves and validated using experimental data.

The combined power production of two aligned wind turbines was finally maximized considering a curtailment strategy and using these two models. The results from the optimization process in full wake conditions show that the more important gains are obtained in the wind speed range 6 – 10 m/s, i.e. when both the Cp and the Ct of the wind turbines are high. The maximum expected increase in combined power production is found to be in the order of 2 to 3% for a particular wind speed bin, however when averaged over the complete wind speed range these gains represent only 0.3 to 0.5%. The width of the wind direction sector in which the coordinated control is profitable could also be assessed to 10°, centered on the full wake direction. These results confirm the high sensitivity of coordinated control to incoming wind conditions, and that gains that are to be expected considering two wind turbines only are small. New scenarios based on the results found
during this thesis are supposed to be implemented during the second field test campaign of SMARTOLE planned for the second semester of 2017.

Optimized process for recovery of glass- and carbon fibers with retained mechanical properties by means of near- and supercritical fluids
Degradation of hybrid fiber composites using near-critical water or supercritical acetone has been investigated in this study. Process parameters such as temperature (T = 260-300 °C), pressure (p = 60-300 bar) and composite/solvent (c/s = 0.29-2.1 g/mL) ratio were varied to determine the effect on the resin degradation efficiency and the quality of the recovered glass and carbon fibers. Supercritical acetone at 260 °C, 60 bar and a c/s ratio up to 2.1 g/mL could achieve nearly complete degradation of the resin. The glass fibers were recovered with up to 89% retained tensile strength compared to the virgin glass fibers. The use of near-critical water reduced the tensile strength of the glass fibers by up to 65%, whereas the carbon fibers were recovered with retained tensile strength compared to the virgin carbon fibers using water or acetone.
Orientation and length scale effects on dislocation structure in highly oriented nanotwinned Cu

Highly oriented nanotwinned Cu has been compressed to 6% strain in directions 90 degrees, 0 degrees and 45 degrees with respect to the twin boundaries of the almost parallel twins. In the 90 degrees and 0 degrees compressed samples, Mode I and Mode II dislocations and their interactions with twin boundaries dominate the deformation of twin/matrix (T/M) lamellae with thickness less than 500 nm. In 45 degrees compressed samples, Mode III dislocations, especially partial dislocations moving along the twin boundaries, dominate the deformation of fine T/M lamellae with thickness less than 100 nm, while dislocations from slip Modes I, II and III are identified in T/M lamellae more than 100 nm thick, where these dislocations extensively interact in the T/M lamellae with thicknesses more than 200 nm. Dislocation cells are observed in a twin lamella with a thickness of about 500 nm.
Perdigão 2015: Methodology for atmospheric multi-Doppler lidar experiments

The long-range and short-range WindScanner systems (LRWS and SRWS), multi-Doppler lidar instruments, when combined together can map the turbulent flow around a wind turbine and at the same time measure mean flow conditions over an entire region such as a wind farm. As the WindScanner technology is novel, performing field campaigns with the WindScanner systems requires a methodology that will maximize the benefits of conducting WindScanner-based experiments. Such a methodology, made up of 10 steps, is presented and discussed through its application in a pilot experiment that took place in a complex and forested site in Portugal, where for the first time the two WindScanner systems operated simultaneously. Overall, this resulted in a detailed site selection criteria, a well-thought-out experiment layout, novel flow mapping methods and high-quality flow observations, all of which are presented in this paper.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, University of Porto
Authors: Vasiljevia, N. (Intern), Palma, J. M. (Ekstern), Angelou, N. (Intern), Matos, J. C. (Ekstern), Menke, R. (Intern), Lea, G. (Intern), Mann, J. (Intern), Courtney, M. (Intern), Ribeiro, L. F. (Ekstern), Gomes, V. M. (Ekstern)
Pages: 3463-3483
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Atmospheric Measurement Techniques
Volume: 10
Issue number: 9
ISSN (Print): 1867-1381
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 1.253 SJR 1.869 CiteScore 3.37
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Performance and Equivalent Loads of Wind Turbines in Large Wind Farms

Ten simulations of large wind farms have been performed using a fully coupled LES and aero-elastic framework to form a database of full turbine operational conditions in terms of both production and loads. The performance is examined in terms of averaged power production and thrust, as well as 10min equivalent flapwise bending, yaw, and tilt moment loads. Certain scenarios operating below rated wind speed shows unexpected peaks in the loads. The influence on the operating conditions are examined for various parameters and compared relative to an effective power production per area.

General information

State: Published
Organisations: Department of Wind Energy, Fluid Mechanics
Authors: Andersen, S. J. (Intern), Sørensen, J. N. (Intern), Mikkelsen, R. F. (Intern)
Number of pages: 10
Publication date: 2017
Performance of four PBL schemes in WRF at Villum Research Station, Station Nord, Greenland

General information
State: Published
Organisations: Department of Wind Energy, National Institute of Meteorology and Hydrology, Aarhus University
Authors: Kirova, H. (Ekstern), Batchvarova, E. (Ekstern), Gryning, S. (Intern), Skov, H. (Ekstern), Sørensen, L. (Ekstern)
Publication date: 2017

Host publication information
Title of host publication: EMS Annual Meeting Abstracts
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Main Research Area: Technical/natural sciences
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Relations
Activities:
Performance of four PBL schemes in WRF at Villum Research Station, Station Nord, Greenland
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2017

PhD defence: How to measure remotely the wind using nacelle lidars for power performance testing

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing
Authors: Borraccino, A. (Intern)
Number of pages: 96
Publication date: 2017

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Original language: English
Main Research Area: Technical/natural sciences
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2017_08_30_ABorraccino_PhD_defence.pdf
Links:
http://orbit.dtu.dk/admin/files/136859224/2017_08_30_Antoine_Borraccino_PhD_defence_SlideShow.mp4
Source: PublicationPreSubmission
Source-ID: 136858300
Publication: Research › Sound/Visual production (digital) – Annual report year: 2017

Potential of Partially Superconducting Generators for Large Direct-Drive Wind Turbines
This paper aims at assessing the potential of partially superconducting generators for 10 MW direct-drive wind turbines by investigating their performance for a very wide range of excitation currents. Performance indicators such as shear stress and efficiency and other generator characteristics are compared for 12 different generator topologies. To be sufficiently attractive, superconducting generators must have significant advantages over permanent magnet direct-drive generators, which typically have shear stresses of the order of 53 kPa and efficiencies of 96%. Therefore, we investigate what excitation is required to obtain a doubled shear stress and an efficiency of 98%. To achieve this, the different topologies require a range of excitation from 200 to 550 kAT (ampere-turns) with a low armature current density of 2 A/mm². The more iron that is used in the core of these topologies, the easier they achieve this performance. By examining the maximum magnetic flux density at the location of the superconducting field winding, feasible superconductors can be chosen according to their engineering current density capabilities. It is found that high- and low-temperature superconductors can meet the performance criteria for many of the topologies. MgB2 superconductors are feasible for the fully iron-cored topology with salient poles but need cooling down to 10 K.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design, Delft University of Technology
Scopus rating (2000): SJR 0.498 SNIP 0.998
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 1.054 SNIP 2.065
Original language: English
DOIs: 10.1109/TASC.2017.2707661
Source: FindIt
Source-ID: 2371492199
Publication: Research - peer-review › Journal article – Annual report year: 2017

Potential solution for rain erosion of wind turbine blades

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Composites and Materials Mechanics, Aerodynamic design, Danish Meteorological Institute , Vestas Technology R&D, E.ON, Vattenfall, Vestas
Number of pages: 22
Publication date: 2017

Publication information
Media of output: Power Point Presentation
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
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Publication: Research - peer-review › Sound/Visual production (digital) – Annual report year: 2017

Power Curve Measurements
The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to Ref. [1]. A site calibration has been carried out; see Ref. [2], and the measured flow correction factors for different wind directions are used in the present analyze of power performance of the turbine

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Kock, C. W. (Intern), Federici, P. (Intern)
Number of pages: 62
Publication date: 2017

Publication information
Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy WTT I
Number: 1182
Main Research Area: Technical/natural sciences
Bibliographical note
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Publication: Research › Report – Annual report year: 2017

Power Curve Measurements
The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to Ref. [1]. A site calibration has been carried out; see Ref. [2], and the measured flow correction factors for different wind directions are used in the present analyze of power performance of the turbine

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Power Curve Measurements
The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to Ref. [1]. A site calibration has been carried out; see Ref. [2], and the measured flow correction factors for different wind directions are used in the present analyze of power performance of the turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Federici, P. (Intern), Vesth, A. (Intern)
Number of pages: 97
Publication date: 2017

Power Curve Measurements
The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to Ref. [1]. A site calibration has been carried out; see Ref. [2], and the measured flow correction factors for different wind directions are used in the present analyze of power performance of the turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Georgieva Yankova, G. (Intern), Federici, P. (Intern)
Number of pages: 66
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Publication: Research › Report – Annual report year: 2017
Power Curve Measurements
The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to Ref. [1]. A site calibration has been carried out; see Ref. [2], and the measured flow correction factors for different wind directions are used in the present analyze of power performance of the turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Gómez Arranz, P. (Intern), Villanueva, H. (Intern)
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Publication date: 2017

Publication information
Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy WTT I
Number: 1199
Main Research Area: Technical/natural sciences

Bibliographical note
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Publication: Research › Report – Annual report year: 2017

Power Curve Measurements
The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to Ref. [1]. A site calibration has been carried out; see Ref. [2], and the measured flow correction factors for different wind directions are used in the present analyze of power performance of the turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Federici, P. (Intern), Kock, C. W. (Intern)
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Publication date: 2017

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Publisher: DTU Wind Energy
Original language: English

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Number: 1196
Main Research Area: Technical/natural sciences

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Publication: Research › Report – Annual report year: 2017

Power Curve Measurements
The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to Ref. [1]. A site calibration has been carried out; see Ref. [2], and the measured flow correction factors for different wind directions are used in the present analyze of power performance of the turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Georgieva Yankova, G. (Intern), Villanueva, H. (Intern)
Number of pages: 66
Publication date: 2017
Power Curve Measurements
The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to Ref. [1]. A site calibration has been carried out; see Ref. [2], and the measured flow correction factors for different wind directions are used in the present analyze of power performance of the turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Federici, P. (Intern), Villanueva, H. (Intern)
Number of pages: 86
Publication date: 2017
Power Curve Measurements
The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to Ref. [1]. A site calibration has been carried out; see Ref. [2], and the measured flow correction factors for different wind directions are used in the present analyze of power performance of the turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Gómez Arranz, P. (Intern), Georgieva Yankova, G. (Intern)
Number of pages: 80
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Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy WTT I
Number: 1208
Main Research Area: Technical/natural sciences

Bibliographical note
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Publication: Research › Report – Annual report year: 2017

Power Curve Measurements
The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to Ref. [1]. A site calibration has been carried out; see Ref. [2], and the measured flow correction factors for different wind directions are used in the present analyze of power performance of the turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Villanueva, H. (Intern), Gómez Arranz, P. (Intern)
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Publication date: 2017

Publication information
Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy WTT I
Number: 1209
Main Research Area: Technical/natural sciences

Bibliographical note
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Publication: Research › Report – Annual report year: 2017

Power Curve Measurements
The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to Ref. [1]. A site calibration has been carried out; see Ref. [2], and the measured flow correction factors for different wind directions are used in the present analyze of power performance of the turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Federici, P. (Intern), Kock, C. W. (Intern)
Number of pages: 73
Publication date: 2017

Publication information
Publisher: DTU Wind Energy
Original language: English
Power Curve Measurements
The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to Ref. [1]. A site calibration has been carried out; see Ref. [2], and the measured flow correction factors for different wind directions are used in the present analyze of power performance of the turbine.

General information
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Organisations: Department of Wind Energy, Test and Measurements
Authors: Gómez Arranz, P. (Intern), Georgieva Yankova, G. (Intern)
Number of pages: 75
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Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy WTT I
Number: 1221
Main Research Area: Technical/natural sciences

Bibliographical note
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Publication: Research › Report – Annual report year: 2017
Power Curve Measurements FGW

This report describes power curve measurements carried out on a given turbine in a chosen period. The measurements are carried out in accordance to IEC 61400-12-1 Ed. 1 and FGW Teil 2.

General information

State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Georgieva Yankova, G. (Intern), Villanueva, H. (Intern)
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Publication date: 2017

Publication information

Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy WTT I
Number: 1192
Main Research Area: Technical/natural sciences

Bibliographical note

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Publication: Research › Report – Annual report year: 2017
Power Curve Measurements FGW

The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to Ref. [1]. A site calibration has been carried out; see Ref. [2], and the measured flow correction factors for different wind directions are used in the present analyze of power performance of the turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Federici, P. (Intern), Kock, C. W. (Intern)
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Publication date: 2017

Publication information
Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy WTT I
Number: 1220
Main Research Area: Technical/natural sciences

Bibliographical note
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Publication: Research › Report – Annual report year: 2017

Power Curve Measurements REWS

The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to a draft of IEC 61400-12-1 Ed.2.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Gómez Arranz, P. (Intern), Villanueva, H. (Intern)
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Publication date: 2017

Publication information
Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy WTT I
Number: 1200
Main Research Area: Technical/natural sciences

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Publication: Research › Report – Annual report year: 2017

Power Curve Measurements REWS

The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to a draft of IEC 61400-12-1 Ed.2.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Federici, P. (Intern), Georgieva Yankova, G. (Intern)
Number of pages: 98
Publication date: 2017
Power performance verification in complex terrain using nacelle lidars: the Hill of Towie (HoT) campaign

Nacelle lidars are an attractive alternative to meteorological masts for power performance testing in complex terrain, because of the ease of deployment. This report presents the comparison of wind speed and power curve measurements using two commercial nacelle lidar system – one Avent 4-beam Wind Iris and one ZephIR Dual Mode – and a ground-based profiling lidar (ZP300), in a complex site. The model-fitting wind field reconstruction technique using measurements between 0.5D and 1D upstream, which has previously been demonstrated in flat terrain (Nørrekær Enge campaign), is here tested in complex terrain. The two nacelle lidars have been deployed on a Siemens 2.3MW turbine at the Hill of Towie wind farm in Scotland between July and October 2017. The data analysis has been performed with three different wind speed estimates applied to the exact same dataset:

1) the ZP300 wind speed measurements at hub height, located 2.7D (220m) from the turbine.

2) the nacelle lidar wind speed estimate using the wind model fitting to the measurement at 2.5D upstream.

3) the nacelle lidar wind speed estimate using the wind-induction model fitting to the measurements between 0.5D and 1D upstream.

With the wind model, the wind speed estimate is within 2% from the ZP300 measurements, corresponding to an error in AEP in the order of 4%. With the wind-induction model, the free stream wind speed estimate is within 1% from the ZP300 corresponding to an AEP error of approximately 2%. In the second case, the reference wind speed is the ZP300 wind speed measurements corrected using the site calibration. The power curve measured using the three measurement systems were compared to the turbine manufacturer warranted power curve as reference. The reduction in the statistical power uncertainty (type A) usually clearly observed in flat terrain when using nacelle lidars was demonstrated to be of a lesser extent. Here, the wind-induction model performed slightly better than the wind model. In this study, measurements from nacelle lidars close to the turbine rotor were used to estimate the free stream wind speed. The resulting measured power curve was at least as accurate as the one obtained using the ground-based profiler measurements corrected with the site calibration. Thus, it was demonstrated that it is possible to measure a turbine's power curve at a (moderately) complex site without the need for a site calibration.

Power Properties of Two Interacting Wind Turbine Rotors

In the current experiments, two identical wind turbine models were placed in uniform flow conditions in a water flume. The initial flow in the flume was subject to a very low turbulence level, limiting the influence of external disturbances on the
development of the inherent wake instability. Both rotors are three-bladed and designed using blade element/lifting line (BE/LL) optimum theory at a tip-speed ratio, λ, of 5 with a constant design lift coefficient along the span, CL = 0.8.

Measurements of the rotor characteristics were conducted by strain sensors installed in the rotor mounting. The resulting power capacity has been studied and analyzed at different rotor positions and a range of tip-speed ratios from 2 to 8, and a simple algebraic relationship between the velocity deficit in the wake of the front turbine and the power of the second turbine was found, when both rotors have the coaxial position.
Power-Smoothing Scheme of a DFIG Using the Adaptive Gain Depending on the Rotor Speed and Frequency Deviation

In an electric power grid that has a high penetration level of wind, the power fluctuation of a large-scale wind power plant (WPP) caused by varying wind speeds deteriorates the system frequency regulation. This paper proposes a power-smoothing scheme of a doubly-fed induction generator (DFIG) that significantly mitigates the system frequency fluctuation while preventing over-deceleration of the rotor speed. The proposed scheme employs an additional control loop relying on the system frequency deviation that operates in combination with the maximum power point tracking control loop. To improve the power-smoothing capability while preventing over-deceleration of the rotor speed, the gain of the additional loop is modified with the rotor speed and frequency deviation. The gain is set to be high if the rotor speed and/or frequency deviation is large. The simulation results based on the IEEE 14-bus system clearly demonstrate that the proposed scheme significantly lessens the output power fluctuation of a WPP under various scenarios by modifying the gain with the rotor speed and frequency deviation, and thereby it can regulate the frequency deviation within a narrow range.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning, Chonbuk National University, National Renewable Energy Laboratory
Authors: Lee, H. (Ekstern), Hwang, M. (Ekstern), Muljadi, E. (Ekstern), Sørensen, P. E. (Intern), Kang, Y. C. (Ekstern)
Number of pages: 13
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Journal: Energies
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.11 SJR 0.67 SNIP 1.34
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.5 SJR 0.662 SNIP 1.106
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.785 SNIP 1.399 CiteScore 2.87
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.844 SNIP 1.565 CiteScore 2.66
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.613 SNIP 1.331 CiteScore 2.29
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.852 SNIP 1.53 CiteScore 2.46
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Prediction of multi-wake problems using an improved Jensen wake model

The improved analytical wake model named as 2D_k Jensen model (which was proposed to overcome some shortcomings in the classical Jensen wake model) is applied and validated in this work for wind turbine multi-wake predictions. Different from the original Jensen model, this newly developed 2D_k Jensen model uses a cosine shape instead of the top-hat shape for the velocity deficit in the wake, and the wake decay rate as a variable that is related to the ambient turbulence as well as the rotor generated turbulence. Coupled with four different multi-wake combination models, the 2D_k Jensen model is assessed through (1) simulating two wakes interaction under full wake and partial wake conditions and (2) predicting the power production in the Horns Rev wind farm for different wake sectors around two different wind directions. Through comparisons with field measurements, results from Large Eddy Simulations (LES) as well as results from other commercial codes, it is found that the predictions obtained with the 2D_k Jensen model exhibit good to excellent agreements with experimental and LES data.
Prediction of the shape of inline wave force and free surface elevation using First Order Reliability Method (FORM)

In design of substructures for offshore wind turbines, the extreme wave loads which are of interest in Ultimate Limit States are often estimated by choosing extreme events from linear random sea states and replacing them by either stream function wave theory or the NewWave theory of a certain design wave height. As these wave theories super from limitations such as symmetry around the crest, other methods to estimate the wave loads are needed. In the present paper, the First Order Reliability Method, FORM, is used systematically to estimate the most likely extreme wave shapes. Two parameters of maximum crest height and maximum inline force are used to define the extreme events. FORM is applied to first and second-order irregular waves in both 2D and 3D. The application is validated against the NewWave model and also the NewForce model, which is introduced as the force equivalent of NewWave theory, that is, the most likely time history of inline force around a force peak of given value. The results of FORM and NewForce are linearly identical and show only minor deviations at second order. The FORM results are then compared to wave averaged measurements of the same criteria for crest height and peak force value. Relatively good agreement between the FORM results of free surface elevation including the second order effects, and the wave averaged measurements is observed. However, the inline force time series reproduced using the numerical method are not as consistent with the measurements as the free surface elevation time series. The discrepancies between the FORM results and the measurements is found to be a result of more nonlinearity in the selected events than second order and negligence of the drag forces above still water level in the present analysis. This paper is one step toward more precise prediction of extreme wave shape and
loads. Ultimately such waves can be used in the design process of offshore structures. The approach can be generalized to fully nonlinear models.

**General information**

**State:** Published  
**Organisations:** Department of Wind Energy, Fluid Mechanics  
**Authors:** Ghadirian, A. (Intern), Bredmose, H. (Intern), Schløer, S. (Intern)  
**Pages:** 162-176  
**Publication date:** 2017  
**Conference:** 14th Deep Sea Offshore Wind R&D Conference, Trondheim, Norway, 18/01/2017 - 18/01/2017  
**Main Research Area:** Technical/natural sciences

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- BFI (2017): BFI-level 1  
- Scopus rating (2017): CiteScore 1.44 SJR 0.495 SNIP 0.799  
- BFI (2016): BFI-level 1  
- Scopus rating (2016): CiteScore 1.16 SJR 0.464 SNIP 0.598  
- Web of Science (2016): Indexed yes  
- BFI (2015): BFI-level 1  
- Scopus rating (2015): SJR 0.359 SNIP 0.562 CiteScore 0.92  
- BFI (2014): BFI-level 1  
- Scopus rating (2014): SJR 0.429 SNIP 0.807 CiteScore 1.09  
- BFI (2013): BFI-level 1  
- Scopus rating (2013): SJR 0.42 SNIP 0.778 CiteScore 1.02  
- ISI indexed (2013): ISI indexed no  
- Web of Science (2013): Indexed yes  
- Scopus rating (2012): SJR 0.411 SNIP 0.55 CiteScore 1.08  
- ISI indexed (2012): ISI indexed no  
- Web of Science (2012): Indexed yes  
- Scopus rating (2011): SJR 0.877 SNIP 1.45 CiteScore 2.42  
- ISI indexed (2011): ISI indexed no  
- Scopus rating (2010): SJR 0.416 SNIP 0.91  
- Web of Science (2009): Indexed yes  
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10.1016/j.egypro.2017.10.343  
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**Probabilistic Design of Wind Turbine Structures: Design Studies and Sensitivities to Model Parameters**

Several societies have envisaged renewables as sources of energy for ecological and geo-strategical considerations. Amongst others, wind energy has gained considerable interest in the past decades due to its high potential to fulfil the aspirations of the societies that opted for it. However, harnessing offshore wind energy poses challenges such as cost of energy reduction, handling of very large structures, randomness pertaining to the metocean environment, and need for better understanding of the mechanical behavior of the structures.

Three means are employed in this thesis for cost reduction: decrease of conservatism level, improvement of design procedures, and development of innovative structural systems that suit well for large wind turbines. The increasing size of the structure introduces new problems that were not present for small structures. These problems include: (i) the preparation of models with sufficient adequacy in replacement of models whose validity ranges were restricted for small size structure; (ii) the upscaling of supplementary structures like mass dampers whose volume or mass become prohibitive; (iii) the satisfaction of fatigue lifetime requirements for jacket substructures. In addition to being aggressive, conditions for offshore environments and the associated models are highly uncertain. Appropriate statistical
Methodologies should be used in order to design robust structures, which are structures whose engineering performance is not significantly affected by reasonably small changes of the environmental conditions. Recent inspections of some installed wind turbines on monopiles have unveiled serious damage to the grouted joints. The subsequent investigations revealed a misunderstanding of phenomena related to the mechanical behaviour of the grouted joints. Explanations have been proposed by previous studies and the present thesis investigates one of the derived solutions.

This study addresses these challenges sorted in three research areas: (i) Area 1: reduction of conservatism; (ii) Area 2: lifetime improvement; and (iii) Area 3: innovative systems. These research areas are differentially implemented through tasks on various wind turbine structures (shaft, jacket, semi-floater, monopile, and grouted joint). In particular the following research questions are answered:

- How are extreme and fatigue loads on a given structure influenced by the design of other structures on the same wind turbine? How can loads be prepared in order to be exchanged between the designers / manufacturers of different wind turbine components with better accuracy and lower conservatism level?
- How can fatigue lifetime of large substructures at deep waters be extended? What techniques are suitable? To which extent do they act on the structures? What are their efficiencies?
- How can innovative structures be developed/adapted which allow installations in deeper waters while maintaining low fatigue load levels and being economically competitive to floating structures? Why is the innovative concept efficient?
- How do the design parameters individually impact the design of monopiles and their engineering performance? What could be the effect of the interaction of these parameters?
- How do the design parameters influence the long term survival of the grouted joint under normal conditions? Given the computational cost of the finite element simulation, how can the grouted joint be assessed under extreme loading taken into account the uncertainties in the variables?

Respectively, the principal contributions and findings of the present work are:

Format for load exchange. A preparative method of loads to be exchanged between the different stakeholders of a complex design process is introduced. The development of this method is buttressed on the stress calculation algorithm. For the extreme loads, the promoted method is in line with the standards' recommendations relative to determination of the extreme loads as the highest of the peak averages of each mean wind speed. Comparison between this method and the conventional load format seen in literature shows that additional structure capacity is revealed by the proposed method and that material saving is possible.

Improvement of fatigue lifetime. Three methods for fatigue lifetime improvement have been developed for jacket substructures. The first focuses on the joint design methodology. Clear guideline rules have been established to help designers to reduce stress concentration factors at joints. The second intends to reduce the vibration of braces based on the application of magneto-rheological dampers. Modelling methods and effectiveness are presented together with installation steps. The third employs an aero-elastically tailored rotor to alleviate fatigue loads on the support structure. Whereas the rotor optimization process was not done within the present study, its effect on the substructure is shown in this work.

Semi-floater: An innovative substructure. The semi-floater concept has been introduced by previous studies. In this work, the detailed design of the universal joint has been proposed together with the installation process of the substructure. A design process of such substructure type has been presented along side with an algorithm to design mooring line at the preliminary phase.

Monopile: Influence of model parameters. The individual influences of some key model parameters (damping, construction errors, soil properties) and their interactions have been quantified in a comparative manner. It has been established for example that the soil-structure interaction can interact with the construction errors to amplify the fatigue demand at some hotspots of the monopile.

Grouted joint: Mechanical behavior and determinant parameters. A probabilistic design approach based on a detailed finite element model has been developed. In order to reduce the computationally expensive analysis of the joint, a method based on load criteria is proposed and the adapted probabilistic analysis process is explained. The influences of the steel wall thickness, of the conical angle, and of the grout length have been respectively identified. Recommendations are given to improve the design process.
Probabilistic prosumer node modeling for estimating planning parameters in distribution networks with renewable energy sources

With the increase in distributed generation, the demand-only nature of many secondary substation nodes in medium voltage networks is becoming a mix of temporally varying consumption and generation with significant stochastic components. Traditional planning, however, has often assumed that the maximum demands of all connected substations are fully coincident, and in cases where there is local generation, the conditions of maximum consumption and minimum generation, and maximum generation and minimum consumption are checked, again assuming unity coincidence. Statistical modelling is used in this paper to produce network solutions that optimize investment, running and interruption costs, assessed from a societal perspective. The decoupled utilization of expected consumption profiles and stochastic generation models enables a more detailed estimation of the driving parameters using the Monte Carlo simulation method. A planning algorithm that optimally places backup connections and three layers of switching has, for real-scale distribution networks, to make millions of iterations within iterations to form a solution, and therefore cannot computationally afford millions of parallel load flows in each iteration. The interface that decouples the full statistical modelling of the combinatorial challenge of prosumer nodes with such a planning algorithm is the main offering of this paper.

General information

State: Published
Organisations: Department of Wind Energy, Integration & Planning, Aalto University, SINTEF
Authors: Millar, R. J. (Ekstern), Ekstrom, J. (Ekstern), Lehtonen, M. (Ekstern), Saarijarvi, E. (Ekstern), Degefa, M. (Ekstern), Koivisto, M. J. (Intern)
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Monte Carlo methods
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General information

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Main Research Area: Technical/natural sciences
Source: PublicationPreSubmission
Prospects for generating electricity by large onshore and offshore wind farms: Letter
The decarbonisation of energy sources requires additional investments in renewable technologies, including the installation of onshore and offshore wind farms. For wind energy to remain competitive, wind farms must continue to provide low-cost power even when covering larger areas. Inside very large wind farms, winds can decrease considerably from their free-stream values to a point where an equilibrium wind speed is reached. The magnitude of this equilibrium wind speed is primarily dependent on the balance between turbine drag force and the downward momentum influx from above the wind farm. We have simulated for neutral atmospheric conditions, the wind speed field inside different wind farms that range from small (25 km²) to very large (105 km²) in three regions with distinct wind speed and roughness conditions. Our results show that the power density of very large wind farms depends on the local free-stream wind speed, the surface characteristics, and the turbine density. In onshore regions with moderate winds the power density of very large wind farms reaches 1 W m⁻², whereas in offshore regions with very strong winds it exceeds 3 W m⁻². Despite a relatively low power density, onshore regions with moderate winds offer potential locations for very large wind farms. In offshore regions, clusters of smaller wind farms are generally preferable; under very strong winds also very large offshore wind farms become efficient.

General information
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Organisations: Department of Wind Energy, Resource Assessment Modelling, Meteorology & Remote Sensing
Authors: Volker, P. (Intern), Hahmann, A. N. (Intern), Badger, J. (Intern), Ejsing Jørgensen, H. (Intern)
Number of pages: 9
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BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.74 SJR 2.71 SNIP 1.624
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.704 SNIP 1.535 CiteScore 4.51
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 2.177 SNIP 1.446 CiteScore 3.91
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 2.304 SNIP 1.671 CiteScore 4.06
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 2.122 SNIP 1.541 CiteScore 3.65
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.897 SNIP 1.503 CiteScore 3.51
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.732 SNIP 1.299
Web of Science (2010): Indexed yes
A sample of Al with grain size of 5.1 μm, prepared by spark plasma sintering, was deformed to a nominal strain of 0.35% under exposure to X-ray synchrotron radiation, allowing spatially resolved orientation measurements to be made during loading by use of a micro-diffraction technique. A significant heterogeneity in the deformation pattern between grains was observed. A statistical analysis shows that grain deformation depends more on crystallographic orientation than on grain size, with grains with tensile axis lying towards the <001>-<101> border of the unit triangle tending to undergo larger deformation. Other possible reasons for the different deformation behaviour between individual grains are briefly discussed.
Ramp events in the marine boundary-layer investigated by a wind lidar.

General information
State: Published
Organisations: Department of Wind Energy, National Institute of Meteorology and Hydrology
Authors: Gryning, S. (Intern), Batchvarova, E. (Ekstern)
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Activities:
Ramp events in the marine boundary-layer investigated by a wind lidar
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2017

Rayleigh’s quotient-based damage detection algorithm: Theoretical concepts, computational techniques, and field implementation strategies
This article proposes a Rayleigh’s quotient-based damage detection algorithm. It aims at efficiently revealing nascent structural changes on a given structure with the capability to differentiate between an actual damage and a change in operational conditions. The first three damage detection levels are targeted: existence, location, and severity. The proposed algorithm is analytically developed from the dynamics theory and the virtual energy principle. Some computational techniques are proposed for carrying out computations, including discretization, integration, derivation, and suitable optimization methods. Field implementation strategies are also considered for the purpose of online damage monitoring. In order to prove the efficiency of this strategy, one experimental and three numerical case studies were conducted. The proposed algorithm successfully detected the damage in all simulated cases and estimated the damage severity with acceptable accuracy. The conclusion is that the proposed algorithm was able to efficiently detect damage appearance in a range of structures for various damage levels and locations, and under different operational conditions.

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Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: NJOMO WANDJI, W. (Intern)
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Ratings:
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.06 SJR 0.849 SNIP 1.862
Web of Science (2017): Indexed Yes
Real-time impact of power balancing on power system operation with large scale integration of wind power

Highly wind power integrated power system requires continuous active power regulation to tackle the power imbalances resulting from the wind power forecast errors. The active power balance is maintained in real-time with the automatic generation control and also from the control room, where regulating power bids are activated manually. In this article, an algorithm is developed to simulate the activation of regulating power bids, as performed in the control room, during power imbalance between generation and load demand. In addition, the active power balance is also controlled through automatic generation control, where coordinated control strategy between combined heat and power plants and wind power plant enhances the secure power system operation. The developed algorithm emulating the control room response, to deal with real-time power imbalance, is applied and investigated on the future Danish power system model. The power system model takes the hour-ahead regulating power plan from power balancing model and the generation and power exchange capacities for the year 2020 into account. The real-time impact of power balancing in a highly wind power integrated power system is assessed and discussed by means of simulations for different possible scenarios.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning
Authors: Basit, A. (Intern), Hansen, A. D. (Intern), Sørensen, P. E. (Intern), Giannopoulos, G. (Intern)
Pages: 202-210
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Publication information
Journal: Journal of Modern Power Systems and Clean Energy (Online)
Volume: 5
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ISSN (Print): 2196-5420
Recommended practices for wind farm data collection and reliability assessment for O&M optimization

The paper provides a brief overview of the aims and main results of IEA Wind Task 33. IEA Wind Task 33 was an expert working group with a focus on data collection and reliability assessment for O&M optimization of wind turbines. The working group started in 2012 and finalized the work in 2016. The complete results of IEA Wind Task 33 are described in the expert group report on recommended practices for "Wind farm data collection and reliability assessment for O&M optimization" which will be published by IEA Wind in 2017. This paper briefly presents the background of the work, the recommended process to identify necessary data, and appropriate taxonomies structuring and harmonizing the collected entries. Finally, the paper summarizes the key findings and recommendations from the IEA Wind Task 33 work. (C) 2017 The Authors. Published by Elsevier Ltd.

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Organisations: Department of Wind Energy, Fraunhofer Institute for Wind Energy and Energy System Technology (IWES), SINTEF Energy Research, Chalmers University of Technology, Delft University of Technology, Offshore Renewable Energy Catapult, Atkins, ServusNet Informatics, Vattenfall Research and Development, Energy research Centre of the Netherlands - ECN, Norwegian University of Science and Technology
Authors: Hahn, B. (Ekstern), Welte, T. (Ekstern), Faulstich, S. (Ekstern), Bangalore, P. (Ekstern), Boussion, C. (Ekstern), Harrison, K. (Ekstern), Miguelanez-Martin, E. (Ekstern), O'Connor, F. (Ekstern), Pettersson, L. (Ekstern), Soraghan, C. (Ekstern), Stock-Williams, C. (Ekstern), Sørensen, J. D. (Intern), van Bussel, G. (Ekstern), Vatn, J. (Ekstern)
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BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.44 SJR 0.495 SNIP 0.799
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Scopus rating (2016): CiteScore 1.16 SJR 0.464 SNIP 0.598
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.359 SNIP 0.562 CiteScore 0.92
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.429 SNIP 0.807 CiteScore 1.09
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.42 SNIP 0.778 CiteScore 1.02
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
Scopus rating (2012): SJR 0.411 SNIP 0.55 CiteScore 1.08
Recrystallization texture in nickel heavily deformed by accumulative roll bonding

The recrystallization behavior of Ni processed by accumulative roll bonding to a total accumulated von Mises strain of 4.8 has been examined, and analyzed with respect to heterogeneity in the deformation microstructure. The regions near the bonding interface are found to be more refined and contain particle deformation zones around fragments of the steel wire brush used to prepare the surface for bonding. Sample-scale gradients are also observed, manifested as differences between the subsurface, intermediate and central layers, where the distributions of texture components are different. These heterogeneities affect the progress of recrystallization. While the subsurface and near-interface regions typically contain lower frequencies of cube-oriented grains than anywhere else in the sample, a strong cube texture forms in the sample during recrystallization, attributed to both a high nucleation rate and fast growth rate of cube-oriented grains. The observations highlight the sensitivity of recrystallization to heterogeneity in the deformation microstructure and demonstrate the importance of characterizing this heterogeneity over several length scales.

General information
State: Published
Organisations: Department of Wind Energy, Materials science and characterization, Tsinghua University
Authors: Mishin, O. V. (Intern), Zhang, Y. B. (Intern), Godfrey, A. (Ekstern)
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Scopus rating (2016): CiteScore 0.39 SJR 0.197 SNIP 0.535
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
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ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 0.183 SNIP 0.257 CiteScore 0.14
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.23 SNIP 0.355 CiteScore 0.1
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.179 SNIP 0.155
Reducing Turbine Mechanical Loads Using Flow Model-Based Wind Farm Controller
Cumulated O&M costs of offshore wind farms are comparable with wind turbine CAPEX of such wind farm. In wind farms, wake effects can result in up to 80% higher fatigue loads at downstream wind turbines [1] and consequently larger O&M costs. The present work therefore investigates to reduce these loads during the provision of grid balancing services using optimal model-based wind farm control. Wind farm controllers coordinate the operating point of wind turbines in a wind farm in order to achieve a given objective. The investigated objective of the control in this work is to follow a total wind farm power reference while reducing the tower bending moments of the turbines in the wind farm. The wind farm controller is tested on a 8 turbine array, which is representative of a typical offshore wind farm. The operation of the wind farm is simulated using the dynamic wind farm simulation tool SimWindFarm [2]. SimWindFarm allows for the simultaneous simulation of the turbulent hub height flow field in the wind farm, the turbine dynamics and the wind farm control. The tests show a reduction of loads when compared to other optimal wind farm control approaches. Future work shall enhance the controller with more advanced turbine fatigue models in order to further improve the controller's performance.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning
Authors: Kazda, J. (Intern), Cutululis, N. A. (Intern)
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Reductions in Offshore Wind Energy

General information
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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Aalborg University
Authors: Poulsen, T. (Ekstern), Hasager, C. B. (Intern)
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Remotely measuring the wind using turbine-mounted lidars: Application to power performance testing
Forward-looking wind lidars mounted on the nacelle of a wind turbines allow to remotely measure the flow upwind. The newest generation of nacelle lidar systems can sense the wind at multiple distances and multiple heights, and consequently has profiling capabilities. Wind lidars are cost-efficient and provide measurements more representative of the wind flow field than conventional meteorology mast. For the purpose of power curve measurement, it is essential that lidars provide traceable measurements and to assess their measurement uncertainty.

A generic calibration methodology was developed, using the so-called whitebox approach. It consists mainly in calibrating the lidar primary measurements of line-of-sight velocities. The line-of-sight velocity is the projection of the wind vector onto the laser beam propagation path. The calibration is performed in situ, by comparing the lidar velocity measurements to a reference quantity itself traceable to the international standards of units. The uncertainty of the line-of-sight velocity measurements was assessed using a normative methodology (GUM) which is based on the law of propagation of uncertainties. The generic calibration procedure was applied to two commercially developed nacelle lidar systems, the Avent 5-beam Demonstrator and the ZephIR Dual Mode lidars. Further, the line-of-sight positioning quantities such as inclination angles or beam trajectory were also calibrated and their uncertainties assessed. Calibration results were of high quality, with line-of-sight velocity measurements within 0.9% of the reference.
In the lidar measurement process, line-of-sight velocities taken in multiple locations (different heights, distances, and directions) are used to reconstruct useful wind characteristics such as wind speed, direction, shear, etc. Wind field reconstruction methods based on model-fitting techniques were developed. The model-fitting wind field reconstruction technique allows to clearly define the wind model – and state its inherent assumptions. Different wind models can be used without changing the general principles of the wind field reconstruction methods. Two wind models were developed in this thesis. The first one employs lidar measurement at a single distance – but several heights –, accounts for shear through a power law profile, and estimates hub height wind speed, direction and the shear exponent. The second model combines the wind model with a simple one-dimensional induction model. The lidar inputs were line-of-sight velocity measurements taken at multiple distances close to the rotor, from 0.5 to 1.25 rotor diameters. Using the combined wind-induction model, hub height free stream wind characteristics are estimated (speed, direction, shear, induction factor).

With the help of a seven-month full-scale measurement campaign at the Nørrekær Enge wind farm, the model-fitting wind field reconstruction technique and models were demonstrated. The same methods were applied to both the Avent 5-beam Demonstrator and ZephIR Dual-Mode nacelle lidars. Nacelle lidar estimates of wind characteristics were compared to those measured by instruments mounted on a mast located 2.5 rotor diameters from the turbine on which the lidars were mounted. For wind directions in the ‘IEC free sector’, the wind speed comparison results showed that lidar-estimates where within 0.7% from the top-mounted cup anemometer measurements. The secondary wind characteristics (direction, shear, induction factor) were also compared to reference quantities and proved to provide valuable information on the upstream flow field. The uncertainties of wind field characteristics estimated by the model-fitting reconstruction method were quantified using numerical error propagation techniques called Monte Carlo methods. These numerical methods are particularly relevant to propagate errors through complex non-linear models, since such models are outside the scope of the GUM methodology. The procedures used to apply Monte Carlo methods to wind field reconstruction codes were detailed. The uncertainty results are provided for a wide-range of wind field characteristics values, and for all the estimated wind characteristics. In particular, the model wind speed uncertainties were shown to be equivalent to the cup anemometer uncertainty that was used to calibrate the lidar line-of-sight velocity.

Finally, the methods were applied to power performance testing, using the experimental data of the Nørrekær Enge campaign. The IEC 61400-12-1 (ed. 2; 2017) standards for ‘Power performance measurements of electricity producing wind turbines’ provided the basis to develop procedures applying to nacelle-mounted lidars. The measured power curves using wind speed measurements from the two profiling nacelle lidars and from the mast top-mounted cup anemometer were compared. The power curve uncertainties were also quantified. Further, the annual energy production (AEP) was computed for a range of annual mean wind speeds. At 8ms⁻¹, the lidar-estimated AEP was within 1% to the one obtained with the cup anemometer. The combined wind-induction reconstruction technique represents a paradigm shift in power performance testing: it is no longer required to measure far upstream the rotor – between two and four rotor diameters – to approximate the free stream wind speed. Instead, measurements taken close to the turbine rotor by nacelle-mounted profiling lidars can be used to accurately estimate the free stream windspeed. In the future, nacelle lidars are likely to replace meteorological masts for turbine power performance testing.
planetary boundary-layer schemes. A reference set of mesoscale tendencies is used to drive microscale simulations using RANS k- and LES turbulence models. The validation is based on rotor-based quantities of interest. Cycle-integrated mean absolute errors are used to quantify model performance. The results of the benchmark are used to discuss input uncertainties from mesoscale modelling, different meso-micro coupling strategies (online vs offline) and consistency between RANS and LES codes when dealing with boundary-layer mean flow quantities. Overall, all the microscale simulations produce a consistent coupling with mesoscale forcings.

**General information**

State: Published

Organisations: Department of Wind Energy, Resource Assessment Modelling, Aerodynamic design, University of Colorado at Boulder, National Renewable Energy Center, University of Porto, Barcelona Supercomputing Centre, National Renewable Energy Laboratory, National Centre for Atmospheric Research, University of Leuven, Technical University of Denmark


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Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33

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BFI (2011): BFI-level 1

Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43

ISI indexed (2011): ISI indexed no

BFI (2010): BFI-level 1

Scopus rating (2010): SJR 0.288 SNIP 0.351

Web of Science (2010): Indexed yes

BFI (2009): BFI-level 1

Scopus rating (2009): SJR 0.259 SNIP 0.346

BFI (2008): BFI-level 1

Scopus rating (2008): SJR 0.264 SNIP 0.301

Web of Science (2008): Indexed yes
Revealing fatigue damage evolution in unidirectional composites for wind turbine blades using x-ray computed tomography

Understanding fatigue damage evolution in the load carrying laminates of wind turbine blade play an important role designing longer and lighter turbine blades. Turbine blades which will make it possible to increase the size of wind turbines or to upgrade existing turbines for lower wind classes'. Thereby, it will be possible to lower the cost of energy for wind energy based electricity. In the presented work, a lab-source x-ray computed tomography equipment (Zeiss Xradia 520 Versa) has been used in connection with ex-situ fatigue testing of uni-directional composites in order to identify fibre failure during the fatigue loading. The load carrying laminates in wind turbine blades is typically based on a number of non-crimp fabrics in where the load carrying fibres are oriented in the axial direction of the blades. In order to ease the handling of the fabric during the dry fabric layup and to ensure a good alignment of the final laminates, approximately 10% of the fibres are oriented in secondary directions as so-called backing bundles and stitched to the uni-directionally oriented bundles. Due to the coarse structure of the non-crimp fabric, test samples with a larger cross-section (compared to other comparable x-ray studies) have been used in order to ensure a representative test volume during the ex-situ fatigue testing. Using the ability of the x-ray computed tomography to zoom into regions of interest, non-destructive, the fatigue damage evolution in a repeating ex-situ fatigue loaded test sample has be explored. Thereby, the fatigue failure mechanism has been uncovered showing fibre breakage regions growing from cross-over regions of the backing bundles. Based on those observations, more realistic micromechanical based fatigue damage models as well as suggestions on bundle arrangement improving the fatigue resistance of non-crimp fabric used in the wind turbine industry can be made.

General information
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Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Mikkelsen, L. P. (Intern)
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Main Research Area: Technical/natural sciences
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Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2017

Role of copper on Laves phase morphology in 9-12%Cr steels

In this work the Laves phase was found to appear in two different morphologies, namely granular shapes and in an elongated shape. No difference in crystallography could be detected between these morphologies. The Laves phase was only observed in its primary form in Cu-containing steels, where it was the primary morphology present after short term ageing. After long term ageing, the elongated Laves phase was replaced by the granular morphology. It is speculated that Cu precipitates act as nucleation sites for the elongated Laves phase, resulting in an unstable orientation relationship with the matrix, an in the meta-stable elongated morphology of Laves phase precipitates.

General information
State: Published
Organisations: Department of Wind Energy, Materials science and characterization, Chalmers University of Technology
Authors: Danielsen, H. K. (Intern), Liu, F. (Ekstern)
Number of pages: 6
Publication date: 2017
Conference: 38th Risø International Symposium on Materials Science, Roskilde, Denmark, 04/09/2017 - 04/09/2017
Main Research Area: Technical/natural sciences
Rotor and wind turbine formalism

The main conventions used in this book for the study of rotors are introduced in this chapter. The main assumptions and notations are provided. The formalism specific to wind turbines is presented. The forces, moments, velocities and dimensionless coefficients used in the study of rotors are defined.
Roughness of grain boundaries in partly recrystallized aluminum

The roughness of grain boundaries in partly recrystallized microstructures has been quantified. Effects of material and processing parameters on the roughening behavior have been statistically investigated. Parameters are sample purity, deformation strain and boundary migration direction in two cold rolled aluminum samples. The results show that particle pinning is not the main reason accounting for recrystallization boundary roughness in the present samples. The roughness is however shown to relate to the deformation microstructure and possible effects of migration rate are discussed.
Scopus rating (2012): SJR 2.292 SNIP 1.996 CiteScore 3.01
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.314 SNIP 2.082 CiteScore 3.21
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.427 SNIP 2.117
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.569 SNIP 1.999
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.607 SNIP 2.108
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 2.216 SNIP 2.157
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 2.079 SNIP 1.899
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.877 SNIP 1.885
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.584 SNIP 1.679
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.622 SNIP 1.687
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.603 SNIP 1.338
Web of Science (2002): Indexed yes
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Web of Science (2001): Indexed yes
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Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 1.476 SNIP 1.151
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Recrystallization, Grain boundary structure, Deformation structure, Grain boundary migration
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Publication: Research - peer-review › Journal article – Annual report year: 2016

RUNE benchmarks
This report contains the description of a number of benchmarks with the purpose of evaluating flow models for near-shore wind resource estimation. The benchmarks are designed based on the comprehensive database of observations that the RUNE coastal experiment established from onshore lidar measurements mostly.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing
Authors: Peña, A. (Intern)
Number of pages: 25
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Publisher: DTU Wind Energy
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Original language: English
Scaling of turbulence spectra measured in strong shear flow near the Earth's surface

Within the lowest kilometer of the Earth's atmosphere, in the so-called atmospheric boundary layer, winds are often gusty and turbulent. Nearest to the ground, the turbulence is predominately generated by mechanical wall-bounded wind shear, whereas at higher altitudes turbulent mixing of heat and moisture also play a role. The variance (square of the standard deviation) of the fluctuation around the mean wind speed is a measure of the kinetic energy content of the turbulence. This kinetic energy can be resolved into the spectral distributions, or spectra, as functions of eddy size, wavenumber, or frequency. Spectra are derived from Fourier transforms of wind records as functions of space or time corresponding to wavenumber and frequency spectra, respectively. Atmospheric spectra often exhibit different subranges that can be distinguished and scaled by the physical parameters responsible for: (1) their generation; (2) the cascade of energy across the spectrum from large- to small-scale; and (3) the eventual decay of turbulence into heat owing to viscosity effects on the Kolmogorov microscale, in which the eddy size is only a fraction of a millimeter. This paper addresses atmospheric turbulence spectra in the lowest part of the atmospheric boundary layer—the so-called surface layer—where the wind shear is strong owing to the nonslip condition at the ground. Theoretical results dating back to Tchen's early work in 1953 'on the spectrum of energy in turbulent shear flow' led Tchen to predict a shear production subrange with a distinct inverse-linear power law for turbulence in a strongly sheared high-Reynolds number wall-bounded flow, as is encountered in the lowest sheared part of the atmospheric boundary layer, also known as the eddy surface layer. This paper presents observations of spectra measured in a meteorological mast at Havseere, Denmark, that support Tchen's prediction of a shear production subrange following a distinct power law of degree −1 in the lowest part of the atmospheric surface layer with the form $\sim u_\ast^2 k^{-1}$, where $u_\ast$ is the surface friction velocity and $k$ is the wavenumber. Tchen's turbulence theory is shown to be able to predict the measured spectra of the wind velocity component parallel to the mean wind direction for eddy sizes larger than the measurement height above the ground. An amended analytical model for the near-neutral surface layer spectrum is then proposed. This model, which is applicable to the scaling of the $u$ spectrum at all heights in the surface layer, is obtained by a combination of Kaimal's classical spectral model for scaling the inertial subrange with Tchen's 1953 and 1954 proposed shear production subrange theory. The shear production-amended spectral model is compared with observations of ensemble-averaged near-neutral spectra selected during a nine-month measurement period from recordings from six sonic anemometers at heights of 10, 20, 40, 60, 80, and 100 m in the meteorological tower at the test site for large wind turbines in Havseere, Denmark. Finally, potential applications of the new spectral model are discussed, in particular for use within the lowest one-third of the surface layer in which the production subrange component of the spectrum is most prominent. The new spectral model can supply wavenumber-resolved turbulent kinetic energies for the prediction of wind loads on buildings, bridges, and wind turbines, and its spectral parameterization can also be used for scale-dependent parameterization of, e.g., surface-released atmospheric dispersion calculations for regions close to the ground.

General information
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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling
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Journal: Physica Scripta
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.14
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scanning Lidar Spatial Calibration and Alignment Method for Wind Turbine Wake Characterization
Sandia National Laboratories and the National Renewable Energy Laboratory conducted a field campaign at the Scaled Wind Farm Technology (SWiFT) Facility using a customized scanning lidar from the Technical University of Denmark. The results from this field campaign will support the validation of computational models to predict wake dissipation and wake trajectory offset downstream of a stand-alone wind turbine. In particular, regarding the effect of changes in the atmospheric boundary layer inflow state and turbine yaw offset. A key step in this validation process involves quantifying, and reducing, the uncertainty in the wake measurements. The present work summarizes the process that was used to calibrate the alignment of the lidar in order to reduce this source of uncertainty in the experimental data from the SWiFT field test.

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Department of Wind Energy, Meteorology & Remote Sensing, Sandia National Laboratories
Authors: Herges, T. (Ekstern), Maniaci, D. (Ekstern), Naughton, B. (Ekstern), Hansen, K. H. (Intern), Sjöholm, M. (Intern), Angelou, N. (Intern), Mikkelsen, T. K. (Intern)
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Main Research Area: Technical/natural sciences
Conference: 35th Wind Energy Symposium, Grapevine, TX, United States, 09/01/2017 - 09/01/2017
DOIs:
Selective Laser Melting of Hot Gas Turbine Components: Materials, Design and Manufacturing Aspects

Selective Laser Melting (SLM) allows the design and manufacturing of novel parts and structures with improved performance e.g. by incorporating complex and more efficient cooling schemes in hot gas turbine parts. In contrast to conventional manufacturing of removing material, with SLM parts are built additively to nearly net shape. This allows the fabrication of arbitrary complex geometries that cannot be made by conventional manufacturing techniques. However, despite the powerful capabilities of SLM, a number of issues (e.g. part orientation, support structures, internal stresses), have to be considered in order to manufacture cost-effective and high quality parts at an industrial scale. These issues are discussed in the present work from an engineering point of view with the aim to provide simple guidelines to produce high quality SLM parts.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Goutianos, S. (Intern)
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Main Research Area: Technical/natural sciences

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  Scopus rating (2017): CiteScore 0.49 SJR 0.201 SNIP 0.573
  BFI (2016): BFI-level 1
  Scopus rating (2016): CiteScore 0.39 SJR 0.197 SNIP 0.535
Web of Science (2016): Indexed yes
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Scopus rating (2015): SJR 0.197 SNIP 0.361 CiteScore 0.22
Scopus rating (2014): SJR 0.206 SNIP 0.362 CiteScore 0.18
Scopus rating (2013): SJR 0.205 SNIP 0.287 CiteScore 0.16
ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 0.183 SNIP 0.257 CiteScore 0.14
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.23 SNIP 0.355 CiteScore 0.1
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.179 SNIP 0.155
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Self-Reinforced PLA Composites: Bio-based and Biodegradable Polymer Materials for Industrial Applications
Self-similarity of far wake behind tandem of two disks

In this work we used digital particle image visualization (PIV) to experimentally establish the self-similarity of far wake behind a tandem of two disks of a diameter D (300 mm) with a common axis along the incident flow. The research was performed in a water flume (Re ≈ 2 · 10⁵) with variation of L, the longitudinal dimension of the tandem. The self-similarity of the velocity profile in the wake behind the tandem has been established; the level of turbulent fluctuations of the profile has been measured. Due to the influence of the second disk, the velocity deficit in the wake behind the tandem exceeded the corresponding value for a single disk, being independent of the distance between the disks (L = 4–8D). The velocity fluctuations behind the tandem did not differ much from the level of fluctuations in the case of a single disk up to a distance of forty calibers downstream, where the wake ceased to differ from the background of natural turbulent fluctuations of the incident flow. It has been found that the position of the second disk in the tandem affects the energy loss in the wake due to its expansion but does not influence the decay. The revealed patterns in the wake development behind tandems of bodies will enable optimization of construction of systems of repetitive elements and their movement in different flows.
Sensitivity analysis of nacelle lidar free stream wind speed measurements to wind-induction reconstruction model and lidar range configuration

The sensitivity of nacelle lidar wind speed measurements to wind-induction models and lidar range configurations is studied using experimental data from the Nørrekær Enge (NKE) measurement campaign and simulated lidar data from Reynold-Averaged Navier Stokes (RANS) aerodynamic computational fluid dynamics (CFD) simulations. In both approaches, the data correspond to measurements (or simulations) from a five-beam Demonstrator (5B-Demo) unit developed by Avent Lidar Technology and a ZephIR Dual-Mode (ZDM) unit developed by Zephir Lidar. The 5B-Demo was configured to measure at ten distances while the ZDM was configured to measure at five distances.

From the configured distances, a large number of range configurations were created and systematically tested to determine the sensitivity of the reconstructed wind speeds to the number of ranges, minimum range and maximum range in the range configurations. The wind speeds were reconstructed using both a one-dimensional and two-dimensional induction model to test the sensitivity towards the wind-induction model. In all cases, the sensitivity of the reconstructed wind speed was determined from the wind speed error and root mean square error (RMSE) of the fitting residuals.

The results demonstrate that it is not possible to use RANS CFD simulated lidar data to determine optimal range configurations for real-time nacelle lidars due to their perfect (unrealistic) representation of the simulated flow field. The recommended range configurations are therefore based on the NKE sensitivity analysis results. Based on these results, it is recommended to configure nacelle lidars to measure at approximately 3-5 ranges. The minimum distance should be configured to roughly 0.5 rotor diameters (Drot) while it is recommended that the maximum range lay within 1-1.5Drot. In addition, the results show that the reconstructed wind speeds are insensitive to the wind-induction reconstruction model.

General information

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Aerodynamic design
Authors: Svensson, E. (Intern), Borraccino, A. (Intern), Meyer Forsting, A. R. (Intern), Troldborg, N. (Intern), Wagner, R. (Intern)
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Main Research Area: Technical/natural sciences
Electronic versions:
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Sensitivity analysis of WRF model PBL schemes in simulating boundary-layer variables in southern Italy: An experimental campaign

The sensitivity of boundary layer variables to five (two non-local and three local) planetary boundary-layer (PBL) parameterization schemes, available in the Weather Research and Forecasting (WRF) mesoscale meteorological model, is evaluated in an experimental site in Calabria region (southern Italy), in an area characterized by a complex orography near the sea. Results of 1km×1km grid spacing simulations are compared with the data collected during a measurement campaign in summer 2009, considering hourly model outputs. Measurements from several instruments are taken into account for the performance evaluation: near surface variables (2m temperature and relative humidity, downward shortwave radiation, 10m wind speed and direction) from a surface station and a meteorological mast; vertical wind profiles from Lidar and Sodar; also, the aerosol backscattering from a ceilometer to estimate the PBL height. Results covering the whole measurement campaign show a cold and moist bias near the surface, mostly during daytime, for all schemes, as well as an overestimation of the downward shortwave radiation and wind speed. Wind speed and direction
are also verified at vertical levels above the surface, where the model uncertainties are, usually, smaller than at the surface. A general anticlockwise rotation of the simulated flow with height is found at all levels. The mixing height is overestimated by all schemes and a possible role of the simulated sensible heat fluxes for this mismatching is investigated. On a single-case basis, significantly better results are obtained when the atmospheric conditions near the measurement site are dominated by synoptic forcing rather than by local circulations. From this study, it follows that the two first order non-local schemes, ACM2 and YSU, are the schemes with the best performance in representing parameters near the surface and in the boundary layer during the analyzed campaign.

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Organisations: Department of Wind Energy, Resource Assessment Modelling , National Research Council of Italy
Authors: Avolio, E. (Ekstern), Federico, S. (Ekstern), Miglietta, M. (Ekstern), Lo Feudo, T. (Ekstern), Calidonna, C. (Ekstern), Sempreviva, A. M. (Intern)
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BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 3.85 SJR 1.533 SNIP 1.447
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 1.619 SNIP 1.657 CiteScore 3.93
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.629 SNIP 1.643 CiteScore 3.36
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.445 SNIP 1.697 CiteScore 3.06
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.141 SNIP 1.519 CiteScore 2.48
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.343 SNIP 1.356 CiteScore 2.3
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.112 SNIP 1.156 CiteScore 2.17
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.965 SNIP 0.966
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.013 SNIP 1.194
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.81 SNIP 0.95
Scopus rating (2007): SJR 1.154 SNIP 1.078
Scopus rating (2006): SJR 0.853 SNIP 0.817
Scopus rating (2005): SJR 0.942 SNIP 1.006
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.856 SNIP 0.806
Short-term residential load forecasting: Impact of calendar effects and forecast granularity

Literature is rich in methodologies for “aggregated” load forecasting which has helped electricity network operators and retailers in optimal planning and scheduling. The recent increase in the uptake of distributed generation and storage systems has generated new demand for “disaggregated” load forecasting for a single-customer or even down at an appliance level. Access to high resolution data from smart meters has enabled the research community to assess conventional load forecasting techniques and develop new forecasting strategies suitable for demand-side disaggregated loads. This paper studies how calendar effects, forecasting granularity and the length of the training set affect the accuracy of a day-ahead load forecast for residential customers. Root mean square error (RMSE) and normalized RMSE were used as forecast error metrics. Regression trees, neural networks, and support vector regression yielded similar average RMSE results, but statistical analysis showed that regression trees technique is significantly better. The use of historical load profiles with daily and weekly seasonality, combined with weather data, leaves the explicit calendar effects a very low predictive power. In the setting studied here, it was shown that forecast errors can be reduced by using a coarser forecast granularity. It was also found that one year of historical data is sufficient to develop a load forecast model for residential customers as a further increase in training dataset has a marginal benefit.
Shot peening speed measurements using lidar technology

The shot peening technique is used for the surface modification of metallic components that are part of wind turbines, such as gears, bolts and blade coatings to prevent erosion. An important parameter of this technique is the dynamic energy of emitted shots. In this context the objective of this project is to present a proof of concept measurement method for the evaluation of the speed of the shots. A remote sensing laser anemometer was selected as a probing instrument of the peening shots’ speed since it avoids any disturbances to the flow from the presence of an in-situ instrument. Furthermore, the risk of damaging the peening machine by installing an instrument inside the chamber during operation is eliminated by this approach. Laser anemometers are being researched and developed in the department of Wind Energy, mainly in the framework of the WindScanner.dk infrastructure project [1], but also validated and used in monitoring the wind conditions around wind turbines (wake and inflow), over complex terrain as well as offshore.

General information

State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Department of Mechanical Engineering, Manufacturing Engineering, Materials science and characterization, Composites and Materials Mechanics, Materials and Surface Engineering
Authors: Angelou, N. (Intern), Zhang, X. (Intern), Sjöholm, M. (Intern), Lorentzen, L. (Intern), Huang, X. (Intern)
Number of pages: 83
Simulating coastal effects on an offshore wind farm

Wind turbine wakes can cause energy losses in wind farms and their effect needs to be modeled in order to design energy efficient wind farm layouts. Wake losses in offshore wind farms are often modeled by assuming offshore conditions for all wind directions; however, many offshore wind farms are built in the vicinity of a coastline. In this study, we simulate the effect of the Danish Peninsula Djursland on the Anholt offshore wind farm, using a Reynolds-averaged Navier-Stokes (RANS) setup. The coastline is modeled as a roughness change, the wind turbines are represented by actuator disks and a neutral atmospheric boundary layer including Coriolis forces is employed. For westerly and south westerly winds, the distance from the coastline to the Anholt wind farm varies between 15 and 50 km, which causes a horizontal wind speed gradient that results in a variation in wind turbine power along the north-south oriented rows. This effect is visible in RANS, as plotted in Figure 1 and is also observed in SCADA data provided by DONG Energy. The wind resources at the wind farm and the power deficits, calculated by RANS, are compared with mesoscale simulations and SCADA data, respectively.

Simulating European wind power generation applying statistical downscaling to reanalysis data

The growing share of electricity production from solar and mainly wind resources constantly increases the stochastic nature of the power system. Modelling the high share of renewable energy sources and in particular wind power - crucially depends on the adequate representation of the intermittency and characteristics of the wind resource which is related to the accuracy of the approach in converting wind speed data into power values. One of the main factors contributing to the uncertainty in these conversion methods is the selection of the spatial resolution. Although numerical weather prediction models can simulate wind speeds at higher spatial resolution (up to 1 x 1 km) than a reanalysis (generally, ranging from about 25 km to 70 km), they require high computational resources and massive storage systems: therefore, the most common alternative is to use the reanalysis data. However, local wind features could not be captured by the use of a reanalysis technique and could be translated into misinterpretations of the wind power peaks, ramping capacities, the behaviour of power prices, as well as bidding strategies for the electricity market. This study contributes to the understanding what is captured by different wind speeds spatial resolution datasets, the importance of using high resolution data for the conversion into power and the implications in power system analyses. It is proposed a methodology to increase the spatial resolution from a reanalysis. This study presents an open access renewable generation time series dataset for the EU-28 and neighbouring countries at hourly intervals and at different geographical aggregation levels (country, bidding zone and administrative territorial unit), for a 30 year period taking into account the wind generating fleet at the end of 2015. (C) 2017 The Authors. Published by Elsevier Ltd.
Simulation and Analysis of Wind Turbine Wakes

Modern wind turbines are often clustered in wind farms in which the turbines are fully or partially influenced by the wake of upstream located turbines. As a consequence, the wake behind the wind turbines has a lower mean wind speed and an increased turbulence level, as compared to the undisturbed flow outside the farm. Hence, wake interaction leads to a decreased total production of power, caused by lower kinetic energy in the wind, and an increase in the turbulence intensity. The turbulence created from wind turbine wakes is mainly due to the presence of the distinct tip and root vortices, which eventually break down and form small-scale turbulent structures. If a wind turbine is located in a wake consisting of tip and root vortices, the fatigue loading is more severe than in the case where the tip vortices have already broken down by instability mechanisms. Therefore, understanding the physical nature of the vortices and their dynamics in the wake of a turbine is important for the optimal design of a wind farm.

Simulation of regional day-ahead PV power forecast scenarios

Uncertainty associated with Photovoltaic (PV) generation can have a significant impact on real-time planning and operation of power systems. This obstacle is commonly handled using multiple forecast realizations, obtained using for example forecast ensembles and/or probabilistic forecasts, often at the expense of a high computational burden. Alternatively, some power system applications may require realistic forecasts rather than actual estimates; able to capture the uncertainty of weather-driven generation. To this end, we propose a novel methodology to generate day-ahead forecast scenarios of regional PV production matching the spatio-temporal characteristics while preserving the statistical properties of actual records.
Simulation of the Flow past a Circular Cylinder Using an Unsteady Panel Method

In the present work, an in-house UnSteady Double Wake Model (USDWM) is developed for simulating general flow problems behind bodies. The model is presented and used to simulate flows past a circular cylinder at subcritical, supercritical, and transcritical flows. The flow model is a two-dimensional panel method which uses the unsteady double wake technique to model flow separation and its dynamics. In the present work the separation location is obtained from experimental data and fixed in time. The highly unsteady flow field behind the cylinder is analyzed in detail. The results are compared with experiments and Unsteady Reynolds-Averaged Navier Stokes (URANS) simulations and show good agreement in terms of the vortex shedding characteristics, drag, and pressure coefficients for the different flow regimes.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Coventry University
Authors: Ramos García, N. (Intern), Sarlak Chivaee, H. (Intern), Andersen, S. J. (Intern), Sørensen, J. N. (Intern)
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Scopus rating (2017): CiteScore 2.68 SJR 0.876 SNIP 1.394
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.03 SJR 1.139 SNIP 1.784
Web of Science (2016): Indexed yes
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Scopus rating (2015): SJR 1.199 SNIP 1.685 CiteScore 2.67
Web of Science (2015): Indexed yes
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Scopus rating (2014): SJR 1.143 SNIP 1.9 CiteScore 2.72
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.074 SNIP 1.974 CiteScore 2.73
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.889 SNIP 1.811 CiteScore 2.22
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.844 SNIP 1.548 CiteScore 2.06
Site assessment
This report describes the site assessment of a given position in a given site, for a wind turbine with a well-defined hub height and rotor diameter. The analysis is carried out in accordance to IEC 61400-12-1 [1], and both an obstacle assessment and a terrain assessment are performed.

General information
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Organisations: Department of Wind Energy, Test and Measurements
Authors: Villanueva, H. (Intern), Vesth, A. (Intern)
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Series: DTU Wind Energy WTT I
Number: 1207
Main Research Area: Technical/natural sciences

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This is an internal report and therefore not available in full text. Please contact author's or director of author's department for further information.

Solving conic optimization problems via self-dual embedding and facial reduction: A unified approach
We establish connections between the facial reduction algorithm of Borwein and Wolkowicz and the self-dual homogeneous model of Goldman and Tucker when applied to conic optimization problems. Specifically, we show that the self-dual homogeneous model returns facial reduction certificates when it fails to return a primal-dual optimal solution or a certificate of infeasibility. Using this observation, we give an algorithm based on facial reduction for solving the primal problem that, in principle, always succeeds. (An analogous algorithm is easily stated for the dual problem.) This algorithm has the appealing property that it only performs facial reduction when it is required, not when it is possible; e.g., if a primal-dual optimal solution exists, it will be found in lieu of a facial reduction certificate even if Slater's condition fails. For the case of linear, second-order, and semidefinite optimization, we show that the algorithm can be implemented by assuming oracle access to the central-path limit point of an extended embedding, a strictly feasible conic problem with a strictly
feasible dual. We then give numerical experiments illustrating barriers to practical implementation.

**General information**

State: Published
Organisations: Department of Wind Energy, Massachusetts Institute of Technology, MOSEK ApS
Authors: Permenter, F. (Ekstern), Friberg, H. A. (Intern), Andersen, E. D. (Ekstern)
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BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 2.61 SJR 2.195 SNIP 1.867
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.22 SJR 2.652 SNIP 2.188
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 3.235 SNIP 2.383 CiteScore 3.32
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.672 SNIP 2.443 CiteScore 2.98
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.043 SNIP 2.618 CiteScore 3.44
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.391 SNIP 2.668 CiteScore 3.05
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.178 SNIP 2.147 CiteScore 2.4
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.233 SNIP 2.257
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.871 SNIP 2.132
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.283 SNIP 2.215
Scopus rating (2007): SJR 2.593 SNIP 2.206
Scopus rating (2006): SJR 1.957 SNIP 2.281
Scopus rating (2005): SJR 3.097 SNIP 2.659
Scopus rating (2004): SJR 3.585 SNIP 2.923
Scopus rating (2003): SJR 3.16 SNIP 2.531
Scopus rating (2002): SJR 2.647 SNIP 2.53
Scopus rating (2001): SJR 2.496 SNIP 1.361
Scopus rating (2000): SJR 3.882 SNIP 1.889
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 4.144 SNIP 2.274

Original language: English

Conic optimization, Facial reduction, Homogeneous model, Self-dual embedding

Electronic versions:
Spatial reliability analysis of a wind turbine blade cross section subjected to multi-axial extreme loading

This paper presents a methodology for structural reliability analysis of wind turbine blades. The study introduces several novel elements by taking into account loading direction using a multiaxial probabilistic load model, considering random material strength, spatial correlation between material properties, progressive material failure, and system reliability effects. An example analysis of reliability against material failure is demonstrated for a blade cross section. Based on the study we discuss the implications of using a system reliability approach, the effect of spatial correlation length, type of material degradation algorithm, and reliability methods on the system failure probability, as well as the main factors that have an influence on the reliability. (C) 2017 Elsevier Ltd. All rights reserved.

General information
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Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Dimitrov, N. K. (Intern), Bitsche, R. (Intern), Blasques, J. P. A. A. (Intern)
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Main Research Area: Technical/natural sciences

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Scopus rating (2017): CiteScore 3.86 SJR 1.899 SNIP 2.58
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
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Scopus rating (2010): SJR 2.029 SNIP 2.714
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Scopus rating (2009): SJR 2.174 SNIP 2.988
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Spatiotemporally resolved characteristics of a gliding arc discharge in a turbulent air flow at atmospheric pressure

A gliding arc discharge was generated in a turbulent air flow at atmospheric pressure driven by a 35kHz alternating current (AC) electric power. The spatiotemporally resolved characteristics of the gliding arc discharge, including glow-type discharges, spark-type discharges, short-cutting events and transitions among the different types of discharges, were investigated using simultaneously optical and electrical diagnostics. The glow-type discharge shows sinusoidal-like voltage and current waveforms with a peak current of hundreds of milliamperes. The frequency of the emission intensity variation of the glow-type discharge is the same as that of the electronic power dissipated in the plasma column. The glow-type discharge can transfer into a spark discharge characterized by a sharp peak current of several amperes and a sudden increase of the brightness in the plasma column. Transitions can also be found to take place from spark-type discharges to glow-type discharges. Short-cutting events were often observed as the intermediate states formed during the spark-glow transition. Three different types of short-cutting events have been observed to generate new current paths between two plasma channel segments, and between two electrodes, as well as between the channel segment and the electrodes, respectively. The short-cut upper part of the plasma column that was found to have no current passing through can be detected several hundreds of microseconds after the short-cutting event. The voltage recovery rate, the period of AC voltage-driving signal, the flow rates and the rated input powers were found to play an important role in affecting the transitions among the different types of discharges.
Spectral analysis of long term measurements of wind and turbulence from tall masts – land and sea based.

In a continuing study we are analyzing wind speed data from tall masts with the purpose of providing answers to some of the outstanding questions concerning the flow in the atmospheric boundary layer. The right answers are essential for one of the NEWA key activities: The building of the model chain and its use for computing the high resolution time series at every grid point which will be an important part of the final wind atlas database. The dataset then allows us to investigate one of the most crucial issues in the concept of the model chain namely that of linking the two-dimensional mesoscale flow models to the three-dimensional microscale turbulence models. The analysis is based on data from five sites: The land based data comes from the two Danish test stations for large wind turbines: Høvsøre and Østerild. The offshore data comes from the wind farms Horns Rev M2 and Horns Rev M8 and from the German research platform FINO3. We are mainly performing spectral analysis on the extensive mean meteorological cup anemometer data and high frequency sonic anemometer data. In the first part of our study we aimed at establishing the full scale spectrum of the boundary layer wind using the data from the 100m mast at Høvsøre and the 62m mast at Horns Rev M2. The results from the study were published in¹. One of the important conclusions was: The spectral gap in the horizontal wind power spectrum exists and can be modeled. The linear composite of the wind variations from the mesoscale and microscale gives the observed power spectrum in the gap range. Depending on the relative contribution to the variation from the microscale and mesoscale, the gap may be visible or invisible.

In the next phase of the current study, data from the Østerild mast is added to our knowledge on the variation with height of the mesoscale and turbulence flows, as we have extended the analysis from 100 m to 241 m. Of a special interest is the variation with height of the spectral gap, the turbulence quantities and the mesoscale spectra. The Østerild study also complements the Horns Rev (off-shore) and the Høvsøre (coastal) study in the sense that Østerild shows clearly land based properties, such as a non-disappearing diurnal peak in the spectra for all the heights. Then a part of this study is devoted to investigate the variation with height of the diurnal cycle of the horizontal wind speed; the difference between land and sea and the special variation over land with a minimum at around 80 – 100 meter and a continuing increase with height after the minimum. The study provides an explanation of these variations. Clearly, it is relevant to examine if the NEWA modeled time series can reproduce the daily variations correctly. We are further analyzing the impact of the frequent occurrence of cellular structures over Northern Europe in the atmospheric boundary layer on the spectral properties, following often cold polar outbreaks. Open cells have a tendency to fill up the spectral gap and as a consequence, in such situations, make load calculations based on contemporary turbulence model schemes questionable. We also attempt to use the full lateral spectrum to estimate wake meandering for different atmospheric conditions, using reasonable estimates of β, the ratio between the Lagrangian – Eulerian timescales of correlation.
Spoiled darkness? Sense of place and annoyance over obstruction lights from the world's largest wind turbine test centre in Denmark

The relation between wind power development and local communities has received considerable attention in literature and practice. Relatively few studies, however, have provided evidence about how local citizens perceive enduring environmental impacts such as aviation obstruction lights installed on wind turbines or on wind farm light masts. Evidence regarding people’s perceived annoyance over obstruction lights is of increasing importance as wind turbines become taller, thus potentially affecting more people in the future. The paper conducts individual web-based surveys and interviews with local residents around the world’s largest onshore test site for tall wind turbines in Denmark – the national test site in the rural area of Østerild. The aim is to explore the nature and extent of perceived annoyance over aviation obstruction lights from the test site and the efficiency of different coping strategies. In particular, the discussion focuses on the perceived annoyance in relation to the perceived changes in sense of place, hereunder the loss of the area’s unique night darkness. We argue that perceived annoyance can only be mitigated through coping strategies to a limited extent, as a) perceived effects on sense of place are distinctive in shaping annoyance, and b) an internalisation of planning-related inequities persists.

Statistical characterization of roughness uncertainty and impact on wind resource estimation

In this work we relate uncertainty in background roughness length (z0) to uncertainty in wind speeds, where the latter are predicted at a wind farm location based on wind statistics observed at a different site. Sensitivity of predicted winds to roughness is derived analytically for the industry-standard European Wind Atlas method, which is based on the geostrophic drag law. We statistically consider roughness and its corresponding uncertainty, in terms of both z0 derived from measured wind speeds as well as that chosen in practice by wind engineers. We show the combined effect of
roughness uncertainty arising from differing wind-observation and turbine-prediction sites; this is done for the case of roughness bias as well as for the general case. For estimation of uncertainty in annual energy production (AEP), we also develop a generalized analytical turbine power curve, from which we derive a relation between mean wind speed and AEP. Following our developments, we provide guidance on approximate roughness uncertainty magnitudes to be expected in industry practice, and we also find that sites with larger background roughness incur relatively larger uncertainties.

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Stored energy and recrystallized microstructures in nickel processed by accumulative roll bonding to different strains
The stored energy and the microstructure have been investigated in polycrystalline Ni processed by accumulative roll bonding (ARB) to different von Mises strains, $\varepsilon_{(VM)} = 1.6-6.4$. The stored energy in Ni after ARB is found to be higher than that in conventionally rolled Ni samples after similar strains, which is attributed to a finer average boundary spacing due to ARB. Annealing at 300 degrees C for 2 h after ARB results in recrystallized microstructures and textures, which are very different in the samples deformed to different strains. Whereas there is no dominant texture component in the ARB-processed samples annealed after strains <3, cube-oriented grains dominate the texture in the higher-strain samples. Nevertheless, regions near the most recently formed bonding interfaces contain a large frequency of non-cube oriented grains even in the high-strain samples. The average recrystallized grain size decreases with increasing strain before annealing, whereas the fraction of LABs formed between recrystallized grains increases. The correlation between the average recrystallized grain size, crystallographic texture and the fraction of LABs is discussed. Results obtained in this study are compared with previous findings for ARB-processed materials.

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BFI (2015): BFI-level 1
Stress and Strain Gradients in a Low Carbon Steel Deformed under Heavy Sliding

A recent study [1] has shown that a microstructure can be refined to a record low of 5 nm and that dislocation glide is still a controlling mechanism at this length scale. In this study, by heavy rotatory sliding of a low carbon steel a gradient structure has been produced extending to about 2.5 mm below the surface reducing the structural scale to the nanometer dimension and increasing the strength to extreme values by dislocation and boundary strengthening. The microstructure and texture gradient are analyzed and stress and strain gradients produced by plastic deformation are evaluated based on the deformation microstructure using the classic stress-structure relationship. Computational and materials modelling has been advanced from bulk to gradient structures leading to dissemination of constitutive stress-strain equations in gradient structures.
Structural degradation of a large composite wind turbine blade in a full-scale fatigue test

Wind turbine blades are expected to sustain a high number of loading cycles typically up to a magnitude of 1,000 million during their targeted service lifetime of 20-25 years. Structural properties of composite blades degrade with the time. Although substantial studies, such as [1,2], have been carried out at a coupon level to characterize fatigue degradation of composite materials, there is no much study focusing on fatigue degradation of rotor blades at a fullscale structural level. Do structural properties of composite blades degrade in a similar manner to what has been observed in material tests at a coupon level? What might be the concerns one should take into account when predicting residual structural properties of rotor blades? To answer, at least to a partial extent, these questions, this study conducts a full-scale fatigue test on a 47m composite rotor blade according to IEC 61400-23 (ed. 2014). A conventional single-axis mass resonance excitation (rotating mass) method is used as it is now still widely used for blade certification. The blade is tested in a flap-wise bending direction with the suction side primarily under compressive stress and pressure side under tensile stress, see Fig. 1. The applied loads are increased to reduce the number of cycles to 2.0 million cycles. Bending stiffness of the blade is measured at different span-wise sections during the fatigue test in order to measure its possible degradation. Natural frequencies and damping ratios are measured both before and after fatigue test. Post-fatigue damage of the blade is examined throughout the blade. It is found that the blade exhibited different stiffness degradation patterns at different cross sections. As shown in Fig. 2, the bending stiffness of the blade from 0 to 19 m did not show obvious degradation during fatigue test. However, the bending stiffness of the blade from 0 to 28 m and that from 0 to 39.5 m showed very similar degradation pattern to composite materials, which is fast at the early stage and slow at the following stage. In addition, it is noted that the overall stiffness degradation is shown to be not significant.

Structural design optimization of a morphing trailing edge flap for wind turbine blades

A flap actuation system, the Controllable Rubber Trailing Edge Flap (CRTEF), for distributed load control on a wind turbine blade had been developed in the period from 2006 to 2013 at DTU (http://www.induflap.dk/). The purpose of the presented work is to optimize the structural design of the flexible part of the CRTEF based on a realistic blade section geometry in order to meet the required objectives and constraints. The objectives include the deflection requirements and the energy efficiency, while the constraints include the bending stiffness of the structure, the local shape deformations, critical material strength, and manufacturing limitations. A model with arches forming concave on the flap surface and enclosing the voids to be pressurized results in the bending movement of the flap when pressure is applied on the voids to straighten the arches. The model is designed using SolidWorks for the parameterization of the design and ANSYS Workbench for the static structural Finite Element Analysis (FEA) simulations. The built-in parametric optimizer of ANSYS Workbench, Direct Optimization of Design Exploration is used to optimize the design with the parameters of the geometry. The surface pressure loads during operation of the turbine with the flap installed are evaluated with XFOIL and included in the simulations. The model is developed first by qualitative analyses to obtain a reasonable preliminary design, and then by parametric optimization to have the final design. The parameterization of the design is improved on the way of optimizations, in order to expand the design space to solve the problem of stress concentration, so that it covers the design with an acceptable material safety factor. With the consideration of surface pressure loads during operation of the turbine, the optimum design fulfills the requirements for flap angle of 15deg and -15deg with the actuation pressure of 0.428 MPa and 0.386 MPa, and the material safety factor margins, respectively. The design also meets the objective for energy efficiency by the lower actuation pressure than in earlier designs and by the small volume of the voids. Besides, the constraint of the bending stiffness is fulfilled with the deflection of less than the flap angle of ±5deg when the turbine is operating without the actuation pressure, and the constraints of the local shape deformations and manufacturing
Structural refinement and property optimization in an Fe-23Cr-8.5Ni duplex stainless steel

An Fe-23Cr-8.5Ni duplex stainless steel was used to prepare samples with different volume-fraction-weighted grain sizes \((d(\alpha \gamma))\), ranging from the nano-scale to the micrometer-scale by cold rolling and subsequent annealing. The cold rolled sample with \(d(\alpha \gamma)\) of 72 nm showed a high yield strength of about 1.3 GPa but only a small tensile elongation. An abrupt increase of ductility was observed as \(d(\alpha \gamma)\) increased to 375 nm, resulting in a good combination of yield strength of 738 MPa and tensile elongation of 29%. Further increase of \(d(\alpha \gamma)\) up to the micrometer-scale results in continued decreases in yield strength but with only a limited improvement in the ductility.

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Studying fatigue damage evolution in uni-directional composites using x-ray computed tomography

Understanding fatigue damage evolution in the load carrying laminates of wind turbine blade plays an important role for designing longer and lighter turbine blades which will make it possible to increase the size of wind turbines or to upgrade existing turbines for lower wind classes. Thereby, it will be possible to lower the costs of energy for wind energy based electricity. In the present work, a lab-source x-ray computed tomography equipment (Zeiss Xradia 520 Versa) has been used in connection with ex-situ fatigue testing of uni-directional composites in order to identify fibre failure during the fatigue loading. The load carrying laminates in wind turbine blades is typically based on a number of non-crimp fabrics in which the load carrying fibres are oriented in the axial direction of the blades. In order to ease the handling of the fabric during the dry fabric layup and to ensure a good alignment of the final laminates, approximately 10% of the fibres are oriented in secondary directions as so-called backing bundles and stitched to the uni-directionally oriented bundles. Due to the coarse structure of the non-crimp fabric, test samples with a larger cross-section (compared to other comparable x-ray studies) have been used in order to ensure a representative test volume during the ex-situ fatigue testing. Using the ability of the x-ray computed tomography to zoom into regions of interest, non-destructive, the fatigue damage evolution in a repeating ex-situ fatigue loaded test sample has been explored. Thereby, the fatigue failure mechanism has been uncovered showing fibre breakage regions growing from cross-over regions of the backing bundles. Based on those observations, more realistic micromechanically based fatigue damage models as well as suggestions on bundle arrangement improving the fatigue resistance of non-crimp fabric used in the wind turbine industry can be made.

Study of integrated optimization design of wind farm in complex terrain

Aiming at the present stage the micro-site selection of wind farm in complex terrain and the wind turbine layout and other close relationship, and selecting more reasonable wind turbine layout, more online power and saving more investment as the goal, analyzing briefly the main factors influencing wind farm design in complex terrain and setting up integrated optimization mathematical model for micro-site selection, power lines and road maintenance design etc.. Based on the existing 1-year wind measurement data in the wind farm area, the genetic algorithm was used to optimize the micro-site selection. On the basis of location optimization of wind turbine, the optimization algorithms such as single-source shortest path algorithm and minimum spanning tree algorithm were used to optimize electric lines and maintenance roads. The practice shows that the research results can provide important process guidance for the actual preliminary work of wind farm construction.

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Scopus rating (2014): SJR 0.208 SNIP 0.539 CiteScore 0.26
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Study on variable pitch strategy in H-type wind turbine considering effect of small angle of attack

Variable-pitch (VP) technology is an effective approach to upgrade the aerodynamics of the blade of an H-type vertical-axis wind turbine (VAWT). At present, most of the research efforts are focused on the performance improvement of the azimuth angle owing to the large angle of attack (AoA). On the blade circular path of an H-type VAWT, there are two azimuth positions where torques are negative, and the performance is the poorest. The vicinity zones of the two azimuths also have low performance and greatly weaken the overall productivity of VAWT. In this paper, we propose a new technology that, unlike the traditional VP-technology, focuses mainly on the aerodynamics improvement of the azimuth position with small AoA. The purpose of this novel approach is to widen the band of azimuth positions with high performance and eventually enhance the power efficiency of the overall VAWT. The performance of the new VP-VAWT is predicted using the Double Multiple Streamtubes model and Prandtl's mathematics to evaluate the blade tip loss. Compared with the fixed-pitch (FP) blade, the VP-blade has a wider zone of the max AoA and tangential force in the upwind half-circle and yields the two new larger max values in the downwind half-circle. The new VP-strategy considerably narrows the two low-torque zones near the 0° and 180° azimuths and markedly widens the high-torque azimuth zone; the torque distribution appears in a trapezoidal shape in the upwind region and an M-like shape in the downwind region. The power distribution in the swept area of turbine changes from an arched shape of the FP-VAWT into a rectangular shape of the VP-VAWT. At last, an 18.9% growth in power efficiency is achieved. All of the above results confirm that the new VP-technology can effectively improve VAWT performance and also widens the highest performance tip speed ratio zone which makes the turbines capable of running with high efficiency in wider zones.

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Suitable Method of Overloading for Fast Primary Frequency Control from Offshore Wind Power Plants in Multi-Terminal DC Grid

Increased penetration of offshore wind power plants (OWPPs) demands frequency control services from them. Overloading the wind turbine, for few seconds after the under frequency event, to utilize its kinetic energy seems promising option for fast primary frequency control. Two methods of overloading the wind turbine (WT), with and without considering the impact of WT dynamics and variation of WT output power during the overload, are proposed in the literature. In this paper, these two methods are applied for fast primary frequency control from OWPPs connected through multi-terminal DC grid considering the operation of the WT at below rated wind speed. Moreover, the impact of release of overload on the dynamics of the wind turbine, therefore on the associated AC and DC grids are studied in this paper. Finally, the suitable overloading method is proposed based on the simulation and experimental results. The time domain simulations for fast primary frequency control are performed on an OWPP connected through a 3-terminal DC grid using DIgSILENT PowerFactory. The experiments are performed on OWPP model integrated to a laboratory scale 3-terminal DC grid test set up. Based on the simulations and experimental results, overloading method which considers the variation of WT output power during the overload provides better performance during and after release of the overload.

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Summary of the Blind Test Campaign to predict the High Reynolds number performance of DU00-W-210 airfoil

This paper summarizes the results of a blind test campaign organized in the AVATAR project to predict the high Reynolds number performance of a wind turbine airfoil for wind turbine applications. The DU00-W-210 airfoil was tested in the DNW-HDG pressurized wind tunnel in order to investigate the flow at high Reynolds number range from 3 to 15 million which is the operating condition of the future large 10MW+ offshore wind turbine rotors. The results of the experiment was used in a blind test campaign to test the prediction capability of the CFD tools used in the wind turbine rotor simulations. As a result of the blind test campaign it was found that although the codes are in general capable of predicting increased max lift and decreased minimum drag with Re number, the Re trend predictions in particular the glide ratio (lift over drag) need further improvement. In addition to that, the significant effect of the inflow turbulence on glide ratio especially at high Re numbers is found as the most important parameter where the prediction as well as the selection of the correct inflow turbulence levels is the key for correct airfoil designs for the future generation 10MW+ wind turbine blades.

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Authors: Yilmaz, Ö. C. (Ekstern), Pires, O. (Ekstern), Munduate, X. (Ekstern), Sørensen, N. N. (Intern), Reichstein, T. (Ekstern), Schaffarczyk, P. (Ekstern), Diakakis, K. (Ekstern), Papadakis, G. (Ekstern), Daniele, E. (Ekstern), Schwarz, M. (Ekstern), Lutz, T. (Ekstern), Prieto, R. (Ekstern)
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Surface crack formation on rails at grinding induced martensite white etching layers

The connection between profile grinding of rails, martensite surface layers and crack initiation has been investigated using visual inspection, optical microscopy and 3D X-ray computerized tomography. Newly grinded rails were extracted and found to be covered by a continuous surface layer of martensite with varying thickness formed by the grinding process. Worn R350HT and R200 rails were extracted from the Danish rail network as they had transverse bands resembling grinding marks on the running surface. The transverse bands were shown to consist of martensite which had extensive crack formation at the martensite/pearlite interface. The cracks in R350HT propagated down into the rail while those in the soft R200 returned to the surface causing only very small shallow spallation. The transverse bands had the same shape, size, orientation, location and periodicity which would be expected from grinding marks, showing a clear connection between grinding and crack initiation.

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Synchrotron measurements of local microstructure and residual strains in ductile cast iron

The local microstructure and distribution of thermally induced residual strains in ferrite matrix grains around an individual spherical graphite nodule in ductile cast iron (DCI) were measured using a synchrotron X-ray micro-diffraction technique. It is found that the matrix grains are deformed, containing dislocations and dislocation boundaries. Each of the residual strain components in the matrix grains exhibits a complex pattern along the circumferential direction of the nodule. Along the radial direction of the nodule, strain gradients from the interface to the grain interior are seen for some strain components, but only in some matrix grains. The observed residual strain patterns have been analysed by finite element modelling, and a comparison between the simulation and experiments is given. The present study of local residual stress by both experimental characterization and simulation provide much needed information for understanding the mechanical properties of DCI, and represent an important contribution for the microstructural design of new DCI materials.

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Synchrotron X-ray measurement of residual strain within the nose of a worn manganese steel railway crossing

Switches and crossings are an integral part of any railway network. Plastic deformation associated with wear and rolling contact fatigue due to repeated passage of trains cause severe damage leading to the formation of surface and sub-surface cracks which ultimately may result in rail failure. Knowledge of the internal stress distribution adds to the understanding of crack propagation and may thus help to prevent catastrophic rail failures. In this work, the residual strains inside the bulk of a damaged nose of a manganese railway crossing that was in service for five years has been investigated by using differential aperture synchrotron X-ray diffraction. The main purpose of this paper is to describe how this method allows non-destructive measurement of residual strains in selected local volumes in the bulk of the rail. Measurements were conducted on the transverse surface at a position about 6.5 mm from the rail running surface of a crossing nose. The results revealed the presence of significant compressive residual strains along the running direction of the rail.

Technical impacts of high penetration levels of wind power on power system stability

With increasing penetrations of wind generation, based on power-electronic converters, power systems are transitioning away from well-understood synchronous generator-based systems, with growing implications for their stability. Issues of concern will vary with system size, wind penetration level, geographical distribution and turbine type, network topology, electricity market structure, unit commitment procedures, and other factors. However, variable-speed wind turbines, both onshore and connected offshore through DC grids, offer many control opportunities to either replace or enhance existing
capabilities. Achieving a complete understanding of future stability issues, and ensuring the effectiveness of new measures and policies, is an iterative procedure involving portfolio development and flexibility assessment, generation cost simulations, load flow, and security analysis, in addition to the stability analysis itself, while being supported by field demonstrations and real-world model validation.

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**Organisations:** Department of Wind Energy, Integration & Planning, SINTEF, Institut de recherche Hydro-Québec, UVIG, University College Dublin, Instituto National de Engenharia e Tecnologia Industrial, University of Castilla–La Mancha, EdF Research & Development

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**The blade element momentum (BEM) method**

The current chapter presents the blade element momentum (BEM) method. The BEM method for a steady uniform inflow is presented in a first section. Some of the ad-hoc corrections that are usually added to the algorithm are discussed in a second section. An exception is made to the tip-loss correction which is introduced early in the algorithm formulation for practical reasons. The ad-hoc corrections presented are: the tip-loss correction, the high-thrust correction (momentum breakdown) and the correction for wake rotation. The formulation of an unsteady BEM code is given in a third section. The dynamic effects discussed are the dynamic wake/inflow model, the yaw and tilt model, the dynamic stall model, and models for the interference of the tower and nacelle. Some examples of steady and unsteady BEM simulations are given in a last section. The source code of a steady and unsteady BEM algorithm implemented in Matlab is given at the end of the chapter. The description of the BEM method includes the latest correction models that are derived and presented in Part IV.
The Contribution of Kawada to the Analytical Solution for the Velocity Induced by a Helical Vortex Filament and Modern Applications of Helical Vortices

Currently, the analytical form of the velocity field induced by a helical vortex filament is well known as Hardin’s solution (1982). But essentially the same result had been obtained by a Japanese scientist Sandi Kawada, which predates Hardin by as long as 46 years. Kawada (1936) provided a comprehensive treatment of deriving the induced velocity by helical vortices with a view to applying it to the propeller theory. This paper recollects Kawada’s contribution, together with his life devoted to lead the Japanese aeronautical engineering in the time of its dawning.

The Effect of Nano-TiC Addition on Sintered Nd-Fe-B Permanent Magnets

This paper addresses the effect of nano-TiC addition on sintered Nd-Fe-B permanent magnets. TiC nanoparticles were added to sintered Nd-Fe-B magnets with a specific aim to improve the Curie temperature and thermal stability. A standard powder metallurgy route was adopted to prepare the magnets. It was found that introducing nano-TiC prior to jet milling was effective as the nanoparticles dispersed in the final alloy, concentrcating in the neodymium-rich phase of the magnets. Magnets with optimal properties were obtained with the addition of 1 wt% TiC nanoparticles. The hysteresis loop for such magnets showed an improved shape and VSM analysis a coercivity value of 1188 kA/m, a remanence value of 0.96 T and a maximum energy product of 132 kJ/m³. The maximum working point and the Curie temperature of the developed magnets were 373 K and 623 K respectively.
The effect of stability on the coastal gradients at the Anholt wind farm

We use Synthetic Aperture Radar (SAR) and SCADA measurements and mesoscale model simulations from the Weather Research and Forecast (WRF) model[3] to analyse the flow conditions at the Danish offshore wind farm at Anholt. The first Danish oshore wind farms have been installed in the North Sea of Denmark's West coast. In this location, the wind conditions have been extensively analysed [2]. Then, around 10 years later the large Anholt wind farm (nominal power of 400 GW) – situated in the Kattegat Strait to the East coast of the Jutland peninsula – has been commissioned. The Anholt wind farm stretches around 20 km in the South-North direction and the fetch increases from 15 km in the southern part to 50 km in the northern part of the wind farm. The relatively complex westerly flow conditions at this location are still not completely understood. We use the 10-year SAR satellite measurements and WRF numerical simulations to identify general differences in wind conditions between Jutland’s West- and East-coast. The 10m neutral wind speeds retrieved from satellite images are obtained between 2002 and 2012. The WRF wind speeds are for the same period and at the same height from simulations that cover in total 1025 x 530 km (fig.1) with a horizontal grid-spacing of 5 km [1]. Furthermore, we investigate how the strength of the wind speed gradient in the South-North direction of the wind farm depends on the atmospheric stability and on the wind speed. Here, we use, additionally to the SAR measurements and WRF simulations, also Supervisory control and data acquisition (SCADA) measurements from the westerly most wind turbines. The SCADA measurements have been kindly provided by DONG Energy and partners.

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Authors: Volker, P. (Intern), Hasager, C. B. (Intern), Badger, M. (Intern), Hansen, K. S. (Intern)
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The flow upstream of a row of aligned wind turbine rotors and its effect on power production

The blockage developing in front of a laterally aligned row of wind turbines and its impact on power production over a single turbine was analysed using two different numerical methods. The inflow direction was varied from orthogonal to the row until 45°, with the turbines turning into the wind, thereby resembling a wind turbine testing site or row in a wind park. The numerical methods included computational fluid dynamics (CFD) with an actuator disc representation of the rotor and a simple vortex method. The forces on the actuator disc were either derived from airfoil data of a modern wind turbine or set as constant. For all methods significant changes were found in the developing flow-field with corresponding effects on the individual power output of the wind turbines. These became more pronounced with increasing inflow angle and predicted a rise in power of up to 2% for the downstream and -1% for the upstream turbines. The vortex method agreed with the CFD method on the overall trend, but its magnitude was lower.

General information
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The influence of carbon and oxygen on the magnetic characteristics of press-less sintered NdFeB magnets

The Pressless Process (PLP) was adopted to manufacture NdFeB sintered magnets, where the investigations on carbon and oxygen residues from heptane milling liquid media and graphite crucibles used for sintering were quantified to evaluate the influence on the magnetic characteristics. The carbon and oxygen content in the magnets produced from wet ball milling of strip cast flakes was found to be of the order 104 ppm and 4·104 ppm respectively, which resulted in soft magnetic behavior. However using jet milling the carbon and oxygen concentration were decreased by an order of magnitude resulting in coercivity of up to 829 kA/m. Thus the influence of the carbon from the graphite crucibles is small.
The influence of multiscale heterogeneity on recrystallization in nickel processed by accumulative roll bonding

Microscopic and sample-scale heterogeneities have been characterized in nickel processed by accumulative roll bonding (ARB) to a von Mises strain of 4.8, and their influence on recrystallization have been analyzed. The microscopic deformation heterogeneities in this material are mostly associated with regions near the bonding interface, which are more refined and thus possess a higher stored energy than other regions. These regions also contain characteristic particle deformation zones around fragments of the steel wire brush used to prepare the surface for bonding. The sample-scale heterogeneities are seen as variations in the distribution of different texture components and in the fractions of high misorientation regions between the subsurface, intermediate, and central layers. Each of these heterogeneities affects the progress of recrystallization. Regions near bonding interfaces and particle deformation zones are found to act as preferential nucleation sites. Preferential nucleation is also observed at shear bands and within cube-oriented lamellae. On the sample scale, recrystallization proceeds faster in the intermediate layer than in the central and subsurface layers.

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Organisations: Department of Wind Energy, Materials science and characterization, Tsinghua University
Authors: Mishin, O. (Intern), Zhang, Y. (Intern), Godfrey, A. (Ekstern)
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Scopus rating (2007): SJR 0.622 SNIP 0.868
Web of Science (2007): Indexed yes
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Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.561 SNIP 0.879
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.587 SNIP 0.986
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.695 SNIP 1.045
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The (R)evolution of China: Offshore Wind Diffusion
This research presents an industry level gap analysis for Chinese offshore wind, which serves as a way to illuminate how China may fast track industry evolution. The research findings provide insight into how the Chinese government strongly and systematically decrees state-owned Chinese firms to expand into overseas markets to speed up learning efforts. Insights are offered regarding the nation-level strategic plans and institutional support policies mobilized by China in order to be able to conquer market shares internationally by building a strong home market and then facilitating an end-to-end and fully financed export solution. This is interesting in itself and in particular so because it now also includes complex billion-dollar megaprojects such as turnkey offshore wind farm assets with an expected lifespan of 30+ years. Research findings are provided on how European and Chinese firms may successfully forge long-term alliances also for future Chinese wind energy export projects. Examples of past efforts of collaboration not yielding desired results have been included as well. At policy level, recommendations are provided on how the evolution of the Chinese offshore wind power industry can be fast-tracked to mirror the revolutionary pace, volume, and velocity which the Chinese onshore wind power industry has mustered.

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Authors: Poulsen, T. (Forskerdatabase), Hasager, C. B. (Intern)
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This paper reveals that logistics make up at least 17% of annual operational expenditure costs for offshore wind farms. Annual operational expenditure is found to vary by a factor of 9.5, making its share of levelized cost of energy for offshore wind range from 13% to 57%. These are key findings of a 20-month research project targeting cost reduction initiatives for offshore wind systems. The findings reveal that cost-out measures are difficult to implement due to cultural differences. Implementation efforts are rendered by personnel located offshore in a harsh sea environment which is in stark contrast to the shore-based office personnel who develop studies directing cost reduction efforts. This paper details the company motivation to join industry-wide cost reduction initiatives. A business case for offshore wind operations and maintenance logistics yielding 1% savings in levelized cost of energy is included on how to expand working hours from daytime to also work at night.
The Triple Spar Campaign: Implementation and Test of a Blade Pitch Controller on a Scaled Floating Wind Turbine Model

In this project by the University of Stuttgart, DTU Wind Energy and CENER, a real-time blade-pitch control system was implemented on a scaled model in a combined wind-and-wave tank. A simplified low-order simulation model including aerodynamics, hydrodynamics, mooring dynamics and structural dynamics was used to design the controller. Some effort has been made to investigate the influence of different gain scheduling methodologies of the collective blade-pitch controller on the dynamic behavior of the floating wind turbine. The issue relating to the negative aerodynamic damping is also investigated in order to find out whether the effects seen in simulation models can be equally reproduced by model tests. Additionally, wind and wave-induced responses with different gain scheduling methodologies and the difference to the tests without blade-pitch control are discussed. A solution for the hardware implementation of the real-time controller has been introduced. The developed controller is proven to function throughout the test campaign, which also proves the reliability of the simplified simulation model for controller design. It has been shown that with the low-Reynolds rotor it is possible to control the rotor speed at Froude-scaled frequencies by actuating the blade pitch angle.

General information

State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, University of Stuttgart, Technical University of Denmark, Centro Nacional de Energias Renovables
The Triple Spar campaign: Model tests of a 10MW floating wind turbine with waves, wind and pitch control

Results of a test campaign for a floating wind turbine in simultaneous wind and wave forcing at scale 1:60 are presented. The floater is the Triple Spar floater, a hybrid between a spar buoy and a semi submersible tri-floater, tested here for the first time. The turbine is a model scale version of the DTU 10 MW reference wind turbine, which, also for the first time, is tested with active blade pitch control. The tests focus on the effects of aerodynamic damping and interaction effects between the wind forcing, wave forcing and the blade pitch control algorithm. Special focus is devoted to the instability of the platform pitch natural mode, that can occur if a standard land-based controller is applied.

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The use of a wave boundary layer model in SWAN

A Wave Boundary Layer Model (WBLM) is implemented in the third-generation ocean wave model SWAN to improve the wind-input source function under idealized, fetch-limited condition. Accordingly, the white capping dissipation parameters are re-calibrated to fit the new wind-input source function to parametric growth curves. The performance of the new pair of wind-input and dissipation source functions is validated by numerical simulations of fetch-limited evolution of wind-driven waves. As a result, fetch-limited growth curves of significant wave height and peak frequency show close agreement with benchmark studies at all wind speeds (5 ∼ 60 ms⁻¹) and fetches (1 ∼ 3000 km). The WBLM wind-input source function explicitly calculates the drag coefficient based on the momentum and kinetic energy conservation. The modeled drag coefficient using WBLM wind-input source function is in rather good agreement with field measurements. Thus, the new pair of wind-input and dissipation source functions not only improve the wave simulation but also have the potential of improving air-sea coupling systems by providing reliable momentum flux estimation at the air-sea interface. This article is protected by copyright. All rights reserved.
Three dimensional fatigue damage evolution in non-crimp glass fibre fabric based composites used for wind turbine blades

This work studies the tension fatigue damage progression of a uni-directional glass fibre composite made from a non-crimp fabric similar to those used for the main load carrying parts of a wind turbine blade. The spatial damage progression in a chosen region of a test specimen is monitored on a micro-structural scale by ex-situ X-ray computed tomography. The centimetre sized specimen remains uncut during the ex-situ experiment. The experimental results indicate that uni-directional fibre fractures initiate from matrix cracks related to the structure of the fabric: first in the thin off-axis backing bundles at triple cross-over regions where the ±45° and 90° backing bundles intersect each other and lie close to a uni-directional bundle, and later followed by damage initiation in the other cross-over regions. Uni-directional fibre fractures were seen to increase in number with increasing number of cycles, and mainly progress in the thickness direction of uni-directional bundles (away from the backing bundles). Furthermore, the crack face separation of individual broken uni-directional fibres was observed to gradually increase with an increasing number of cycles. The progression path of the uni-directional fibre fractures was seen to be very dependent on the local backing bundle arrangement.

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Three-Dimensional X-Ray Diffraction Technique for Metals Science

The three-dimensional X-ray diffraction (3DXRD) is a new, advanced technique for materials characterization. This technique utilizes high-energy synchrotron X-rays to characterize the 3D crystallographic structure and strain/stress state of bulk materials. As the measurement is non-destructive, the microstructural evolution as a function of time can be followed, i.e. it allows 4D (x, y, z characterizations, t). The high brilliance of synchrotron X-rays ensures that diffraction signals from volumes of micrometer scale can be quickly detected and distinguished from the background noise, i.e. its spatial resolution can be micrometer scale and the measurement can be conducted within a reasonable time frame (a few hours). The 3DXRD microscope has originally been developed in cooperation between former RisÅ› National Laboratory and the European Synchrotron Radiation Facility. Currently, this technique has been implemented in several large synchrotron facilities, e.g. the Advanced Photon Source (APS) in USA and the Spring-8 in Japan. Another family of 3DXRD technique that utilizes white beam synchrotron X-rays has also been developed in parallel in cooperation between Oak Ridge National Laboratory and APS. This article reviews the 3DXRD technique. The content includes the idea behind the technique, the principle and specification (spatial, angular, temporal resolutions and sample environment etc.) of the technique. Several applications of the techniques in metallurgy are given, including: grain-scaled stress analysis during tensile deformation, recrystallization growth kinetics, recrystallization nucleation, growth of individual recrystallized grain, grain growth after recrystallization, and local residual strain/stress analysis. The recent development of the 3DXRD technique and its potential use for materials science in the future will be briefly discussed at the end.
Topology Comparison of Superconducting Generators for 10-MW Direct-Drive Wind Turbines: Cost of Energy Based

This paper aims at finding feasible electromagnetic designs of superconducting synchronous generators (SCSGs) for a 10-MW direct-drive wind turbine. Since a lower levelized cost of energy (LCoE) increases the feasibility of SCSGs in this application, 12 generator topologies are compared regarding their LCoE in a simplified form of levelized equipment cost of energy (LCoE$_{\text{eq}}$). MgB$_2$ wires are employed in the field winding. Based on the current unit cost and critical current density capability of the MgB$_2$ wire at 20 K, the topologies with more iron have a much lower LCoE$_{\text{eq}}$ than the topologies with more nonmagnetic cores. The fully iron-cored topology with salient poles has the lowest LCoE$_{\text{eq}}$. Then a scenario study shows that the difference of LCoE$_{\text{eq}}$ between the topologies will become much smaller when the unit cost of the MgB$_2$ wire drops to a quarter and the current density capability of the MgB$_2$ wire increases to four times. Then the topologies with more nonmagnetic cores will become comparable to those with more iron. Aiming at a lower LCoE$_{\text{eq}}$ to increase the feasibility of SCSGs for large wind turbines, those topologies having the most iron in the core are the most promising for both now and the long term. If low weight is required, the topologies with more nonmagnetic cores should be considered.
Translational, rotational, vibrational and electron temperatures of a gliding arc discharge

Translational, rotational, vibrational and electron temperatures of a gliding arc discharge in atmospheric pressure air were experimentally investigated using in situ, non-intrusive optical diagnostic techniques. The gliding arc discharge was driven by a 35 kHz alternating current (AC) power source and operated in a glow-type regime. The two-dimensional distribution of the translational temperature (Tt) of the gliding arc discharge was determined using planar laser-induced Rayleigh scattering. The rotational and vibrational temperatures were obtained by simulating the experimental spectra. The OH A–X (0, 0) band was used to simulate the rotational temperature (Tr) of the gliding arc discharge whereas the NO A–X (1, 0) and (0, 1) bands were used to determine its vibrational temperature (Tv). The instantaneous reduced electric field strength E/N was obtained by simultaneously measuring the instantaneous length of the plasma column, the discharge voltage and
the translational temperature, from which the electron temperature (Te) of the gliding arc discharge was estimated. The uncertainties of the translational, rotational, vibrational and electron temperatures were analyzed. The relations of these four different temperatures (Te>Tv>Tr>Tt) suggest a high-degree non-equilibrium state of the gliding arc discharge.
Turbulence and entrainment length scales in large wind farms

A number of large wind farms are modelled using large eddy simulations to elucidate the entrainment process. A reference simulation without turbines and three farm simulations with different degrees of imposed atmospheric turbulence are presented. The entrainment process is assessed using proper orthogonal decomposition, which is employed to detect the largest and most energetic coherent turbulent structures. The dominant length scales responsible for the entrainment process are shown to grow further into the wind farm, but to be limited in extent by the streamwise turbine spacing, which could be taken into account when developing farm layouts. The self-organized motion or large coherent structures also yield high correlations between the power productions of consecutive turbines, which can be exploited through dynamic farm control. This article is part of the themed issue 'Wind energy in complex terrains'.

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Authors: Andersen, S. J. (Intern), Sørensen, J. N. (Intern), Mikkelsen, R. F. (Intern)
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.26 SJR 0.986 SNIP 1.193
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.865 SNIP 1.116 CiteScore 2.08
Web of Science (2015): Indexed yes
We present two methods to characterize turbulence in the turbine inflow using radial velocity measurements from nacelle-mounted lidars. The first uses a model of the three-dimensional spectral velocity tensor combined with a model of the spatial radial velocity averaging of the lidars, and the second uses the ensembleaveraged Doppler radial velocity spectrum. With the former, filtered turbulence estimates can be predicted, whereas the latter model-free method allows us to estimate unfiltered turbulence measures. Two types of forwardlooking nacelle lidars are investigated: a pulsed system that uses a five-beam configuration and a continuouswave system that scans conically. For both types of lidars, we show how the radial velocity spectra of the lidar beams are influenced by turbulence characteristics, and how to extract the velocity-tensor parameters that are useful to predict the loads on a turbine. We also show how the velocity-component variances and co-variances can be estimated from the radial-velocity unfiltered variances of the lidar beams. We demonstrate the methods using measurements from an experiment conducted at the Nørrekær Enge wind farm in northern Denmark, where both types of lidars were installed on the nacelle of a wind turbine. Comparison of the lidar-based along-wind unfiltered variances with those from a cup anemometer installed on a meteorological mast close to the turbine shows a bias of just 2%. The ratios of the unfiltered and filtered radial velocity variances of the lidar beams to the cup-anemometer variances are well predicted by the spectral model. However, other lidar-derived estimates of velocity-component variances and co-variances do not agree with those from a sonic anemometer on the mast, which we mostly
attribute to the small cone angle of the lidar. The velocity-tensor parameters derived from sonic-anemometer velocity spectra and those derived from lidar radial velocity spectra agree well under both near-neutral atmospheric stability and high wind-speed conditions, with differences increasing with decreasing wind speed and increasing stability. We also partly attribute these differences to the lidar beam configuration.

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**Turbulence estimation from a continuous-wave scanning lidar (SpinnerLidar)**
One of the current challenges using lidars for wind energy measurements is the inability of lidars to accurately measure turbulence. Two important factors affecting lidar measurements of turbulence are: 1) the spatial averaging by the lidars sounding volume leading to smaller eddies being filtered out, and 2) the mixing of velocity covariances from other components into the line-of-sight variance measurements. However, turbulence measurements based on upwind horizontal rotor plane scanning of the line-of-sight variance measurements combined with ensemble-averaged Doppler spectra width measurements has earlier been shown to provide unfiltered, un-truncated line-of-sight turbulence measurements [1], [2]. Turbulence measurements from a continuous-wave scanning lidar, i.e. the DTU SpinnerLidar, mounted on the nacelle of the CART3 turbine at the National Renewable Energy Laboratory (NREL) wind site in Colorado, USA are presented. The standard deviation of the turbulence component < u’ > in the mean wind direction has been compared to turbulence measurements from a cup anemometer installed at hub height in an upwind reference met tower, cf. fig. 1. Lidar and cup anemometer measured standard deviations averaged over 10-min sampling periods are compared. Lidar variances are inherently more prone to noise which always yields a positive bias. The 5.3 % higher turbulence level measured by the SpinnerLidar relative to the cup anemometer may equally well be attributed to truncation of turbulent structures smaller than the cup anemometers length scale.

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Authors: Barnhoorn, J. (Ekstern), Sjöholm, M. (Intern), Mikkelsen, T. K. (Intern)
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**Two years of wind-lidar measurements at an Italian Mediterranean Coastal Site**
Reliable measurements of vertical profiles of wind speed and direction are needed for testing models and methodologies of use for wind energy assessment. In particular, modelling complex terrain such as coastal areas is challenging due to the coastal discontinuity that is not accurately resolved in mesoscale numerical model. Here, we present a unique database from a coastal site in South Italy (middle of the Mediterranean area) where vertical profiles of wind speed and
direction have been collected during a two-year period from a wind-lidar ZEPHIR-300® at a coastal-suburban area. We show an overview analysis on two-year 10-minute averaged wind profiles.

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Organisations: Department of Wind Energy, Resource Assessment Modelling, National Research Council of Italy  
Authors: Gullí, D. (Ekstern), Avolio, E. (Ekstern), Calidonna, C. R. (Ekstern), Lo Feudo, T. (Ekstern), Torcasio, R. C. (Ekstern), Sempreviva, A. M. (Intern)  
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**Ultimate design load analysis of planetary gearbox bearings under extreme events**

This paper investigates the impact of extreme events on the planet bearings of a 5 MW gearbox. The system is simulated using an aeroelastic tool, where the turbine structure is modeled, and MATLAB/Simulink, where the drivetrain (gearbox and generator) are modeled using a lumped-parameter approach. Three extreme events are assessed: low-voltage ride through, emergency stop and normal stop. The analysis is focused on finding which event has the most negative impact on the bearing extreme radial loads. The two latter events are carried out following the guidelines of the International Electrotechnical Commission standard 61400-1. The former is carried out by applying a voltage fault while simulating the wind turbine under normal turbulent wind conditions. The voltage faults are defined by following the guidelines from four different grid codes in order to assess the impact on the bearings. The results show that the grid code specifications have a dominant role in the maximum loads achieved by the bearings during a low-voltage ride through. Moreover, the emergency brake shows the highest impact by increasing the bearing loads up to three times the rated value.
Ultra-low-angle boundary networks within recrystallizing grains

We present direct evidence of a network of well-defined ultra-low-angle boundaries in bulk recrystallizing grains of 99.5% pure aluminium (AA1050) by means of a new, three-dimensional X-ray mapping technique; dark-field X-ray microscopy. These boundaries separate lattice orientation differences on the order of 0.05° and thus subdivide the recrystallizing grain into 2–7 μm wide domains. During further annealing the orientation differences decrease and the overall structure become more uniform while the network remains. It is observed that the morphology of the grain boundaries surrounding the recrystallizing grains relate to the intragranular network and effects hereof on the boundary migration is discussed.

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Uncertainty quantification in wind farm flow models
This thesis formulates a framework to perform uncertainty quantification within wind energy. This framework has been applied to some of the most common models used to estimate the annual energy production in the planning stages of a wind energy project. Efficient methods to propagate input uncertainties through a model chain are presented and applied to several wind energy related problems such as: annual energy production estimation, wind turbine power curve estimation, wake model calibration and validation, and estimation of lifetime equivalent fatigue loads on a wind turbine. Statistical methods to describe the joint distribution of multiple variables are applied to the description of the wind resources at a given location. A new method to predict the performance of an aeroelastic wind turbine model, and its corresponding uncertainty, is presented. This approach helps understand the uncertainty in the lifetime performance of a wind turbine under realistic inflow conditions. Operational measurements of several large offshore wind farms are used to perform model calibration and validation of several stationary wake models. These results provide a guideline to identify the regions in which a model fails to make accurate predictions, and therefore help guide research and development to focus on areas with the biggest uncertainty to lower costs of energy effectively.
Using a 1-D model to reproduce the diurnal variability of SST

A wide range of applications, from air-sea interaction studies to fisheries and biological modeling, need accurate, high-resolution SST which requires that the diurnal signal is known; for many applications, diurnal estimates are necessary and should be included in blended SST products. A widely preferred approach to bridge the gap between in situ and remotely sensed measurements and obtain diurnal warming estimates at large spatial scales is modeling of the upper ocean temperature. This study uses the one-dimensional General Ocean Turbulence Model (GOTM) to resolve diurnal signals identified from satellite SSTs and in situ measurements. Focus is given on testing and validation of different parameterizations of the basic physical processes known to influence the generation of a warm surface layer. GOTM is tested and validated using in situ measurements obtained at three locations, two in the Atlantic Ocean and one in the...
Baltic Sea, where different oceanographic and atmospheric conditions occur, in order to obtain an insight into its general performance. It is found that the model, with a 9 band solar absorption model rather than the standard 2 band scheme, performs well when using 3 hourly NWP forcing fields and is able to resolve daily SST variability seen both from satellite and in situ measurements. As such, and due to its low computational cost, it is proposed as a candidate model for diurnal variability estimates.

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Danish Meteorological Institute, ESTEC
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ISI indexed (2011): ISI indexed yes
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BFI (2010): BFI-level 2
Scopus rating (2010): SJR 3.056 SNIP 1.753
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Using a finite element pediatric hip model in clinical evaluation - a feasibility study

The paper describe a method to construct a finite element model of the hip joint of a child based on clinical recorded CT data. A model which can be used for diagnostic aid and pre-operative surgical evaluation. First part of this development is a feasibility study of this method. A scan of the asymptomatic left hip of a 10-year-old girl with a dysplastic right hip was used. Cartilage was not visible why it was modeled as an interaction with constant thickness between two surfaces. For every point on the acetabular and femoral bone surfaces, the shortest distance to the other surface was used to calculate the resulting stress in the normal direction. At a load of 233% BW the model predicted peak pressures in the hip joint of 9.7-13.8 MPa and an area in contact of 351-405 mm². Experimental validation using the hip joint of a child was not ethical viable. Instead, our results were compared to previous published experimental studies and computational models investigating the adult hip joint. Good correlation between the current model and previous models were found. The current case specific modeling technique may be a useful complement to the previously developed hip models.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Department of Wind Energy, Composites and Materials Mechanics, Copenhagen University Hospital
Authors: Skytte, T. L. (Ekstern), Mikkelsen, L. P. (Intern), Sonne-Holm, S. (Forskerdatabase), Wong, C. (Ekstern)
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Using wind speed from a blade-mounted flow sensor for power and load assessment on modern wind turbines

In this paper an alternative method to evaluate power performance and loads on wind turbines using a blade-mounted flow sensor is investigated. The hypothesis is that the wind speed measured at the blades has a high correlation with the power and loads such that a power or load assessment can be performed from a few hours or days of measurements. In the present study a blade-mounted five-hole pitot tube is used as the flow sensor as an alternative to the conventional approach, where the reference wind speed is either measured at a nearby met mast or on the nacelle using lidar technology or cup anemometers. From the flow sensor measurements, an accurate estimate of the wind speed at the rotor plane can be obtained. This wind speed is disturbed by the presence of the wind turbine, and it is therefore different from the free-flow wind speed. However, the recorded wind speed has a high correlation with the actual power production as well as the flap-wise loads as it is measured close to the blade where the aerodynamic forces are acting. Conventional power curves are based on at least 180 h of 10 min mean values, but using the blade-mounted flow sensor both the observation average time and the overall assessment time can potentially be shortened. The basis for this hypothesis is that the sensor is able to provide more observations with higher accuracy, as the sensor follows the rotation of the rotor and because of the high correlation between the flow at the blades and the power production. This is the research question addressed in this paper. The method is first tested using aeroelastic simulations where the dependence of the radial position and effect of multiple blade-mounted flow sensors are also investigated. Next the method is evaluated on the basis of full-scale measurements on a pitch-regulated, variable-speed 3.6 MW wind turbine. It is concluded that the wind speed derived from the blade-mounted flow sensor is highly correlated with the power and flap-wise bending moment and that the method has advantages over the traditional approach where the met-mast wind speed is used as reference, e.g. the capability of measuring the shear, veer and turbulence. The aeroelastic simulations show that the assessment time can be reduced, but this reduction cannot be confirmed from the current measurement database due to sensor problems and practical circumstances. Measuring the wind speed at the rotor plane comes with a price as the wind speed is affected by the induction which may be sensitive to the changes you want to evaluate, e.g. different vortex generator configurations. Furthermore it is concluded that a robust instrument and measurement system is required to obtain accurate and reliable wind speed recordings from pitot-tube measurements.

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Authors: Pedersen, M. M. (Intern), Larsen, T. J. (Intern), Madsen, H. A. (Intern), Larsen, G. C. (Intern)
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Main Research Area: Technical/natural sciences

Validation of a CFD model with a synchronized triple-lidar system in the wind turbine induction zone

A novel validation methodology allows verifying a CFD model over the entire wind turbine induction zone using measurements from three synchronized lidars. The validation procedure relies on spatially discretizing the probability density function of the measured free-stream wind speed. The resulting distributions are reproduced numerically by weighting steady-state Reynolds averaged Navier-Stokes simulations accordingly. The only input varying between these computations is the velocity at the inlet boundary. The rotor is modelled using an actuator disc. So as to compare lidar and simulations, the spatial and temporal uncertainty of the measurements is quantified and propagated through the data processing. For all velocity components the maximal difference between measurements and model are below 4.5% relative to the average wind speed for most of the validation space. This applies to both mean and standard deviation. One rotor radius upstream the difference reaches maximally 1.3% for the axial component.

General information
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Organisations: Department of Wind Energy, Aerodynamic design, Resource Assessment Modelling, Meteorology & Remote Sensing
High-accuracy wind data for coastal regions is needed today, e.g., for the assessment of wind resources. Synthetic Aperture Radar (SAR) is the only satellite borne sensor that has enough resolution to resolve wind speeds closer than 10 km to shore but the Geophysical Model Functions (GMF) used for SAR wind retrieval are not fully validated here. Ground based scanning light detection and ranging (LiDAR) offer high horizontal resolution wind velocity measurements with high accuracy, also in the coastal zone. This study, for the first time, examines accuracies of SAR wind retrievals at 10 m height with respect to the distance to shore by validation against scanning LiDARs. Comparison of 15 Sentinel-1A wind retrievals using the GMF called C-band model 5.N (CMOD5.N) versus LiDARs show good agreement. It is found, when nondimensionalising with a reference point, that wind speed reductions are between 4% and 8% from 3 km to 1 km from shore. Findings indicate that SAR wind retrievals give reliable wind speed measurements as close as 1 km to the shore. Comparisons of SAR winds versus two different LiDAR configurations yield root mean square error (RMSE) of 1.31 ms$^{-1}$ and 1.42 ms$^{-1}$ for spatially averaged wind speeds.
Validation of the dynamic wake meander model with focus on tower loads

This paper presents a comparison between measured and simulated tower loads for the Danish offshore wind farm Nysted 2. Previously, only limited full scale experimental data containing tower load measurements have been published, and in many cases the measurements include only a limited range of wind speeds. In general, tower loads in wake conditions are very challenging to predict correctly in simulations. The Nysted project offers an improved insight to this field as six wind turbines located in the Nysted II wind farm have been instrumented to measure tower top and tower bottom moments. All recorded structural data have been organized in a database, which in addition contains relevant wind turbine SCADA data as well as relevant meteorological data - e.g. wind speed and wind direction - from an offshore mast located in the immediate vicinity of the wind farm. The database contains data from a period extending over a time span of more than 3 years. Based on the recorded data basic mechanisms driving the increased loading experienced by wind turbines operating in offshore wind farm conditions have been identified, characterized and modeled. The modeling is based on the Dynamic Wake Meandering (DWM) approach in combination with the state-of-the-art aeroelastic model HAWC2, and has previously as well as in this study shown good agreement with the measurements. The conclusions from the study have several parts. In general the tower bending and yaw loads show a good agreement between measurements and simulations. However, there are situations that are still difficult to match. One is tower loads of single-wake operation near rated ambient wind speed for single wake situations for spacing's around 7-8D. A specific target of the study was to investigate whether the largest tower fatigue loads are associated with a certain downstream distance. This has been identified in both simulations and measurements, though a rather flat optimum is seen in the measurements.

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Validation of the dynamic wake meander model with focus on tower loads: Paper
This paper presents a comparison between measured and simulated tower loads for the Danish offshore wind farm Nysted 2. Previously, only limited full scale experimental data containing tower load measurements have been published, and in many cases the measurements include only a limited range of wind speeds. In general, tower loads in wake conditions are very challenging to predict correctly in simulations. The Nysted project offers an improved insight to this
field as six wind turbines located in the Nysted II wind farm have been instrumented to measure tower top and tower bottom moments. All recorded structural data have been organized in a database, which in addition contains relevant wind turbine SCADA data as well as relevant meteorological data - e.g. wind speed and wind direction - from an offshore mast located in the immediate vicinity of the wind farm. The database contains data from a period extending over a time span of more than 3 years. Based on the recorded data basic mechanisms driving the increased loading experienced by wind turbines operating in offshore wind farm conditions have been identified, characterized and modeled. The modeling is based on the Dynamic Wake Meandering (DWM) approach in combination with the state-of-the-art aeroelastic model HAWC2, and has previously as well as in this study shown good agreement with the measurements. The conclusions from the study have several parts. In general the tower bending and yaw loads show a good agreement between measurements and simulations. However, there are situations that are still difficult to match. One is tower loads of single-wake operation near rated ambient wind speed for single wake situations for spacing’s around 7-8D. A specific target of the study was to investigate whether the largest tower fatigue loads are associated with a certain downstream distance. This has been identified in both simulations and measurements, though a rather flat optimum is seen in the measurements.

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Validation of the Revised WAsP Park Model
The DTU Wind Energy wind-resource model WAsP contains a wind farm wake model Park (Park1). This Park model in has been revised, Park2, to improve prediction accuracy in large wind farms, based on sound physical and mathematical principles: consistent wake-modelling and perturbation theory for wake-wake-interaction. Park2 has been validated and calibrated using a number of off-shore and on-shore wind farms. The calibration has resulted in recommended values for the wake expansion coefficients of the Park2 model.

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Organisations: Department of Wind Energy, Resource Assessment Modelling, Test and Measurements, Vestas
Authors: Rathmann, O. S. (Intern), Hansen, B. O. (Intern), Leon, J. M. (Ekstern), Hansen, K. S. (Intern), Mortensen, N. G. (Intern)
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Validation of the Revised WAsP Park Model
The DTU Wind Energy wind-resource model WAsP contains a wind farm wake model Park (Park1). This Park model in has been revised, Park2, to improve prediction accuracy in large wind farms, based on sound physical and mathematical principles: consistent wake-modelling and perturbation theory for wake-wake-interaction. Park2 has been validated and calibrated using a number of off-shore and on-shore wind farms. The calibration has resulted in recommended values for the wake expansion coefficients of the Park2 model.
Variable speed control for Vertical Axis Wind Turbine

A robust variable speed control for vertical axis wind turbine applications is implemented. It is a PI rotor speed controller based on an induction generator model operated at variable frequency. The generator dynamics are approximated by a first order differential equation with a prescribed slip. In order to allow variability in the rotor speed an inverter is assumed which changes the nominal generator speed. Below rated power the optimum tip speed ratio is tracked, while above the power is constrained to rated. The wind speed which is needed in the control it is considered as a known signal and used after a first order low pass filtering with a certain time-constant. The controller has been developed and coded by Torben Larsen and it is compiled as an external DLL file. The simulations are done in the HAWC2 aero-servo-elastic code using a 3-bladed H-type VAWT which has been built within the Inflow project. The investigation of the VAWT performance under different control parameters such as the PI gains has been performed by Christos Galinos. Deterministic and turbulent wind speed steps of 2 m/s from 6 m/s to 24 m/s and back to 12 m/s are applied. The controller gives smooth transient response on rotor speed and the produced power with a small overshoot in the power when the rated wind speed is reached for a wide range of PI gains for both the deterministic and the turbulent wind field. Lastly, it is not affected from the inherent variation in blade loading of VAWTs for each rotor revolution due to a low pass filter in the measured electrical power.
Vortex and source rings

The velocity field, vector potential and velocity gradient of a vortex ring is derived in this chapter. The Biot-Savart law for the vector potential and velocity is expressed in a first section. Then, the flow is derived at specific locations: on the axis, near the axis and in the far field where the analogy to a doublet field is made. The following section derive the value of the vector potential and velocity field in the full domain. The expression for the velocity gradient is also provided since it may be relevant in a simulation with vortex particles and vortex rings. Most of this chapter is dedicated to vortex rings. Source rings are only briefly mentioned.

Wake developments behind different configurations of passive disks and active rotors: Paper

The present paper takes a broad view on our previous experimental studies of flows behind different single and dual configurations from passive disks or active rotors to establish new aspects of the wake development [1-4]. The aim of the present examination is to obtain a better understanding of the wake formations and interactions between wind turbines in wind farms. A correlation between independent investigations of the near [1] and far wakes behind single [2] and dual [3-4] systems will be established to the same operating regimes and flow conditions. New examinations of the old data need
because two main differences in the wake behaviour for the disk-disk and the rotor-rotor systems were found: the wake intensity grows for the dual disks in comparison with the single one, but in contrast to this, wake intensity behind the dual rotor system is smaller than the one behind a single rotor. These differences may be explained by an influence of the rotor tip vortices which are absent in the disk-disk model. The present retesting of the near and far wake data should provide an evidence of this conclusion.

**Wake Expansion Models**

Different models of wake expansion are presented in this chapter: the 1D momentum theory model, the cylinder analog model and Theodorsen’s model. Far wake models such as the ones from Frandsen or Rathmann or only briefly mentioned. The different models are compared to each other. Results from this chapter are used in Chap. 16 to link near-wake and far-wake parameters and in Chap. 20 to study the influence of expansion on tip-losses.
Why the Coriolis force turns a wind farm wake clockwise in the Northern Hemisphere

The interaction between the Coriolis force and a wind farm wake is investigated by Reynolds-averaged Navier–Stokes simulations, using two different wind farm representations: a high roughness and 5 × 5 actuator disks. Surprisingly, the calculated wind farm wake deflection is the opposite in the two simulations. A momentum balance in the cross flow direction shows that the interaction between the Coriolis force and the 5 × 5 actuator disks is complex due to turbulent mixing of veered momentum from above into the wind farm, which is not observed for the interaction between the Coriolis force and a roughness change. When the wind farm simulations are performed with a horizontally constant Coriolis force in order to isolate the effect of the wind veer, the wind farm wake deflection of the 5 × 5 actuator disks simulation remains unchanged. This proves that the present wind veer deflects the wind farm wake and not the local changes in the Coriolis force in the wake deficit region. An additional simulation of a single actuator disk, operating in a shallow atmospheric boundary layer, confirms that the Coriolis force indirectly turns a wind turbine wake clockwise, as observed from above, due to the presence of a strong wind veer.

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Authors: van der Laan, P. (Intern), Sørensen, N. N. (Intern)
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Wind and Yaw correlation
The report describes measurements carried out on a given turbine and period. The measurements are carried out in accordance to Ref. [1]. A comparison between wind speed and wind direction on the met mast and nacelle wind speed and yaw direction is made in accordance to Ref. [2] and the results are presented on graphs and in a table.

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Wind farm design in complex terrain: the FarmOpt methodology
Designing wind farms in complex terrain is becoming more and more important, especially for countries like China, where a large portion of the territory is featured as complex terrain. Although potential richer wind resources could be expected at complex terrain sites (thanks to the terrain effects), they also expose many challenges for wind farm designers/developers. In this study, we present the FarmOpt methodology for designing wind farms in complex terrain, which combines the state-of-the-art wind resource assessment methods with engineering wake models adapted for complex terrain and
advanced layout optimization algorithms. Various constraints are also modelled and considered in the design optimization problem for maximizing the annual energy production (AEP). A case study is presented to illustrate the effectiveness of the methodology. Further developments of the FarmOpt tool are also briefly introduced.

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Organisations: Department of Wind Energy, Fluid Mechanics, Test and Measurements, Resource Assessment Modelling, Wind turbine loads & control, Hohai University, China Hydropower Consulting Group, Northwest Survey and Design Institute, Aalborg Universitet København
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Publication: Research - peer-review › Paper – Annual report year: 2017

Wind farm design in complex terrain: the FarmOpt methodology
Designing wind farms in complex terrain is becoming more and more important, especially for countries like China, where a large portion of the territory is featured as complex terrain. Although potential richer wind resources could be expected at complex terrain sites (thanks to the terrain effects), they also expose many challenges for wind farm designers/developers. In this study, we present the FarmOpt methodology for designing wind farms in complex terrain, which combines the state-of-the-art wind resource assessment methods with engineering wake models adapted for complex terrain and advanced layout optimization algorithms. Various constraints are also modelled and considered in the design optimization problem for maximizing the annual energy production (AEP). A case study is presented to illustrate the effectiveness of the methodology. Further developments of the FarmOpt tool are also briefly introduced.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Test and Measurements, Resource Assessment Modelling, Wind turbine loads & control, Hohai University, China Hydropower Consulting Group, Northwest Survey and Design Institute, Aalborg Universitet København
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Electronic versions:
Wind_farm_design_in_complexTerrain_the_FarmOpt_methodology_presentation_in_CWP2017.pdf
Publication: Research › Sound/Visual production (digital) – Annual report year: 2017

Wind farm power production in the changing wind: Robustness quantification and layout optimization
Wind farms operate often in the changing wind. The wind condition variations in a wide range of time scales lead to the variability of wind farms’ power production. This imposes a major challenge to the power system operators who are facing a higher and higher penetration level of wind power. Thus, wind farm developers/owners need to take the variability into consideration in the designing/planning stage, in addition to the conventional main objective of maximizing the expected power output under a fixed wind distribution. In this study, we first propose a new metric to evaluate the variability of wind power based on the characteristics of the wind farm and its local wind conditions. Then a series of robustness metrics are proposed to quantify wind farm’s ability to produce power with high mean value and low variability under changing wind, considering both short-term and long-term wind condition variations. Based on these metrics, wind farm layout optimization is performed to maximize the robustness of a real offshore wind farm in Denmark. The results demonstrate that the robustness metrics are more flexible and complete than the conventional metrics for characterizing wind farm power production, such as mean power output or wind power variability alone, and it is feasible to design wind farms to produce power with high mean value and low variability.
Wind Farm Wake

On 25 January 2016 at 12:45 UTC several photographs of the offshore wind farm Horns Rev 2 were taken by helicopter pilot Gitte Lundorff with an iPhone. A very shallow layer of fog covered the sea. The photos of the fog over the sea dramatically pictured the offshore wind farm wake. Researchers got together to investigate the atmospheric conditions at the time of the photos by analysing local meteorological observations and wind turbine information, satellite remote sensing and nearby radiosonde data. Two wake models and one mesoscale model were used to model the case and explain what was seen.

Wind Farm Wake: The 2016 Horns Rev Photo Case

Offshore wind farm wakes were observed and photographed in foggy conditions at Horns Rev 2 on 25 January 2016 at 12:45 UTC. These new images show highly contrasting conditions regarding the wind speed, turbulence intensity, atmospheric stability, weather conditions and wind farm wake development as compared to the Horns Rev 1 photographs from 12 February 2006. The paper examines the atmospheric conditions from satellite images, radiosondes, lidar and wind turbine data and compares the observations to results from atmospheric meso-scale modelling and large eddy simulation. Key findings are that a humid and warm air mass was advected from the southwest over cold sea and the dew-point temperature was such that cold-water advection fog formed in a shallow layer. The flow was stably stratified and the freestream wind speed was 13 m/s at hub height, which means that most turbines produced at or near rated power. The wind direction was southwesterly and long, narrow wakes persisted several rotor diameters downwind of the wind turbines. Eventually mixing of warm air from aloft dispersed the fog in the far wake region of the wind farm.
Wind field determination from multiple Spinner-Lidar line-of-sight measurements using linearized CFD

General information
State: Published
Organisations: Resource Assessment Modelling, Department of Wind Energy, Meteorology & Remote Sensing, University of Oldenburg
Authors: Astrup, P. (Intern), Mikkelsen, T. K. (Intern), van Dooren, M. F. (Ekstern)
Number of pages: 24
Publication date: 2017

Publication information
ISBN (Electronic): 978-87-93278-57-8
Wind Field Reconstruction from Nacelle-Mounted Lidars Short Range Measurements

Profiling nacelle lidars probe the wind at several heights and several distances upstream of the rotor. The development of such lidar systems is relatively recent, and it is still unclear how to condense the lidar raw measurements into useful wind field characteristics such as speed, direction, vertical and longitudinal gradients (wind shear). In this paper, we demonstrate an innovative method to estimate wind field characteristics using nacelle lidar measurements taken within the induction zone. Model-fitting wind field reconstruction techniques are applied to nacelle lidar measurements taken at multiple distances close to the rotor, where a wind model is combined with a simple induction model. The method allows robust determination of free-stream wind characteristics. The method was applied to experimental data obtained with two different types of nacelle lidar (five-beam Demonstrator and ZephIR Dual Mode). The reconstructed wind speed was within 0.5% of the wind speed measured with a mast-top-mounted cup anemometer at 2.5 rotor diameters upstream of the turbine. The technique described in this paper overcomes measurement range limitations of the currently available nacelle lidar technology.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, University of Stuttgart
Authors: Borraccino, A. (Intern), Schlipf, D. (Ekstern), Haizmann, F. (Ekstern), Wagner, R. (Intern)
Pages: 269-283
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Main Research Area: Technical/natural sciences

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Relations
Activities:
Power curve measurement using Wind Power Curve estimation from nacelle lidars and its uncertainty
Source: FindIt
Source-ID: 2357339786
Publication: Research - peer-review › Journal article – Annual report year: 2017

Wind field re-construction of 3D Wake measurements from a turbine-installed scanning lidar

High-resolution wake flow measurements obtained from a turbine-mounted scanning lidar have been obtained from 1D to 5D behind a V27 test turbine. The measured line-of-sight projected wind speeds have, in connection with a fast CFD wind field reconstruction model, been used to generate 3D wind fields in the scan planes consisting of all three wind components. The combination of a fast-scanning wind lidar and a corresponding fast wind field reconstruction model is shown to be able to provide detailed wind data useful for proactive steering of wakes in real time and also for advanced feed-forward turbine control.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Sandia National Laboratories
Authors: Mikkelsen, T. K. (Intern), Herges, T. (Ekstern), Astrup, P. (Intern), Sjöholm, M. (Intern), Naughton, B. (Ekstern)
Wind power forecasting-a review of the state of the art
This chapter gives an overview over past and present attempts to predict wind power for single turbines, wind farms or for whole regions, for a few minutes up to a few days ahead. It is based on a survey and report (Giebel et al., 2011) initiated in the frame of the European project ANEMOS, which brought together many groups from Europe involved in the field with long experience in short-term forecasting. It was then continued in the frame of the follow-up European projects SafeWind and ANEMOS.plus, which concentrated respectively on the forecasting of extreme events and the best possible integration of the forecasts in the work flow of end users.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning, MINES ParisTech
Authors: Giebel, G. (Intern), Kariniotakis, G. (Ekstern)
Pages: 59-109
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Chapter: 3

Series: Woodhead Publishing Series in Energy
Main Research Area: Technical/natural sciences
DOIs: 10.1016/B978-0-08-100504-0.00003-2
Source: FindIt
Source-ID: 2392668715
Publication: Research - peer-review › Book chapter – Annual report year: 2017

Wind power variability and power system reserves in South Africa
Variable renewable generation, primarily from wind and solar, introduces new uncertainties in the operation of power systems. This paper describes and applies a method to quantify how wind power development will affect the use of short-term automatic reserves in the future South African power system. The study uses a scenario for wind power development in South Africa, based on information from the South African transmission system operator (Eskom) and the Department of Energy. The scenario foresees 5% wind power penetration by 2025. Time series for wind power production and forecasts are simulated, and the duration curves for wind power ramp rates and wind power forecast errors are applied to assess the use of reserves due to wind power variability. The main finding is that the 5% wind power penetration in 2025 will increase the use of short-term automatic reserves by approximately 2%.

General information
State: Published
Authors: Sørensen, P. E. (Intern), Litong-Palima, M. (Intern), Hahmann, A. N. (Intern), Heunis, S. (Ekstern), Ntusi, M. (Ekstern), Hansen, J. C. (Intern)
Number of pages: 13
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Main Research Area: Technical/natural sciences

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Volume: 29
Wind resource error estimation from mesoscale modeling for the Wind Atlas for South Africa

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling, Integration & Planning, University of Cape Town
Authors: Hahmann, A. N. (Intern), Mortensen, N. G. (Intern), Volker, P. (Intern), Lennard, C. (Ekstern), Hansen, J. C. (Intern)
Publication date: 2017
Main Research Area: Technical/natural sciences
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Wind resource error estimation from mesoscale modeling for the Wind Atlas for South Africa
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Wind Turbine Aerodynamics and Vorticity-Based Methods: Fundamentals and Recent Applications

General information
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Organisations: Department of Wind Energy
Authors: Branlard, E. S. P. (Intern)
Number of pages: 632
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Volume: 7
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Main Research Area: Technical/natural sciences
DOIs:
Wind turbine influence on surfers wind conditions at Hanstholm

In this report a consequence study regarding the surfers wind conditions east of the Hanstholm harbour area. Four existing turbines with a nominal power of 525kW is planned replaced with three new 4.3MW turbines near the beach area. It is investigated whether these wind turbines could potentially alter the wind conditions on the lee side, which is an important area for wind and kite surfers. The Dynamic Wake Meander Model is used to investigate the wind conditions north east of the planned new turbines at Hanstholm covering a surf area from a location called “Fish Factory” to a location called “Hamborg”. This model, which predicts instationary wind conditions behind one or more wind turbines, has previously been used to predict the changed power and load conditions for wind turbines in wind farm conditions. A very fine agreement to measurements is seen and the model is therefore considered sufficient for this particular study also. Furthermore a more advanced flow solver has been used to give a qualitative understanding of the flow conditions near the existing and new turbines. In general the impact of the new wind turbines are very limited and the same order of magnitude as the existing smaller turbines. The reason is that the new turbines mainly disturbs the wind conditions from 30m and upwards.

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control, Fluid Mechanics
Authors: Larsen, T. J. (Intern), Andersen, S. J. (Intern)
Number of pages: 28
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Series: DTU Wind Energy E
Number: 0143
Main Research Area: Technical/natural sciences
Electronic versions:
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Source: PublicationPreSubmission
Source-ID: 131007754
Publication: Research - peer-review › Report – Annual report year: 2017

Wind Turbine Technologies
The wind turbine technology is a very complex technology involving multidisciplinary and broad technical disciplines such as aerodynamics, mechanics, structure dynamics, meteorology as well as electrical engineering addressing the generation, transmission, and integration of wind turbines into the power system. Wind turbine technology has matured over the years and become the most promising and reliable renewable energy technology today. It has moved very fast, since the early 1980s, from wind turbines of a few kilowatts to today’s multimegawatt-sized wind turbines [13]. Besides their size, the design of wind turbines has changed from being convention driven to being optimized driven within the operating regime and market environment.

Wind turbine designs have progressed from fixed speed, passive controlled and with drive trains with gearboxes, to become variable speed, active controlled, and with or without gearboxes, using the latest in power electronics, aerodynamics, and mechanical drive train designs [4]. The main differences between all wind turbine concepts developed over the years, concern their electrical design and control. Today, the wind turbines on the market mix and match a variety of innovative concepts, with proven technology for both generators and power electronics [4]. The continuously increased and concentrated electrical penetration of large wind turbines into electrical power systems inspires the designers to develop both custom generators and power electronics [5,6] and to implement modern control system strategies.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning
Authors: Hansen, A. D. (Intern)
Pages: 145-160
Publication date: 2017

Host publication information
Title of host publication: Wind energy engineering - A handbook for onshore and offshore wind turbines
Publisher: Elsevier
Yaw-modelling using a skewed vortex cylinder

The cylindrical vortex wake model presented in Chap. 17 for the case of uniform inflow is extended in the current chapter to the case of yawed inflow. Generalities regarding yaw are presented in Sect. 6.1 and only the skewed cylindrical vortex model is presented in this chapter. The chapter starts with a literature review on the topic of yaw-models and vorticity-based methods. The description of the model follows. The novelty of the current model is that the assumption of infinite tip-speed ratio is relaxed. The bound vorticity is assumed to be identical to the case of uniform inflow but the vortex cylinder and the root vortex are skewed with respect to the normal of the rotor disk. Closed form formulae for the induced velocities are provided. They can only be evaluated analytically for a limited part of the domain. A numerical integration is required to obtain the velocity everywhere in the domain. The numerical integration poses no difficulty for modern computers. Semi-empirical models are established to obtain the velocity at the rotor disk. The contribution from each vorticity components to the induced velocity at the rotor disk is investigated. The content of this chapter is based on the publication of the author titled A cylindrical vortex wake model: skewed cylinder, application to yawed or tilted rotors (Branlard, Gaunaa, Wind Energy, 2015, [1]). Details on the mathematical derivations used in this chapter are provided in Chap. 38. Results from this chapter are applied in Chap. 22 to derive a new yaw-model applicable to a BEM code. The induction zone in front of a yawed wind turbine or rotor is investigated in Chap. 24 based on the results from the current chapter. A Matlab source code to evaluate the induced velocity field in the entire domain due to the main vorticity component is provided in Sect. 38.1.4.

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Organisations: Department of Wind Energy
Authors: Branlard, E. S. P. (Intern)
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Series: Research Topics in Wind Energy
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Source: FindIt
Source-ID: 2371424115
Publication: Research - peer-review › Book chapter – Annual report year: 2017

A strain gauge

The invention relates to a strain gauge of a carrier layer and a meandering measurement grid positioned on the carrier layer, wherein the strain gauge comprises two reinforcement members positioned on the carrier layer at opposite ends of the measurement grid in the axial direction. The reinforcement members are each placed within a certain axial distance to the measurement grid with the axial distance being equal to or smaller than a factor times the grid spacing. The invention further relates to a multi-axial strain gauge such as a bi-axial strain gauge or a strain gauge rosette where each of the strain gauges comprises reinforcement members. The invention further relates to a method for manufacturing a strain gauge as mentioned above.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Mikkelsen, L. P. (Intern), Zike, S. (Intern)
Publication date: 11 Feb 2016

Publication information
3D Characterization of Recrystallization Boundaries

A three-dimensional (3D) volume containing a recrystallizing grain and a deformed matrix in a partially recrystallized pure aluminum was characterized using the 3D electron backscattering diffraction technique. The 3D shape of a recrystallizing boundary, separating the recrystallizing grain and deformed matrix, was reconstructed. The result shows a very complex structure containing several large protrusions and retrusions. A correlation between the protrusions/retrusions and the deformed matrix in front of the boundary shows that the deformed microstructure has a very strong influence on the formation of protrusions/retrusions.

3D characterization of rolling contact fatigue crack networks

Rolling contact fatigue (RCF) damage is becoming more frequent with increased traffic, accelerations, and loading conditions in the railway industry. Defects which are characterized by a two-lobe darkened surface and a V-shaped surface-breaking crack are defined as squats. The origination and propagation of squats in railway rails is the topic of many recent studies; the associated crack networks develop with complicated geometry near the surface of rails, but can be difficult to detect and distinguish from normally existing head checks in their early stages, using in-field non-destructive detection techniques. After cutting out damaged sections of rail, there are a number of options to characterize the damage. The aim of this study was to evaluate different methods to geometrically describe squat crack networks; through X-ray radiography complemented with geometrical reconstruction, metallography, X-ray tomography, and topography measurements. The experiments were performed on squats from rail sections taken from the field. In the first method, high-resolution and high-energy X-ray images exposed through the entire rail head from a range of angles were combined using a semi-automated image analysis method for geometrical reconstruction, and a 3D representation of the complex crack network was achieved. This was compared with measurements on cross-sections after repeated metallographic sectioning to determine the accuracy of prediction of the geometrical reconstruction. A second squat was investigated by X-ray tomography after extraction of a section of the rail head. A third squat was opened by careful cutting, which gave full access to the crack faces, and the topography was measured by stylus profilometry. The high-energy X-ray, 3D reconstruction method showed accurate main crack geometry at medium depths; the advantage of the method being that it potentially could be developed for non-destructive testing in field. However significant drawbacks exist due to limitations in radiography in terms of detecting tightly closed cracks in very thick components. This includes the inability to detect the crack tips which is an important factor in determining the risks associated to a specific crack. Metallographic investigation of the cracks gave good interpretation of crack geometry along the sections examined, and gave the possibility to study microstructure and plastic deformation adjacent to the crack face. However this time-consuming method requires...
destruction of the specimen investigated. The X-ray tomography revealed the 3D crack network including side branches in a 10×10×30mm³ sample, and provided topographic information without completely opening the squat. Topography measurements acquired by stylus profilometry provided an accurate description of the entire main crack surface texture, including features such as surface ridges and beach marks.

**General information**

State: Published
Organisations: Department of Wind Energy, Materials science and characterization, Chalmers University of Technology
Authors: Jessop, C. (Ekstern), Ahlström, J. (Ekstern), Hammar, L. (Ekstern), Fæster, S. (Intern), Danielsen, H. K. (Intern)
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Main Research Area: Technical/natural sciences

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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.512 SNIP 1.997 CiteScore 2.73
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.711 SNIP 2.328 CiteScore 2.46
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.317 SNIP 2.382 CiteScore 2.37
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.345 SNIP 2.151 CiteScore 1.85
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.526 SNIP 2.83 CiteScore 2.43
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Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.475 SNIP 2.146
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.649 SNIP 2.06
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.585 SNIP 1.954
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.269 SNIP 1.866
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.437 SNIP 1.998
**General information**

State: Published  
Organisations: Department of Wind Energy, Composites and Materials Mechanics, University of Manchester, LM Wind Power  
Authors: Jespersen, K. M. (Intern), Zangenberg Hansen, J. (Ekstern), Lowe, T. (Ekstern), Withers, P. J. (Ekstern), Mikkelsen, L. P. (Intern)  
Number of pages: 1  
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Main Research Area: Technical/natural sciences

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**Accuracy of an efficient framework for structural analysis of wind turbine blades**

This paper presents a novel framework for the structural design and analysis of wind turbine blades and establishes its accuracy. The framework is based on a beam model composed of two parts—a 2D finite element-based cross-section analysis tool and a 3D beam finite element model. The cross-section analysis tool is able to capture the effects stemming from material anisotropy and inhomogeneity for sections of arbitrary geometry. The proposed framework is very efficient and therefore ideally suited for integration within wind turbine aeroelastic design and analysis tools. A number of benchmark examples are presented comparing the results from the proposed beam model to 3D shell and solid finite element models. The examples considered include a square prismatic beam, an entire wind turbine rotor blade and a detailed wind turbine blade cross section. Phenomena at both the blade length scale—deformation and eigenfrequencies—and cross section scale—3D material strain and stress fields—are analyzed. Furthermore, the effect of the different assumptions regarding the boundary conditions is discussed in detail. The benchmark examples show excellent agreement suggesting that the proposed framework is a highly efficient alternative to 3D finite element models for structural analysis of wind turbine blades. Copyright © 2015 John Wiley & Sons, Ltd.

**General information**

State: Published  
Organisations: Department of Wind Energy, Wind Turbines, Department of Mechanical Engineering, Solid Mechanics
A comparative study on the flow over an airfoil using transitional turbulence models

This work addresses the simulation of the flow over NREL S826 airfoil under a relatively low Reynolds number (Re = 1 × 105) using the CFD solvers OpenFoam and ANSYS Fluent. The flow is simulated using two different transition models, γ−Reθ and k − kL − ω model, and the results are examined against the k − ω SST model without transitional formulations. By comparing the simulations with the available experimental data, we find that the using the transitional model can effectively improve the flow prediction, especially the drag coefficient results, before the stall.

General information

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Organisations: Department of Wind Energy, Fluid Mechanics, Technical University of Denmark
Authors: Lin, M. (Ekstern), Sarlak Chivaee, H. (Intern)
Number of pages: 5
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BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.26 SJR 0.165 SNIP 0.3
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Scopus rating (2016): CiteScore 0.21 SJR 0.165 SNIP 0.246
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.18 SNIP 0.218 CiteScore 0.18
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.171 SNIP 0.202 CiteScore 0.17
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.164 SNIP 0.187 CiteScore 0.16
ISI indexed (2013): ISI indexed no
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.176 SNIP 0.193 CiteScore 0.14
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.161 SNIP 0.16 CiteScore 0.12
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.166 SNIP 0.158
BFI (2009): BFI-level 1
A Comparison of sector-scan and dual Doppler wind measurements at Høvsøre Test Station – one lidar or two?

Long range scanning lidars have the ability to be deployed along the coastline to measure the near shore wind resource. Within the wind energy scope, this is most applicable to assessing the potential energy production (and thus revenue) of a prospected near shore wind farm (here defined as 3-12km from the coast). Ground based remote sensing has numerous advantages over traditional in-situ (offshore met mast) and buoy based installations, mainly in terms or cost, complexity, and failure/delay risk. Since each lidar can only measure a portion of the wind vector, it is necessary to either deploy two devices in tandem (dual Doppler) or employ a single Doppler scanning strategy such as PPI (plan position indicator, or sector scan) which allows for estimation of the two component horizontal wind vector. In preparation for a six month long measurement campaign along the Danish North Sea, a one week experiment was performed at DTU’s test centre for large wind turbines (Høvsøre), which lies 1.8km inland and consists of flat terrain with predominate winds from offshore. Two lidars in staring dual Doppler mode and one lidar performing 60 degree sector scans had their beams collocated atop a 116.5m met-mast, which provided reference wind speed and direction values. The 10 minute reconstructed lidar measurements were in excellent agreement with the reference instrumentation. The dual Doppler results matched within 0.1% of the reference wind speed, with very low levels of unbiased scatter. Sector scan results also indicate very good agreement with the met-mast, corresponding within 0.2% for wind speed, with an R2 of 0.998. The sector scan results for wind speed exhibit larger amounts of scatter than with dual Doppler, however the bias is centred around the regression line which gives good indication that wind measurements taken using the sector scan method are valid and acceptable for use in performing wind resource studies in simple terrain and in offshore conditions. Further, we show that when measuring in these cases, a sector size of 38 degrees still measures within 0.6% of the reference data for wind speed.

General information
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Organisations: Department of Wind Energy, Meteorology & Remote Sensing
Authors: Simon, E. (Intern), Courtney, M. (Intern)
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Publication date: 2016

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Original language: English

Series: DTU Wind Energy E
Volume: 0112
Main Research Area: Technical/natural sciences
Electronic versions:
A comprehensive investigation of trailing edge damage in a wind turbine rotor blade

Wind turbine rotor blades are sophisticated, multipart, lightweight structures whose aeroelasticity-driven geometrical complexity and high strength-to-mass utilization lend themselves to the application of glass-fibre or carbon-fibre composite materials. Most manufacturing techniques involve separate production of the multi-material subcomponents of which a blade is comprised and which are commonly joined through adhesives. Adhesive joints are known to represent a weak link in the structural integrity of blades, where particularly, the trailing-edge joint is notorious for its susceptibility to damage. Empiricism tells that adhesive joints in blades often do not fulfil their expected lifetime, leading to considerable expenses because of repair or blade replacement. Owing to the complicated structural behaviour—in conjunction with the complex loading situation—literature about the root causes for adhesive joint failure in blades is scarce. This paper presents a comprehensive numerical investigation of energy release rates at the tip of a transversely oriented crack in the trailing edge of a 34m long blade for a 1.5MW wind turbine. First, results of a non-linear finite element analysis of a 3D blade model, compared with experimental data of a blade test conducted at Danmarks Tekniske Universitet (DTU) Wind Energy (Department of Wind Energy, Technical University of Denmark), showed to be in good agreement. Subsequently, the effects of geometrical non-linear cross-section deformation and trailing-edge wave formation on the energy release rates were investigated based on realistic aeroelastic load simulations. The paper concludes with a discussion about critical loading directions that trigger two different non-linear deformation mechanisms and their potential impact on adhesive trailing-edge joint failure. Copyright © 2016 John Wiley & Sons, Ltd.
A computational method for sharp interface advection

We devise a numerical method for passive advection of a surface, such as the interface between two incompressible fluids, across a computational mesh. The method is called isoAdvector, and is developed for general meshes consisting of arbitrary polyhedral cells. The algorithm is based on the volume of fluid (VOF) idea of calculating the volume of one of the fluids transported across the mesh faces during a time step. The novelty of the isoAdvector concept consists of two parts. First, we exploit an isosurface concept for modelling the interface inside cells in a geometric surface reconstruction step. Second, from the reconstructed surface, we model the motion of the face–interface intersection line for a general polygonal face to obtain the time evolution within a time step of the submerged face area. Integrating this submerged area over the time step leads to an accurate estimate for the total volume of fluid transported across the face. The method was tested on simple two-dimensional and three-dimensional interface advection problems on both structured and unstructured meshes. The results are very satisfactory in terms of volume conservation, boundedness, surface sharpness and efficiency. The isoAdvector method was implemented as an OpenFOAM® extension and is published as open source.

General information
State: Published
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Main Research Area: Technical/natural sciences
A coupled near and far wake model for wind turbine aerodynamics

In this paper, an aerodynamic model consisting of a lifting line-based trailed vorticity model and a blade element momentum (BEM) model is described. The focus is on the trailed vorticity model, which is based on the near wake model (NWM) by Beddoes and has been extended to include the effects of downwind convection and to enable a faster and more accurate computation of the induction, especially close to the blade root and tip. The NWM is introduced to model the detailed steady and unsteady induction from the first part of the trailed vorticity behind the individual rotor blades. The model adds a radial coupling between the blade sections and provides a computation of tip loss effects that depends on the actual blade geometry and the respective operating point. Moreover, the coupling of the NWM with a BEM theory-based far wake model is presented. To avoid accounting for the near wake induction twice, the induction from the BEM model is reduced by a coupling factor, which is continuously updated during the computation to ensure a good behavior of the model in varying operating conditions. The coupled near and far wake model is compared with a simple prescribed wake lifting line model, a BEM model and full rotor computational fluid dynamics (CFD) to evaluate the steady-state results in different cases. The model is shown to deliver good results across the whole operation range of the NREL 5-MW reference wind turbine.
Actuator disk model of wind farms based on the rotor average wind speed

Due to difficulty of estimating the reference wind speed for wake modeling in wind farm, this paper proposes a new method to calculate the momentum source based on the rotor average wind speed. The proposed model applies volume correction factor to reduce the influence of the mesh recognition of disk regions. The coefficient C4ε of the turbulent source term is also discussed and modified to improve the simulation accuracy. To validate the model, results are presented for the Nibe-B wind turbine and Horns Rev I offshore wind farm and show a good agreement with the measurements.

General information
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Organisations: Department of Wind Energy, Fluid Mechanics, Hohai University, Chinese Academy of Sciences
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Source-ID: 2304202727
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Aerial LIDAR scans for validation of CFD models in complex forested terrain

General information
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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling, Aerodynamic design, Uppsala University, Siemens Wind Power A/S
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Main Research Area: Technical/natural sciences
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Publication: Research › Conference abstract for conference – Annual report year: 2016

Aerial sensor for wind turbines Design, Implementation and demonstration of the technology
The EUDP-2012 proposal, "Improved wind turbine efficiency using synchronized sensors" is a project which focuses on improving the efficiency of energy production, primarily for wind turbines, but as a spinoff, also traditional power plants. It builds on the experience and proven technology from three previous wind turbine projects: • A wing mounted inflow sensor for wind turbines. This
Aeroacoustic calculations of a full scale Nordtank 500kW wind turbine

The Actuator Line/ Navier-stokes technique is used to compute the incompressible flow around a full scale Nordtank 500kW wind turbine under different complex flow conditions such as atmospheric turbulence and wind shear. The flow field is used as an input to aeroacoustic calculations based on; a semi empirical noise model; and a Navier-Stokes based computational aeroacoustic code (CAA). The Navier-Stokes based approach is solving acoustic perturbation equations and is capable of taking propagation and ground effects into account, but is limited to low frequency noise due to feasible mesh resolution, and due to the simplification in the actuator line method using body forces to represent the blade. Noise levels are compared to field measurements of a Nordtank 500kW wind turbine at different wind speeds and in flow profiles.
Aeroacoustic Calculations of Wind Turbine Noise with the Actuator Line/ Navier-Stokes Technique

Noise regulations in many countries are becoming extremely strict and wind turbine noise is thus becoming a barrier for further development of onshore wind turbines. Low noise wind turbine airfoil and blade design is an important technique for noise reduction. However, the ow situation of a wind turbine in wind farms is very complicated. In order to accurately model the noise generation and propagation from wind turbines in wind farms, it is urgent to develop a high-fidelity noise model to predict the noise features in complex situations. In the present study, we develop a flow-acoustic splitting technique where the wind turbine flow is calculated by using the in-house actuator line/LES/Navier-Stokes technique and the acoustics is obtained by solving the acoustic perturbation equations. In the flow solver, the wind turbine blades are modelled by rotating lines with body forces determined according to the local conditions and airfoil data. In the acoustic solver, the aeroacoustics is simulated by: (1) calculating the noise source using the improved engineering model (IBPM) based on the model developed by Brook, Pope and Marcolini (BPM); (2) introducing the noise source with an expected range of frequencies along the blade lines in the acoustic solver; (3) solving the acoustic perturbation equations with the introduced source and the source captured in the flow. The model can be used to study the prediction and propagation of low-frequency noise in complex situations. Noise generated by a wind turbine with and without yaw under wind shear and inflow turbulence will be presented in the paper.

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Aerodynamically shaped vortex generators
An aerodynamically shaped vortex generator has been proposed, manufactured and tested in a wind tunnel. The effect on the overall performance when applied on a thick airfoil is an increased lift to drag ratio compared with standard vortex generators. Copyright © 2015 John Wiley & Sons, Ltd.
Aerodynamic modeling of floating vertical axis wind turbines using the actuator cylinder flow method

Recently the interest in developing vertical axis wind turbines (VAWTs) for offshore application has been increasing. Among the aerodynamic models of VAWTs, double multi-streamtube (DMST) and actuator cylinder (AC) models are two favorable methods for fully coupled modeling and dynamic analysis of floating VAWTs in view of accuracy and computational cost. This paper deals with the development of an aerodynamic code to model floating VAWTs using the AC method developed by Madsen. It includes the tangential load term when calculating induced velocities, addresses two different approaches to calculate the normal and tangential loads acting on the rotor, and proposes a new modified linear solution to correct the linear solution. The effect of dynamic stall is also considered using the Beddoes-Leishman dynamic stall model. The developed code is verified to be accurate by a series of comparisons against other numerical models and experimental results. It is found that the effect of including the tangential load term when calculating induced velocities on the aerodynamic loads is very small. The proposed new modified linear solution can improve the power performance compared with the experiment data. Finally, a comparison of the developed AC method and the DMST method is performed using two rotors and shows that the AC method can predict more accurate aerodynamic loads and power than the DMST method, at least for the considered rotors. (C) 2016 The Authors. Published by Elsevier Ltd.
Aerodynamic Optimization of Vertical Axis Wind Turbine with Trailing Edge Flap

Vertical Axis Wind Turbines (VAWT) are competitive concepts for very large scale (10-20 MW) floating offshore applications. Rotor circulation control (loading control) opens a wide design space to enhance the aerodynamic and operational features of VAWT. The modified linear derivation of the Actuator Cylinder Model (Mod-Lin ACM) is used as the aerodynamic model to assess VAWT performance throughout the work. As the first step, optimum aerodynamic loadings of a VAWT with infinite number of blades are studied. Next, for the case of a finite number of blades, direct and inverse optimization approaches are used. The direct method is coupled with a hybrid numerical optimizer to serve as a global method for designing gap sequences. The effectiveness of trailing edge gap on VAWT is investigated for three aerodynamic objectives which lead to improved power efficiency, rated power control and peak load control. The aerodynamic gains for various solidity, tip-speed ratio, maximum gap deflection and gap size are quantified in inviscid flow. This extensive work presents new insights on the performance of a VAWT with infinite number of blades as well as it provides a solid foundation for gap usage on a real VAWT rotor to enhance its capabilities.

General information
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Publication: Research - peer-review › Article in proceedings – Annual report year: 2016

Aerodynamics
Wind turbine aerodynamics is a central discipline for modelling and prediction of the aerodynamic forces on a wind turbine. From the aerodynamic analysis the performance and loads on the rotor blades, as well as other structures exposed to the wind, are determined. An aerodynamic model is normally integrated with models for wind conditions and structural dynamics. Integrated aeroelastic models for predicting performance and structural deflections are a prerequisite for the design, development and optimisation of wind turbines. Aerodynamic modelling also concerns the design of specific components, such as rotor blade geometry, and systems of wind turbines, such as performance and optimisation of wind farms.

General information
Aerodynamic wind-turbine rotor design using surrogate modeling and three-dimensional viscous-inviscid interaction technique

In this paper a surrogate optimization methodology using a three-dimensional viscous-inviscid interaction code for the aerodynamic design of wind-turbine rotors is presented. The framework presents a unique approach because it does not require the commonly-used blade element momentum (BEM) method. The three-dimensional viscous-inviscid interaction code used here is the accurate and fast MIRAS code developed at the Technical University of Denmark. In comparison with BEM, MIRAS is a higher-fidelity aerodynamic tool and thus more computationally expensive as well. Designing a rotor using MIRAS instead of an inexpensive BEM code represents a challenge, which is resolved by using the proposed surrogate-based approach. As a verification case, the methodology is applied to design a model wind-turbine rotor and is compared in detail with the one designed with BEM. Results demonstrate that nearly identical aerodynamic performance can be achieved using the new design method and that the methodology is effective for the aerodynamic design of wind-turbine rotors.
Aeroelastic Optimization of a 10 MW Wind Turbine Blade with Active Trailing Edge Flaps

This article presents the aeroelastic optimization of a 10 MW wind turbine ‘smart blade’ equipped with active trailing edge flaps. The multi-disciplinary wind turbine analysis and optimization tool HawtOpt2 is utilized, which is based on the open-source framework Open-MDAO. The tool interfaces to several state-of-the-art simulation codes, allowing for a wide variety of problem formulations and combinations of models. A simultaneous aerodynamic and structural optimization of a 10 MW wind turbine rotor is carried out with respect to material layups and outer shape. Active trailing edge flaps are integrated in the design taking into account their achieved fatigue load reduction. The optimized ‘smart blade’ design is compared to an aeroelastically optimized design with no flaps and the baseline design.
Aeroservoelastic analysis of storm-ride-through control strategies for wind turbines

An investigation of a control strategy to allow wind turbines to operate at high wind speeds by derating the rotor speed and generator torque set-points is presented. The investigation analyzes the wind turbine aeroservoelastic behavior in the above rated operational range by computing the aerodynamic gains and closed-loop eigenvalue solutions using a high-fidelity linear model. A simple strategy to reduce the reference rotor speed based on a pitch angle feedback is presented and analyzed. It is shown that high aerodynamic gains for operation at high wind speeds requires special handling in the scheduling of the controller gains. The computed closed-loop modal frequencies and damping ratios show how most turbine modes become less damped as the rotor speed is derated, and at very high winds the frequency and damping of the first drivetrain torsion mode are significantly reduced. Possible resonance problems can also be seen from the computed frequencies, and these problems may be worsened by the decreased damping during storm-ride-through. Finally it is shown that the dynamics of the pitch feedback to the derated generator speed is significantly affected by the operational wind speed, resulting in a slow response at high wind speeds.

Aerosol dynamics within and above forest in relation to turbulent transport and dry deposition

A 1-D atmospheric boundary layer (ABL) model coupled with a detailed atmospheric chemistry and aerosol dynamical model, the model SOSAA, was used to predict the ABL and detailed aerosol population (characterized by the number size distribution) time evolution. The model was applied over a period of 10 days in May 2013 to a pine forest site in southern Finland. The period was characterized by frequent new particle formation events and simultaneous intensive aerosol transformation. The aim of the study was to analyze and quantify the role of aerosol and ABL dynamics in the vertical transport of aerosols. It was of particular interest to what extent the fluxes above the canopy deviate from the particle dry deposition on the canopy foliage due to the above-mentioned processes. The model simulations revealed that the particle concentration change due to aerosol dynamics frequently exceeded the effect of particle deposition by even an order of magnitude or more. The impact was, however, strongly dependent on particle size and time. In spite of the fact that the timescale of turbulent transfer inside the canopy is much smaller than the timescales of aerosol dynamics and dry deposition, leading us to assume well-mixed properties of air, the fluxes at the canopy top frequently deviated from deposition inside the forest. This was due to transformation of aerosol concentration throughout the ABL and resulting complicated pattern of vertical transport. Therefore we argue that the comparison of timescales of aerosol dynamics and deposition defined for the processes below the flux measurement level do not unambiguously describe the importance of aerosol dynamics for vertical transport above the canopy. We conclude that under dynamical conditions reported in the current study the micrometeorological particle flux measurements can significantly deviate from the dry deposition into the canopy. The deviation can be systematic for certain size ranges so that the time-averaged particle fluxes can be also biased with respect to deposition sink.
A novel despiking method is presented for in-stationary wind lidar velocity measurements. A finite difference approach yields the upper and lower bounds for a valid velocity reading. The sole input to the algorithm is the velocity series and optionally a far-field reference to the temporal variation in the velocity. The new algorithm is benchmarked against common despiking algorithms using a dataset acquired by three synchronised lidars in the upstream area of a full-scale wind turbine rotor and an artificially created space-time series with controlled spike contamination. By accounting for variations in space and time, this approach yields improvements in spike detection for in-stationary lidar measurements of about 25% over other more established stationary methods. Furthermore it proofs to be robust even for large numbers of spikes.
Ag-catalyzed InAs nanowires grown on transferable graphite flakes

Semiconducting nanowires grown by quasi-van-der-Waals epitaxy on graphite flakes are a new class of hybrid materials that hold promise for scalable nanostructured devices within opto-electronics. Here we report on high aspect ratio and stacking fault free Ag-seeded InAs nanowires grown on exfoliated graphite flakes by molecular beam epitaxy. Ag catalyzes the InAs nanowire growth selectively on the graphite flakes and not on the underlying InAs substrates. This allows for easy transfer of the flexible graphite flakes with as-grown nanowire ensembles to arbitrary substrates by a micro-needle manipulator. Besides the possibilities for fabricating novel nanostructure device designs, we show how this method is used to study the parasitic growth and bicrystal match between the graphite flake and the nanowires by transmission electron microscopy.

General information
State: Published
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A gradient nanostructure generated in pure copper by platen friction sliding deformation
A modified friction sliding process with a large applied normal load has been used to develop a gradient nano structure in Cu using only a short processing time. A quantitative characterization of the variation in microstructure and strength has been carried out by combined use of electron backscatter diffraction and hardness measurements, and the data used to estimate the effective strain profile resulting from the processing treatment. The affected deformation volume extends to a large depth of more than 1 mm, with a top surface hardness of 228 GPa, corresponding to a four-fold increase compared to the initial undeformed material. (C) 2016 Elsevier Ltd. All rights reserved.
A heuristic for the synthesis of credible operating states in the presence of renewable energy sources

Experience has shown the limitations of deterministic criteria when accommodating the intrinsic uncertainties associated to modern power systems. Hereof, probabilistic risk assessment represent a powerful enhancement in order to ensure the overall power system reliability rather than a worst-case scenario analysis. This paper presents a general-purpose methodology intended to generate plausible operating states. The main focus lies on the generation of correlated random samples using a heuristic of the NORmal-to-Anything (NORTA) method. The proposed methodology was applied to model wind generation in the Danish Western power system, analyzing the effect of the marginal distributions and errors in the correlation matrix definition.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning
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Source-ID: 2349553211
Publication: Research - peer-review › Article in proceedings – Annual report year: 2016
A hybrid model for the wind profile (direction and speed) for the whole

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling
Authors: Gryning, S. (Intern), Batchvarova, E. (Intern)
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Publisher: European Meteorological Society
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A LIDAR-assisted model predictive controller added on a traditional wind turbine controller
LIDAR-assisted collective pitch control shows promising results for load reduction in the full load operating region of horizontal axis wind turbines (WT). Utilizing LIDARs in WT control can be approached in different ways: One method is to design the WT controller from ground up based on the LIDAR measurements. Nevertheless, to make the LIDAR-assisted controller easily implementable on existing wind turbines, one can design a controller that is added to the original and existing WT controller. This add-on solution makes it easier to prove the applicability and performance of the LIDAR-assisted WT control and opens the market of retrofitting existing wind turbines with the new technology. In this paper, we suggest a model predictive controller (MPC) that is added to the basic gain scheduled PI controller of a WT to enhance the performance of the closed loop system using LIDAR measurements. The performance of the MPC controller is compared against two controllers. The controllers are 1) a gain scheduled PI controller and 2) a controller with the same feedback as controller no. 1 and an added feed-forward loop (FF+PI controller). Simulations are used to compare their performances. The simulation scenarios include the extreme operating gust and normal power production using stochastic wind field in the full load region. The results show superior performance compared to the PI controller and a performance marginally better compared to the FF+PI controller. The reason for a better performance against the PI controller is that the MPC controller employs the LIDAR wind speed measurements to predict and compensate future disturbances. The MPC controller is designed based on the closed loop model of the wind turbine including the pitch actuator and therefore an appropriate pitch signal is calculated, while the FF+PI controller employs filter and delay compensation to take the actuator dynamics into account.

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Organisations: Department of Wind Energy, Wind turbine loads & control
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Alternative approach for establishing the Nacelle Transfer Function

The IEC 61400-12-2:2013 is an alternative for all the power performance measurements and analysis when the requirements of the IEC 61400-12-1:2005 are not met. The methodology in the IEC 61400-12-2 standard is solely based on the nacelle anemometry instead of the more traditional methods involving a met-mast, as per the IEC 61400-12-1 standard. In the IEC 61400-12-2 standard the wind speed, which is the key for all the power performance characteristics, will be measured using an anemometer mounted on or near the wind turbine’s nacelle. Thus the measured wind speed in this location will be strongly affected by the wind turbine’s rotor and the nacelle. Suitable correction against such flow distortion is applied through a nacelle transfer function (NTF). The -12-2 standard requires a self-consistency check performed on such established NTF using the nacelle power curve. Most of these self-consistency checks have failed to meet the criteria listed in the standard. The root cause analysis against such failure showed that the methodology followed by the standard is less accurate in estimating the free stream wind speed. Suitable changes were made in the process of establishing the nacelle transfer function and the subsequent self-consistency checks were found to be clearing the criteria set by the standard.

General information

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Organisations: Department of Wind Energy, Fluid Mechanics, Technical University of Denmark, VESTAS Wind Systems A/S
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Scopus rating (2016): SJR 0.258 SNIP 0.528 CiteScore 0.58
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BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.358 SNIP 0.671 CiteScore 0.63
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.392 SNIP 0.97 CiteScore 0.78
BFI (2013): BFI-level 1
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BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.298 SNIP 1.024 CiteScore 0.56
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ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.347 SNIP 0.638
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.344 SNIP 0.687
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.267 SNIP 0.6
Scopus rating (2007): SJR 0.565 SNIP 0.803
A Micropulse eye-safe all-fiber molecular backscatter coherent temperature lidar

In this paper, we analyze the performance of an all-fiber, micropulse, 1.5 μm coherent lidar for remote sensing of atmospheric temperature. The proposed system benefits from the recent advances in optics/electronics technology, especially an all-fiber image-reject homodyne receiver, where a high resolution spectrum in the baseband can be acquired. Due to the presence of a structured spectra resulting from the spontaneous Rayleigh-Brillouin scattering, associated with the relevant operating regimes, an accurate estimation of the temperature can be carried out. One of the main advantages of this system is the removal of the contaminating Mie backscatter signal by electronic filters at the baseband (before signal conditioning and amplification). The paper presents the basic concepts as well as a Monte-Carlo system simulation as the proof of concept.
A model for Quick Load Analysis for monopile-type offshore wind turbine substructures

A model for Quick Load Analysis, QuLA, of an offshore wind turbine substructure is presented. The aerodynamic rotor loads and damping are precomputed for a load-based configuration. The dynamic structural response is represented by the first global fore-aft mode only and is computed in the frequency domain using the equation of motion. The model is compared against the state of the art aeroelastic code, Flex5, and both life time fatigue and extreme loads are considered in the comparison. In general there is good similarity between the two models. Some derivation for the sectional forces are explained in terms of the model simplifications. The difference in the sectional moments are found to be within 14% for the fatigue load case and 10% for the extreme load condition.
An acentric rotation of helical vortex pair

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Organisations: Department of Wind Energy, Fluid Mechanics
Authors: Okulov, V. (Intern)
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An acentric rotation of two helical vortices of the same circulations

The aim of this paper is to test the possibility of a secondary solution of the acentric rotation of helical vortex pairs with the same pitch, sign and strength. The investigation addresses the three-dimensional vortex dynamics of thin vortex filaments. As a result of the current investigation, this secondary solution with acentric vortex positions in the helical pairs is found. This fact was not discussed in previous studies, and the existence of the new equilibrium solution for the helical vortex pairs is an original result.

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Analysis and design of bend-twist coupled wind turbine blades

Bend-twist coupling allows wind turbine blades to self-alleviate sudden inflow changes, as in gusty or turbulent conditions, resulting in reduced ultimate and fatigue loads. If the coupling is introduced by changing the fibre direction of the anisotropic blade material, the assumptions of classical beam theory are not necessarily valid. This chapter reviews the effects of anisotropic material on the structural response of beams and identifies those relevant for wind turbine blade analysis. A framework suitable for the structural analysis of wind turbine blades is proposed and guidance for the design of bend-twist coupled blades is given.

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Organisations: Department of Wind Energy, Wind turbine loads & control
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Analysis of different atmospheric physical parameterizations in COAWST modeling system for the Tropical Storm Nock-ten application

A coupled ocean–atmosphere–wave–sediment transport modeling system was applied to study the atmosphere and ocean dynamics during Tropical Storm Nock-ten. Different atmospheric physical parameterizations in WRF model were investigated through ten groups of numerical experiments. Results of atmosphere, ocean wave and current features were compared with storm observations, ERA-Interim data, NOAA sea surface temperature data, AVISO current data and HYCOM data, respectively. It was found that the storm track and intensity are sensitive to the cumulus and radiation schemes in WRF, especially around the storm center area. As a result, using Kain–Fritsch cumulus scheme, Goddard shortwave radiation scheme and RRTM longwave radiation scheme in WRF may lead to much larger wind intensity, significant wave height, current intensity, as well as lower SST and sea surface pressure. Thus, they are not recommended for this study. Ocean parameters such as significant wave height, SST and current speed are more sensitive to Single-Moment 6-class microphysics scheme than to Eta microphysics scheme at the storm center. By analyzing modeled data with JASON-2 altimeter data, ERA-Interim data and HYCOM data in terms of fitting coefficient, root-mean-square error, correlation coefficient and model performance, the recommended atmospheric physical parameterization in this coupled system, have been obtained.
This paper aims at predicting trajectories of the detached fragments from wind turbines, in order to better quantify consequences of wind turbine failures. The trajectories of thrown objects are attained using the solution to equations of motion and rotation, with the external loads and moments obtained using blade element approach. We have extended an earlier work by taking into account dynamic stall and wind variations due to shear, and investigated different scenarios of throw including throw of the entire or a part of blade, as well as throw of accumulated ice on the blade. Trajectories are simulated for modern wind turbines ranging in size from 2 to 20 MW using upscaling laws. Extensive parametric analyses are performed against initial release angle, tip speed ratio, detachment geometry, and blade pitch setting. It is found that, while at tip speeds of about 70 m/s (normal operating conditions), pieces of blade (with weights in the range of approximately 7-16 ton) would be thrown out less than 700 m for the entire range of wind turbines, and turbines operating at the extreme tip speed of 150 m/s may be subject to blade throw of up to 2 km from the turbine. For the ice throw cases, maximum distances of approximately 100 and 600 m are obtained for standstill and normal operating conditions of the wind turbine, respectively, with the ice pieces weighting from 0.4 to 6.5 kg. The simulations can be useful for revision of wind turbine setback standards, especially when combined with risk assessment studies. Copyright © 2015 John Wiley & Sons, Ltd.

**Analysis of throw distances of detached objects from horizontal-axis wind turbines**

This paper aims at predicting trajectories of the detached fragments from wind turbines, in order to better quantify consequences of wind turbine failures. The trajectories of thrown objects are attained using the solution to equations of motion and rotation, with the external loads and moments obtained using blade element approach. We have extended an earlier work by taking into account dynamic stall and wind variations due to shear, and investigated different scenarios of throw including throw of the entire or a part of blade, as well as throw of accumulated ice on the blade. Trajectories are simulated for modern wind turbines ranging in size from 2 to 20 MW using upscaling laws. Extensive parametric analyses are performed against initial release angle, tip speed ratio, detachment geometry, and blade pitch setting. It is found that, while at tip speeds of about 70 m/s (normal operating conditions), pieces of blade (with weights in the range of approximately 7-16 ton) would be thrown out less than 700 m for the entire range of wind turbines, and turbines operating at the extreme tip speed of 150 m/s may be subject to blade throw of up to 2 km from the turbine. For the ice throw cases, maximum distances of approximately 100 and 600 m are obtained for standstill and normal operating conditions of the wind turbine, respectively, with the ice pieces weighting from 0.4 to 6.5 kg. The simulations can be useful for revision of wind turbine setback standards, especially when combined with risk assessment studies. Copyright © 2015 John Wiley & Sons, Ltd.

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Analytical techniques and tools for power balancing assessments

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An efficient second-order SQP method for structural topology optimization
This article presents a Sequential Quadratic Programming (SQP) solver for structural topology optimization problems named TopSQP. The implementation is based on the general SQP method proposed in Morales et al. J Numer Anal 32(2):553–579 (2010) called SQP+. The topology optimization problem is modelled using a density approach and thus, is classified as a nonconvex problem. More specifically, the SQP method is designed for the classical minimum compliance problem with a constraint on the volume of the structure. The sub-problems are defined using second-order information. They are reformulated using the specific mathematical properties of the problem to significantly improve the efficiency of the solver. The performance of the TopSQP solver is compared to the special-purpose structural optimization method, the Globally Convergent Method of Moving Asymptotes (GCMMA) and the two general nonlinear solvers IPOPT and SNOPT. Numerical experiments on a large set of benchmark problems show good performance of TopSQP in terms of number of function evaluations. In addition, the use of second-order information helps to decrease the objective function value.

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An experimental and numerical study of the atmospheric stability impact on wind turbine wakes

In this paper, the impact of atmospheric stability on a wind turbine wake is studied experimentally and numerically. The experimental approach is based on full-scale (nacelle based) pulsed lidar measurements of the wake flow field of a stall-regulated 500 kW turbine at the DTU Wind Energy, Rønne campus test site. Wake measurements are averaged within a mean wind speed bin of 1 m s⁻¹ and classified according to atmospheric stability using three different metrics: the Obukhov length, the Bulk–Richardson number and the Froude number. Three test cases are subsequently defined covering various atmospheric conditions. Simulations are carried out using large eddy simulation and actuator disk rotor modeling. The turbulence properties of the incoming wind are adapted to the thermal stratification using a newly developed spectral tensor model that includes buoyancy effects. Discrepancies are discussed, as basis for future model development and improvement. Finally, the impact of atmospheric stability on large-scale and small-scale wake flow characteristics is presently investigated. Copyright © 2015 John Wiley & Sons, Ltd.
An exponential chemorheological model for viscosity dependence on degree-of-cure of a polyfurfuryl alcohol resin during the post-gel curing stage

In the present study, the chemorheological behavior of a bio-based polyfurfuryl alcohol (PFA) resin has been determined by rheological isothermal tests at different curing temperatures for the post-gel curing stage of the resin, using three different amounts of catalyst (2, 4 and 6 wt %). Instead of modeling the evolution of the complex viscosity using a widely used chemorheological model such as the Arrhenius model for each tested temperature, the change of the complex viscosity as a function of the degree-of-cure was predicted using a new exponential type model. In this model, the logarithm of the normalized degree-of-cure is used to predict the behavior of the logarithm of the normalized complex viscosity. The model shows good quality of fitting with the experimental data for 4 and 6 wt % amounts of catalyst. For the 2 wt % amount of catalyst, scattered data leads to a slightly lower quality of fitting. Altogether, it is demonstrated that the new exponential model is a good alternative to conventional chemorheological models due to its simplicity and suitability.
An innovative method to calibrate a spinner anemometer without the use of yaw position sensor

A spinner anemometer can be used to measure the yaw misalignment and flow inclination experienced by a wind turbine. Previous calibration methods used to calibrate a spinner anemometer for flow angle measurements were based on measurements of a spinner anemometer with default settings (arbitrary values, generally $k_1,d=1$ and $k_2,d=1$) and a reference yaw misalignment signal measured with a yaw position sensor. The yaw position sensor is normally present in wind turbines for control purposes; however, such a signal is not always available for a spinner anemometer calibration. Therefore, an additional yaw position sensor was installed prior to the spinner anemometer calibration. An innovative method to calibrate the spinner anemometer without a yaw position sensor was then developed. It was noted that a non-calibrated spinner anemometer that overestimates (underestimates) the inflow angle will also overestimate (underestimate) the wind speed when there is a yaw misalignment. The new method leverages the non-linearity of the spinner anemometer algorithm to find the calibration factor $F_\alpha$ by an optimization process that minimizes the dependency of the wind speed on the yaw misalignment. The new calibration method was found to be rather robust, with $F_\alpha$ values within $\pm2.7\%$ of the mean value for four successive tests at the same rotor position.

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Main Research Area: Technical/natural sciences

An Inter-Comparison Study of Multi- and DBS Lidar Measurements in Complex Terrain

Wind measurements using classical profiling lidars suffer from systematic measurement errors in complex terrain. Moreover, their ability to measure turbulence quantities is unsatisfactory for wind-energy applications. This paper presents results from a measurement campaign during which multiple WindScanners were focused on one point next to a reference mast in complex terrain. This multi-lidar (ML) technique is also compared to a profiling lidar using the Doppler beam swinging (DBS) method. First- and second-order statistics of the radial wind velocities from the individual instruments and the horizontal wind components of several ML combinations are analysed in comparison to sonic anemometry and DBS measurements. The results for the wind speed show significantly reduced scatter and directional error for the ML method in comparison to the DBS lidar. The analysis of the second-order statistics also reveals a significantly better correlation for the ML technique than for the DBS lidar, when compared to the sonic. However, the probe volume averaging of the lidars leads to an attenuation of the turbulence at high wave numbers. Also the configuration (i.e., angles) of the WindScanners in the ML method seems to be more important for turbulence measurements. In summary, the results clearly show the advantages of the ML technique in complex terrain and indicate that it has the potential to achieve significantly higher accuracy in measuring turbulence quantities for wind-energy applications than classical profiling lidars.

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An investigation on wind turbine resonant vibrations

Wind turbine resonant vibrations are investigated based on aeroelastic simulations both in frequency and time domain. The investigation focuses on three different aspects: the need of a precise modeling when a wind turbine is operating close to resonant conditions; the importance of estimating wind turbine loads also at low turbulence intensity wind conditions to identify the presence of resonances; and the wind turbine response because of external excitations. In the first analysis, three different wind turbine models are analysed with respect to the frequency and damping of the aeroelastic modes. Fatigue loads on the same models are then investigated with two different turbulence intensities to analyse the wind turbine response. In the second analysis, a wind turbine model is excited with an external force. This analysis helps in identifying the modes that might be excited, and therefore, the frequencies at which minimal excitation should be present during operations. The study shows that significant edgewise blade vibrations can occur on modern wind turbines even if the aeroelastic damping of the edgewise modes is positive. When operating close to resonant conditions, small differences in the modeling can have a large influence on the vibration level. The edgewise vibrations are less visible in high turbulent conditions. Using simulations with low-level turbulence intensity will ease this identification and could avoid a redesign. Furthermore, depending on the external excitation, different aeroelastic modes can be excited. The investigation is performed using aeroelastic models corresponding to a 1.5 MW class wind turbine with slight variations in blade properties. Copyright © 2015 John Wiley & Sons, Ltd.

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Organisations: Department of Wind Energy, Aeroelastic Design, Alstom Wind, Alstom Wind France
Authors: Tibaldi, C. (Intern), Kim, T. (Intern), Larsen, T. J. (Intern), Rasmussen, F. (Intern), Rocca Serra, R. D. (Ekstern), Sanz, F. (Ekstern)
A noise generation and propagation model for large wind farms

A wind turbine noise calculation model is combined with a ray tracing method in order to estimate wind farm noise in its surrounding assuming an arbitrary topography. The wind turbine noise model is used to generate noise spectra for which each turbine is approximated as a point source. However, the detailed three-dimensional directivity features are taken into account for the further calculation of noise propagation over the surrounding terrain. An arbitrary number of turbines constituting a wind farm can be spatially distributed. The noise from each individual turbine is propagated into the far-field using the ray tracing method. These results are added up assuming the noise from each turbine is uncorrelated. The methodology permits to estimate a wind farm noise map over the surrounding terrain in a reasonable amount of computational time on a personal computer.

A novel full scale experimental characterization of wind turbine aero-acoustic noise sources - preliminary results

The paper describes a novel full scale experiment on a 500 kW wind turbine with the main objective to characterize the aero-acoustic noise sources. The idea behind the instrumentation is to study the link and correlation between the surface pressure (SP) fluctuations in the boundary layer of the blade and the noise on the ground in a distance of about one rotor diameter. In total six surface microphones were used to measure the SP at the leading edge (LE) and trailing edge (TE) of the blade. In parallel noise was measured by eight microphones placed on plates on the ground around the turbine in equidistant angles on a circle with a radius of about one rotor diameter. The data were analyzed in segments of 2.2 s which is the time for one rotor revolution. The spectra for the TE microphones on the suction side of the blade show a characteristic roll-off pattern around a frequency of 600-700 Hz. For increasing wind speed the spectral energy increases below this point and the same is seen on the ground microphones spectra. The decrease in the spectral energy above this point is also found for the blade surface microphones but not on the microphones on the ground. An interesting spectrum was observed for the microphone on the pressure side close to the TE. For increasing wind speed the spectra show a very distinct increase in spectral energy up to about 300 Hz after which the spectra collapse. As the boundary layer is laminar it is thought that this spectral energy is due to sound waves from the TE noise on the suction side.
An Overview of Offshore Wind Farm Design

For offshore wind energy to be viable, the design of wind turbines is not the only important factor—rather, the design of wind farms is also crucial. The current chapter discusses the challenges of designing an optimum wind farm and identifies the various factors that need to be considered. Lastly, the chapter presents the novel EERA-DTOC tool for designing offshore wind farm clusters.

A numerical study on the flow upstream of a wind turbine on complex terrain

The interaction of a wind turbine with the upstream flow-field in complex and flat terrain is studied using Reynolds-averaged Navier-Stokes (RANS) simulations with a two equation turbulence closure. The complex site modelled is Perdigao (Portugal), where a turbine is located on one of two parallel running ridges. Simulating various wind directions with and without rotor, the impact of the rotor on the flow-field upstream is determined. This is compared and related to simulations with sheared and uniform inflow. The induction zones forming for these two inflows agree to such an extent, that shear could be interpreted as linear perturbation to the uniform inflow solution. However, for complex terrain this is not the case, as it is highly dependant on flow features caused by the topography and their interaction with the rotor. Separation in the lee of the ridge plays a crucial role, as it dictates the wind turbine wake trajectory which in turn governs the orientation of the induction zone.
Apparent interfacial shear strength of short-flax-fiber/starch acetate composites

The paper deals with an indirect industry-friendly method for identification of the interfacial shear strength (IFSS) in a fully bio-based composite. The IFSS of flax fiber/starch acetate is evaluated by a modified Bowyer and Bader method based on an analysis of the stress-strain curve of a short-fiber-reinforced composite in tension. A shear lag model is developed for the tensile stress-strain response of short-fiber-reinforced composites allowing for an elastic-perfectly plastic stress transfer. Composites with different fiber volume fractions and a variable content of plasticizer have been analyzed. The apparent IFSS of flax/starch acetate is within the range of 5.5-20.5 MPa, depending on composition of the material. The IFSS is found to be greater for composites with a higher fiber loading and to decrease with increasing content of plasticizer. The IFSS is equal or greater than the yield strength of the neat polymer, suggesting good adhesion, as expected for the chemically compatible constituents.
Application of helical vortex solutions to determine wind turbine tip loss

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Organisations: Department of Wind Energy, Fluid Mechanics, University of Alberta, University of Calgary
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Application of short-range dual-Doppler lidars to evaluate the coherence of turbulence

Two synchronized continuous wave scanning lidars are used to study the coherence of the along-wind and across-wind velocity components. The goal is to evaluate the potential of the lidar technology for application in wind engineering. The wind lidars were installed on the Lysefjord Bridge during four days in May 2014 to monitor the wind field in the horizontal plane upstream of the bridge deck. Wind records obtained by five sonic anemometers mounted on the West side of the bridge are used as reference data. Single- and two-point statistics of wind turbulence are studied, with special emphasis on the root-coherence and the co-coherence of turbulence. A four-parameter decaying exponential function has been fitted to the measured co-coherence, and a good agreement is observed between data obtained by the sonic anemometers and the lidars. The root-coherence of turbulence is compared to theoretical models. The analytical predictions agree rather well with the measured coherence for the along-wind component. For increasing wavenumbers, larger discrepancies are, however, noticeable between the measured coherence and the theoretical predictions. The WindScanners are observed to slightly overestimate the integral length scales, which could not be explained by the laser beam averaging effect alone. On the other hand, the spatial averaging effect does not seem to have any significant effect on the coherence.

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**Approach for investigations of progressive fatigue damage in 3D in fibre composites using X-ray tomography**
Understanding fatigue damage initiation and evolution in the load carrying laminates inside wind turbine blade plays a key factor designing longer and lighter turbine blades. Thereby, it is possible to lower the Cost of Energy for the wind energy
based electricity production either by simply building larger wind turbines or by upgrading existing turbines for lower wind classes’. In the presented work, a Zeiss Xradia Versa 520 scanner has been used in connection with ex-situ fatigue testing with the purpose of identifying fibre failure during the fatigue loading. The load carrying laminates is typically based on stacking of a number of non-crimp fabrics in where the load carrying fibres are oriented in the axial direction of the wind turbine blade. In order to ease the handling of the fabric during the dry fabric layup and ensure a good alignment of the final laminates, approximately 10% of the fibres are oriented in secondary directions. Thereby, the non-crimp fabric is given some shear stiffness. The figures below show the results from a scanning of a fatigue damaged material. The width of the full scanned cross section is 15 mm, while the size of the zoomed scan is approximately 2.5 mm. The small black points visible in the two lower slices taken from the zoomed scan indicate fibre failure. From the red slice, the fibre failure is seen to be located in regions with the backing bundles are located. The backing bundles in the red slice are pointing out of the figure plan. In the green slice, it can be seen that the fibre failure in the load carrying fibres, are following the 45 degree orientation of the backing bundles where the 45 degree backing bundle can be seen at the left side of the green slice figure. In addition, to the scan case shown here, an ex-situ study of the fibre progression (Jespersen & Mikkelsen, 2016) has been performed. An ex-situ study where it has been important to design a good gripping strategy inside the scanning machine. Doing this, it has been possible to scan the same region multiple times. Thereby, a progressive fatigue damage evolution has been observed.

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A refined tip correction based on decambering
A new tip correction for use in performance codes based on the blade element momentum (BEM) or the lifting-line techniques presented. The correction modifies the circulation by taking into account the additional influence of the induction of the vortices in the wake, using the so-called decambering effect and thin-airfoil theory. A limitation of the standard Prandtl tip correction is that it represents the surface loading by a line distribution that does not take into account the actual shape of the rotor blade. Thus, the chord distribution does not appear as a parameter in the model, and the loading in the proximity of the tip is generally found to be overestimated. The new tip correction is implemented as an additional correction in order to represent the surface loading by a line distribution. Comparing computations using the new model with standard BEM results and computations using a 3D panel code show that the inclusion of the correction greatly improves the results. The new model also explains some of the discrepancies that earlier on have been observed when using a BEM technique based alone upon standard tip corrections.

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A relaxed-certificate facial reduction algorithm based on subspace intersection

A “facial reduction”-like regularization algorithm is established for general conic optimization problems by relaxing requirements on the reduction certificates. This yields a rapid subspace reduction algorithm challenged only by representational issues of the regularized cone. A condition for practical usage is analyzed and shown to always be satisfied for single second-order cone optimization problems. Should the condition fail on some other class of instances,
only partial regularization is achieved based on the success of the individual subspace intersection.
A simplified model predicting the weight of the load carrying beam in a wind turbine blade

Based on a simplified beam model, the loads, stresses and deflections experienced by a wind turbine blade of a given length is estimated. Due to the simplicity of the model used, the model is well suited for work investigating scaling effects of wind turbine blades. Presently, the model is used to predict the weight of the load carrying beam when using glass fibre reinforced polymers, carbon fibre reinforced polymers or an aluminium alloy as the construction material. Thereby, it is found that the weight of a glass fibre wind turbine blade is increased from 0.5 to 33 tons when the blade length grows from 20 to 90 m. In addition, it can be seen that for a blade using glass fibre reinforced polymers, the design is controlled by the deflection and thereby the material stiffness in order to avoid the blade to hit the tower. On the other hand if using aluminium, the design will be controlled by the fatigue resistance in order to make the material survive the 100 to 500 million load cycles experience of the wind turbine blade throughout the lifetime. The aluminium blade is also found to be considerably heavier compared with the composite blades.
Large Eddy Simulations (LES) are performed in order to study the wake and power characteristics of a horizontal-axis wind turbine in a wind tunnel. Using an actuator line technique, the effect of wind tunnel blockage ratio (defined as the ratio of the rotor swept area to the tunnel cross-sectional area) is investigated for a wide range of tip speed ratios from 1 to 12, and for four blockage ratios (0.2, 0.09, 0.05 and 0.02). The results demonstrate how the blockage effect increases with the tip speed ratio. When the tip speed ratio is close to or above the optimal design value, blockage ratios of larger than 0.05 affect both tangential and normal forces on the blades and therefore on the power and thrust coefficients. At the highest blockage ratio of 0.2, the mean velocity of the wake is also affected significantly, although the effect on the wake mixing rate is less pronounced. Further, the effect of the Reynolds number on the wake development is illustrated and the impact of numerics and subgrid-scale models are investigated by comparing two different LES codes. Finally, the importance of tip loss correction in actuator-line modeling of wind turbines is illustrated using comparative computations.
A Two-Level Undercut-Profile Substrate for Chemical-Solution-Based Filamentary Coated Conductors

A recently developed two-level undercut-profile substrate (2LUPS), containing two levels of plateaus connected by a curved wall with an undercut profile, enables self-forming filaments in a coated conductor during physical line-of-sight deposition of buffer and superconducting layers. In the present study, the 2LUPS concept is applied to a commercial cube-textured Ni-5at.% W tape, and the surface of the 2LUPS coated with two Gd2Zr2O7 buffer layers using chemical solution deposition is examined. Except for narrow regions near the edge of upper plateaus, the plateaus are found to be covered by strongly textured Gd2Zr2O7 buffer layers after dip coating and sintering.
Bayesian inference model for fatigue life of laminated composites

A probabilistic model for estimating the fatigue life of laminated composite plates is developed. The model is based on lamina-level input data, making it possible to predict fatigue properties for a wide range of laminate configurations. Model parameters are estimated by Bayesian inference. The reference data used consists of constant-amplitude cycle test results for four laminates with different layup configurations. The paper describes the modeling techniques and the parameter estimation procedure, supported by an illustrative application.

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Simulations of a stiff rotor configuration of the DTU 10MW Reference Wind Turbine are performed in order to assess the impact of prescribed flap motion on the aerodynamic loads on a blade sectional and rotor integral level. Results of the engineering models used by DTU (HAWC2), TUDelft (Bladed) and NTUA (hGAST) are compared to the CFD predictions of USTUTT-IAG (FLOWer). Results show fairly good comparison in terms of axial loading, while alignment of tangential and drag-related forces across the numerical codes needs to be improved, together with unsteady corrections associated with rotor wake dynamics. The use of a new wake model in HAWC2 shows considerable accuracy improvements.
Blade-element/momentum theory

Although there exists a large variety of methods for predicting performance and loadings of wind turbines, the only approach used today by wind turbine manufacturers is based on the blade-element/momentum (BEM) theory by Glauert (Aerodynamic theory. Springer, Berlin, pp. 169-360, 1935). A basic assumption in the BEM theory is that the flow takes place in independent stream tubes and that the loading is determined from two-dimensional sectional airfoil characteristics.
Breaking phase focused wave group loads on offshore wind turbine monopiles
The current method for calculating extreme wave loads on offshore wind turbine structures is based on engineering models for non-breaking regular waves. The present article has the aim of validating previously developed models at DTU, namely the OceanWave3D potential flow wave model and a coupled OceanWave3D-OpenFOAM solver, against measurements of focused wave group impacts on a monopile. The focused 2D and 3D wave groups are reproduced and the free surface elevation and the in-line forces are compared to the experimental results. In addition, the pressure distribution on the monopile is examined at the time of maximum force and discussed in terms of shape and magnitude. Relative pressure time series are also compared between the simulations and experiments and detailed pressure fields for a 2D and 3D impact are discussed in terms of impact type. In general a good match for free surface elevation, in-line force and wave-induced pressures is found.
Calculating the sensitivity of wind turbine loads to wind inputs using response surfaces

This paper presents a methodology to calculate wind turbine load sensitivities to turbulence parameters through the use of response surfaces. A response surface is a high-dimensional polynomial surface that can be calibrated to any set of input/output data and then used to generate synthetic data at a low computational cost. Sobol sensitivity indices (SIs) can then be calculated with relative ease using the calibrated response surface. The proposed methodology is demonstrated by calculating the total sensitivity of the maximum blade root bending moment of the WindPACT 5 MW reference model to four turbulence input parameters: a reference mean wind speed, a reference turbulence intensity, the Kaimal length scale, and a novel parameter reflecting the nonstationarity present in the inflow turbulence. The input/output data used to calibrate the response surface were generated for a previous project. The fit of the calibrated response surface is evaluated in terms of error between the model and the training data and in terms of the convergence. The Sobol SIs are calculated using the calibrated response surface, and the convergence is examined. The Sobol SIs reveal that, of the four turbulence parameters examined in this paper, the variance caused by the Kaimal length scale and nonstationarity parameter are negligible. Thus, the findings in this paper represent the first systematic evidence that stochastic wind turbine load response statistics can be modeled purely by mean wind wind speed and turbulence intensity.

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control
Authors: Rinker, J. M. (Intern)
Number of pages: 11
Publication date: 2016
Conference: The Science of Making Torque from Wind, Munich, Germany, 05/10/2016 - 05/10/2016
BFI conference series: European Academy of Wind Energy : The Science of Making Torque from Wind (5010078)
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Physics: Conference Series (Online)
Volume: 753
Issue number: 3
Article number: 032057
ISSN (Print): 1742-6596
Calibration of a spinner anemometer for wind speed measurements

The power curve of a wind turbine can be measured, according to IEC 61400-12-2 with a nacelle-mounted anemometer. Typically, a sonic anemometer or a cup anemometer and a wind vane are mounted on the back of the nacelle roof. Another option is to use a spinner anemometer. The measurement principle of the spinner anemometer is based on the flow distortion caused by the wind turbine spinner. The flow on the spinner surface is measured by means of three 1D sonic sensors mounted on the spinner and a conversion algorithm to convert the wind velocity components measured by the three sonic sensors to horizontal wind speed, yaw misalignment and flow inclination angle. The algorithm utilizes two calibration constants that are specific to the spinner shape, blade root design and to the mounting positions of the sonic sensors on the spinner. The present analysis describes methods to determine the calibration constant related to wind speed measurements. The first and preferred method is based on the definition of the calibration constant and uses wind speed measurements during the stopped condition of the wind turbine. Two alternative methods that did not require the turbine to be stopped were investigated: one used relatively high wind speed measurements during normal operation of
the wind turbine, while the other one used a CFD simulation of the flow over the spinner. The method that entails stopping
the turbine in good wind conditions showed the best results and is recommended. The evaluation of uncertainty was not
included in the present analysis.

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State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Aerodynamic design
Authors: Demurtas, G. (Intern), Friis Pedersen, T. (Intern), Zahle, F. (Intern)
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Scopus rating (2017): CiteScore 3.18 SJR 1.051 SNIP 1.834
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.37 SJR 1.079 SNIP 2.316
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.201 SNIP 2.165 CiteScore 3.06
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.209 SNIP 3.688 CiteScore 3.42
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.235 SNIP 2.486 CiteScore 2.75
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.062 SNIP 2.297 CiteScore 2.36
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.892 SNIP 2.582 CiteScore 2.49
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.364 SNIP 2.026
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BFI (2009): BFI-level 2
Scopus rating (2009): SJR 0.885 SNIP 1.439
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.743 SNIP 1.555
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.942 SNIP 1.42
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.586 SNIP 1.653
Calibration of Ground-based Lidar instrument

This report presents the result of the lidar calibration performed for the given Ground-based Lidar at DTU’s test site for large wind turbines at Høvsøre, Denmark. Calibration is here understood as the establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements. The comparison of the lidar measurements of the wind direction with that from wind vanes measurements are given for information only.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Villanueva, H. (Intern), Gómez Arranz, P. (Intern)
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Series: DTU Wind Energy LC I
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Bibliographical note
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Publication: Research › Report – Annual report year: 2016

Calibration of Ground-based Lidar instrument

This report presents the result of the lidar calibration performed for the given Ground-based Lidar at DTU’s test site for large wind turbines at Høvsøre, Denmark. Calibration is here understood as the establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements. The comparison of the lidar measurements of the wind direction with that from wind vanes measurements are given for information only.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Villanueva, H. (Intern), Gómez Arranz, P. (Intern)
Number of pages: 29
Publication date: 2016
Calibration of Ground-based Lidar instrument
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General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Villanueva, H. (Intern), Georgieva Yankova, G. (Intern)
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Publication date: 2016
Calibration of Ground-based Lidar instrument

This report presents the result of the lidar calibration performed for the given Ground-based Lidar at DTU’s test site for large wind turbines at Høvsøre, Denmark. Calibration is here understood as the establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements. The comparison of the lidar measurements of the wind direction with that from wind vanes measurements are given for information only.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Villanueva, H. (Intern), Gómez Arranz, P. (Intern)
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Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy LC I
Number: 092(EN)
Main Research Area: Technical/natural sciences
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Publication: Research › Report – Annual report year: 2016
Calibration of Ground-based Lidar instrument
This report presents the result of the lidar calibration performed for the given Ground-based Lidar at DTU's test site for large wind turbines at Høvsøre, Denmark. Calibration is here understood as the establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements. The comparison of the lidar measurements of the wind direction with that from wind vanes measurements are given for information only.

General information
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Organisations: Department of Wind Energy, Test and Measurements
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Calibration of Ground-based Lidar instrument
This report presents the result of the lidar calibration performed for the given Ground-based Lidar at DTU's test site for large wind turbines at Høvsøre, Denmark. Calibration is here understood as the establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements. The comparison of the lidar measurements of the wind direction with that from wind vanes measurements are given for information only.

General information
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Publisher: DTU Wind Energy
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Series: DTU Wind Energy LC I
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Calibration of Ground-based Lidar instrument
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from wind vanes measurements are given for information only.

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Publication: Research › Report – Annual report year: 2016

**Calibration of Nacelle-based Lidar instrument**
This report presents the result of the lidar calibration performed for a two-beam nacelle based lidar at DTU’s test site for large wind turbines at Høvsøre, Denmark. Calibration is here understood as the establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements.

**General information**
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Organisations: Department of Wind Energy, Test and Measurements, Meteorology & Remote Sensing
Authors: Georgieva Yankova, G. (Intern), Courtney, M. (Intern)
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**Calibration of Nacelle-based Lidar instrument**
This report presents the result of the lidar calibration performed for a two-beam nacelle based lidar at DTU’s test site for large wind turbines at Høvsøre, Denmark. Calibration is here understood as the establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements.

**General information**
State: Published
Organisations: Department of Wind Energy, Test and Measurements, Meteorology & Remote Sensing
Authors: Georgieva Yankova, G. (Intern), Courtney, M. (Intern)
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Publication date: 2016
Calibration of Nacelle-based Lidar instrument
This report presents the result of the lidar calibration performed for a two-beam nacelle based lidar at DTU’s test site for large wind turbines at Høvsøre, Denmark. Calibration is here understood as the establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements, Meteorology & Remote Sensing
Authors: Georgieva Yankova, G. (Intern), Courtney, M. (Intern)
Number of pages: 29
Publication date: 2016

Calibration of Nacelle-based Lidar instrument
This report presents the result of the lidar calibration performed for a four-beam nacelle based lidar at DTU’s test site for large wind turbines at Høvsøre, Denmark. Calibration is here understood as the establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements, Meteorology & Remote Sensing
Authors: Georgieva Yankova, G. (Intern), Courtney, M. (Intern)
Number of pages: 34
Publication date: 2016
Calibration of Nacelle-based Lidar instrument
This report presents the result of the lidar calibration performed for a two-beam nacelle based lidar at DTU’s test site for large wind turbines at Høvsøre, Denmark. Calibration is here understood as the establishment of a relation between the reference wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements.

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State: Published
Organisations: Department of Wind Energy, Test and Measurements, Meteorology & Remote Sensing
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Main Research Area: Technical/natural sciences
DTU Wind Energy LC I-101(EN), LC-I-101, LC-I-101EN)

Bibliographical note
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Publication: Research › Report – Annual report year: 2016

Calibration report for Avent 5-beam Demonstrator Lidar
Nacelle-based profiling LiDARs may be the future of power performance assessment. Due to their large rotor size, single-point measurements are insufficient to quantify the power modern wind turbines can harness. The available energy in the wind indeed varies with heights. Improving power performance assessment by measuring simultaneously at different heights has been demonstrated using ground-based profiling LiDARs. Using nacelle lidars avoids the erection of
expensive meteorology masts, especially offshore.

As for any other measuring system, lidars measurements have uncertainties. Their estimation is the ultimate goal of a calibration: a relation is established between reference measurements from calibrated instruments and corresponding LiDAR indications. Traceability in the calibration is obtained by transferring measurement uncertainties from the reference instrument through the calibration process.

A generic methodology to calibrate profiling nacelle lidars has been developed and performed on a 5-beam Demonstrator lidar manufactured by Avent Lithar Technology. In essence, the generic methodology calibrates the inputs of the wind reconstruction algorithms rather than their outputs.

This report presents the calibration procedures and results of a 5-beam Demonstrator unit. The calibration was performed at DTU’s test site for large wind turbines, Høvsøre, Denmark. The methods to assess radial wind speed uncertainties are detailed together with an example of how to derive reconstructed wind parameters’ uncertainties.
Carbon fiber/carbon nanotube reinforced hierarchical composites: Effect of CNT distribution on shearing strength

The strength and fracture behavior of carbon fiber reinforced polymer composites with carbon nanotube (CNT) secondary reinforcement are investigated experimentally and numerically. Short Beam Shearing tests have been carried out, with SEM observations of the damage evolution in the composites. 3D multiscale computational (FE) models of the carbon/polymer composite with varied CNT distributions have been developed and employed to study the effect of the secondary CNT reinforcement, its distribution and content on the strength and fracture behavior of the composites. It is shown that adding secondary CNT nanoreinforcement into the matrix and/or the sizing of carbon fiber/reinforced composites ensures strong increase of the composite strength. The effect of secondary CNTs reinforcement is strongest when some small addition of CNTs in the polymer matrix is complemented by the fiber sizing with high content of CNTs.

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General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics, KU Leuven, China University of Mining And Technology
Authors: Zhou, H. W. (Ekstern), Mishnaevsky, L. (Intern), Yi, H. Y. (Ekstern), Liu, Y. Q. (Ekstern), Hu, X. (Ekstern), Warrier, A. (Ekstern), Dai, G. (Intern)
Number of pages: 11
Pages: 201-211
Publication date: 2016
Main Research Area: Technical/natural sciences

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Journal: Composites Part B: Engineering
Volume: 88
ISSN (Print): 1359-8368
Ratings:
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 5.41 SJR 2.039 SNIP 2.104
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.19 SJR 2.115 SNIP 2.378
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.967 SNIP 2.222 CiteScore 4.29
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.951 SNIP 2.39 CiteScore 3.87
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.373 SNIP 2.441 CiteScore 3.31
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
CBLIB 2014: a benchmark library for conic mixed-integer and continuous optimization

The Conic Benchmark Library is an ongoing community-driven project aiming to challenge commercial and open source solvers on mainstream cone support. In this paper, 121 mixed-integer and continuous second-order cone problem instances have been selected from 11 categories as representative for the instances available online. Since current file formats were found incapable, we embrace the new Conic Benchmark Format as standard for conic optimization. Tools are provided to aid integration of this format with other software packages.

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Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Friberg, H. A. (Intern)
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Journal: Mathematical Programming Computation
Volume: 8
Issue number: 2
ISSN (Print): 1867-2949
Ratings:
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 2.775 SJR 1.293 CiteScore 3.43
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 2.169 SNIP 2.847 CiteScore 3.86
The current paper presents the effort, in the EU AVATAR project, to establish the necessary requirements to obtain consistent lift over drag ratios among seven CFD codes. The flow around a 2D airfoil case is studied, for both transitional and fully turbulent conditions at Reynolds numbers of $3 \times 10^6$ and $15 \times 10^6$. The necessary grid resolution, domain size, and iterative convergence criteria to have consistent results are discussed, and suggestions are given for best practice. For the fully turbulent results four out of seven codes provide consistent results. For the laminar-turbulent transitional results only three out of seven provided results, and the agreement is generally lower than for the fully turbulent case.

**General information**

State: Published
Organisations: Department of Wind Energy, Aerodynamic design, Department of Civil Engineering, Centro Nacional de Energías Renovables, Centre for Renewable Energy Sources, University of Stuttgart, National Technical University of Athens, University of Glasgow, Delft University of Technology
Authors: Sørensen, N. N. (Intern), Méndez, B. (Ekstern), Muñoz, A. (Ekstern), Sieros, G. (Ekstern), Jost, E. (Ekstern), Lutz, T. (Ekstern), Papadakis, G. (Ekstern), Voutsinas, S. (Ekstern), Barakos, G. N. (Ekstern), Colonia, S. (Ekstern), Baldacchino, D. (Ekstern), Baptista, C. (Ekstern), Ferreira, C. M. D. (Intern)
Number of pages: 11
Publication date: 2016
Conference: The Science of Making Torque from Wind, Munich, Germany, 05/10/2016 - 05/10/2016
BFI conference series: European Academy of Wind Energy: The Science of Making Torque from Wind (5010078)
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ISSN (Print): 1742-6596
Ratings:
BFI (2018): BFI-level 1
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Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
CFD computations of the second round of MEXICO rotor measurements

A comparison, between selected wind tunnel data from the NEW MEXICO measuring campaign and CFD computations are shown. The present work, documents that a state of the art CFD code, including a laminar turbulent transition model, can provide good agreement with experimental data. Good agreement is shown for the integral loads, radial distributions of blades forces, pressure distributions, and the velocity profiles up- and downstream of the rotor.
Characterization and modelling of the mechanical properties of mineral wool

Mineral wool designates a highly porous network of fibres drawn by spinning molten minerals. Traditionally, mineral wool products have found application as thermal and acoustic insulation of buildings. Recent concepts where mineral wool products are subjected to higher structural loads have emerged and as a consequence focus on the mechanical properties of mineral wool has intensified. Also understanding the deformation mechanisms during compression of low density mineral wool is crucial since better thickness recovery after compression will result in significant savings on transport costs. The mechanical properties of mineral wool relate closely to the arrangement and characteristics of the fibres inside the material. Because of the complex architecture of mineral wool, the characterization and the understanding of the mechanism of deformations require a new methodology.

In this PhD thesis, a methodology based on image analysis to characterize the 3D structure of mineral wool materials in terms of fibre orientation, fibre diameter, contacts and pore size is proposed. The method uses 3D data obtained by X-ray tomography. The measured data are fitted to probability distributions in order to facilitate the comparison of individual characteristics of different mineral wool materials and provide simple descriptors of the 3D structure. All the methods described here are applied to glass wool and stone wool.

By developing a FEM model including the real characteristic of the mineral wool fibre structure, the effect of the structure on mechanical properties can be explored. The size of the representative volume elements for the prediction of the elastic properties is determined for two types of applied boundary conditions. For sufficiently large volumes, the predicted elastic properties are consistent with results from the literature and confirm the transverse isotropy of mineral wool.

Finally, the overall methodology is applied to study the compression of mineral wool products. X-ray tomography and the developed image analysis techniques are employed to quantify the change of the fibre structure under compression and confirm the reorientation of the fibres. A numerical model of the cyclic compression of mineral wool is developed and reproduces successfully the hysteresis observed experimentally. The results of the modelling indicate that the size of the hysteresis is linked to the friction coefficient between the fibres.

Elastic and compressive properties of mineral wool products can now be predicted and optimized with respect to the fibre structure, binder and fibre content using the micromechanical FEM model developed in this PhD study.

Characterization Of Biaxial Strain Of Poly(L-Lactide) Tubes

Poly(L-lactide) (PLLA) in its L-form has promising mechanical properties. Being a semi-crystalline polymer, it can be subjected to strain-induced crystallization at temperatures above Tg and can thereby become oriented. Following a simultaneous (SIM) biaxial strain process or a sequential (SEQ) biaxial strain process, the mechanical properties of biaxial strained tubes can be further improved. This study investigated these properties in relation to their morphology and crystal orientation. Both processes yield the same mechanical strength and modulus, yet exhibit different crystal orientation. Through further WAXS analysis it was found that the SEQ biaxial strain yields larger interplanar spacing and distorted crystals and looser packing of chains. However, this does not influence the mechanical properties negatively. A loss of orientation in SEQ biaxial strained samples at high degrees of strain was detected, but not seen for SIM biaxial strain, and did not correlate with mechanical performance in either case. However, post-annealing reduced the orientation to the
same level in both cases, and the modulus and strength is decreased for both SIM and SEQ biaxial. It is therefore concluded that mechanical properties after biaxial strain are related to strain-induced amorphous orientation and the packing of crystals, rather than strain-induced crystallinity.

**General information**

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BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.11 SNIP 0.952
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Scopus rating (2003): SJR 0.79 SNIP 0.811
Scopus rating (2002): SJR 0.774 SNIP 0.927
Characterization of wind velocities in the upstream induction zone of a wind turbine using scanning continuous-wave lidars

As a wind turbine generates power, induced velocities, lower than the freestream velocity, will be present upstream of the turbine due to perturbation of the flow by the rotor. In this study, the upstream induction zone of a 225kW horizontal axis Vestas V27 wind turbine located at the Danish Technical University’s Risø campus is investigated using a scanning Light Detection and Ranging (lidar) system. Three short-range continuous-wave “WindScanner” lidars are positioned in the field around the V27 turbine allowing detection of all three components of the wind velocity vectors within the induction zone. The time-averaged mean wind speeds at different locations in the upstream induction zone are measured by scanning a horizontal plane at hub height and a vertical plane centered at the middle of the rotor extending roughly 1.5 rotor diameters (D) upstream of the rotor. Turbulence statistics in the induction zone are studied by more rapidly scanning along individual lines perpendicular to the rotor at different radial distances from the hub. The mean velocity measurements reveal that the longitudinal velocity reductions become greater closer to the rotor plane and closer to the center of the rotor. Velocity deficits of 1%–3% of the freestream value were observed 1 D upstream of the rotor, increasing at the rotor plane to 7.4% near the edge of the rotor and 16% near the center of the rotor while the turbine was operating with a high estimated mechanical coefficient of power (CP) of 0.56 yielding an estimated axial induction factor of 0.25. The velocity reductions relative to the freestream velocity become smaller when the turbine’s coefficient of power decreases; for a low CP of 0.16 resulting in an estimated induction factor of 0.04, the velocity deficits are 1% of the freestream value 1 D upstream of the rotor and only 6% at the rotor plane near the center of the rotor. Additionally, the mean radial wind speeds were found to increase close to the edge of the rotor disk indicating an expansion of the incoming flow around the rotor. Radial velocity magnitudes at the edge of the rotor disk of approximately 9% and 3% of the freestream longitudinal wind speed were measured for the abovementioned high and low CP values, respectively. Turbulence statistics, calculated using 2.5-min time series, suggest that the standard deviation of the longitudinal wind component decreases close to the rotor, while the standard deviation of the radial wind component appears to increase. When the turbine was operating with a high CP of 0.54 resulting in an estimated induction factor of 0.22, standard deviation decreases of up to 22% of the estimated freestream value and increases of up to 22% of the estimated freestream value and increases of up to 46% were observed for the longitudinal and radial components, respectively, near the center of the rotor.
Characterization of wind velocities in the wake of a full scale wind turbine using three ground-based synchronized WindScanners

The wind energy community is in need of detailed full-field measurements in the wake of wind turbines. Here, three dimensional (3D) wind vector field measurements obtained in the near-wake region behind a full-scale test turbine are presented. Specifically, the wake of a NEG Nordtank turbine, installed at Risoe test field, has been measured from 0 to 2 diameters downstream. For this, three ground-based synchronised short-range WindScanners and a spinner lidar have been used. The 3D wind velocity field has been reconstructed in horizontal and vertical planes crossing the hub. The 10-min mean values of the three wind components reveal detailed information regarding the wake properties while propagating downwind over flat terrain. Furthermore, the wake centre is tracked from the measurements and its meander is investigated as function of yaw misalignment of the turbine. The centre-line wake deficit is calculated both in a Nacelle and Moving Frame of Reference. The results can be used in quantitative validation of numerical wake models.

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China's experimental pragmatics of "Scientific development" in wind power: Algorithmic struggles over software in wind turbines

This article presents a case study on the development of China's wind power market. As China's wind industry has experienced a quality crisis, the Chinese government has intervened to steer the industry towards a turn to quality, indicating a pragmatist and experimental mode of market development. This increased focus on quality, to ensure the sustainable and scientific development of China's wind energy market, requires improved indigenous Chinese innovation capabilities in wind turbine technology. To shed light on how the turn to quality impacts upon the industry and global competition, this study adopts the micro-processual, socio-technical, relational and empiricist lens of Science & Technology Studies (STS). It illustrates how Sino-foreign collaborative relations around the core technology of software (in control systems and simulation tools) have become politicised, and how controversies unfold over issues associated with intellectual property rights (IPRs), certification and standardisation of software algorithms. The article concludes that the use of this STS lens makes a fresh contribution to the often path-dependent, structuralist and hierarchical China literature, offering instead a possibility- and agency-filled account that can shed light on the dynamics of China's fragmented governance and experimental market development.
Cluster Control of Offshore Wind Power Plants Connected to a Common HVDC Station

In this paper a coordinated control for cluster of offshore WPPs connected to the same HVDC connection is being implemented and analyzed. The study is targeting two cases as; coordination of reactive power flow between HVDC converter and the WPP cluster while providing offshore AC grid voltage control, and coordinated closed loop control between the HVDC and the WPPs while the cluster is providing Power Oscillation Damping (POD) via active power modulation. It is shown that the coordinated cluster control helps to improve the steady-state and dynamic response of the
offshore AC grid in case of offshore AC grid voltage control and onshore ancillary services provision, i.e. POD by the active power modulation of the cluster. The two cases are simulated using DlgSILENT PowerFactory, where the IEC 61400-27-1 wind turbine and WPP control models and a generic offshore layout with cluster of three WPPs are utilized. (C) 2016 The Authors. Published by Elsevier Ltd.

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Coarsening kinetics of fine-scale microstructures in deformed materials
In this work we consider three representative continuous coarsening processes, namely subgrain growth in deformed subgrain structures, triple junction motion in deformed lamellar structures, and grain growth in deformed nanocrystalline structures, spanning a large range in structural scale and driving force. We propose a unified coarsening model, which is based on recovery kinetics and allows the apparent activation energy to change during coarsening. The model is successfully applied to the three coarsening processes in different materials of different structural morphology and scale, showing that the apparent activation energy increases during coarsening, which is verified by direct calculation. The increase in the apparent activation energy dominates the coarsening kinetics and leads to a significant decrease in the coarsening rate as coarsening proceeds. This suggests that a conventional grain growth model is not applicable in an
analysis of coarsening of nanostructured materials. Our analysis also shows that an initial low thermal stability of nanostructured materials is inherently related to their large boundary area per unit volume and their high content of stored energy, providing a large driving force and, it appears, a low activation energy for structural coarsening. (C) 2016 Acta Materialia Inc. Published by Elsevier Ltd. All rights reserved.
Coastal wind study based on Sentinel-1 and ground-based scanning lidar

Winds in the coastal zone have importance for near-shore wind farm planning. Recently the Danish Energy Agency gave new options for placing offshore wind farms much closer to the coastlines than previously. The new tender areas are located from 3 to 8 km from the coast. Ground-based scanning lidar located on land can partly cover this area out to around 15 km. In order to improve wind farm planning for near-shore coastal areas, the project ‘Reducing the Uncertainty of Near-shore Energy estimates from meso- and micro-scale wind models’ (RUNE) is established. The measurement campaign starts October 2015 and has 3-month duration at the Danish North Sea coast at around 56.5°N, 8.2°E. Ocean surface winds derived from Sentinel-1 will be compared to the ground-based scanning lidar observations of winds as well as to winds observed at the coastline, at a floating wind lidar buoy and at a wave buoy. The various observation types have advantages and limitations; one advantage of both the Sentinel-1 and the scanning lidar is that they both observe wind fields covering a large area and so can be combined for studying the spatial variability of winds. Sentinel-1 are being processed near-real-time at DTU Wind Energy (Badger et al. 2016) using GFS winds as input. Wind direction can be checked from the various other observations. Sensitivity to possible deviations in wind directions in the near-shore area will be investigated. Furthermore, oceanic features not related to winds but to e.g. surface current, breaking waves, etc. will be investigated. The plan is to establish high-quality coastal wind speed cases based on Sentinel-1 for quantification of the coastal winds, for verification of wind resource modelling best practices in the coastal zone. The study is supported by RUNE and New European Wind Atlas projects and satellite data from Copernicus Sentinel-1.

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Cohesive zone modelling and the fracture process of structural tape

Structural tapes provide comparable toughness as structural adhesives at orders of magnitude lower stresses. This is potentially useful to minimize the effects of differences in thermal expansion in the joining of mixed materials. The strength properties are modelled using the cohesive zone model. Thus, a cohesive zone represents the tape, i.e. stresses in the tape are transmitted to the substrates through tractions determined by the separations of the surfaces of substrates. This simplification allows for structural analysis of large complex structures. The relation between the traction and the separation is measured experimentally using methods based on the path independence of the J-integral. Repeated experiments are performed at quasi-static loading. A mixed mode cohesive law is adapted to the experimental data. The law is implemented as a UMAT in Abaqus. Simulations show minor thermal distortions due to thermal loading and substantial structural strength in mechanical loading of a mixed material structure.
Comparative analysis of methods for modelling the short-term probability distribution of extreme wind turbine loads

We have tested the performance of statistical extrapolation methods in predicting the extreme response of a multi-megawatt wind turbine generator. We have applied the peaks-over-threshold, block maxima and average conditional exceedance rates (ACER) methods for peaks extraction, combined with four extrapolation techniques: the Weibull, Gumbel and Pareto distributions and a double-exponential asymptotic extreme value function based on the ACER method. For the successful implementation of a fully automated extrapolation process, we have developed a procedure for automatic identification of tail threshold levels, based on the assumption that the response tail is asymptotically Gumbel distributed. Example analyses were carried out, aimed at comparing the different methods, analysing the statistical uncertainties and identifying the factors, which are critical to the accuracy and reliability of the extrapolation. The present paper describes the modelling procedures and makes a comparison of extrapolation methods based on the results from the example calculations.
Comparison of a Coupled Near and Far Wake Model With a Free Wake Vortex Code

This paper presents the integration of a near wake model for trailing vorticity, which is based on a prescribed wake lifting line model proposed by Beddoes, with a BEM-based far wake model and a 2D shed vorticity model. The resulting coupled aerodynamics model is validated against lifting surface computations performed using a free wake panel code. The focus of the description of the aerodynamics model is on the numerical stability, the computation speed and the accuracy of 5 unsteady simulations. To stabilize the near wake model, it has to be iterated to convergence, using a relaxation factor that has to be updated during the computation. Further, the effect of simplifying the exponential function approximation of the near wake model to increase the computation speed is investigated in this work. A modification of the dynamic inflow weighting factors of the far wake model is presented that ensures good induction modeling at slow time scales. Finally, the unsteady airfoil aerodynamics model is extended to provide the unsteady bound circulation for the near wake model and to improve 10 the modeling of the unsteady behavior of cambered airfoils. The model comparison with results from a free wake panel code and a BEM model is centered around the NREL 5 MW reference turbine. The
response to pitch steps at different pitching speeds is compared. By means of prescribed vibration cases, the effect of the aerodynamic model on the predictions of the aerodynamic work is investigated. The validation shows that a BEM model can be improved by adding near wake trailed vorticity computation. For all prescribed vibration cases with high aerodynamic damping, results similar to those obtained by 15 the free wake model can be achieved in a small fraction of computation time with the proposed model. In the cases with low aerodynamic damping, the addition of trailed vorticity modeling shifts the results closer to those obtained by using the free wake code, but differences remain.

Comparison of classical methods for blade design and the influence of tip correction on rotor performance

The classical blade-element/momentum (BE/M) method, which is used together with different types of corrections (e.g. the Prandtl or Glaeuer tip correction), is today the most basic tool in the design of wind turbine rotors. However, there are other classical techniques based on a combination of the blade-element approach and lifting-line (BE/LL) methods, which are less used by the wind turbine community. The BE/LL method involves different interpretations for rotors with finite or infinite numbers of blades and different assumptions with respect to the optimum circulation distribution. In the present study we compare the performance and the resulting design of the BE/M method by Glaeuer [1] and the BE/LL method by Betz [2] for finite as well as for infinite-bladed rotors, corrected for finiteness through the tip correction. In the first part of the paper, expressions are given for the optimum design, including blade plan forms and local pitch distributions. The comparison shows that the resulting geometry of the rotor depends on the method used, but that the differences mainly exist in the inner part of the blade and at relatively small tip speed ratios (TSR).
Comparison of OpenFOAM and EllipSys3D for neutral atmospheric flow over complex terrain

The flow solvers OpenFOAM and EllipSys3D are compared in the case of neutral atmospheric flow over terrain using the test cases of Askervein and Bolund hills. Both solvers are run using the steady-state Reynolds-averaged Navier–Stokes k–turbulence model. One of the main modeling differences between the two solvers is the wall-function approach. The OpenFOAM v.1.7.1 uses a Nikuradse’s sand roughness model, while EllipSys3D uses a model based on the atmospheric roughness length. It is found that Nikuradse’s model introduces an error dependent on the near-wall cell height. To mitigate this error the near-wall cells should be at least 10 times larger than the surface roughness. It is nonetheless possible to obtain very similar results between EllipSys3D and OpenFOAM v.1.7.1. The more recent OpenFOAM v.2.2.1, which includes the atmospheric roughness length wall-function approach, has also been tested and compared to the results of OpenFOAM v.1.7.1 and EllipSys3D. The numerical results obtained using the same wall-modeling approach in both EllipSys3D and Open-FOAM v.2.2.1 proved to be almost identical. Two meshing strategies are investigated using HypGrid and SnappyHexMesh. The performance of Open-FOAM on SnappyHexMesh-based low-aspect-ratio unstructured meshes is found to be almost an order of magnitude faster than on HypGrid-based structured and high-aspect-ratio meshes. However, proper control of boundary layer resolution is found to be very difficult when using SnappyHexMesh tool is utilized for grid generation purposes. The OpenFOAM is generally found to be 2–6 times slower than EllipSys3D in achieving numerical results of the same order of accuracy on similar or identical computational meshes, when utilization of EllipSys3D default grid sequencing procedures is included.

General information
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Comparison of superconducting generators and permanent magnet generators for 10-MW direct-drive wind turbines

Large offshore direct-drive wind turbines of 10-MW power levels are being extensively proposed and studied because of a reduced cost of energy. Conventional permanent magnet generators currently dominating the direct-drive wind turbine market are still under consideration for such large wind turbines. In the meantime, superconducting generators (SCSGs) have been of particular interest to become a significant competitor because of their compactness and light weight. This paper compares the performance indicators of these two direct-drive generator types in the same 10-MW wind turbine under the same design and optimization method. Such comparisons will be interesting and insightful for commercialization of superconducting generators and for development of future wind energy industry, although SCSGs are still far from a high technology readiness level. The results show that the SCSGs may not be too expensive regarding capital cost of energy. If other major costs and reliability factors related to superconductivity are taken into consideration, however, the SCSGs may not be competitive yet at the moment.

Comparison of the far wake behind dual rotor and dual disk configurations

There is an increasing interest in studying the development of far wakes behind two or more interacting wind turbines in order to determine the influence of wake interaction in relation to the design of wind farms. The focus of this experimental study is to understand and describe the resulting wake features for two rotors subjected to different operating and spatial conditions. As a part of this, a comparison with the wake development behind two disks replacing the rotor models was performed to determine the difference between the two wake systems. LDA and Stereo PIV experiments were carried out to study the development of far wakes behind configurations of dual HAWT wind turbine rotors and dual circular disks. The setups were placed in the middle of a water flume. The initial flow in the flume is subjected to a very low turbulence level, limiting the influence of all external disturbances in order to focus the study to the inherent wake instability. As a result of the investigation, we obtained decays of profiles of the velocity deficit and turbulent pulsations in the far wakes behind both dual rotor and dual disk configurations. By using regression techniques to fit the obtained velocity profiles the
experimental data were approximated by identical analytical models and compared to each other. An identical rational dependence with the same powers, but with different coefficients, was found for the two configurations.
Comparison of the near-wake between actuator-line simulations and a simplified vortex model of a horizontal-axis wind turbine

The flow around an isolated horizontal-axis wind turbine is estimated by means of a new vortex code based on the Biot–Savart law with constant circulation along the blades. The results have been compared with numerical simulations where the wind turbine blades are replaced with actuator lines. Two different wind turbines have been simulated: one with constant circulation along the blades, to replicate the vortex method approximations, and the other with a realistic circulation distribution, to compare the outcomes of the vortex model with real operative wind-turbine conditions (Tjæreborg wind turbine). The vortex model matched the numerical simulation of the turbine with constant blade circulation in terms of the near-wake structure and local forces along the blade. The results from the Tjæreborg turbine case showed some discrepancies between the two approaches, but overall, the agreement is qualitatively good, validating the analytical method for more general conditions. The present results show that a simple vortex code is able to provide an estimation of the flow around the wind turbine similar to the actuator-line approach but with a negligible computational effort. Copyright © 2015 John Wiley & Sons, Ltd.

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Organisations: Department of Wind Energy, Fluid Mechanics, KTH - Royal Institute of Technology, Uppsala University
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Compatibility of IEC 61400-27-1 Ed 1 and WECC 2nd Generation Wind Turbine Models

The IEC TC88 WG27 and the Western Electric Coordinating Council (WECC) Renewable Energy Modeling Task Force, in North America, have been developing the IEC 61400-27-1 and WECC 2nd Generation Wind Turbine generic electrical models, where the first editions are published in 2014 and 2013, respectively. Although the two working groups have been collaborating closely, there are small differences between the approaches of the two modelling standards, especially in terms of parameter sets and complexities for different functions. In this paper, compatibility of the IEC and WECC wind turbine models has been investigated, via pointing out the common parts and small discrepancies. It is shown that via parametrizing accordingly, similar responses can be obtained from both of the models and both models can be utilized well to represent the real wind turbines. The compatibility is shown via model to model comparison of the IEC and WECC wind turbines’ simulation results for the wind turbine types 3 and 4, which are the most common technologies. Additionally, detailed behavior of the IEC type 3 model during voltage drop and recovery are compared against measurements.

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Compensating active power imbalances in power system with large-scale wind power penetration

Large-scale wind power penetration can affect the supply continuity in the power system. This is a matter of high priority to investigate, as more regulating reserves and specified control strategies for generation control are required in the future power system with even more highwind power penetration. This paper evaluates the impact of large-scale wind power integration on future power systems. An active power balance control methodology is used for compensating the power imbalances between the demand and the generation in real time, caused by wind power forecast errors. The methodology for the balance power control of future power systems with large-scale wind power integration is described and exemplified considering the generation and power exchange capacities in 2020 for Danish power system.

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Computing the flow past Vortex Generators: Comparison between RANS Simulations and Experiments

The flow around a wind turbine airfoil equipped with Vortex Generators (VGs) is examined. Predictions from three different Reynolds Averaged Navier Stokes (RANS) solvers with two different turbulence models and two different VG modelling approaches are compared between them and with experimental data. The best results are obtained with the more expensive fully resolved VG approach. The cost efficient BAY model can also provide acceptable results, if grid related
numerical diffusion is minimized and only force coefficient polars are considered.

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Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.259 SNIP 0.346
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.264 SNIP 0.301
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.258 SNIP 0.399
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.272 SNIP 0.311
Web of Science (2006): Indexed yes
Original language: English

Applied fluid mechanics, General fluid dynamics theory, simulation and other computational methods, Compressible flows; shock and detonation phenomena, Rotational flow, vortices, buoyancy and other flows involving body forces, Turbulent flows, convection, and heat transfer, Fluid mechanics and aerodynamics (mechanical engineering), aerodynamics,
computational fluid dynamics, flow simulation, Navier-Stokes equations, turbulence, vortices, wind turbines, RANS simulations, flow, wind turbine airfoil, vortex generators, Reynolds averaged Navier Stokes solvers, RANS solvers, turbulence models, VG modelling, force coefficient polars

Electronic versions:
JPCS_753_2_022014.pdf
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Publication: Research - peer-review › Conference article – Annual report year: 2016

Conceptual optimal design of jackets
Structural optimization can explore a large design space (400 jackets) in a short time (2 hours), and thus lead to better conceptual jacket designs.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Sandal, K. (Intern), Verbart, A. (Intern), Stolpe, M. (Intern)
Number of pages: 1
Publication date: 2016
Main Research Area: Technical/natural sciences
Electronic versions:
WED2016_KasperSandal_poster_1.pdf

Relations
Activities:
Wind Energy Denmark 2016
13th Deep Sea Offshore Wind R&D Conference
Publication: Research - peer-review › Poster – Annual report year: 2017

Condensation of long-term wave climates for the fatigue design of hydrodynamically sensitive offshore wind turbine support structures
Cost-efficient and reliable fatigue designs of offshore wind turbine support structures require an adequate representation of the site-specific wind–wave joint distribution. Establishment of this wind–wave joint distribution for design load calculation purposes requires typically a correlation of the marginal wind and wave distribution. This is achieved by condensation of the site-specific wave climate in terms of wave period or wave height lumping, subsequently used as input for a correlation with the corresponding wind climate. The quality of this resulting wind–wave correlation is especially important for hydrodynamically sensitive structures since the applied met-ocean parameters have a non-linear influence on calculated fatigue design loads. The present article introduces a new wave lumping method for condensation of the wave climate. The novelty is predominantly based on refined equivalence criterions for fatigue loads aiming at preservation of the fatigue damage distribution over either the wave height or wave period distribution. This new method is assessed in comparison with different other traditional wave lumping methods on the basis of the site-specific wave climate for the offshore wind farm project Gemini which has kindly been made available by the developer Typhoon Offshore. It is shown that the new method allows for a significantly better preservation of the hydrodynamic fatigue in comparison to the traditional methods.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbines, RAMBØLL Wind
Authors: Passon, P. (Ekstern), Branner, K. (Intern)
Number of pages: 25
Pages: 142-166
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
Journal: Ships and Offshore Structures
The hazards of planetary gearboxes’ failures are the most crucial in the machinery which directly influence human safety like aircrafts. But also in an industry their damages can cause the large economic losses. Planetary gearboxes are used in wind turbines which operate in non-stationary conditions and are exposed to extreme events. Also bucket-wheel excavators are equipped with high-power gearboxes that are exposed to shocks. Continuous monitoring of their condition is crucial in view of early failures, and to ensure safety of exploitation. Artificial neural networks allow for a quick and effective association of the symptoms with the condition of the machine. Extensive research shows that neural networks can be successfully used to recognize gearboxes’ failures; they allow for detection of new failures which were not known at the time of training and can be applied for identification of failures in variable-speed applications. In a majority of the studies conducted so far neural networks were implemented in the software, but for dedicated engineering applications the hardware implementation is being used increasingly, due to high efficiency, flexibility and resistant to harsh environmental conditions. In this paper, a hardware implementation of an artificial neural network designed for condition monitoring of a planetary gearbox is presented. The implementation was done on a Field Programmable Gate Array (FPGA). It is characterized by much higher efficiency and stability than the software one. To assess condition of a gearbox working in non-stationary conditions and for chosen failure modes, a signal pre-processing algorithm based on filtration and
estimation of statistics from the vibration signal was used. Additionally, the rewards-punishments training process was
improved for a selected neural network, which is based on a Learning Vector Quantization (LVQ) algorithm. Presented
classifier can be used as an independent diagnostic system or can be combined with traditional data acquisition systems
using FPGAs. (C) 2016 Elsevier Ltd. All rights reserved.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Dabrowski, D. (Intern)
Pages: 295-308
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
Journal: Measurement
Volume: 91
ISSN (Print): 0263-2241
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.62 SJR 0.733 SNIP 1.566
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.52 SJR 0.727 SNIP 1.685
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.662 SNIP 1.501 CiteScore 2.18
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.676 SNIP 1.7 CiteScore 1.89
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.566 SNIP 1.743 CiteScore 1.8
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.523 SNIP 1.57 CiteScore 1.43
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.387 SNIP 1.38 CiteScore 1.16
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.394 SNIP 1.16
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.367 SNIP 1.107
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.398 SNIP 0.975
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.373 SNIP 0.801
Scopus rating (2006): SJR 0.319 SNIP 1.14
Scopus rating (2005): SJR 0.507 SNIP 1.178
Scopus rating (2004): SJR 0.401 SNIP 0.803
Scopus rating (2003): SJR 0.497 SNIP 1.088
Scopus rating (2002): SJR 0.437 SNIP 1.524
Scopus rating (2001): SJR 0.444 SNIP 0.647
Configuration of technology networks in the wind turbine industry. A comparative study of technology management models in European and Chinese lead firms

Through a comparative analysis of technology management at the component level by wind turbine manufacturers from Europe and China, this article compares strategies of internalisation of core technology components by European and Chinese lead firms and outlines how different internalisation strategies impact the networks established by the two types of lead firms. Building on the concept of governance developed by the global value chain literature, the article identifies two different types of networks: European lead firms internalise core technology components and keep strong captive or relational ties with key component suppliers, whereas Chinese lead firms modularise and externalise core technology components, hence adopting a more flexible approach to technology management. The latter model mirrors a strategy of overcoming technological barriers by tapping into knowledge through global innovation networks. The article contributes to the network governance literature by introducing scales of component technology complexity and lead firm capabilities for understanding network constructs.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning, Copenhagen Business School
Authors: Haakonsson, S. J. (Ekstern), Kirkegaard, J. K. (Intern)
Pages: 281-299
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
Journal: International Journal of Technology Management
Volume: 70
Issue number: 4
ISSN (Print): 0267-5730
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): SNIP 0.698 SJR 0.411 CiteScore 1.31
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.25 SJR 0.462 SNIP 0.634
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.416 SNIP 0.628 CiteScore 1.09
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.402 SNIP 0.692 CiteScore 0.88
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.367 SNIP 0.568 CiteScore 0.83
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 0.381 SNIP 0.529 CiteScore 0.78
This paper provides an overview of two technologies for connecting offshore wind power plants (offshore WPPs, OWPPs) to high-voltage direct current (HVDC) networks: voltage source converters (VSCs) and diode rectifiers (DRs). Current grid code requirements for the connection of such power plants are also addressed, and their implications when using such technologies are discussed.

**General information**

**State:** Published  
**Organisations:** Department of Wind Energy, Integration & Planning  
**Authors:** Saborío-Romano, O. (Intern), Bidadfar, A. (Intern), Göksu, Ö. (Intern), Altin, M. (Intern), Cutululis, N. A. (Intern), Sørensen, P. E. (Intern)  
**Number of pages:** 4  
**Publication date:** 2016  
**Event:** Paper presented at 15th International Workshop on Large-Scale Integration of Wind Power into Power Systems as well as on Transmission Networks for Offshore Wind Power Plants, Vienna, Austria.  
**Main Research Area:** Technical/natural sciences  
**HVDC, Offshore wind power plant, Diode rectifier, Voltage source converter, Grid code requirements**

**Electronic versions:**  
Connection_of_OWPPs.pdf  
Bibliographical note

Poster presentation  
**Relations**
Projects:
Connection of OWPPs to HVDC networks using VSCs and Diode Rectifiers: an Overview
Source: PublicationPreSubmission
Source-ID: 127353032
Publication: Research - peer-review › Paper – Annual report year: 2016

Connection of OWPPs to HVDC networks using VSCs and Diode Rectifiers: an Overview

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning
Authors: Saborío-Romano, O. (Intern), Bidadfar, A. (Intern), Göksu, Ö. (Intern), Altin, M. (Intern), Cutululis, N. A. (Intern), Sørensen, P. E. (Intern)
Number of pages: 1
Publication date: 2016
Event: Poster session presented at 15th International Workshop on Large-Scale Integration of Wind Power into Power Systems as well as on Transmission Networks for Offshore Wind Power Plants, Vienna, Austria.
Main Research Area: Technical/natural sciences
Electronic versions:
Poster

Bibliographical note
Poster presentation

Relations
Projects:
Connection of OWPPs to HVDC networks using VSCs and Diode Rectifiers: an Overview
Publication: Research › Poster – Annual report year: 2016

Control and design of volumetric composition in pultruded hybrid fibre composites
Hybrid composites consist of two or more fibre phases in a common matrix phase. This is a challenge for the control and design of the volumetric composition and microstructural uniformity of such composites. In the present study, a model is presented for the prediction of the complete volumetric composition (i.e. volume fractions of fibres, matrix and porosity) in hybrid fibre composites. The model is based on a constant local fibre volume fraction criterion. Good agreement is found between model predictions and experimental data of pultruded hybrid kenaf/glass fibre composites with variable hybrid fibre weight mixing ratios. To demonstrate the suitability of the model, simulations are performed for four different cases of volumetric composition in hybrid kenaf/glass composites.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics, University Putra Malaysia
Authors: Madsen, B. (Intern), Hashemi, F. (Ekstern), Tahir, P. (Ekstern)
Number of pages: 12
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
Journal: I O P Conference Series: Materials Science and Engineering
Volume: 139
ISSN (Print): 1757-8981
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.49 SJR 0.201 SNIP 0.573
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.39 SJR 0.197 SNIP 0.535
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.197 SNIP 0.361 CiteScore 0.22
Scopus rating (2014): SJR 0.206 SNIP 0.362 CiteScore 0.18
Scopus rating (2013): SJR 0.205 SNIP 0.287 CiteScore 0.16
Controlled retting of hemp fibres: Effect of hydrothermal pre-treatment and enzymatic retting on the mechanical properties of unidirectional hemp/epoxy composites

The objective of this work was to investigate the use of hydrothermal pre-treatment and enzymatic retting to remove non-cellulosic compounds and thus improve the mechanical properties of hemp fibre/epoxy composites. Hydrothermal pre-treatment at 100 kPa and 121 °C combined with enzymatic retting produced fibres with the highest ultimate tensile strength (UTS) of 780 MPa. Compared to untreated fibres, this combined treatment exhibited a positive effect on the mechanical properties of hemp fibre/epoxy composites, resulting in high quality composites with low porosity factor ($\alpha_{pf}$) of 0.08. Traditional field retting produced composites with the poorest mechanical properties and the highest $\alpha_{pf}$ of 0.16. Hydrothermal pretreatment at 100 kPa and subsequent enzymatic retting resulted in hemp fibre composites with the highest UTS of 325 MPa, and stiffness of 38 GPa with 50% fibre volume content, which was 31% and 41% higher, respectively, compared to field retted fibres.

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, Department of Wind Energy, Composites and Materials Mechanics, Technical University of Denmark, Swedish University of Agricultural Sciences
Authors: Liu, M. (Intern), Silva, D. A. S. (Ekstern), Fernando, D. (Ekstern), Meyer, A. S. (Intern), Madsen, B. (Intern), Daniel, G. (Ekstern), Thygesen, A. (Intern)
Pages: 253–262
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
Journal: Composites Part A: Applied Science and Manufacturing
Volume: 88
ISSN (Print): 1359-835X
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4.92 SJR 1.539 SNIP 2.105
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4.82 SJR 1.478 SNIP 2.146
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.532 SNIP 2.219 CiteScore 4.09
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.703 SNIP 2.568 CiteScore 4.08
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.635 SNIP 2.86 CiteScore 3.92
ISI indexed (2013): ISI indexed yes
This paper proposes a new approach of providing ancillary services to AC and DC grids from offshore wind power plants (OWPPs), connected through multi-terminal HVDC network. A coordinated control scheme where OWPP's AC grid frequency modulated according to DC grid voltage variations is used to detect and provide ancillary service requirements of both AC and DC grids, is proposed in this paper. In particular, control strategies for onshore frequency control, fault ride通过 support in the onshore grid, and DC grid voltage control are considered. The proposed control scheme involves only local measurements and therefore avoids the need of communication infrastructure otherwise required for communication based control, and thus increases the reliability of the control system. The effectiveness of the proposed control scheme is demonstrated on a MTDC connected wind power system developed in DIgSILIENT PowerFactory.
Coordinated Fast Primary Frequency Control from Offshore Wind Power Plants in MTDC System

In this paper, coordinated fast primary frequency control (FPFC) from offshore wind power plants (OWPPs) integrated to surrounding onshore AC power system through a three terminal VSC HVDC system is presented. The onshore AC grid frequency variations are emulated at offshore AC grid through appropriate control blocks, based on modulation of the DC grid voltage. The proposed FPFC produces a power reference to the OWPP based on the frequency deviation and its rate of change measured in the offshore AC grid. Moreover, the impact of wind speed variations on the OWPP active power output and the dynamics of wind turbine are also discussed. The corresponding impact of OWPPs active power output variation at different wind speeds on the power system frequency control and DC grid voltage is also presented. The results show that the proposed coordinated fast primary frequency control from OWPPs improves the power system frequency while relieving the stress on the other AC grid participating in frequency control.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning
Authors: Sakamuri, J. N. (Intern), Hansen, A. D. (Intern), Cutululis, N. A. (Intern), Altin, M. (Intern), Sørensen, P. E. (Intern)
Number of pages: 8
Publication date: 2016

Coordinated Voltage Control in Offshore HVDC Connected Cluster of Wind Power Plants

This paper presents a coordinated voltage control scheme (CVCS) for a cluster of offshore wind power plants (OWPPs) connected to a VSC HVDC system. The primary control point of the proposed voltage control scheme is the introduced Pilot bus, which is having the highest short circuit capacity in the offshore AC grid. The developed CVCS comprehends an optimization algorithm, aiming for minimum active power losses in the offshore grid, to generate voltage reference to the Pilot bus. During steady state operation, the Pilot bus voltage is controlled by dispatching reactive power references to each wind turbine (WT) in the WPP cluster based on their available reactive power margin and network sensitivity based participation factors, which are derived from the dV/dQ sensitivity of a WT bus w.r.t the Pilot bus. This method leads to minimization of the risk of undesired effects, particularly overvoltage at the terminals of the WT located far away from the AC collector substation, by dispatching lower reactive power references compared to the ones nearer to the substation. In addition, the paper proposes a control strategy for improved voltage ride through capability of WTs for faults in the offshore grid, thus leading to improved dynamic voltage profile in the offshore AC grid.

General information
State: Published
Authors: Sakamuri, J. N. (Intern), Rather, Z. H. (Ekstern), Rimez, J. (Ekstern), Altin, M. (Intern), Göksu, Ö. (Intern), Cutululis, N. A. (Intern)
Number of pages: 10
Pages: 1592-1601
Publication date: 2016
Main Research Area: Technical/natural sciences
Correlation of mesoscale wind speeds over the sea

A large offshore observational data set from stations across the North and Baltic Sea is used to investigate the planetary boundary layer wind characteristics and their coherence, correlation and power spectra. The data of thirteen sites, with pairs of sites at a horizontal distance of 4 to 848 km, are analyzed for typical wind turbine nacelle heights. Mean wind characteristics, correlation and coherence are also calculated for analogous wind data from simulations with the Weather Research and Forecasting (WRF) model.

Results indicate a general good agreement for the coherence calculated based on measurements and the WRF-derived time series. By normalising the frequency axes with the distance and mean wind speed it can be demonstrated that even for data with a wide range of distances, the coherence is a function of the frequency, mean wind and distance, which is consistent with earlier studies. The correlation coefficient as a function of the distance calculated from WRF is however higher than observed in the measurements. For the power spectra, wind speed and wind speed step changes distribution the results for all sites are quite similar. The land masses strongly influence the individual wind direction distribution of each site. The ability of the WRF model to reproduce the coherence of the measurements demonstrates that its output can be used to estimate the coherence of fluctuations for the integration of offshore energy. The power spectra of WRF time series underestimates the high frequency fluctuations. Due to the large number of measurement sites, the results can be used for further plausibility validation for mesoscale model runs over the sea.

General information

State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling, University of Oldenburg
Authors: Mehrens, A. R. (Ekstern), Hahmann, A. N. (Intern), Hahmann, A. N. (Intern), Larsén, X. G. (Intern), von Bremen, L. (Ekstern)
Number of pages: 12
Coupled simulations and comparison with multi-lidar measurements of the wind flow over a double-ridge

The wind flow over a double-ridge site has been numerically simulated with a nested model-chain coupling, down to horizontal resolutions of 40 m. The results were compared with field measurements attained using a triple-lidar instrument, the long-range WindScanner system, which allowed measurements up to 500 m height and the mapping of the wind speed onto a two-dimensional transect crossing the valley. The site, known as Serra do Perdigão, is located in central Portugal and consists of two parallel ridges 1.4 km apart with height differences of 200 m in between, being characterized by rough terrain and forested areas. The analysis was restricted to June 10th 2015, for which measurements and simulations both predicted gravity wave activity, the later showing formation of rotors in the lee of both ridges and some events of wave breaking above the ridge top.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, University of Porto
Authors: Veiga Rodrigues, C. (Ekstern), Palma, J. (Ekstern), Vasiljevic, N. (Intern), Courtney, M. (Intern), Mann, J. (Intern)
Number of pages: 10
Publication date: 2016
Conference: The Science of Making Torque from Wind, Munich, Germany, 05/10/2016 - 05/10/2016
BFI conference series: European Academy of Wind Energy: The Science of Making Torque from Wind (5010078)
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Physics: Conference Series (Online)
Volume: 753
Issue number: 3
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Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Cross-wind fatigue analysis of a full scale offshore wind turbine in the case of wind–wave misalignment.

Wind–wave misalignment is often necessary to consider during the design of offshore wind turbines due to excitation of side–side vibration and the low aerodynamic damping in that direction. The measurements from a fully instrumented 3.6 MW pitch regulated-variable speed offshore wind turbine were used for the estimation of the side–side fatigue loads at the tower bottom. The joint wind–wave distribution and the distribution of the wind–wave misalignment angles were considered. The side–side fatigue at the tower bottom and the damping from site measurements are presented as function of the misalignment angles. A model of the same wind turbine was set-up and simulations with the aero-hydro-servo-elastic code HAWC2 were performed to investigate the effect of damping on the side–side fatigue. Turbulent wind field, irregular waves and flexible soil are used in the simulations based on site-measurements. The aim of the current study is to examine the sensitivity of the side–side fatigue to the wind–wave misalignment and different values of additional offshore damping in the system. It was found that the additional offshore damping of the physical system may be higher than what is typically used in offshore wind turbine sub-structure design, due to the low sensitivity of the measured side–side fatigue loads to the misalignment angle. Choice of an accurate damping value implemented in the model during the design of the wind turbine sub-structure can lead to material and cost savings.

General information
State: Published
Authors: Koukoura, C. (Intern), Brown, C. (Ekstern), Natarajan, A. (Intern), Vesth, A. (Intern)
Pages: 147–157
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
Journal: Engineering Structures
Volume: 120
ISSN (Print): 0141-0296
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.32 SJR 1.69 SNIP 2.165
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.93 SJR 1.547 SNIP 2.037
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.631 SNIP 2.15 CiteScore 2.59
Crystallographic Analysis of Nucleation at Hardness Indentations in High-Purity Aluminum

Nucleation at Vickers hardness indentations has been studied in high-purity aluminum cold-rolled 12 pct. Electron channeling contrast was used to measure the size of the indentations and to detect nuclei, while electron backscattering diffraction was used to determine crystallographic orientations. It is found that indentations are preferential nucleation sites. The crystallographic orientations of the deformed grains affect the hardness and the nucleation potentials at the indentations. Higher hardness gives increased nucleation probabilities. Orientation relationships between nuclei developed at different indentations within one original grain are analyzed and it is found that the orientation distribution of the nuclei is far from random. It is suggested that it relates to the orientations present near the indentation tips which in turn depend on the orientation of the selected grain in which they form. Finally, possible nucleation mechanisms are briefly discussed.

General information

State: Published
Organisations: Department of Wind Energy, Materials science and characterization, Chongqing University
Authors: Xu, C. (Ekstern), Zhang, Y. (Intern), Lin, F. (Intern), Wu, G. (Ekstern), Liu, Q. (Ekstern), Juul Jensen, D. (Intern)
Number of pages: 8
Pages: 5863-5870
Cylindrical vortex wake model: skewed cylinder, application to yawed or tilted rotors

A vortex system consisting of a bound vortex disk, a root vortex and a vortex cylinder is presented and applied for skewed wake situations. Both the longitudinal and tangential components of vorticity of the cylinder are considered. A subset of this system leads to a model, which is commonly used in Blade Element Momentum method codes for yawed conditions. Here, all the components of the full vortex system are analyzed in view of extending Blade Element Momentum models. The main assumptions of the current study are a constant uniform circulation, an infinite number of blades, an un-expanding wake shape and a finite tip-speed ratio. The investigation remains within the context of inviscid potential flow theory. The model is derived for horizontal-axis rotors in general, but results are presented for wind turbine applications. For each vortex element, the velocity components in all directions are computed analytically or semi-analytically for the entire domain. Simplified engineering models are provided to ease the evaluation of velocities in the rotor plane. The predominant velocity components are assessed. Copyright © 2015 John Wiley & Sons, Ltd.
In this paper, we propose a new method for topology optimization with local stress constraints. In this method, material in which a stress constraint is violated is considered as damaged. Since damaged material will contribute less to the overall performance of the structure, the optimizer will promote a design with a minimal amount of damaged material. We tested the method on several benchmark problems, and the results show that the method is a viable alternative for conventional stress-based approaches based on constraint relaxation followed by constraint aggregation.
The objective of this deliverable is to present the requirements for adapting available tools/models and identifying data needs for reliability analysis and optimal decision-making for asset management decision making process. It will serve as a basis for the next tasks of GARPUR work package 5 addressing to the requirements of RMAC criterion developed in work package 2. The report has been written by several partners, three of them being European TSOs, and the three other being academic partners. Special attention has been paid to address every topic in asset management decision making process, and so that no important issue has been forgotten in the grey zones at the interfaces between the different time-frames (long-, mid- and short-term).

Adhering to the title of the task, the various chapters in the deliverable discuss the exogenous factors, i.e., load forecasting, maintenance planning, component failure rates, influence of renewable energy penetration and weather on mid-term planning. Accurate estimation of the variation of uncertainty behind exogenous and endogenous factors is crucial to support reliable calculations/estimations by proposed approaches for RMACs for asset management decision making process, as described in work package 2. Some advanced models exist in scientific literature to characterize the spatio-temporal variation and correlations of relevant factors. Some of these models have been proposed in academia, and offer improved representation with respect to those models currently in use by TSOs. The most relevant to GARPUR are presented and discussed in this report.

This report also outlines the gaps that might hinder implementation of the new approaches of GARPUR for reliability assessment and control, and provides recommendations for bridging them towards pilot testing in GARPUR, and for further improvement/extension beyond GARPUR.

**General Information**

**State:** Published

**Organisations:** Department of Wind Energy, Integration & Planning, RTE (TSO France), Delft University of Technology

**Authors:** Catrinu-Renstrom, M. (Ekstern), Clement, R. (Ekstern), Tournebise, P., (Ekstern), Nikolaev, N. (Ekstern), Andreev, A. (Ekstern), Gamov, N. (Ekstern), Zahov, V. (Ekstern), Chovikov, B. (Ekstern), Khuntia, S. R. (Ekstern), Rueda, J. L. (Ekstern), Janeček, P. (Ekstern), Nuño Martinez, E. (Intern)

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**Can only be accessed internally by the project partners**

**Publication:** Research › Report – Annual report year: 2016

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**Data needs and computational requirements for ST decision making. Internal deliverable ID6.2.1**

The objective of this deliverable is to present the requirements for adapting available tools/models and identifying data needs for probabilistic reliability analysis and optimal decision-making in the short-term decision making process. It will serve as a basis for the next tasks of GARPUR work package 6 addressing to the requirements of RMAC criterion developed in work package 2, and also to validate the functional specifications of the GARPUR Quantification Platform (work carried out in work package 7) as well as for designing the pilot test requirements in work package 8. The report has been written by several partners, two of them being European TSOs, and the four other being academic partners. Special attention has been paid to address every topic in short-term decision making process as considered within GARPUR, and so that no important issue has been forgotten in the grey zones at the interfaces between the short-term operation planning and real-time decision making process.

Adhering to the title of the task, the various chapters in the deliverable discusses the exogenous factors, i.e., load forecasting, component failure rates and influence of weather and renewable energy sources. Accurate estimation of the variation of uncertainty behind exogenous and endogenous factors is crucial to support reliable calculations/estimations by proposed approaches for short-term RMAC and real-time RMAC, as described in work package 2. Cross-border exchanges, operational reserves and outage duration are extensively studied for short-term operation planning. Contingency selection in real-time is discussed with special focus on risk-based contingency selection. Failure of corrective action and recent trend in energy management services in real-time is also tackled in this report. Some advanced models exist in scientific literature to characterize the spatio-temporal variation and correlations of relevant factors. Some of these models have been proposed in academia, and offer improved representation with respect to those models currently in use by TSOs. The most relevant to GARPUR are presented and discussed in this report.

This report also outlines the gaps that might hinder implementation of the new approaches of GARPUR for reliability assessment and control, and provides recommendations for bridging them towards pilot testing in GARPUR, and for further improvement/extension beyond GARPUR.
Delamination initiated by a defect

Composite materials in wind turbines are mainly joined with adhesives. Adhesive joining is preferable since it distributes the stresses over a larger area. This study shows how a defect can influence the fracture behaviour of adhesively joined composite. Repeated experiments are performed using double cantilever beam specimens loaded with bending moments. The specimens consist of two 8 mm thick GFRP-laminates which are joined by a 3 mm thick epoxy adhesive. A thin foil close to one of the laminates is used to start the crack. For some of the specimens a defect is created by an initial load-unload operation. During this operation, a clamp is used in order to prevent crack propagation in the main direction. For the specimens without defect, the crack propagates in the middle of the adhesive layer. For the specimens with defect, the crack directly deviates into the laminate. After about 25 mm propagation in the laminate, the crack returns to the adhesive. Compared to the adhesive the fracture energy for the laminate is significantly higher.
Demonstration of a Basis for Tall Wind Turbine Design, EUDP Project Final Report

Wind turbine design using calibrated wind models have been proposed to be used in conjunction with load cases which lead to reduced uncertainties in the design of wind turbines with hub heights above 60m. These recommended wind profiles have been made for shear, wind directional change and turbulence. The wind turbulence models used in the loads simulations have been calibrated so that their model parameters reflect the atmospheric stability conditions and the quantile of turbulence intensity considered. Consequently large multi megawatt turbines being designed today can benefit from these more advanced wind inflow models. A revision of the IEC 61400-1 standard is being developed and has incorporated some of the recommendations made from this project. This project demonstrated the impact of wind models by simulating wind turbine loads based on high frequency wind measurements taken between 100m and 200m altitude performed at Høvsøre in Denmark. The project also demonstrated the impact of the new wind models on load cases and the certification envelope of turbines. Further the project provided a detailed assessment of safety factors for IEC 61400-1 load cases using reliability-based procedures incorporating the new models and this has been made as an Annex to the new standard that is due to be issued.

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Electronic versions:
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Bibliographical note

EUDP 11-II 64011 -0352
Publication: Research › Report – Annual report year: 2016

Demonstration of partial pitch 2-bladed wind turbine

This is the final report for the EUDP project performed from January 2012 to December 2015. The main objective for the project was to demonstrate the potential of the partial pitch two-bladed (PP-2B) technology. DTU Wind Energy took a responsibility for three workpackages (WPs) among 6 WPs which were aerodynamic evaluation of partial pitch technology (WP2), aeroelastic analysis of two-bladed turbine (WP3) and On-site testing (WP4). For the WP2, a comprehensive set of 3D CFD simulations including the gap between inner and outer part of the blade and vortex generators (VGs) of both cross-sections on the blade as well as fully resolved rotor simulations, and finally simulations coupling HAWC2 with EllipSys3D, investigating the behaviors of the rotor at standstill, has been performed. For the WP3, the state-of-the art aeroelastic analysis tool, HAWC2, has been updated in order to consider the partial pitch concept and detailed load analyses were performed. Also the comparison studies between numerical results and experimental results were performed. Moreover stability analyses for the PP-2B turbine have been performed with HAWC2 and modal analysis using Hill's method was performed to calculate the mode shapes and modal frequencies. For the WP4, the onsite measurements were successfully carried out at Harboøre Tange, Thyborøn, Denmark in the period 28th September 2012
to 14th of January 2016. The structural loads, produced power and turbine controller signals were measured and sampled together with detailed inflow information from the met mast nearby.

**Demonstration of synchronised scanning Lidar measurements of 2D velocity fields in a boundary-layer wind tunnel**

This paper combines the currently relevant research methodologies of scaled wind turbine model experiments in wind tunnels with remote-sensing short-range WindScanner Lidar measurement technology. The wind tunnel of the Politecnico di Milano was equipped with three wind turbine models and two short-range WindScanner Lidars to demonstrate the benefits of synchronised scanning Lidars in such experimental surroundings for the first time. The dual-Lidar system can provide fully synchronised trajectory scans with sampling time scales ranging from seconds to minutes. First, staring mode measurements were compared to hot wire probe measurements commonly used in wind tunnels. This yielded goodness of fit coefficients of 0.969 and 0.902 for the 1 Hz averaged u- and v-components of the wind speed, respectively, validating the 2D measurement capability of the Lidar scanners. Subsequently, the measurement of wake profiles on a line as well as wake area scans were executed to illustrate the applicability of Lidar scanning to measuring small scale wind flow effects. The downsides of Lidar with respect to the hot wire probes are the larger measurement probe volume and the loss of some measurements due to moving blades. In contrast, the benefits are the high flexibility in conducting both point measurements and area scanning, and the fact that remote sensing techniques do not disturb the flow while measuring. The research campaign revealed a high potential for using short-range WindScanner Lidar for accurately measuring small scale flow structures in a wind tunnel.
Deploying scanning lidars at coastal sites

This report presents the concept of scanning lidars placed at coastal sites in order to measure the near-coastal (offshore) wind resource. In particular, the site requirements for such scanning lidars are examined in the context of the siting choices made for the RUNE project. It is seen that the most desirable sites are away from sand dunes and with some significant elevation above the sea surface, such as at the top of a cliff. Coastal planning restrictions in Denmark are quite restrictive and it was important to allow sufficient time to obtain permission from the relevant authorities. At the same time, with our particular application, the authorities and land owners were quite favourably inclined to give permission to temporary installations in support of wind energy research. The report concludes with the final positions and a pictorial description of the three RUNE scanning lidars.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing
Authors: Courtney, M. (Intern), Simon, E. (Intern)
Number of pages: 26
Publication date: 2016
DeRisk - Accurate prediction of ULS wave loads. Outlook and first results

Loads from extreme waves can be dimensioning for the substructures of offshore wind turbines. The DeRisk project (2015-2019) aims at an improved load evaluation procedure for extreme waves through application of advanced wave models, laboratory tests of load effects, development of hydrodynamic load models, aero-elastic response calculations and statistical analysis. This first paper from the project outlines the content and philosophy behind DeRisk. Next, the first results from laboratory tests with irregular waves are presented, including results for 2D and 3D focused wave groups. The results of focused wave group tests and a 6-hour (full scale duration) test are reproduced numerically by re-application of the wave paddle signal in a fully nonlinear potential flow wave model. A good match for the free surface elevation and associated exceedance probability curve is obtained. Finally, the utilization of DeRisk’s results in practical design is discussed. (C) 2016 Published by Elsevier Ltd.
Derivation of Path Independent Coupled Mix Mode Cohesive Laws from Fracture Resistance Curves

A generalised approach is presented to derive coupled mixed mode cohesive laws described with physical parameters such as peak traction, critical opening, fracture energy and cohesive shape. The approach is based on deriving mix mode fracture resistance curves from an effective mix mode cohesive law at different mode mixities. From the fracture resistance curves, the normal and shear stresses of the cohesive laws can be obtained by differentiation. Since, the mixed mode cohesive laws are obtained from a fracture resistance curve (potential function), path independence is automatically satisfied. The effective mix mode cohesive law can have different shape and cohesive law parameters at different mode mixities so that the approach can be applied to various material failure models.
Terrestrial photogrammetry nowadays offers a reasonably cheap, intuitive and effective approach to 3D-modelling. However, the important choice, which sensor and which software to use is not straightforward and needs consideration as the choice will have effects on the resulting 3D point cloud and its derivatives. We compare five different sensors as well as four different state-of-the-art software packages for a single application, the modelling of a vegetated rock face. The five sensors represent different resolutions, sensor sizes and price segments of the cameras. The software packages used are: (1) Agisoft PhotoScan Pro (1.16), (2) Pix4D (2.0.89), (3) a combination of Visual SFM (V0.5.22) and SURE (1.2.0.186), and (4) MicMac (1.0). We took photos of a vegetated rock face from identical positions with all sensors. Then we compared the results of the different software packages regarding the ease of the workflow, visual appeal, similarity and quality of the point cloud. While PhotoScan and Pix4D offer the user-friendliest workflows, they are also "black-box" programmes giving only little insight into their processing. Unsatisfying results may only be changed by modifying settings within a module. The combined workflow of Visual SFM, SURE and CloudCompare is just as simple but requires more user interaction. MicMac turned out to be the most challenging software as it is less user-friendly. However, MicMac offers the most possibilities to influence the processing workflow. The resulting point-clouds of PhotoScan and MicMac are the most appealing.
Design Load Basis for Offshore Wind Turbines: DTU Wind Energy Report No. E-0133

DTU Wind Energy is not designing and manufacturing wind turbines and does therefore not need a Design Load Basis (DLB) that is accepted by a certification body. However, to assess the load consequences of innovative features and devices added to existing offshore turbine concepts or new offshore turbine concept developed in our research, it is useful to have a full DLB that follows the current design standard and is representative of a general DLB used by the industry. It will set a standard for the offshore wind turbine design load evaluations performed at DTU Wind Energy, which is aligned with the challenges faced by the industry and therefore ensures that our research continues to have a strong foundation in this interaction. Furthermore, the use of a full DLB that follows the current standard can improve and increase the feedback from the research at DTU Wind Energy to the international standardization of design load calculations.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design, Wind turbine loads & control
Authors: Natarajan, A. (Intern), Hansen, M. H. (Intern), Wang, S. (Intern)
Number of pages: 32
Publication date: 2016

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DTU Wind Energy Report No. E-0133
Source: PublicationPreSubmission
Source-ID: 126310945
Publication: Research › Report – Annual report year: 2016

Design of an aeroelastically tailored 10 MW wind turbine rotor
This work presents an integrated multidisciplinary wind turbine optimization framework utilizing state-of-the-art aeroelastic and structural tools, capable of simultaneous design of the outer geometry and internal structure of the blade. The framework is utilized to design a 10 MW rotor constrained not to exceed the design loads of an existing reference wind turbine. The results show that through combined geometric tailoring of the internal structure and aerodynamic shape of the blade it is possible to achieve significant passive load alleviation that allows for a 9% longer blade with an increase in AEP of 8.7%, without increasing blade mass and without significant increases in ultimate and fatigue loads on the hub and tower.

General information
Design of floating offshore wind turbines

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Cranfield University
Authors: Borg, M. (Intern), Collu, M. (Ekstern)
Pages: 359-385
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Series: Woodhead Publishing Series in Energy
Volume: 92
Main Research Area: Technical/natural sciences

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Source-ID: 127359018
Publication: Research - peer-review › Book chapter – Annual report year: 2016

Design of Large Wind Turbines using Fluid-Structure Coupling Technique

Aerodynamic and structural dynamic performance analysis of modern wind turbines are routinely carried out in the wind energy field using computational tools known as aero-elastic codes. Most aero-elastic codes use the blade element momentum (BEM) technique to model the rotor aerodynamics and a modal, multi-body, or finite-element approach to model the turbine structural dynamics. A novel aeroelastic code has been developed called MIRAS-FLEX. MIRAS-FLEX is an improvement on standard aero-elastic codes because it uses a more advanced aerodynamic model than BEM. MIRAS-FLEX combines the three-dimensional viscous-inviscid interactive method, MIRAS, with the dynamics model used in the aero-elastic code FLEX5. Following the development of MIRAS-FLEX, a surrogate optimization methodology using MIRAS alone has been developed for the aerodynamic design of wind-turbine rotors. Designing a rotor using a computationally expensive MIRAS instead of an inexpensive BEM code represents a challenge, which is resolved by using the proposed surrogate-based approach. The approach is unique because most aerodynamic wind-turbine rotor design codes use the more common and inexpensive BEM technique. As a verification case, the methodology is applied to design a model wind-turbine rotor and is compared in detail with the one designed with BEM. Results demonstrate the methodology is effective for the aerodynamic design of wind-turbine rotors. To perform more realistic large wind-turbine rotor designs, a structural design code was needed. Such a structural design code has been developed to minimize the cost of energy (COE) of the NREL 5MW wind-turbine blade. Blade stiffness and mass are computed using the NREL PreComp code based on the classical laminate theory, while blade natural frequencies are obtained from the NREL BModes code. The aero-elastic program FLEX5 computes loads based on design load cases from the IEC standards, which are then used to compute the deflections, strains, and buckling constraints. The minimum COE is found by implementing the procedure with a gradient-based optimizer and using the wind turbine design cost and scaling model of NREL. Last, a unique framework to design large wind-turbine rotors has been developed by combining MIRAS-FLEX, the surrogate optimization code, and the structural design code. The optimization framework was used to design large wind turbine blades using both FLEX5 and MIRAS-FLEX with good results obtained.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Technical University of Denmark
Authors: Sessarego, M. (Intern), Shen, W. Z. (Ekstern), Sørensen, J. N. (Intern), Ramos García, N. (Intern)
Design of Wind Turbine Blades
In this section the research program framework for European PhD network MARE-WINT is presented, particularly the technology development work focussing on reliability/maintenance and the models describing multi-body fluid structure interaction for the Rotor Blade structure. In order to give a context for the effort undertaken by the individual researchers this section gives a general background for Wind Turbine blades identifying the trends and issues of importance for these structures as well as concepts for “smarter” blades that address these issues.

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Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: McGugan, M. (Intern)
Pages: 13-24
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Design_of_Wind_Turbine_Blades.pdf
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10.1007/978-3-319-39095-6_2
Publication: Research - peer-review › Book chapter – Annual report year: 2016

Design optimization of jacket structures for mass production
This work includes a model and method for very fast preliminary design of jackets. Results indicate that the method works well, and current research aims to improve the model.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Sandal, K. (Intern), Verbart, A. (Intern), Stolpe, M. (Intern)
Number of pages: 1
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Main Research Area: Technical/natural sciences
Electronic versions:
Deepwind2016_poster.pdf

Relations
Activities:
13th Deep Sea Offshore Wind R&D Conference
Publication: Research - peer-review › Poster – Annual report year: 2017
Design Optimization of Piles for Offshore Wind Turbine Jacket Foundations

Numerical methods can optimize the pile design. The aim of this study is to automatically design optimal piles for offshore wind turbine jacket foundations (Figure 1). Pile mass is minimized with constraints on axial and lateral capacity. Results indicate that accurate knowledge about soil characteristics can translate into significant cost reductions.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design, Department of Civil Engineering, Section for Geotechnics and Geology
Authors: Sandal, K. (Intern), Zania, V. (Intern)
Number of pages: 1
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Event: Poster session presented at 12th EAWE PhD seminar on Wind Energy in Europe, Lyngby, Denmark.
Main Research Area: Technical/natural sciences
Electronic versions:
Poster
Publication: Research › Poster – Annual report year: 2016

Detailed field test of yaw-based wake steering
This paper describes a detailed field-test campaign to investigate yaw-based wake steering. In yaw-based wake steering, an upstream turbine intentionally misaligns its yaw with respect to the inflow to deflect its wake away from a downstream turbine, with the goal of increasing total power production. In the first phase, a nacelle-mounted scanning lidar was used to verify wake deflection of a misaligned turbine and calibrate wake deflection models. In the second phase, these models were used within a yaw controller to achieve a desired wake deflection. This paper details the experimental design and setup. All data collected as part of this field experiment will be archived and made available to the public via the U.S. Department of Energy’s Atmosphere to Electrons Data Archive and Portal.

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Web of Science (2017): Indexed yes
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Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.351
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.259 SNIP 0.346
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.264 SNIP 0.301
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Web of Science (2007): Indexed yes
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Determination of a cohesive law for delamination modelling - Accounting for variation in crack opening and stress state across the test specimen width
The cohesive law for Mode I delamination in glass fibre Non-Crimped Fabric reinforced vinylester is determined for use in finite element models. The cohesive law is derived from a delamination test based on DCB specimens loaded with pure bending moments taking into account the presence of large-scale bridging and the multi-axial state of stress in the test specimen. The fracture resistance is calculated from the applied moments, the elastic material properties and the geometry of the test specimen. The cohesive law is then determined in a three step procedure: 1) Obtain the bridging law by differentiating the fracture resistance with respect to opening displacement at the initial location of the crack tip, measured at the specimen edge. 2) Extend the bridging law to a cohesive law by accounting for crack tip fracture energy. 3) Fine-tune the cohesive law through an iterative modelling approach so that the changing state of stress and deformation across the width of the test specimen is taken into account. The changing state of stress and deformation across the specimen width is shown to be significant for small openings (small fracture process zone size). This will also be important for the initial part of the cohesive law with high stress variation for small openings (a few microns), but the effects are expected to be smaller for large-scale-bridging where the stress varies slowly over an increase in crack opening of several millimetres. The accuracy of the proposed approach is assessed by comparing the results of numerical simulation using the cohesive law derived by the above method, with those of physical testing for the standard DCB Mode I delamination test (ASTM D 5528). (C) 2016 Elsevier Ltd. All rights reserved.

General information
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Organisations: Department of Wind Energy, Composites and Materials Mechanics, SINTEF, University of Oslo
Authors: Joki, R. K. (Ekstern), Grytten, F. (Ekstern), Hayman, B. (Ekstern), Sørensen, B. F. (Intern)
Pages: 49-57
Publication date: 2016
Main Research Area: Technical/natural sciences

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  Web of Science (2018): Indexed yes
  BFI (2017): BFI-level 2
  Scopus rating (2017): CiteScore 5.59 SJR 1.702 SNIP 1.912
  Web of Science (2017): Indexed Yes
  BFI (2016): BFI-level 2
  Scopus rating (2016): CiteScore 5.37 SJR 1.59 SNIP 2.027
  Web of Science (2016): Indexed yes
  BFI (2015): BFI-level 2
  Scopus rating (2015): SJR 1.456 SNIP 1.964 CiteScore 4.44
  BFI (2014): BFI-level 2
  Scopus rating (2014): SJR 1.751 SNIP 2.435 CiteScore 4.62
  Web of Science (2014): Indexed yes
  BFI (2013): BFI-level 2
  Scopus rating (2013): SJR 1.718 SNIP 2.54 CiteScore 4.56
  ISI indexed (2013): ISI indexed yes
  Web of Science (2013): Indexed yes
  BFI (2012): BFI-level 2
  Scopus rating (2012): SJR 1.872 SNIP 2.761 CiteScore 4.12
  ISI indexed (2012): ISI indexed yes
  Web of Science (2012): Indexed yes
  BFI (2011): BFI-level 2
  Scopus rating (2011): SJR 1.782 SNIP 2.781 CiteScore 3.87
  ISI indexed (2011): ISI indexed yes
  Web of Science (2011): Indexed yes
  BFI (2010): BFI-level 2
  Scopus rating (2010): SJR 1.956 SNIP 2.473
  BFI (2009): BFI-level 2
  Scopus rating (2009): SJR 1.738 SNIP 2.12
  Web of Science (2009): Indexed yes
  BFI (2008): BFI-level 2
  Scopus rating (2008): SJR 1.876 SNIP 2.276
  Web of Science (2008): Indexed yes
  Scopus rating (2007): SJR 1.408 SNIP 2.212
  Web of Science (2007): Indexed yes
  Scopus rating (2006): SJR 1.826 SNIP 2.696
  Scopus rating (2005): SJR 1.629 SNIP 2.221
  Scopus rating (2004): SJR 1.616 SNIP 1.956
  Scopus rating (2003): SJR 1.333 SNIP 1.683
  Web of Science (2003): Indexed yes
  Scopus rating (2002): SJR 1.91 SNIP 1.613
  Scopus rating (2001): SJR 1.397 SNIP 1.423
  Scopus rating (2000): SJR 0.877 SNIP 1.207
  Web of Science (2000): Indexed yes
  Scopus rating (1999): SJR 1.018 SNIP 1.4

Original language: English

Engineering (all), Ceramics and Composites, Delamination, Finite element analysis (FEA), Polymer-matrix composites (PMCs), Crack propagation, Crack tips, Cracks, Deformation, Failure (mechanical), Fracture, Fracture toughness, Iterative methods, Numerical methods, Polymer matrix composites, Stress intensity factors, Elastic material properties,
Determination of mode-I cohesive strength for interfaces

The cohesive strength is one of the governing parameters controlling crack deflection at interfaces, but measuring its magnitude is challenging. In this paper, we demonstrate a novel approach to determine the mode-I cohesive strength of an interface by using a 4-point single-edge-notch beam specimen. The test specimen is made of a glue cast onto a unidirectional, glass-fiber laminate. A crack is cut in the glue, orthogonal to the interface, which creates a high normal stress across the glue/laminate interface during loading. It is observed that a new crack can be initiated along the interface in response to this stress, before the main crack starts to grow. Observations using 2D digital-image correlation showed that an "apparent" strain across the interface initially increases linearly with the applied load, but becomes nonlinear upon the initiation of the interface crack. The cohesive strength is determined, using a 2D, linear-elastic, finite-element model of the experiment, as the stress value where the experimental measured 'apparent" strain value becomes non-linear across the interface.

General information

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Organisations: Department of Wind Energy, Composites and Materials Mechanics, LM Wind Power, University of Michigan
Authors: Jørgensen, J. B. (Ekstern), Thouless, M. D. (Ekstern), Sørensen, B. F. (Intern), Kildegaard, C. (Ekstern)
Number of pages: 8
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BFI (2017): BFI-level 1
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BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.39 SJR 0.197 SNIP 0.535
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.197 SNIP 0.361 CiteScore 0.22
Scopus rating (2014): SJR 0.206 SNIP 0.362 CiteScore 0.18
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ISI indexed (2013): ISI indexed no
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ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.179 SNIP 0.155
Original language: English
Electronic versions:
Determination_of_mode_I.pdf
MSE_139_1_012025.pdf
DOIs:
10.1088/1757-8981/139/1/012025
Development and design of a semi-floater substructure for multi-megawatt wind turbines at 50+ m water depths

A semi-floater concept as a substructure for multi-megawatt wind turbines is developed herein for installation at 50+ m water depths. The semi-floater concept is a hybrid between a fixed monopile type support structure and a floating spar buoy. The configuration of the substructure is composed of a floating system, a mooring system, and an articulated joint. A case study is carried out under specific design conditions and constraints. The detailed designs of the mooring system and of the articulated joint are iteratively carried out using a hydro-servo-elastic analysis tool for structure response, HAWC2, coupled with dedicated in-house software packages for structural design analysis, and Abaqus. A reliability analysis and fatigue load calculations are made to ensure a desired life expectancy of the structure. The semi-floater concept is shown to maintain acceptable fatigue load levels for all turbine components, and to exhibit low platform displacement at the mean sea level. Finally, the overall performance of the structure related to energy production is similar to that of a reference wind turbine situated on land.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: NJOMO WANDJI, W. (Intern), Natarajan, A. (Intern), Dimitrov, N. K. (Intern)
Pages: 226–237
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
Journal: Ocean Engineering
Volume: 125
ISSN (Print): 0029-8018
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.7 SJR 1.284 SNIP 1.929
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.46 SJR 1.258 SNIP 1.975
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.235 SNIP 1.908 CiteScore 2.19
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.188 SNIP 2.249 CiteScore 2.11
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.129 SNIP 2.719 CiteScore 2.2
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.14 SNIP 2.407 CiteScore 1.71
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.952 SNIP 2.411 CiteScore 1.85
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.05 SNIP 2.106
BFI (2009): BFI-level 1
Diagnosis of wind turbine rotor system

This paper describes a model free method for monitoring and fault diagnosis of the elements in a rotor system for a wind turbine. The diagnosis as well as the monitoring is done without using any model of the wind turbine and the applied controller or a description of the wind profile. The method is based on available standard sensors on wind turbines. The method can be used both on-line as well as off-line. Faults or changes in the rotor system will result in asymmetries, which can be monitored and diagnosed. This can be done by using the multi-blade coordinate transformation. Changes in the rotor system that can be diagnosed and monitored are: actuator faults, sensor faults and internal blade changes as e.g. change in mass of a blade.

General information

State: Published
Organisations: Department of Electrical Engineering, Automation and Control, Department of Applied Mathematics and Computer Science, Department of Wind Energy, Wind turbine loads & control, Dynamical Systems, AF Consult
Authors: Niemann, H. H. (Intern), Mirzaei, M. (Intern), Henriksen, L. C. (Ekstern), Poulsen, N. K. (Intern)
Pages: 3170-3175
Publication date: 2016

Host publication information

Title of host publication: Proceedings of the American Control Conference (ACC 2016)
Publisher: IEEE
ISBN (Print): 978-1-4673-8682-1
Main Research Area: Technical/natural sciences
Conference: American Control Conference (ACC 2016), Boston, United States, 06/07/2016 - 06/07/2016
DOIs: 10.1109/ACC.2016.7525405
Publication: Research - peer-review › Article in proceedings – Annual report year: 2016

Direct calculation of wind turbine tip loss

The usual method to account for a finite number of blades in blade element calculations of wind turbine performance is through a tip loss factor. Most analyses use the tip loss approximation due to Prandtl which is easily and cheaply calculated but is known to be inaccurate at low tip speed ratio. We develop three methods for the direct calculation of the tip loss. The first is the computationally expensive calculation of the velocities induced by the helicoidal wake which requires the evaluation of infinite sums of products of Bessel functions. The second uses the asymptotic evaluation of those sums by Kawada. The third uses the approximation due to Okulov which avoids the sums altogether. These
methods are compared to the tip loss determined independently and exactly for an ideal three-bladed rotor at tip speed ratios between zero and 15. Kawada's asymptotic approximation and Okulov's equations are preferable to the Prandtl factor at all tip speed ratios, with the Okulov equations being generally more accurate. In particular the tip loss factor exceeds unity near the axis of rotation by a large amount at all tip speed ratios, which Prandtl's factor cannot reproduce. Neither the Kawada nor the Okulov equations impose a large computational burden on a blade element program.

**General information**

State: Published  
Organisations: Department of Wind Energy, Fluid Mechanics, University of Calgary  
Authors: Wood, D. (Ekstern), Okulov, V. (Intern), Bhattacharjee, D. (Ekstern)  
Number of pages: 8  
Pages: 269-276  
Publication date: 2016  
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Renewable Energy  
Volume: 95  
ISSN (Print): 0960-1481  
Ratings:  
BFI (2018): BFI-level 1  
Web of Science (2018): Indexed yes  
BFI (2017): BFI-level 1  
Scopus rating (2017): CiteScore 5.38 SJR 1.847 SNIP 2.008  
Web of Science (2017): Indexed yes  
BFI (2016): BFI-level 1  
Scopus rating (2016): CiteScore 4.83 SJR 1.661 SNIP 2.05  
Web of Science (2016): Indexed yes  
BFI (2015): BFI-level 1  
Scopus rating (2015): SJR 1.767 SNIP 2.085 CiteScore 4.51  
Web of Science (2015): Indexed yes  
BFI (2014): BFI-level 1  
Scopus rating (2014): SJR 1.925 SNIP 2.621 CiteScore 4.51  
Web of Science (2014): Indexed yes  
BFI (2013): BFI-level 1  
Scopus rating (2013): SJR 1.989 SNIP 2.719 CiteScore 4.63  
ISI indexed (2013): ISI indexed yes  
Web of Science (2013): Indexed yes  
BFI (2012): BFI-level 1  
Scopus rating (2012): SJR 1.787 SNIP 2.699 CiteScore 3.97  
ISI indexed (2012): ISI indexed yes  
Web of Science (2012): Indexed yes  
BFI (2011): BFI-level 1  
Scopus rating (2011): SJR 1.634 SNIP 2.349 CiteScore 3.9  
ISI indexed (2011): ISI indexed yes  
Web of Science (2011): Indexed yes  
BFI (2010): BFI-level 1  
Scopus rating (2010): SJR 1.459 SNIP 2.215  
Web of Science (2010): Indexed yes  
BFI (2009): BFI-level 1  
Scopus rating (2009): SJR 1.272 SNIP 1.963  
Web of Science (2009): Indexed yes  
BFI (2008): BFI-level 2  
Scopus rating (2008): SJR 1.436 SNIP 1.891  
Web of Science (2008): Indexed yes  
Scopus rating (2007): SJR 1.194 SNIP 1.63  
Web of Science (2007): Indexed yes
Discontinuous Galerkin methodology for Large-Eddy Simulations of wind turbine airfoils

This paper aims at evaluating the potential of the Discontinuous Galerkin (DG) methodology for Large-Eddy Simulation (LES) of wind turbine airfoils. The DG method has shown high accuracy, excellent scalability and capacity to handle unstructured meshes. It is however not used in the wind energy sector yet. The present study aims at evaluating this methodology on an application which is relevant for that sector and focuses on blade section aerodynamics characterization. To be pertinent for large wind turbines, the simulations would need to be at low Mach numbers ($M \leq 0.3$) where compressible approaches are often limited and at large Reynolds numbers ($Re \geq 10^6$) where wall-resolved LES is still unaffordable. At these high $Re$, a wall-modeled LES (WMLES) approach is thus required. In order to first validate the LES methodology, before the WMLES approach, this study presents airfoil flow simulations at low and high Reynolds numbers and compares the results to state-of-the-art models used in industry, namely the panel method (XFOIL with boundary layer modeling) and Reynolds Averaged Navier-Stokes (RANS). At low Reynolds number ($Re = 6 \times 10^4$), involving laminar boundary layer separation and transition in the detached shear layer, the Eppler 387 airfoil is studied at two angles of attack. The LES results agree slightly better with the experimental chordwise pressure distribution than both XFOIL and RANS results. At high Reynolds number ($Re = 1.64 \times 10^6$), the NACA4412 airfoil is studied close to stall condition. In this case, although the wall model approach used for the WMLES is very basic and not supposed to handle separation nor adverse pressure gradients, all three methods provide equivalent accuracy on averaged quantities. The present work is hence considered as a strong step forward in the use of LES at high Reynolds numbers.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design, CenAero, Universite Catholique de Louvain
Authors: Frère, A. (Ekstern), Sørensen, N. N. (Intern), Hillewaert, K. (Ekstern), Winckelmans, G. (Ekstern)
Number of pages: 11
Publication date: 2016
Conference: The Science of Making Torque from Wind, Munich, Germany, 05/10/2016 - 05/10/2016
BFI conference series: European Academy of Wind Energy : The Science of Making Torque from Wind (5010078)
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Physics: Conference Series (Online)
Volume: 753
Article number: 022037
ISSN (Print): 1742-6596
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
The tensile properties and the deformation microstructure of pearlitic steel (0.8 wt % C) have been quantified in wires drawn to strains in the range from 3.7 to 5.4, having a flow stress in the range from 3.5 to 4.5 GPa. With increasing strain the interlamellar spacing (ILS) decreases from about 20 to 10 nm and the thickness of the cementite lamellae decreases from about 2 nm to about 0.7 nm, representing a structure, which breaks up at large strains, decomposes and releases carbon to the ferrite lamellae. The dislocation density increases continuously with strain and reaches about $5 \times 10^{16} \text{ m}^{-2}$ at a strain of 5.4; the dislocations are stored as threading dislocations, as dislocation tangles and as cell boundaries with low to medium misorientation angles. An analysis of the evolution of microstructure and strength with increasing strain suggests that dislocation-based plasticity is a dominating mechanism in the wire and three strengthening mechanisms are
applied: boundary strengthening, dislocation strengthening and solid solution hardening with their relative contributions to the total flow stress which change as the strain is increased. Based on linear additivity good correspondence between the calculated and the measured flow stress is observed over the strain range 0-5.4. However at large strains beyond 3.7 deviations are observed which are discussed in terms of the applied strength-structure relationships.

General information
State: Published
Organisations: Department of Wind Energy, Materials science and characterization, Tsinghua University
Authors: Zhang, X. (Intern), Hansen, N. (Intern), Godfrey, A. (Ekstern), Huang, X. (Intern)
Pages: 176-183
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
Journal: Acta Materialia
Volume: 114
ISSN (Print): 1359-6454
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.18 SJR 3.263 SNIP 2.737
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.67 SJR 3.21 SNIP 2.702
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 3.417 SNIP 2.831 CiteScore 5.22
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 3.885 SNIP 3.166 CiteScore 5.16
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 3.238 SNIP 2.674 CiteScore 4.37
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 3.37 SNIP 2.875 CiteScore 4.28
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 3.215 SNIP 2.768 CiteScore 4.27
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 3.709 SNIP 2.698
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 3.663 SNIP 2.625
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 3.82 SNIP 2.774
Web of Science (2008): Indexed yes
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 3.615 SNIP 3.118
Web of Science (2006): Indexed yes
Dynamical and statistical-dynamical modelling of wind farm flows with WRF

A pledge to increase the share of renewable energies has led to a focus on offshore wind energy in many western European countries. With an increasing number of offshore wind farms to be installed it becomes important to understand (I) the degree to which wakes from neighbouring wind farms affect the power production of a target wind farm and (II) how large wind farms can get if they are to remain efficient and productive power generators. The modelling of wind farm wake flows is challenging, since it includes processes from the micro- to mesoscale meteorology. We use the Weather Research and Forecast (WRF) model that allows us to simulate mesoscale features of wind farm wakes. Its limited horizontal resolution – in microscale terms – however, requires flow characteristics, such as single turbine wakes, to be parametrised.

Dynamic behavior of parked wind turbine at extreme wind speed

In wind turbine design process, a series of load analysis is generally performed to determine ultimate and fatigue loads under various design load cases (DLCs) which is specified in IEC 61400. These design load scenario covers not only normal operating condition but also startup, shutdown, parked and other scenario which is assumed to occur during the expected lifetime of wind turbine. This research focus on vibration problem under 50-year storm conditions while rotor is parked and blades are feathered. In this parked scenario, effect of a wind direction change of up to ± 180 degrees for both cases of standstill and idling is analyzed by time domain simulations using two different coupled aero-hydro-servo-elastic codes. Trend in modern wind turbines is development of bigger, lighter and more flexible rotors where vibration issues may cause aero-elastic instabilities which have a serious impact on the ultimate loads. The DTU 10MW Reference Wind Turbine (RWT) is chosen as wind turbine model in this research.
Dynamic Droop-Based Inertial Control of a Doubly-Fed Induction Generator

If a large disturbance occurs in a power grid, two auxiliary loops for the inertial control of a wind turbine generator have been used: droop loop and rate of change of frequency (ROCOF) loop. Because their gains are fixed, difficulties arise in determining them suitable for all grid and wind conditions. This paper proposes a dynamic droop-based inertial control scheme of a doubly-fed induction generator (DFIG). The scheme aims to improve the frequency nadir (FN) and ensure stable operation of a DFIG. To achieve the first goal, the scheme uses a droop loop, but it dynamically changes its gain based on the ROCOF to release a large amount of kinetic energy during the initial stage of a disturbance. To do this, a shaping function that relates the droop to the ROCOF is used. To achieve the second goal, different shaping functions, which depend on rotor speeds, are used to give a large contribution in high wind conditions and prevent over-deceleration in low wind conditions during inertial control. The performance of the proposed scheme was investigated under various wind conditions using an EMTP-RV simulator. The results indicate that the scheme improves the FN and ensures stable operation of a DFIG.
Dynamic Reactive Power Control In Offshore HVDC Connected Wind Power Plants

This paper presents a coordinated reactive power control for a HVDC connected cluster of offshore wind power plants (WPPs). The reactive power reference for the WPP cluster is estimated by an optimization algorithm aiming at minimum active power losses in the offshore AC Grid. For each optimal reactive power set point, the OWPP cluster controller generates reactive power references for each WPP which further sends the AC voltage/reactive power references to the associated WTs based on their available reactive power margin. The impact of faults at different locations in the offshore grid, such as wind turbine (WT) terminal, collector cable, and export cable, on the dynamic voltage profile of the offshore grid is investigated. Furthermore, the dynamic reactive power contribution from WTs from different WPPs of the cluster for such faults has also been studied.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning, University College Dublin
Authors: Sakamuri, J. N. (Intern), Cutululis, N. A. (Intern), Rather, Z. H. (Ekstern), Rimez, J. (Ekstern)
Number of pages: 6
Publication date: 2016

Dynamics of the interaction between the rotor and the induction zone

Traditionally met masts are used for power and load verifications. They are normally placed 2-4 rotor diameters ahead of the turbine. However in complex terrain this can lead to complex analysis of the effect of the terrain on the flow field. A nacelle mounted lidar can provide a better tool for wind field measurements in all terrains. Provided that the measurement is close enough to the rotor disc, the uncertainty in the flow field measurement can be reduced significantly. Therefore any complex terrain calibration and changes in the wind direction can be avoided. However, close distance lidar measurements are affected by the presence of the wind turbine, due to its induction zone. In this work, the dynamic coupling between changes in the wind turbine operating point and the velocities inside the induction zone is studied. Reynolds-Averaged Navier-Stokes (RANS) simulations are used to investigate this interaction. Thereafter, system identification is used to fit first order dynamic models to the simulation results. The parameters of the model are given for the turbine induction zone. These results possibly reduce the uncertainty in lidar measurements, arising from wind turbine blockage.

General information
State: Published
Effectiveness of the random sequential absorption algorithm in the analysis of volume elements with nanoplatelets

In this work, a study of the Random Sequential Absorption (RSA) algorithm in the generation of nanoplatelet Volume Elements (VEs) is carried out. The effect of the algorithm input parameters on the reinforcement distribution is studied through the implementation of statistical tools, showing that the platelet distribution is systematically affected by these parameters. The consequence is that a parametric analysis of the VE input parameters may be biased by hidden differences in the filler distribution. The same statistical tools used in the analysis are implemented in a modified RSA algorithm to overcome this issue.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics, University of Padova
Authors: Pontefisso, A. (Intern), Zappalorto, M. (Ekstern), Quaresimin, M. (Ekstern)
Number of pages: 7
Pages: 511-517
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
Journal: Computational Materials Science
Volume: 117
ISSN (Print): 0927-0256
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 1.251 SJR 1.766 CiteScore 2.57
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.37 SJR 0.893 SNIP 1.228
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.953 SNIP 1.289 CiteScore 2.3
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.098 SNIP 1.612 CiteScore 2.47
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.951 SNIP 1.306 CiteScore 2.15
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.006 SNIP 1.616 CiteScore 2.14
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.987 SNIP 1.44 CiteScore 1.97
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.952 SNIP 1.245
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 0.975 SNIP 1.288
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.913 SNIP 1.297
Effect of Carrier to Noise Ration threshold filtering on the long-term wind speed and Weibull distribution parameters for a pulsed heterodyne wind lidar

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling, Meteorology & Remote Sensing, National Institute of Meteorology and Hydrology
Authors: Gryning, S. (Intern), Batchvarova, E. (Ekstern), Floors, R. R. (Intern), Pena Diaz, A. (Intern)
Number of pages: 1
Publication date: 2016

Host publication information
Title of host publication: Proceedings of 18th International Symposium for the Advancement of Boundary-Layer Remote Sensing
Article number: V-2
Main Research Area: Technical/natural sciences
Conference: 18th International Symposium for the Advancement of Boundary-Layer Remote Sensing, Varna, Bulgaria, 06/06/2016 - 06/06/2016
Electronic versions:
Effect_of_Carrier.pdf
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2017

Effect of Reynolds number and inflow parameters on mean and turbulent flow over complex topography
A characterization of mean and turbulent flow behaviour over complex topography was conducted using a large-scale (1:25) model in the WindEEE Dome at Western University. The specific topographic feature considered was the Bolund Hill escarpment facing westerly winds. A total of eight unique inflow conditions were tested in order to isolate the impact of key parameters such as Reynolds number, inflow shear profile, and effective roughness, on flow behaviour over the escarpment.

The results show that the mean flow behaviour was generally not affected by the Reynolds number; however, a slight increase in speed-up over the escarpment was observed for cases with lower inflow roughness. The shape of the inflow wind shear profile also had a minor impact on the mean flow near the escarpment. More significant effects were observed in the turbulent flow behaviour, where the turbulent kinetic energy (TKE) over the escarpment was found to be a strong function of inflow roughness and a weak function of the Reynolds number. The local change in the inflow wind shear was found to have the most significant influence on the TKE magnitude, which more closely approximated the full-scale TKE data, a result which had not been previously observed in wind tunnel modelling of this topography.

General information
Effect of Turbulence on Power for Bend-Twist Coupled Blades

Bend-twist coupling of wind turbine blades reduces the structural loads of the turbine but it also results in a decrease of the annual energy production. The main part of the power loss can be mitigated by pretwisting the blade, but some power loss remains and previous studies indicate that it might be related to the dynamic response of bend-twist coupled blades in turbulent flow. This paper contains estimations of the power curve from nonlinear time simulations, a linear frequency domain based method and a normal distribution weighted average method. It is shown that the frequency domain based estimation is highly dependant on the validity of the linearized model, thus estimations are poor for operational points close to rated wind speed. The weighted average method gives good results if an appropriate standard deviation is known a priori. The nonlinear time simulations show that changes in power due to turbulence are similar for coupled and uncoupled blades. Power gains at low wind speeds are related to the curvature of the steady state power curve. Losses around rated wind speed are caused by the effects of controller switching between partial and full power operation.

General information

State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control
Authors: Stäblein, A. (Intern), Hansen, M. H. (Intern)
Number of pages: 10
Publication date: 2016
Conference: The Science of Making Torque from Wind, Munich, Germany, 05/10/2016 - 05/10/2016
BFI conference series: European Academy of Wind Energy : The Science of Making Torque from Wind (5010078)
Main Research Area: Technical/natural sciences

Publication information

Journal: Journal of Physics: Conference Series (Online)
Volume: 753
Article number: 042018
ISSN (Print): 1742-6596
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BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
Effects of finite aspect ratio on wind turbine airfoil measurements

Wind turbines partly operate in stalled conditions within their operational cycle. To simulate these conditions, it is also necessary to obtain 2-D airfoil data in terms of lift and drag coefficients at high angles of attack. Such data has been obtained previously, but often at low aspect ratios and only barely past the stall point, where strong wall boundary layer influence is expected. In this study, the influence of the wall boundary layer on 2D airfoil data, especially in the post stall domain, is investigated. Here, a wind turbine airfoil is tested at different angles of attack and with two aspect ratios of AR = 1 and AR = 2. The tests are conducted in a wind tunnel that is pressurized up to 150 bar in order to achieve a constant Reynolds number of Rec = 3.106, despite the variable chord length.

General information

State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Princeton University
Authors: Kiefer, J. (Ekstern), Miller, M. A. (Ekstern), Hultmark, M. (Ekstern), Hansen, M. O. L. (Intern)
Number of pages: 6
Publication date: 2016
Conference: The Science of Making Torque from Wind, Munich, Germany, 05/10/2016 - 05/10/2016
BFI conference series: European Academy of Wind Energy: The Science of Making Torque from Wind (5010078)
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Physics: Conference Series (Online)
Volume: 753
Article number: 022040
ISSN (Print): 1742-6596
Ratings:
Effects of spark plasma sintering conditions on the anisotropic thermoelectric properties of bismuth antimony telluride

Bismuth antimony telluride (BixSb2-xTe3, 0.4 <x<0.6) is one of the best and most-used p-type semiconductor materials for near-room-temperature thermoelectric power generation. In this work, p-type Bi0.4Sb1.6Te3 samples were prepared under various conditions (temperature, holding time, and ramp-rate) using spark plasma sintering (SPS). The effects of SPS conditions on the anisotropic thermoelectric properties and microstructure evolutions were systematically investigated. The change of sintering temperature showed stronger influence than other sintering parameters to the resulting thermoelectric properties. Samples sintered over the temperature range between 653 K and 773 K showed significant differences in the degrees of orientations. The change was mainly caused by grain growth and re-orientation. Despite of the anisotropy, zT value as high as 1.2 to 1.3 was achieved over the temperature range of 300 to 360 K by directly using commercial power sintered at 723 and 773 K. The sintering profiles and microstructure evolutions during SPS were illustrated and the thermoelectric properties as a function of the degrees of orientations were shown and discussed in detail.
Effects of surface finish and mechanical training on Ni-Ti sheets for elastocaloric cooling

Elastocaloric cooling has emerged as a promising alternative to vapor compression in recent years. Although the technology has the potential to be more efficient than current technologies, there are many technical challenges that must be overcome to realize devices with high performance and acceptable durability. We study the effects of surface finish and training techniques on dog bone shaped polycrystalline samples of NiTi. The fatigue life of several samples with four different surface finishes was measured and it was shown that a smooth surface, especially at the edges, greatly improved fatigue life. The effects of training both on the structure of the materials and the thermal response to an applied strain was studied. The load profile for the first few cycles was shown to change the thermal response to strain, the structure of the material at failure while the final structure of the material was weakly influenced by the surface finish.
Elements of extreme wind modeling for hurricanes

The report summarizes characteristics of the winds associated with Tropical Cyclones (Hurricanes, Typhoons). It has been conducted by the authors across several years, from 2012-2015, to identify the processes and aspects that one should consider when building at useful computer support system for evaluation hurricane extreme wind conditions for a given offshore site. It was initiated by a grant from DNV that has as well been represented by one of the authors in this report. Finally, we wish to emphasize the debt of this report to an earlier work at the DTU-Wind Energy Department on “Extreme winds in the North Pacific” (Ott, 2006).

General information

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling, DNV GL A/S
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Number: 0109
Main Research Area: Technical/natural sciences
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Publication: Research › Report – Annual report year: 2016
Enhancement of fracture resistance of composite laminates by the creation of multiple delaminations
Cohesive zone modeling is used to study delamination. A secondary crack can open when the peak traction value of its cohesive law is less than that of the primary crack and the layer between the two interfaces is sufficiently thin.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Sørensen, B. F. (Intern), Goutianos, S. (Intern)
Publication date: 2016

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ESA STSE Project “Sea Surface Temperature Diurnal Variability: Regional Extend – Implications in Atmospheric Modelling”
Sea Surface Temperature (SST) and ocean-surface winds have been identified as essential variables by the Global Climate Observing system (GCO). Satellite observations have aided the understanding of air-sea interactions and the important role these two parameters hold in climate related studies, atmospheric and oceanic modelling, bio-chemical processes and oceanic CO2 studies. The diurnal variability of SST, driven by the coincident occurrence of low enough wind and solar heating, is currently not properly understood. Atmospheric, oceanic and climate models are currently not adequately resolving the daily SST variability, resulting in biases of the total heat budget estimates and therefore, demise model accuracies. The ESA STSE funded project SSTDV:R.EX.-IM.A.M. aimed at characterising the regional extend of diurnal SST signals and their impact in atmospheric modelling. This study will briefly present the final project findings regarding the analysis of hourly SEVIRI SSTs from SEVIRI over the Atlantic Ocean and the European Seas, revealing the regional extend of diurnal warming. As satellite SSTs are representative of the upper centimetre of the water column, they do not provide information of the vertical extend of diurnal signals. Drifting buoys provide measurements close to the surface but are not always available. Moored buoys are generally not able to resolve the daily SST signal, which strongly weakens with depth within the upper water column. For such reasons, the General Ocean Turbulence Model (GOTM) was used to resolve the vertical temperature structure of the upper water column and provide the link between surface temperatures and the ones observed at some depth. The model proved able to reproduce signals observed from satellite and in situ instruments, thus can be a candidate model for operational analysis of the daily SST variability. Such an analysis can be useful for the already operational L4 SST analysis products. Moreover, the project aimed at characterizing how the diurnal SST signals impact atmospheric modelling. Hourly SST fields, were used to initialize the high resolution Weather Research & Forecasting (WRF) model. The perturbations in the atmospheric model, associated with the daily SST cycle were assessed through comparisons of the modelled 10-m wind fields against the ESA's ENVISAT ASAR 10-m winds and in situ measurements at various atmospheric levels, from meteorological masts located offshore. The project resulted in expanding the scientific background for understanding the spatial and temporal variability of key climate variables and their representativity in atmospheric and oceanic models.

General information
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Authors: Karagali, I. (Intern)
Number of pages: 1
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Main Research Area: Technical/natural sciences
Links: http://lps16.esa.int/page_session186.php#988p
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2016

ESA STSE “SST Diurnal Variability: Regional Extend - Implications in Atmospheric Modelling”
The diurnal variability of SST, driven by the coincident occurrence of low enough wind and solar heating, has been observed in various regions of the global ocean [4, 5, 6]. Atmospheric, oceanic and climate models are not adequately resolving the daily SST cycle, resulting in biases of the total heat budget estimates and demise model accuracies [2, 1]. The ESA STSE project SSTDV:R.EX.-IM.A.M. focused on different aspects.
Estimating near-shore wind resources

An evaluation and sensitivity study using the WRF mesoscale model to estimate the wind in a coastal area is performed using a unique data set consisting of scanning, profiling and floating lidars. The ability of the WRF model to represent the wind speed was evaluated by running the model for a four month period in twelve different set-ups. The atmospheric boundary layer was parametrized using the first-order YSU scheme and the 1.5-order MYJ scheme. Simulations with two sources of land use data, two sources of reanalysis data, two sources of sea-surface temperatures and three different horizontal grid spacings were performed for each of the two schemes. An evaluation of the wind profile using vertical profilers revealed small differences in modelled mean wind speed between the different set-ups, with the YSU scheme predicting slightly higher mean wind speeds. Larger differences between the different simulations were observed when comparing the root-mean-square error (RMSE) between modelled and measured wind, with the ERA interim-based simulations having the lowest errors. The simulations with finer horizontal grid spacing had a larger MSE. Horizontal transects of mean wind speed across the coastline measured with the scanning lidars were compared with the model simulations, showing that the shape of the horizontal gradient was well captured but the modelled mean wind speed was slightly underestimated. An evaluation of model performance with Taylor diagrams, showed that the sensitivity was largest to the PBL scheme and the reanalysis data. The simulations using the MYJ scheme had a lower RMSE and higher correlation coefficient than those using the YSU scheme, but also a lower variance compared to the observations. Using ERA interim instead of FNL as boundary conditions also led to a lower RMSE and correlation coefficient. Using a finer grid spacing of 1 and 0.5 km did not give better results and sensitivity to the input of different SST and land cover data in the RUNE area was small. The difference in mean wind speed between all simulations over a region 80 km around the RUNE area were less than 1 m s⁻¹, with the largest differences over land due to the roughness length deviations and over sea due to SST differences. Simulations using the YSU scheme were more sensitive to variations in land use near the coastline, SST and forcing than those using the MYJ scheme. The forcing data had an impact on the simulated mean wind speed offshore, but the impact was negligible in the immediate RUNE region. The variance varied little as a function of the model grid spacing. Finally a wind resource estimation was made using the WAsP model, the mesoscale model and scanning lidar measurements and the uncertainties in each of the estimations is discussed.
Estimation of turbulence intensity using rotor effective wind speed in Lillgrund and Horns Rev-I offshore wind farms

Turbulence characteristics of the wind farm inflow have a significant impact on the energy production and the lifetime of a wind farm. The common approach is to use the meteorological mast measurements to estimate the turbulence intensity (TI) but they are not always available and the turbulence varies over the extent of the wind farm. This paper describes a method to estimate the TI at individual turbine locations by using the rotor effective wind speed calculated via high frequency turbine data. The method is applied to Lillgrund and Horns Rev-I offshore wind farms and the results are compared with TI derived from the meteorological mast, nacelle mounted anemometer on the turbines and estimation based on the standard deviation of power. The results show that the proposed TI estimation method is in the best agreement with the meteorological mast. Therefore, the rotor effective wind speed is shown to be applicable for the TI assessment in real-time wind farm calculations under different operational conditions. Furthermore, the TI in the wake is seen to follow the same trend with the estimated wake deficit which enables to quantify the turbulence in terms of the wake loss locally inside the wind farm.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning
Authors: Gögm en, T. (Intern), Giebel, G. (Intern)
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Main Research Area: Technical/natural sciences

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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 5.38 SJR 1.847 SNIP 2.008
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.83 SJR 1.661 SNIP 2.05
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.767 SNIP 2.085 CiteScore 4.51
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.925 SNIP 2.621 CiteScore 4.51
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.989 SNIP 2.719 CiteScore 4.63
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.787 SNIP 2.699 CiteScore 3.97
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.634 SNIP 2.349 CiteScore 3.9
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.459 SNIP 2.215
Web of Science (2010): Indexed yes
Estimation of wake propagation behind the rotors of wind-powered generators

The objectives of this work are to develop the experimental model of wake behind the wind-power generator rotor to estimate its propagation distance and the impact on the average and pulsation characteristics of incident flow with the possibility of further use of these data in the calculation models of wind and climate changes in the regions and to determine the optimal operation of wind turbines. For experimental modeling, the laboratory model of wind-powered generator with a horizontal axis was used that operated as wind turbine in optimal mode. The kinematic characteristics of flow and changes in the wake structure in the distance of more than 40 rotor diameters downstream with a slight level of turbulent pulsations (less than 2%) of free flow were investigated. A significant impact of external intense pulsations typical for natural atmospheric conditions was purposely excluded in the experimental research in order to define the degree of self-damping of perturbations generated by oneself wind-powered generator. The obtained experimental data for the wake dynamics behind the model of wind-powered generator allowed ascertaining its impact on slowing down of incident vortex flow and determining the distance at which its impact on the stream disappears, and the deceleration values are comparable to the level of pulsations of incident flow. This experimental model with the same degree of damping its velocity and pulsations can be used to adjust the theoretical approximation of the far wake. It is shown that the recovery of velocity of incident flow is faster than has been previously defined in the models of calculating the impact of wind electric power plants on the regional climate changes. Thus, existing wind loss calculated on the model of wake behind the wind-powered generator, adjusted in this study can be even less significant.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Department of Mechanical Engineering, Russian Academy of Sciences
Authors: Naumov, I. V. (Ekstern), Mikkelsen, R. F. (Intern), Okulov, V. (Intern)
Number of pages: 6
Pages: 208-213
Publication date: 2016
Main Research Area: Technical/natural sciences
Evaluation of three lidar scanning strategies for turbulence measurements

Several errors occur when a traditional Doppler beam swinging (DBS) or velocity-azimuth display (VAD) strategy is used to measure turbulence with a lidar. To mitigate some of these errors, a scanning strategy was recently developed which employs six beam positions to independently estimate the u, v, and w velocity variances and covariances. In order to assess the ability of these different scanning techniques to measure turbulence, a Halo scanning lidar, WindCube v2 pulsed lidar, and ZephIR continuous wave lidar were deployed at field sites in Oklahoma and Colorado with collocated sonic anemometers. Results indicate that the six-beam strategy mitigates some of the errors caused by VAD and DBS scans, but the strategy is strongly affected by errors in the variance measured at the different beam positions. The ZephIR and WindCube lidars overestimated horizontal variance values by over 60% under unstable conditions as a result of variance contamination, where additional variance components contaminate the true value of the variance. A correction method was developed for the WindCube lidar that uses variance calculated from the vertical beam position to reduce variance contamination in the u and v variance components. The correction method reduced WindCube variance estimates by over 20% at both the Oklahoma and Colorado sites under unstable conditions, when variance contamination is largest. This correction method can be easily applied to other lidars that contain a vertical beam position and is a promising method for accurately estimating turbulence with commercially available lidars.

General information
State: Published
Authors: Newman, J. F. (Ekstern), Klein, P. M. (Ekstern), Wharton, S. (Ekstern), Sathe, A. (Intern), Bonin, T. A. (Ekstern), Chilson, P. B. (Ekstern), Muschinski, A. (Ekstern)
Pages: 1993-2013
Publication date: 2016
Main Research Area: Technical/natural sciences
Experimental and numerical study of a 10MW TLP wind turbine in waves and wind

This paper presents tests on a 1:60 version of the DTU 10MW wind turbine mounted on a tension leg platform and their numerical reproduction. Both the experimental setup and the numerical model are Froude-scaled, and the dynamic response of the floating wind turbine to wind and waves is compared in terms of motion in the six degrees of freedom, nacelle acceleration and mooring line tension. The numerical model is implemented in the aero-elastic code Flex5, featuring the unsteady BEM method and the Morison equation for the modelling of aerodynamics and hydrodynamics, respectively. It was calibrated with the tests by matching key system features, namely the steady thrust curve and the decay tests in water. The calibrated model is used to reproduce the wind-wave climates in the laboratory, including regular and irregular waves, with and without wind. The model predictions are compared to the measured data, and a good agreement is found for surge and heave, while some discrepancies are observed for pitch, nacelle acceleration and line tension. The addition of wind generally improves the agreement with test results. The aerodynamic damping is identified in both tests and simulations. Finally, the sources of the discrepancies are discussed and some improvements in the numerical model are suggested in order to obtain a better agreement with the experiments.
Experimental and Numerical Study of Rotor Dynamics of a Two- and Three-Bladed Wind Turbine

In this paper the dynamics of a two-bladed turbine is investigated numerically as well as experimentally with respect to how the turbine frequencies change with the rotor speed. It is shown how the turbine frequencies of a two-bladed rotor change with the azimuthal position at standstill and how the frequencies change due to rotor rotation. The frequency of the asymmetric rotor modes changes with multiple $P$ contributions, not only with $\pm 1P$, as has previously been seen for three-bladed wind turbine rotors. A three-bladed turbine is also analyzed in a similar way, and the results are compared. This turbine is investigated both in a perfect isotropic condition, where all blades have identical properties, and in an imbalanced edition, where one blade had increased mass.
Experimental benchmark and code validation for airfoils equipped with passive vortex generators

Experimental results and complimentary computations for airfoils with vortex generators are compared in this paper, as part of an effort within the AVATAR project to develop tools for wind turbine blade control devices. Measurements from two airfoils equipped with passive vortex generators, a 30% thick DU97W300 and an 18% thick NTUA T18 have been used for benchmarking several simulation tools. These tools span low-to-high complexity, ranging from engineering-level integral boundary layer tools to fully-resolved computational fluid dynamics codes. Results indicate that with appropriate calibration, engineering-type tools can capture the effects of vortex generators and outperform more complex tools. Fully resolved CFD comes at a much higher computational cost and does not necessarily capture the increased lift due to the VGs. However, in lieu of the limited experimental data available for calibration, high fidelity tools are still required for assessing the effect of vortex generators on airfoil performance.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Aerodynamic design, Delft University of Technology, National Technical University of Athens, Centro Nacional de Energías Renovables
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Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Experimental determination of the micro-scale strength and stress-strain relation of an epoxy resin

An approach is developed for determining the stress-strain law and a failure stress appropriate for micro-mechanical models of polymer materials. Double cantilever beam test specimens, made of an epoxy polymer with notches having finite root radius, were subjected to pure bending moments in an environmental scanning electron microscope. The recorded images were used to measure strains around the notch with a 2D digital image correlation method. The strain in front of the notch was found to reach 20% before the failure initiation, which significantly exceeds the failure strain measured at the macro-scale (5–6%). The hardening exponent of a power law hardening material was obtained by the use of the J-integral, estimating the strain energy density around the notch. The hardening exponent was found to be within the range of 5–6 and the corresponding micro-scale failure stress was in the range of 220–300 MPa. Furthermore, the experimentally measured strains around the notch edge were compared with the strain field of the HRR-field. In addition, our experimental study shows that the strain fields between the notches with different notch root radii are comparable, if all length parameters are normalized with the width of deformed notch.
Experimental investigation of wake evolution behind a couple of flat discs in a hydrochannel

The decay of a far wake and its turbulent fluctuations behind two thin discs of the same diameter D, oriented normal to the incident flow, have been studied using the Particle Image Velocimetry (PIV). The experimental study was carried out in a water flume (Re ≈ 2·105) with varying distances between the discs (Lx = 4−8D) and their axes shift relative to each other (0, 0.5D and 1D). It is found that the velocity deficit behind two discs depends weakly on Lx, and at Lx > 40D, it becomes indistinguishable from the level of turbulent fluctuations of the incident flow. It is found that the decay of the average velocity deficit and its turbulent fluctuations in a wake of a tandem of discs can be described by the same analytical dependence with exponent −2/3 as for the wake decay of a single disc. However, at the same distance downstream, the value of deficit behind two discs is substantially higher than the corresponding value behind a single disc. Velocity fluctuations in a far wake behind a pair of discs depend weakly on longitudinal dimension Lx, but at the same time, in contrast to the velocity deficit, their level does not differ significantly from the level of fluctuations behind a single disc.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Russian Academy of Sciences
Authors: Naumov, I. (Ekstern), Litvinov, I. (Ekstern), Mikkelsen, R. F. (Intern), Okulov, V. (Intern)
Pages: 657-666
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Web of Science (2017): Indexed Yes
Scopus rating (2016): CiteScore 0.81 SJR 0.428 SNIP 1.372
Web of Science (2016): Indexed yes
Scopus rating (2015): SJR 0.323 SNIP 0.742 CiteScore 0.4
Scopus rating (2014): SJR 0.282 SNIP 0.876 CiteScore 0.39
Web of Science (2014): Indexed yes
Scopus rating (2013): SJR 0.382 SNIP 0.718 CiteScore 0.37
ISI indexed (2013): ISI indexed yes
Scopus rating (2012): SJR 0.295 SNIP 0.523 CiteScore 0.28
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Scopus rating (2011): SJR 0.259 SNIP 0.646 CiteScore 0.27
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.21 SNIP 0.502
Scopus rating (2009): SJR 0.251 SNIP 0.804
Scopus rating (2008): SJR 0.211 SNIP 0.361
Scopus rating (2007): SJR 0.185 SNIP 0.046
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Wake behind a bluff body, Level of turbulence of the incident flow, Pair of discs, Velocity deficit, Particle Image Velocimetry (PIV)

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10.1134/S0869864316050048

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Publication: Research - peer-review › Journal article – Annual report year: 2016
Ex-situ time-lapse x-ray CT study of 3D micro-structural fatigue damage evolution in uni-directional composites

In this study, the progress of damage under tension-tension fatigue of a uni-directional (UD) glass fibre composite made from a non-crimp fabric is studied using transilluminated white light imaging (TWLI) and X-ray computed tomography (CT). TWLI images are automatically captured throughout the fatigue test, and at two damage levels the test is stopped and the sample is examined by X-ray computed tomography. From the TWLI observations it is apparent that part of the measured initial stiffness drop might be caused by edge effects rather than off-axis cracking. Some of the off-axis cracks are seen to initiate already after the first cycle, whereas some grow gradually and others appear suddenly during cycling. The off-axis cracks are observed to saturate after a few thousand cycles. The UD fibre fracture damage in the region observed by X-ray CT is probably already saturated at the first interruption point, as no significant change is seen between the two X-ray images. However, the study indicates how TWLI can be used as an initial indicator to locate damage regions at an early stage for the future ex-situ X-ray CT experiments.

Extension of Goldstein's circulation function for optimal rotors with hub

The aerodynamic interaction or interference between rotor blades and hub body is usually very complicated, but some useful simplifications can be made by considering the hub with an infinite cylinder. Various attempts to find the optimum distribution of circulation by the lifting vortex lines method have been previously proposed to describe the blade interaction with the hub modeled by the infinite cylinder. In this case, the ideal distribution of bound circulation on the rotor blades is such that the shed vortex system in the hub-area is a set of helicoidal vortex sheets moving uniformly as if rigid, exactly as in the case where there is no influence of the streamtube deformations by the central hub-body. In the present investigation, we consider a more specific problem of the rotor-hub interaction where the initial flow streamtubes and the rotor slipstream submitted strong deformations at the nose-area of the semi-infinite hub.
Extrapolating Satellite Winds to Turbine Operating Heights

Ocean wind retrievals from satellite sensors are typically performed for the standard level of 10 m. This restricts their full exploitation for wind energy planning, which requires wind information at much higher levels where wind turbines operate. A new method is presented for the vertical extrapolation of satellite-based wind maps. Winds near the sea surface are obtained from satellite data and used together with an adaptation of the Monin–Obukhov similarity theory to estimate the wind speed at higher levels. The thermal stratification of the atmosphere is taken into account through a long-term stability correction that is based on numerical weather prediction (NWP) model outputs. The effect of the long-term stability correction on the wind profile is significant. The method is applied to Envisat Advanced Synthetic Aperture Radar scenes acquired over the south Baltic Sea. This leads to maps of the long-term stability correction and wind speed at a height of 100 m with a spatial resolution of 0.028. Calculations of the corresponding wind power density and Weibull parameters are shown. Comparisons with mast observations reveal that NWP model outputs can correct successfully for long-term stability effects and also, to some extent, for the limited number of satellite samples. The satellite-based and NWP-simulated wind profiles are almost equally accurate with respect to those from the mast. However, the satellite-based maps have a higher spatial resolution, which is particularly important in nearshore areas where most offshore wind farms are built.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling, Laboratoire d’Études en Géophysique et Oceanographie Spatiales
Authors: Badger, M. (Intern), Pena Diaz, A. (Intern), Hahmann, A. N. (Intern), Mouche, A. (Ekstern), Hasager, C. B. (Intern)
Extreme load alleviation using industrial implementation of active trailing edge flaps in a full design load basis

The application of active trailing edge flaps in an industrial oriented implementation is evaluated in terms of capability of alleviating design extreme loads. A flap system with basic control functionality is implemented and tested in a realistic full Design Load Basis (DLB) for the DTU 10MW Reference Wind Turbine (RWT) model and for an upscaled rotor version in DTU's aeroelastic code HAWC2. The flap system implementation shows considerable potential in reducing extreme loads in components of interest including the blades, main bearing and tower top, with no influence on fatigue loads and power performance. In addition, an individual flap controller for fatigue load reduction in above rated power conditions is also implemented and integrated in the general controller architecture. The system is shown to be a technology enabler for rotor upscaling, by combining extreme and fatigue load reduction.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design, Technical University of Denmark
Authors: Barlas, A. (Intern), Pettas, V. (Ekstern), Gertz, D. P. (Intern), Aagaard Madsen, H. (Intern)
Number of pages: 10
Publication date: 2016
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.351
Extreme Wind Calculation Applying Spectral Correction Method – Test and Validation

This report presents a test and validation of extreme wind calculation applying the Spectral Correction method as implemented in the WAsP Engineering 4 software package. The test and validation is based on four sites located in Denmark, one site located in the Netherlands and one site located in the USA. Calculations have been carried out using wind data from on-site meteorological masts as well as long-term reference wind data.

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling, Meteorology & Remote Sensing
Authors: Hansen, B. O. (Intern), Larsén, X. G. (Intern), Kelly, M. C. (Intern), Rathmann, O. S. (Intern), Berg, J. (Intern), Bechmann, A. (Intern), Sempreviva, A. M. (Intern), Ejstrup Jørgensen, H. (Intern)
Number of pages: 45
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Main Research Area: Technical/natural sciences
Electronic versions: DTU_Wind_Energy_E_0098.pdf
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Extreme Wind Calculation Applying Spectral Correction Method – Test and Validation

We present a test and validation of extreme wind calculation applying the Spectral Correction (SC) method as implemented in a DTU Wind Condition Software. This method can do with a short-term (~1 year) local measured wind data series in combination with a long-term (10-20 years) reference modelled wind data series like CFSR and CFDDA reanalysis data for the site in question. The validation of the accuracy was performed by comparing with estimates by the traditional Annual Maxim a (AM) method and the Peak Over Threshold (POT) method, applied to measurements, for six sites: four sites located in Denmark, one site located in the Netherlands and one site located in the USA, comprising both on-shore and off-shore sites. The SC method was applied to 1-year measured wind data while the AM and POT methods were applied to long-term measured wind data. Further, the consistency of the SC method was validated from the variance of the extreme wind prediction when different years are used as the period of the short-term measured wind data. For all six sites, the SC method was found to be quite accurate and very consistent when applied to one-year on-site wind data periods. It is concluded that the SC method in combination with widely available long-term reference data is a valid alternative to estimate extreme winds in cases where only short-term on-site measured wind data are available.

General information
State: Published
Fatigue damage assessment of uni-directional non-crimp fabric reinforced polyester composite using X-ray computed tomography

In this study, the progression of tension-tension fatigue ($R=0.1$) damage in a unidirectional (UD) composite made from a non-crimp glass fibre fabric used for wind turbine blades is investigated using multi-scale 3D X-ray computed tomography (CT). Initially, a representative volume is examined at one specific damage level. UD fibre fractures are only observed close to the supporting thin transverse backing layers. Furthermore, UD fibre fractures are only observed at locations where backing fibre bundles intersect one another and are at the same time locally close to a UD bundle. In addition, to study the progression of damage as a function of stiffness degradation at higher resolution four samples are subjected to different numbers of cycles before examination by CT. One sample is examined during the initial stiffness drop, two samples during stable stiffness degradation, and one close to final failure. Damage is observed to occur as chains of individual fibre breaks or clusters of fibre fractures rather than large fracture planes. Our work indicates how fracture of UD fibres initiates from intersecting $\pm 80^\circ$ backing bundles extending progressively further into the UD layer. The fibre fracture zone becomes more diffuse further from the backing layer. Our work supports a scheme explaining stiffness degradation in terms of UD fibre damage accumulation and demonstrates the importance of 3D and ideally time-lapse imaging studies.
Fatigue damage observed non-destructively in fibre composite coupon test specimens by X-ray CT

This study presents a method for monitoring the 3D fatigue damage progression on a micro-structural level in a glass fibre/polymer coupon test specimen by means of laboratory X-ray Computed Tomography (CT). A modified mount and holder made for the standard test samples to fit into the X-ray CT scanner along with a tension clamp solution is presented. Initially, the same location of the test specimen is inspected by ex-situ X-ray CT during the fatigue loading history, which shows the damage progression on a micro-structural level. The openings of individual uni-directional (UD) fibre fractures are seen to generally increase with the number of cycles, and new regions of UD fibre fractures also appear. There are some UD fibre fractures that are difficult to detect since their opening is small. Therefore, the effect of tension on the crack visibility is examined afterwards using a tension clamp solution. With applied tension some additional cracks become visible and the openings of fibre fractures increases, which shows the importance of applied tension during the scan.

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Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Jespersen, K. M. (Intern), Mikkelsen, L. P. (Intern)
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FBG_SiMul V1.0: Fibre Bragg grating signal simulation tool for finite element method models

FBG_SiMul V1.0 is a tool to study and design the implementation of fibre Bragg grating (FBG) sensors into any kind of structure or application. The software removes the need of an fibre optic expert user, becoming more obvious the sensor response of a structural health monitoring solution using FBG sensors. The software uses a modified T-Matrix method to simulate the FBG reflected spectrum based on the stress and strain from a finite element method model. The article describes the theory and algorithm implementation, followed by an empirical validation.

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Fiber pull-out test and single fiber fragmentation test - analysis and modelling
A mathematical model is developed for the analysis of the fiber debonding phase of a pull-out experiment where the matrix is supported at the same end as the fiber is loaded in tension. The mechanical properties of the fiber/matrix are described in terms of two parameters, a fracture energy for fiber/matrix debonding and a frictional sliding shear stress. Results for the debond length and fiber debond displacement are compared with results from similar models for single fiber pull-out experiments where the specimen is gripped at the end opposite to the end where the fiber is pulling-out and with results for a single fiber fragmentation test.

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Fibre Bragg Grating as a Multi-Stage Structure Health Monitoring Sensor
There is a clear need to implement models and measurement systems through the entire life of the wind turbine blade. In this chapter will be presented some work conducted to implement optical fibres as a multi-stage sensor, capable to measure different structural properties, and link them with all the different life stages and support a better design of the wind turbine blades. The characteristics and functionality of fibre Bragg grating sensors are briefly introduced. Their application as multi-stage structure health monitoring sensors for polymer laminate composite is then described. At the manufacturing stage, where the sensors can measure several parameters of infusion and curing, sensor feedback can help control the process, avoid residual strain, and contribute to the product certification; and then in operation where cracks can be detected and monitored. Experimental mechanical testing involving crack growth and fibre Bragg sensing is
described that highlights the response from the fibre optic which will correctly detect the presence and growth of damage. Models to implement these results in a damage detection system for a wind turbine blade can then be developed.

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Fibre Bragg Grating Sensor Signal Post-processing Algorithm: Crack Growth Monitoring in Fibre Reinforced Plastic Structures

A novel method to assess a crack growing/damage event in fibre reinforced plastic, using conventional single mode Fibre Bragg Grating sensors embedded in the host material is presented in this article. Three different damage mechanisms that can change the sensor output, longitudinal strain $\varepsilon_{xx}$, transversal stress $\sigma_{yy}$, and non-uniform strain $\varepsilon_{xx}(x)$, were identified. These damage mechanisms were identified during the experimental testing and linked with the sensor output using a digital image correlation technique. A dedicated algorithm to extract information from the reflected spectrum that enables crack detection was developed. Double Cantilever Beams specimens made with glass fibre and bonded with structural adhesive, were instrumented with a Fibre Bragg Grating array embedded in the host material, and tested using an experimental fracture procedure. This method was successfully validated in three different loading conditions, where were obtained very promising results that enable crack growth monitoring.

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Field Validation of IEC 61400-27-1 Wind Generation Type 3 Model with Plant Power Factor Controller

Generic electrical simulation models of wind power generation have been developed as standards, such as the IEC 61400-27-1, to be used by wind industry, system operators, and academia for power system stability studies. In this paper, the IEC type 3 wind turbine model with wind turbine level voltage controller and with wind power plant level power factor controller is validated based on field measurements from a 52-MW wind power plant. In addition to the validation of the
IEC type 3 wind turbine and wind power plant controller models, a comparison of the validation approaches, which are the full grid and play-back simulation, is provided together with a survey of the existing validation studies and recommendations for future modeling and validation tasks. The implemented IEC models are tuned to match the measurements accurately and the validated values for the control parameters of the reference wind power plant model are given.

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Scopus rating (2005): SJR 1.153 SNIP 2.173
Scopus rating (2004): SJR 1.218 SNIP 2.201
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Floating substructure flexibility of large-volume 10MW offshore wind turbine platforms in dynamic calculations

Designing floating substructures for the next generation of 10MW and larger wind turbines has introduced new challenges in capturing relevant physical effects in dynamic simulation tools. In achieving technically and economically optimal floating substructures, structural flexibility may increase to the extent that it becomes relevant to include in addition to the standard rigid body substructure modes which are typically described through linear radiation-diffraction theory. This paper describes a method for the inclusion of substructural flexibility in aero-hydro-servo-elastic dynamic simulations for large-volume substructures, including wave-structure interactions, to form the basis of deriving sectional loads and stresses within the substructure. The method is applied to a case study to illustrate the implementation and relevance. It is found that the flexible mode is significantly excited in an extreme event, indicating an increase in predicted substructure internal loads.
Flow Curvature Effects for VAWT: a Review of Virtual Airfoil Transformations and Implementation in XFOIL

Blades on a Vertical Axis Wind Turbine (VAWT) experience curved streamlines, caused by the rotation of the turbine. This phenomenon is known as flow curvature and has effects on the aerodynamic loading of the blades. Several authors have proposed methods to account for flow curvature, resulting in methods to transform the original airfoil in curved flow to a virtual airfoil, which can be analysed in straight flow. This paper reviews multiple of such virtual airfoil transformations and compares the outcomes. All methods show good correspondence to the curved flow pressure distribution, but small errors remain that are intrinsic to the conformal methods used. It is shown that VAWT rotation is equivalent to an eternal pitching motion. Using this similarity, flow curvature modeling has been added to the airfoil analysis tool XFOIL. The various changes have been made in the inviscid solver, in a way that the viscous solver need not to be changed.

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Organisations: Department of Wind Energy, Fluid Mechanics, Delft University of Technology
Authors: van der Horst, S. (Ekstern), van de Wiel, J. E. (Ekstern), Ferreira, C. S. (Ekstern), Ramos García, N. (Intern)
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Flow over complex terrain. The secrets of Bolund
Since the Bolund field campaign in 2007, the Bolund peninsula in the Roskilde Fjord in Denmark is a well-known reference case for numerical and physical modelling for wind modelling and wind turbine siting. Its well-described characteristics and boundary conditions makes it ideal for the analysis and the understanding of flow over complex terrain. The work presented in this thesis contains two diverse approaches to help understand the flow behavior over a complex terrain site, in this case the Bolund peninsula. The first approach investigates the wake and recirculation zone downstream of the Bolund escarpment with the help of a continuous-wave Doppler lidar (light detection and ranging). The instrument measures the line-of-sight windspeed 390 times per second in highly resolved 7-m tall profiles by rapidly changing the focus distance and beam direction. The profiles reveal a detailed and rapidly changing structure of the recirculation zone induced by the Bolund escarpment. This wake grows with distance from the escarpment, with the wake height depending strongly on the wind direction, such that the minimum height appears when the flow is perpendicular to the escarpment.

Although the presented full-scale experiments around the Bolund escarpment has been performed with great success, experiments in controlled environments such as wind tunnels provide the opportunity to study problems systematically in greater detail. Such a controlled experiment was realized at the WindEEE Dome, a wind tunnel facility of the Western University, London, Ontario, Canada and presents the second approach of this thesis. This large-scale wind laboratory investigation of the flow field over a large-scale model of the Bolund peninsula shows that the mean wind, wind shear and turbulence level are extremely sensitive to the exact details of the terrain. A modification of the escarpment of the Bolund model to give a sharper edge has dramatic consequences for a wind turbine positioned close to the edge. Additionally the wind tunnel investigations show only a modest Reynolds number dependence of the flow, while it is more sensitive to the details of the inflow wind profile.

Fluid-structure interaction computations for geometrically resolved rotor simulations using CFD
This paper presents a newly developed high-fidelity fluid–structure interaction simulation tool for geometrically resolved rotor simulations of wind turbines. The tool consists of a partitioned coupling between the structural part of the aero-elastic solver HAWC2 and the finite volume computational fluid dynamics (CFD) solver EllipSys3D. The paper shows that the implemented loose coupling scheme, despite a non-conservative force transfer, maintains a sufficient numerical stability and a second-order time accuracy. The use of a strong coupling is found to be redundant. In a first test case, the newly developed coupling between HAWC2 and EllipSys3D (HAWC2CFD) is utilized to compute the aero-elastic response of the NREL 5-MW reference wind turbine (RWT) under normal operational conditions. A comparison with the low-fidelity but state-of-the-art aero-elastic solver HAWC2 reveals a very good agreement between the two approaches. In a second test case, the response of the NREL 5-MW RWT is computed during a yawed and thus asymmetric inflow. The continuous good agreement confirms the qualities of HAWC2CFD but also illustrates the strengths of a computationally cheaper blade element momentum theory (BEM) based solver, as long as the solver is applied within the boundaries of the employed engineering models. Two further test cases encompass flow situations, which are expected to exceed the limits of the BEM model. However, the simulation of the NREL 5-MW RWT during an emergency shut down situation still shows good agreements in the predicted structural responses of HAWC2 and HAWC2CFD since the differences in the computed force
signals only persist for an insignificantly short time span. The considerable new capabilities of HAWC2CFD are finally demonstrated by simulating vortex-induced vibrations on the DTU 10-MW wind turbine blade in standstill. Copyright © 2016 John Wiley & Sons, Ltd.
Fractographic observations of the microstructural characteristics of flax fibre composites

Natural fibre composites possess a number of special microstructural characteristics, which need to be documented to aid in the further development of these materials. Using field emission scanning electron microscopy, fractographic observations of the microstructural characteristics of aligned flax fibre/thermoplastic composites are presented. The findings are presented in relation to the three operational parts in composites: fibres, matrix and fibre/matrix interface. For the flax fibres, the striated structure on the fibre surface is shown to consist of cellulose macrofibrils oriented in the fibre direction, which indicates that the external primary and secondary cell wall layers (P and S1) have been removed during fibre processing, leaving the S2 layer to form the outer surface. The observed fracture surfaces of the flax fibres support a previously proposed failure mechanism of transverse failure followed by longitudinal splitting. For the thermoplastic matrix, concentric rings with different points of origin are observed in the matrix regions of the composite fracture surface. The concentric rings have a microporous structure consisting of nanoscale polymer fibrils. The concentric rings form mirror zones with no riverlines, followed by repeated mist and hackle zones with distinct radiating riverlines. For the flax fibre/thermoplastic matrix interface, microscale imprints of whole fibres, and nanoscale imprints of fibre surface structures are observed on the matrix surface. This demonstrates a good fibre/matrix compatibility enabling the two parts to be in intimate contact. The composite fracture surfaces show fibres that have been pulled-out in different lengths, in addition to fibres that have failed in the same plane as the fracture surface. Altogether, the present study provides novel observations, measurements and interpretations to be used in the further analysis and understanding of the properties of natural fibre composites. (C) 2015 Elsevier Ltd. All rights reserved.
Fracture resistance enhancement of layered structures by multiple cracks

A theoretical model is developed to test if the fracture resistance of a layered structure can be increased by introducing weak layers changing the cracking mechanism. An analytical model, based on the J integral, predicts a linear dependency between the number of cracks and the steady state fracture resistance. A finite element cohesive zone model, containing two cracking planes for simplicity, is used to check the theoretical model and its predictions. It is shown that for a wide range of cohesive law parameters, the numerical predictions agree well quantitatively with the theoretical model. Thus, it is possible to enhance considerably the fracture resistance of a structure by adding weak layers.

General information
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Framework of Multi-objective Wind Farm Controller Applicable to Real Wind Farms

Optimal wind farm control can mitigate adverse wake effects that can potentially cause up to 40% power loss and 80% increased fatigue loads in wind farms. The aim of this work is to outline a methodological framework of an optimal wind farm controller, which provides improved solutions to critical areas of optimal wind farm control research. The basis of this framework is a review of optimal wind farm control methodologies, which is presented first. It is observed that there is, at present, mainly a need for more advanced wind farm operation models. Thereafter the framework of a multi-objective optimal wind farm controller is outlined with the following key characteristics.

Available control objectives are (i) to maximize the total wind farm power output or (ii) to follow a specified power reference for the wind farm’s total power output while reducing the fatigue loads of the wind turbines in the wind farm. The controller design provides improved solutions for the modelling of wind farm aerodynamics and turbine operation, that is the PossPOW algorithm and a HAWC2-based turbine model, respectively. Moreover, all components of the framework are designed as to enable the applicability of the controller to real wind farms.
Frequency control modelling - basics
The purpose of this report is to provide an introduction on how the system balance in an island system can be maintained by controlling the frequency. The power balance differential equation, which is fundamental in understanding the effect on the system frequency of the unbalance between generation and consumption, is addressed. Basic topics on the main components of a generating unit, such as generators, prime movers and governors are presented. A simple dynamic model for an island power system, containing realistic dynamic representations of generators, loads, prime movers, governors, is described specifically for the assessment of the performance of frequency droop control loop, i.e. primary control.

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Organisations: Department of Wind Energy, Integration & Planning
Authors: Hansen, A. D. (Intern), Sørensen, P. E. (Intern), Zeni, L. (Intern), Altin, M. (Intern)
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Full-Scale Spectrum of Boundary-Layer Winds
Extensive mean meteorological data and high frequency sonic anemometer data from two sites in Denmark, one coastal onshore and one offshore, have been used to study the full-scale spectrum of boundary-layer winds, over frequencies $f$ from about $1 \text{ yr}^{-1}$ to $10 \text{ Hz}$. 10-min cup anemometer data are used to estimate the spectrum from about $1 \text{ yr}^{-1}$ to $0.05 \text{ min}^{-1}$; in addition, using 20-Hz sonic anemometer data, an ensemble of 1-day spectra covering the range $1 \text{ day}^{-1}$ to $10 \text{ Hz}$ has been calculated. The overlapping region in these two measured spectra is in good agreement. Classical topics regarding the various spectral ranges, including the spectral gap, are revisited. Following the seasonal peak at $1 \text{ yr}^{-1}$, the frequency spectrum $S(f)$ increases with $f +1$ and gradually reaches a peak at about $0.2 \text{ day}^{-1}$. From this peak to about $1 \text{ hr}^{-1}$, the spectrum $S(f)$ decreases with frequency with a $\sim 2$ slope, followed by a $\sim 2/3$ slope, which can be described by $f S(f) = al f^{-2/3} + a2 f^{-2}$, ending in the frequency range for which the debate on the spectral gap is ongoing. It is shown here that the spectral gap exists and can be modelled. The linear composition of the horizontal wind variation from the mesoscale and microscale gives the observed spectrum in the gap range, leading to a suggestion that mesoscale and microscale processes are uncorrelated. Depending on the relative strength of the two processes, the gap may be deep or shallow, visible or invisible. Generally, the depth of the gap decreases with height. In the low frequency region of the gap, the mesoscale spectrum shows a two-dimensional isotropic nature; in the high frequency region, the classical three-dimensional boundary-layer turbulence is evident. We also provide the cospectrum of the horizontal and vertical components, and the power spectra of the three velocity components over a wide range from $1 \text{ day}^{-1}$ to $10 \text{ Hz}$, which is useful in determining the necessary sample duration when measuring turbulence statistics in the boundary layer.

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Organisations: Department of Wind Energy, Resource Assessment Modelling
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Full scale wind turbine test of vortex generators mounted on the entire blade

Measurements on a heavily instrumented pitch regulated variable speed Vestas V52 850 kW wind turbine situated at the DTU Risø Campus are carried out, where the effect of vortex generators mounted on almost the entire blade is tested with and without leading edge roughness. The measurements are compared to the predictions carried out by a developed design tool, where the effect of vortex generators and leading edge roughness is simulated using engineering models. The measurements showed that if vortex generators are mounted there is an increase in flapwise blade moments if the blades are clean, but also that the loads are almost neutral when vortex generators are installed if there is leading edge roughness on the blades. Finally, it was shown that there was a good agreement between the measurements and the predictions from the design tool.

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Gaussian vs non-Gaussian turbulence: impact on wind turbine loads

From large-eddy simulations of atmospheric turbulence, a representation of Gaussian turbulence is constructed by randomizing the phases of the individual modes of variability. Time series of Gaussian turbulence are constructed and compared with its non-Gaussian counterpart. Time series from the two types of turbulence are then used as input to wind turbine load simulations under normal operations with the HAWC2 software package. A slight increase in the extreme loads of the tower base fore-aft moment is observed for high wind speeds when using non-Gaussian turbulence but is insignificant when taking into account the safety factor for extreme moments. Other extreme load moments as well as the fatigue loads are not affected because of the use of non-Gaussian turbulent inflow. It is suggested that the turbine thus acts like a low-pass filter that averages out the non-Gaussian behaviour, which is mainly associated with the fastest and smallest scales. Copyright © 2016 John Wiley & Sons, Ltd.
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General Momentum Theory for Horizontal Axis Wind Turbines

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Generic Methodology for Field Calibration of Nacelle-Based Wind Lids

Nacelle-based Doppler wind lidars have shown promising capabilities to assess power performance, detect yaw misalignment or perform feed-forward control. The power curve application requires uncertainty assessment. Traceable measurements and uncertainties of nacelle-based wind lidars can be obtained through a methodology applicable to any type of existing and upcoming nacelle lidar technology. The generic methodology consists in calibrating all the inputs of the wind field reconstruction algorithms of a lidar. These inputs are the line-of-sight velocity and the beam position, provided by the geometry of the scanning trajectory and the lidar inclination. The line-of-sight velocity is calibrated in atmospheric conditions by comparing it to a reference quantity based on classic instrumentation such as cup anemometers and wind vanes. The generic methodology was tested on two commercially developed lidars, one continuous wave and one pulsed systems, and provides consistent calibration results: linear regressions show a difference of ~0.5% between the lidar-measured and reference line-of-sight velocities. A comprehensive uncertainty procedure propagates the reference uncertainty to the lidar measurements. At a coverage factor of two, the estimated line-of-sight velocity uncertainty ranges from 3.2% at 3 m·s⁻¹ to 1.9% at 16 m·s⁻¹. Most of the line-of-sight velocity uncertainty originates from the reference: the cup anemometer uncertainty accounts for 90% of the total uncertainty. The propagation of uncertainties to lidar-reconstructed wind characteristics can use analytical methods in simple cases, which we demonstrate through the example of a two-beam system. The newly developed calibration methodology allows robust evaluation of a nacelle lidar's performance and uncertainties to be established. Calibrated nacelle lidars may consequently be further used for various wind turbine applications in confidence.
Gliding arc surface modification of carrot nanofibre coating - perspective for composite processing

Surfaces of carrot nanofibre coatings were modified by a gliding arc in atmospheric pressure air. The treatment strengthened wetting of deionized water and glycerol, increased an oxygen content, C-O and C=O, and moderately roughened the surfaces. In the perspective of composite materials, these changes to the nanofibres can potentially improve their processability when they are to be impregnated with a polymeric matrix. However, longer exposure to the gliding arc reduced oxidation and roughness of the surface, and thus there exists an optimum condition to achieve good wetting to solvents.

General information
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Scopus rating (2017): CiteScore 0.49 SJR 0.201 SNIP 0.573
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.39 SJR 0.197 SNIP 0.535
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.197 SNIP 0.361 CiteScore 0.22
Scopus rating (2014): SJR 0.206 SNIP 0.362 CiteScore 0.18
Scopus rating (2013): SJR 0.205 SNIP 0.287 CiteScore 0.16
ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 0.183 SNIP 0.257 CiteScore 0.14
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.23 SNIP 0.355 CiteScore 0.1
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.179 SNIP 0.155
Original language: English
Electronic versions:
MSE_139_1_012027.pdf
DOIs:
10.1088/1757-8981/139/1/012027
Gust factor based on research aircraft measurements: A new methodology applied to the Arctic marine boundary layer: Gust Factors in the Marine Arctic

There is as yet no standard methodology for measuring wind gusts from a moving platform. To address this, we have developed a method to derive gusts from research aircraft data. First we evaluated four different approaches, including Taylor's hypothesis of frozen turbulence, to derive the gust length-scales that correspond to the gust time-scales, namely the gust duration (s) and the sample period (typically 10 min). The novelty of our method lies in using peak factors (deviation of the gust from the mean wind speed normalized by the local turbulence) to convert between the scales. After devising a way to derive the gust length-scales, we calculated the gust factors from aircraft observations and tested them against those from four parametrizations originally developed for weather stations. Three of them performed well (R²=0.66 or higher), while the fourth overestimated the gust factors in unstable conditions (R²=0.52). The mean errors for all methods were low, from -0.02 to 0.05, indicating that wind gust factors can indeed be measured from research aircraft. Moreover, we showed that aircraft can provide gust measurements within the whole boundary layer, if horizontal legs are flown at multiple levels over the same track. This is a significant advance, as gust measurements are usually limited to heights reached by weather masts. In unstable conditions over the open ocean, the gust factor was nearly constant with height throughout the boundary layer, the near-surface values only slightly exceeding those at upper levels. Furthermore, we found gust factors to be strongly dependent on surface roughness conditions, which differed between the open ocean and sea ice in the Arctic marine environment. The roughness effect on the gust factor was stronger than the effect of boundary-layer stability.

General information

State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling, Finnish Meteorological Institute, Alfred Wegener Institute for Polar and Marine Research
Authors: Suomi, I. (Ekstern), Lüpkes, C. (Ekstern), Hartmann, J. (Ekstern), Vihma, T. (Ekstern), Gryning, S. (Intern), Fortelius, C. (Ekstern)
Number of pages: 16
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Main Research Area: Technical/natural sciences

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Journal: Royal Meteorological Society. Quarterly Journal
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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 1.306 SJR 2.258 CiteScore 3.1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.33 SJR 2.538 SNIP 1.446
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.502 SNIP 1.416 CiteScore 3.1
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 5.248 SNIP 2.38 CiteScore 5
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 4.325 SNIP 2.027 CiteScore 4.17
ISI indexed (2013): ISI indexed yes
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Hierarchical machining materials and their performance

Machining is an important technological process in many areas of industry. The efficiency of machining determines the quality of many industrial products. Machining efficiency and cost depend on the properties, strength, and microstructure of the machining materials. One of the promising ways to increase the reliability and wear resistance of machining tools is the development and use of hierarchical machining materials. In the area of machining materials, designed typically as binder/reinforcement composites, hierarchical structures are realized as lower-scale secondary reinforcements (such as nanoparticles in the binder, or polycrystalline, aggregate-like reinforcements, also at several scale levels). Such materials can ensure better productivity, efficiency, and lower costs of drilling, cutting, grinding, and other technological processes. This article reviews the main groups of hierarchical machining materials and their performance.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics, National University of Science and Technology MISIS
Authors: Sidorenko, D. (Ekstern), Loginov, P. (Ekstern), Levashov, E. (Ekstern), Mishnaevsky, L. (Intern)
Number of pages: 5
Pages: 678-682
Publication date: 2016
Main Research Area: Technical/natural sciences

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Journal: M R S Bulletin
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Hierarchical materials: Background and perspectives
Hierarchical design draws inspiration from analysis of biological materials and has opened new possibilities for enhancing performance and enabling new functionalities and extraordinary properties. With the development of nanotechnology, the necessary technological requirements for the manufacturing of hierarchical materials are advancing at a fast pace, opening new challenges and opportunities. This article presents an overview of possible applications of and perspectives on hierarchical materials.
Hierarchical nanoreinforced composites: Computational analysis of damage mechanisms
The potential of hierarchical composites with secondary nanoreinforcement is discussed and analysed on the basis of the computational modelling. The concept of nanostructuring of interfaces as an important reserve of the improvement of the composite properties is discussed. The influence of distribution, shape, orientation of nanoparticles (carbon nanotube, graphene) in unidirectional polymer matrix composites on the strength and damage resistance of the composites is studied in computational studies. The possible directions of the improvement of nanoreinforced composites by controlling shapes, localization and other parameters of nanoreinforcements are reviewed.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics, Siemens Wind Power A/S
Authors: Mishnaevsky, L. (Intern), Pontefisso, A. (Intern), Dai, G. (Ekstern)
Number of pages: 6
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Main Research Area: Technical/natural sciences

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Volume: 139
ISSN (Print): 1757-8981
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BFI (2017): BFI-level 1
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BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.39 SJR 0.197 SNIP 0.535
Web of Science (2016): Indexed yes
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Scopus rating (2015): SJR 0.197 SNIP 0.361 CiteScore 0.22
Scopus rating (2014): SJR 0.206 SNIP 0.362 CiteScore 0.18
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ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 0.183 SNIP 0.257 CiteScore 0.14
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Source-ID: 2343056230
Publication: Research - peer-review › Editorial – Annual report year: 2016

This paper reveals that logistics may conservatively amount to 18% of the levelized cost of energy for offshore wind farms. This is the key finding from an extensive case study carried out within the organization of the world’s leading offshore wind farm developer and operator. The case study aimed to, and produced, a number of possible opportunities for offshore wind cost reductions through logistics innovation; however, within the case study company, no company-wide logistics organization existed to focus horizontally on reducing logistics costs in general. Logistics was not well defined within the case study company, and a logistics
strategy did not exist. With full life-cycle costs of offshore wind farms still high enough to present a political challenge within the European Union in terms of legislation to ensure offshore wind diffusion beyond 2020, our research presents logistics as a next frontier for offshore wind constituencies. This important area of the supply chain is ripe to academically and professionally cultivate and harvest in terms of offshore wind energy cost reductions. Our paper suggests that a focused organizational approach for logistics both horizontally and vertically within the company organizations could be the way forward, coupled with a long-term legislative environment to enable the necessary investments in logistics assets and transport equipment.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Aalborg University
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Number of pages: 23
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Journal: Energies
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Article number: 437
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Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.11 SJR 0.67 SNIP 1.34
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.5 SJR 0.662 SNIP 1.106
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.785 SNIP 1.399 CiteScore 2.87
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.844 SNIP 1.565 CiteScore 2.66
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.613 SNIP 1.331 CiteScore 2.29
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.852 SNIP 1.53 CiteScore 2.46
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.651 SNIP 1.396 CiteScore 2.24
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.302 SNIP 0.734
Original language: English
Offshore wind, Logistics, Logistics innovation, Organization, Levelized cost of energy, LCoE (levelized cost of energy)
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Bibliographical note
© 2016 by the authors; licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC-BY) license (http://creativecommons.org/licenses/by/4.0/).
How Forest Inhomogeneities Affect the Edge Flow

Most of our knowledge on forest-edge flows comes from numerical and wind-tunnel experiments where canopies are horizontally homogeneous. To investigate the impact of tree-scale heterogeneities (>1 m) on the edge-flow dynamics, the flow in an inhomogeneous forest edge on Falster island in Denmark is investigated using large-eddy simulation. The three-dimensional forest structure is prescribed in the model using high resolution helicopter-based lidar scans. After evaluating the simulation against wind measurements upwind and downwind of the forest leading edge, the flow dynamics are compared between the scanned forest and an equivalent homogeneous forest. The simulations reveal that forest inhomogeneities facilitate flow penetration into the canopy from the edge, inducing important dispersive fluxes in the edge region as a consequence of the flow spatial variability. Further downstream from the edge, the forest inhomogeneities accentuate the canopy-top turbulence and the skewness of the wind-velocity components while the momentum flux remains unchanged. This leads to a lower efficiency in the turbulent transport of momentum within the canopy. Dispersive fluxes are only significant in the upper canopy. Above the canopy, the mean flow is less affected by the forest inhomogeneities. The inhomogeneities induce an increase in the mean wind speed that was found to be equivalent to a decrease in the aerodynamic height of the canopy. Overall, these results highlight the importance of forest inhomogeneities when looking at canopy–atmosphere exchanges in forest-edge regions.

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling, Meteorology & Remote Sensing, INRA Institut National de La Recherche Agronomique
Authors: Boudreault, L. (Ekstern), Dupont, S. (Ekstern), Bechmann, A. (Intern), Dellwik, E. (Intern)
Number of pages: 26
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Main Research Area: Technical/natural sciences

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Journal: Boundary-Layer Meteorology
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BFI (2018): BFI-level 1
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Scopus rating (2017): SJR 1.262 SNIP 1.193 CiteScore 2.47
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.65 SJR 1.525 SNIP 1.325
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.854 SNIP 1.279 CiteScore 2.32
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.802 SNIP 1.785 CiteScore 2.74
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.72 SNIP 1.605 CiteScore 2.4
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.923 SNIP 1.628 CiteScore 2.12
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.378 SNIP 1.345 CiteScore 1.9
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Hydropower flexibility and transmission expansion to support integration of offshore wind

In 2013, offshore wind grew over 50%. This increase, concentrated in a relatively small geographical area, can lead to an increased variability of the power produced by offshore wind. The variability is one of the key issues, along transmission, in integrating offshore wind power. Hydro power is one of the fast responding sources of electricity, thus power systems with considerable amounts of flexible hydro power can potentially offer easier integration of offshore wind power. The interaction between offshore wind and hydro power can be beneficial, especially when looking at how the flexibility of hydro generation can match the variability of offshore wind, allowing for larger shares of variable generation to be integrated in the power systems without decreasing its stability. The analysis includes two interrelated models, a market model and a flow-based model. The results show that hydropower systems are a very good option for balancing the natural variability of wind power production, especially when installed offshore. The flexibility of hydropower systems allows power systems with a high share of RES to maintain stability. The analysis presented indicates that the value of hydropower flexibility to the European power system is significant, consequently justifying the investment costs for transmission expansion.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning, Norwegian University of Science and Technology, SINTEF, Danish District Heating Suppliers, Energinet.dk
Authors: Cutululis, N. A. (Intern), Farahmand, H. (Ekstern), Jaehnert, S. (Ekstern), Detlefsen, N. (Ekstern), Byriel, I. (Ekstern), Sørensen, P. E. (Intern)
Pages: 495-523
Publication date: 2016

Host publication information
Title of host publication: Offshore Wind Farms : Technologies, Design and Operation
Publisher: Woodhead Publishing
Editors: Ng, C., Ran, L.
Ice detection on wind turbines using observed power curve

Icing on the blades of a wind turbine can lead to significant production losses during the winter months for wind parks in cold climate regions. However, there is no standard way of identifying ice-induced power loss. This paper describes three methods for creating power threshold curves that can be used to separate iced production periods from non-iced production periods. The first approach relies on a percentage deviation from the manufacturer’s power curve. The other two approaches fit threshold curves based on the observed variance of non-iced production data. These approaches are applied to turbines in four wind parks and compared with each other and to observations of icing on the nacelle of one of the turbines in each park. It is found that setting an ice threshold curve using 0.1 quantile of the observed power data during normal operation with a 2-h minimum duration is the best approach for icing identification. The quantile should be fit based on at least 1 year of data, and a smoothing function should be applied to the quantile results to remove any outliers caused by limited numbers of data points.

General information

State: Published
Authors: Davis, N. (Intern), Byrkjedal, Ø. (Ekstern), Hahmann, A. N. (Intern), Clausen, N. (Intern), Zagar, M. (Ekstern)
Number of pages: 12
Pages: 999–1010
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Main Research Area: Technical/natural sciences

Publication information

Journal: Wind Energy
Volume: 19
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BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.18 SJR 1.051 SNIP 1.834
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.37 SJR 1.079 SNIP 2.316
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.201 SNIP 2.165 CiteScore 3.06
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.209 SNIP 3.688 CiteScore 3.42
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.235 SNIP 2.486 CiteScore 2.75
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.062 SNIP 2.297 CiteScore 2.36
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Identifying and characterizing the impact of turbine icing on wind farm power generation: Impact of turbine icing on wind farm production

Wind park power production in cold climate regions is significantly impacted by ice growth on turbine blades. This can lead to significant errors in power forecasts and in the estimation of expected power production during turbine siting. A modeling system is presented that uses a statistical modeling approach to estimate the power loss due to icing, using inputs from both a physical icing and a numerical weather prediction model. The physical icing model is that of Davis et al., [1] with updates to the simulation of ice ablation. A new approach for identifying periods of turbine blade icing from power observations was developed and used to calculate the observed power loss caused by icing. The observed icing power loss for 2 years at six wind parks was used to validate the modeling system performance. Production estimates using the final production loss model reduce the root mean squared error when compared with the empirical wind park power curve (without icing influence) at five of the six wind parks while reducing the mean bias at all six wind parks. In addition to performing well when fit to each wind park, the production loss model was shown to improve the estimate of power when fit using all six wind parks, suggesting it may also be useful for wind parks where production data are not available.

General information
State: Published
Authors: Davis, N. (Intern), Pinson, P. (Intern), Hahmann, A. N. (Intern), Clausen, N. (Intern), Žagar, M. (Ekstern)
Pages: 1503-1518
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication Information
Journal: Wind Energy
Volume: 19
Issue number: 8
ISSN (Print): 1095-4244
Impact of atmospheric stability conditions on wind farm loading and production
The project has created a new basis for further development and optimization of WT’s designed for WF operation. This has been accomplished through developing of more realistic modelling of WF flow fields as well as of such fields interactions with WT’s under non-neutral ABL stability conditions. On this basis a verified model complex for prediction of structural loads as well as production losses for wind turbines operating in wind farm conditions, which takes into account the effects from ABL stability conditions, is established. Thereby the way to increased reliability and cost efficiency of future wind turbines as well as to more precise prediction of the WF power output is paved.

General information
State: Published
Authors: Larsen, G. C. (Intern), Ott, S. (Intern), Trolldborg, N. (Intern), Chougule, A. S. (Intern), Mann, J. (Intern), Machefaux, E. (Intern), Verelst, D. R. (Intern), Larsen, T. J. (Intern), Mirzaei, M. (Intern), Bertagnolio, F. (Intern), Kelly, M. C. (Intern), Hansen, K. S. (Intern), Marion, L. (Intern)
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Number: 136
Main Research Area: Technical/natural sciences
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Final_Report_EUDP_DTU_9_with_front_page.pdf
Publication: Research - peer-review › Report – Annual report year: 2016

Impact of a wind turbine on turbulence: Un-freezing turbulence by means of a simple vortex particle approach
A vortex particle representation of turbulent fields is devised in order to address the following questions: Does a wind turbine affect the statistics of the incoming turbulence? Should this imply a change in the way turbulence boxes are used in wind turbine aero-elastic simulations? Is it acceptable to neglect the influence of the wake and the wind turbine on the turbulent inflow? Is there evidence to justify the extra cost of a method capable of including these effects correctly? To this end, a unified vorticity representation of the flow is used: the wind turbine model is represented by a bound vorticity lifting line while the turbine wake vorticity and the turbulence vorticity are projected onto vortex particles. In the present work the rotor blades are stiff leaving aero-elastic interactions for future work. Inflow turbulence is generated with the model of Mann and converted to vortex particles that are inserted at the inlet of the computational domain. First the quality of the reconstructed turbulent flow field is evaluated and then the wind turbine is added in the simulations. The lack of a driving-force to sustain turbulence is found to give a progressive decay of turbulence away from the insertion point. The presence of the wind turbine and its wake is found to have insignificant effect on upstream turbulence. Finally, the mean velocity profiles in the wake are found to be in good agreement with both lidar measurements and CFD simulations. (C) 2016 Elsevier Ltd. All rights reserved.

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control, Aerodynamic design, Technical University of Denmark, National Technical University of Athens
Authors: Branlard, E. S. P. (Intern), Mercier, P. (Ekstern), Machefaux, E. (Intern), Gaunaa, M. (Intern), Voutsinas, S. (Ekstern)
Number of pages: 11
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Main Research Area: Technical/natural sciences

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Journal: Journal of Wind Engineering and Industrial Aerodynamics
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BFI (2018): BFI-level 1
Improved blade element momentum theory for wind turbine aerodynamic computations

Blade element momentum (BEM) theory is widely used in aerodynamic performance predictions and design applications for wind turbines. However, the classic BEM method is not quite accurate which often tends to under-predict the aerodynamic forces near root and over-predict its performance near tip. The reliability of the aerodynamic calculations and design optimizations is greatly reduced due to this problem. To improve the momentum theory, in this paper the influence of pressure drop due to wake rotation and the effect of radial velocity at the rotor disc in the momentum theory are considered. Thus the axial induction factor in far downstream is not simply twice of the induction factor at disc. To calculate the performance of wind turbine rotors, the improved momentum theory is considered together with both Glauert's tip correction and Shen's tip correction. Numerical tests have been performed for the MEXICO rotor. Results show that the improved BEM theory gives a better prediction than the classic BEM method, especially in the blade tip region, when comparing to the MEXICO measurements. (C) 2016 Elsevier Ltd. All rights reserved.
Improved Frequency Control from Wind Power Plants Considering Wind Speed Variation

A fast frequency controller (FFC) for wind power plants (WPPs), which produces a temporary overloading power reference based on frequency deviation and rate of change of frequency, is proposed in this paper. Contrary to standard controllers proposed in the literature, the gains of the FFC are optimized for different wind speeds ensuring an improved frequency control from WPPs over the whole wind speed range. Two options for temporary frequency control implementations from WPPs are analyzed and compared. Moreover, the impact of mechanical, electrical and control limitations at different wind speeds and its effect on frequency control is discussed in the paper. Results show that by optimizing the gains, an improved frequency control can be obtained compared to standard controllers which apply a fixed gain over whole the wind speed range.

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State: Published
Organisations: Department of Wind Energy, Integration & Planning, KU Leuven
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Main Research Area: Technical/natural sciences
Frequency Control, Inertial Response, Temporary Overloading, Wind Power Plants
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Source-ID: 123980175
Publication: Research - peer-review › Article in proceedings – Annual report year: 2016
Improvement of airfoil trailing edge bluntness noise model

In this article, airfoil trailing edge bluntness noise is investigated using both computational aero-acoustic and semi-empirical approach. For engineering purposes, one of the most commonly used prediction tools for trailing edge noise are based on semi-empirical approaches, for example, the Brooks, Pope, and Marcolini airfoil noise prediction model developed by Brooks, Pope, and Marcolini (NASA Reference Publication 1218, 1989). It was found in previous study that the Brooks, Pope, and Marcolini model tends to over-predict noise at high frequencies. Furthermore, it was observed that this was caused by a lack in the model to predict accurately noise from blunt trailing edges. For more physical understanding of bluntness noise generation, in this study, we also use an advanced in-house developed high-order computational aero-acoustic technique to investigate the details associated with trailing edge bluntness noise. The results from the numerical model form the basis for an improved Brooks, Pope, and Marcolini trailing edge bluntness noise model.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, University of Copenhagen
Authors: Zhu, W. J. (Intern), Shen, W. Z. (Intern), Sørensen, J. N. (Intern), Leloudas, G. (Ekstern)
Number of pages: 12
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Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
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Web of Science (2017): Indexed Yes
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Web of Science (2016): Indexed yes
Scopus rating (2015): SJR 0.26 SNIP 0.596 CiteScore 0.64
Scopus rating (2014): SJR 0.249 SNIP 0.576 CiteScore 0.63
Web of Science (2014): Indexed yes
Scopus rating (2013): SJR 0.366 SNIP 1.048 CiteScore 1.11
ISI indexed (2013): ISI indexed yes
Scopus rating (2012): SJR 0.402 SNIP 0.857 CiteScore 0.88
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.359 SNIP 1.086 CiteScore 1
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.102 SNIP 0
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Wind turbine noise, Trailing edge bluntness noise, Semi-empirical noise prediction model, Computational aero-acoustics, Mechanical Engineering

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Improvement_of_airfoil_trailing_edge.pdf
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Source: FindIt
Source-ID: 2292302487
Publication: Research - peer-review › Journal article – Annual report year: 2016
**Improvement of TNO type trailing edge noise models**

The paper describes an improvement of the so-called TNO model to predict the noise emission from aerofoil sections due to the interaction of the boundary layer turbulence with the trailing edge. The surface pressure field close to the trailing edge acts as source of sound in the TNO model. It is computed by solving a Poisson equation which includes flow turbulence cross correlation terms. Previously published TNO type models used the assumption of Blake to simplify the Poisson equation. This paper shows that the simplification should not be used. We present a new model which fully models the turbulence cross correlation terms. The predictions of the new model are in better agreement with measurements of the surface pressure and far field sound spectra. The computational cost of the new model is only slightly higher than the one of the TNO model, because we derived an analytical solution for the turbulence cross correlation terms.

**General information**

State: Published
Organisations: Department of Wind Energy, Aerodynamic design
Authors: Fischer, A. (Intern), Bertagnolio, F. (Intern), Aagaard Madsen, H. (Intern)
Number of pages: 9
Publication date: 2016

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**Influence of specimen type and reinforcement on measured tension-tension fatigue life of unidirectional GFRP laminates**

It is well known that standardised tension-tension fatigue test specimens of unidirectional (UD) glass-fibre-reinforced plastics (GFRP) laminates tend to fail at end tabs. The true fatigue life is then underestimated. The first objective of this study was to find for UD GFRP laminates a test specimen that fails in the gauge section. The second objective was to compare fatigue performance of two laminates, one having a newly developed UD powder-bound fabric as a reinforcement and the other having a quasi-UD stitched non-crimp fabric as a reinforcement. In the first phase, a rectangular specimen in accordance with the ISO 527-5 standard and two slightly different dog-bone shaped specimens were evaluated by means of finite element modelling. Subsequent comparative fatigue tests were performed for the laminates with the three specimen types. The results showed that the test specimen type has a significant effect on the failure mode and measured fatigue life of the laminates. A significantly higher fatigue life was measured for the laminate with the powder-bound fabric reinforcement when compared to the laminate with the stitched reinforcement.

**General information**

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Organisations: Department of Wind Energy, Composites and Materials Mechanics, Aalto University, Tampere University of Technology
Authors: Korkiakoski, S. (Ekstern), Brøndsted, P. (Intern), Sarlin, E. (Ekstern), Saarela, O. (Ekstern)
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- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 1
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Influence of strain rate on the orientation dependence of microstructure in nickel single crystals

The deformation microstructures of nickel single crystals (99.945 wt.%) during dynamic plastic deformation and quasi-static compression to a true strain of 0.20 were comparatively investigated. The deformation microstructures are orientation dependent, forming cell structure, slip plane aligned or not slip plane aligned extended boundaries. It is found that the orientation spread decreases, remains unchanged and becomes enhanced when loading along $\langle 001 \rangle$, $\langle 011 \rangle$ and $\langle 111 \rangle$, respectively, as strain rate increases.
Influence of the control system on wind turbine loads during power production in extreme turbulence: Structural reliability

The wind energy industry is continuously researching better computational models of wind inflow and turbulence to predict extreme loading (the nature of randomness) and their corresponding probability of occurrence. Sophisticated load alleviation control systems are increasingly being designed and deployed to specifically reduce the adverse effects of extreme load events resulting in lighter structures. The main objective herein is to show that despite large uncertainty in the extreme turbulence models, advanced load alleviation control systems yield both a reduction in magnitude and scatter of the extreme loads which in turn translates in a change in the shape of the annual maximum load distribution function resulting in improved structural reliability. Using a probabilistic loads extrapolation approach and the first order reliability method, a large multi-megawatt wind turbine blade and tower structural reliability are assessed when the extreme turbulence model is uncertain. The structural reliability is assessed for the wind turbine when three configurations of an industrial grade load alleviation control system of increasing complexity and performance are used. The load alleviation features include a cyclic pitch, individual pitch, static thrust limiter, condition based thrust limiter and an active tower vibration damper. We show that large uncertainties in the extreme turbulence model can be mitigated and significantly reduced while maintaining an acceptable structural reliability level when advanced load alleviation control systems are used. We end by providing a rational comparison between the long term loads extrapolation method and the environmental contour method for the three control configurations. © 2015 Elsevier Ltd. All rights reserved.
Influence of the curing cycles on the fatigue performance of unidirectional glass fiber reinforced epoxy composites

During the manufacturing process of fiber reinforced polymers the curing reaction of the resin results in shrinkage of the resin and introduces internal stresses in the composites. When curing at higher temperatures in order to shorten up the processing time, higher curing stresses and thermal stresses are built up and frozen, as residual stresses occur. In the present work, a glass fiber reinforced epoxy composite laminate with an unidirectional architecture based on non-crimp fabrics with backing fibers is investigated. Three different curing cycles (time-temperature cycles) are used, leading to different levels of internal stresses. The mechanical properties, static strength and fatigue life time, are measured in three different directions of the material, i.e. the fiber direction, 0°, the 30° off axis direction, and the 90° direction transverse to the fiber direction. It is experimentally demonstrated that the resulting residual stresses barely influences the quasi-static mechanical properties of reinforced glass-fiber composites. It is found that the fatigue performance in the 0° direction is significantly influenced by the internal stresses, whereas the fatigue performance in the off axes directions so is not significantly influenced of these stresses. This is related to the observations that the damage mechanisms in the off axes directions are mainly related to shear failure in the matrix and in the interface between fiber and matrix and different from the damage mechanisms in the fiber direction, where the damage initiates in the transverse backing fibers and is directly related to fiber fractures in the load-carrying axial fiber bundles.
Initiation of trailing edge failure in full-scale wind turbine blade test

The reliability and accuracy of a numerical shell model simulation and its predictive capabilities with existing failure criteria are compared to experiments of a 34 m long blade tested to ultimate failure. Strengths and weaknesses of in-plane failure criteria are highlighted and the geometrical non-linear buckling effect of the trailing edge under combined loading, and how it affects the ultimate strength of a blade in a trailing-edge failure dominated load direction were investigated. The study details the interaction between trailing edge buckling on damage onset and sandwich panel failure. The numerically applied fracture mechanics approaches showed good agreement with the experimental results.

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BFI (2014): BFI-level 2
In search for a canonical design ABL stability class for wind farm turbines

Production as well as loading of wake exposed wind turbines is known to depend significantly on stability of the Atmospheric Boundary Layer (ABL), which adds a new dimension to design of wind farm turbines. Adding this new aspect in wind turbine design makes the number of design cycle computations to blow up with a factor equal to the number of representative stability bin classes. The research question to be answered in this paper is: Can an ABL stability probability distribution in a meaningful way be collapsed into a representative design stability class as based on a (predefined) confidence level.
Integration of Renewable Generation in Power System Defence Plans

Increasing levels of penetration of wind power and other renewable generations in European power systems pose challenges to power system security. The power system operators are continuously challenged especially when generations from renewables are high thereby reducing online capacity of conventional controllable generations to minimum. In such operation hours, the system is typically more vulnerable to disturbances in general and major disturbances in particular. This was the case in the major disturbance on 4th November 2006, where the Central European power system was split into 3 areas, one of them being the North East area with high share of wind power generation. The aim of this study is to investigate how renewable generations like wind power can contribute to the power system defence plans. This PhD project "Integration of Renewable Generation in Power System Defence Plans" develops a new methodology to analyse the adequacy of reserves for future power systems with high penetration of windpower generation. This methodology assesses the requirements of frequency restoration reserves in order to contain the power imbalance caused by forecast errors within the designed frequency containment reserves. A set of sensitivity studies of the frequency containment process are performed where reserves are deployed from different power plant technologies including wind turbine. Recommendations for protection and control strategies from windturbines during overfrequency emergency are developed and discussed. Optimal underfrequency load shedding schemes for power systems with high penetration of distributed generation are developed and assessed through simulations. Results show the ability of such schemes to prevent additional load shedding, have minimum generation disconnection and better frequency response.

Introduction

In the following chapter, a brief historical introduction will be given to the development of the modern wind turbine and the associated development of wind turbine aerodynamics.
Introduction to wind power models for frequency control studies

This document covers some basic aspects regarding wind power models, which can be used in power system frequency control studies. Different issues like aerodynamic power, power curve, as well as different wind turbine concepts and their methods to optimize or limit the power extracted from the wind, are thus addressed and briefly discussed.

Investigating Coherent Structures in the Standard Turbulence Models using Proper Orthogonal Decomposition

The wind turbine design standards recommend two different methods to generate turbulent wind for design load analysis, the Kaimal spectra combined with an exponential coherence function and the Mann turbulence model. The two turbulence models can give very different estimates of fatigue life, especially for offshore floating wind turbines. In this study the spatial distributions of the two turbulence models are investigated using Proper Orthogonal Decomposition, which is used to characterize large coherent structures. The main focus has been on the structures that contain the most energy, which are the lowest POD modes. The Mann turbulence model generates coherent structures that stretches in the horizontal direction for the longitudinal component, while the structures found in the Kaimal model are more random in their shape. These differences in the coherent structures at lower frequencies for the two turbulence models can be the reason for differences in fatigue life estimates for wind turbines.
The article introduces steel fiber reinforced polymer composites, which is considered new for composite product developments. These composites consist of steel fibers or filaments of 0.21 mm diameter embedded in a polyester resin. The goal of this investigation is to characterize the mechanical performance of steel fiber reinforced polyester composites at room temperature. The mechanical properties of unidirectional steel fiber reinforced polyester composites (SFRP) are evaluated experimentally and compared with the predicted values by micro-mechanical models. These predictions help to...
understand the role of material and process parameters on material properties. Two types of SFRP were studied: polyester resin reinforced by both steel fabric containing unidirectional fibers and steel fibers wound on a metal frame with 0° orientations. The effects of the fiber volume fraction and the role of polymer yarns (weft) on mechanical properties were analyzed through tensile, compressive, and shear tests. These tests were performed as per the standard test procedures. In particular, issues related to processing difficulties, polymer yarns effect on properties, standardized testing, and properties under various loading conditions were addressed. Microscopic observations were analyzed to assess the laminate quality and the macroscopic fracture surfaces of shear test specimens were studied by standard techniques.
Investigation of the theoretical load alleviation potential using trailing edge flaps controlled by inflow data

A novel control concept for fatigue load reduction with trailing edge flaps based on the measurement of the inflow locally on the blade was presented. The investigation was conducted with the aeroelastic code HAWC2. The aerodynamic modelling in the code is based on blade element momentum theory. The simulations were carried out for the NREL 5MW reference wind turbine, and the mean wind speed at hub height was 8 m s⁻¹. The turbine was operated with fixed rotational speed. The energy at the blade is concentrated in spectral bands centred at multiples of the rotational frequency up to three times the rotational frequency. The highest fatigue load reduction was achieved when the inflow sensor was placed at the outer parts of the blade. In the best case, the reduction of the local fatigue loads induced by the blade sectional normal force was 60%. The control method gave the highest fatigue load reductions in conditions with strong wind shear. The demands for the flap actuator in terms of deflection angles was ±10°. The requirements in terms of the flap deflection velocity depend mainly on the inflow turbulence intensity. The maximum value was ±40°s⁻¹ for 20% inflow turbulence intensity. Unsteady aerodynamic effects seem to be negligible. Copyright © 2015 John Wiley & Sons, Ltd.

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In this paper, wake interaction resulting from two stall regulated turbines aligned with the incoming wind is studied experimentally and numerically. The experimental work is based on a full-scale remote sensing campaign involving three nacelle mounted scanning lidars. A thorough analysis and interpretation of the measurements is performed to overcome either the lack of or the poor calibration of relevant turbine operational sensors, as well as other uncertainties inherent in resolving wakes from full-scale experiments. The numerical work is based on the in-house EllipSys3D computational fluid dynamics flow solver, using large eddy simulation and fully turbulent inflow. The rotors are modelled using the actuator disc technique. A mutual validation of the computational fluid dynamics model with the measurements is conducted for a selected dataset, where wake interaction occurs. This validation is based on a comparison between wake deficit, wake generated turbulence, turbine power production and thrust force. An excellent agreement between measurement and simulation is seen in both the fixed and the meandering frame of reference. Copyright © 2015 John Wiley & Sons, Ltd.
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Web of Science (2010): Indexed yes
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Scopus rating (2009): SJR 0.885 SNIP 1.439
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Scopus rating (2008): SJR 0.743 SNIP 1.555
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Kawada's Contribution to Induced Velocity by Helical Vortices with Application to Propeller Theory

The analytical form of the velocity field induced by a helical vortex filament is well known as Hardin's solution (1982). But the essentially same result had been obtained by a Japanese scientist Kawada in 1936, which predates Hardin by 46 years. This talk exposes Kawada's paper (1939) which provides a comprehensive treatment of induced velocity by helical vortices with application to the propeller theory. Sandi Kawada was a pioneer of aeronautics engineering in Japan, and played a leading role in opening up this field in Japan. He was born on May 26, 1899 and died on July 16, 1970. Kawada was one of the first graduates, in March 1923, of Department of Aeronautics, Faculty of Engineering, the Imperial University of Tokyo, currently being known as the University of Tokyo. After working in Aviation Laboratory as a part-time employee and in the Japanese Army as an aviation soldier for a few years, he was appointed as associate professor of the Imperial University of Tokyo in 1926, and in parallel, he worked as a researcher in Aviation Laboratory. In 1939, he was promoted to a professor. Kawada widely conducted aerodynamic research with his fields ranging over propeller theory, axial blower, turbo jet and high-speed aerodynamics (sub-sonic, transonic and super-sonic regimes). He committed in building a number of wind tunnels of the first generation in Japan. Among others, he led the Japanese society of aeronautics engineering with his theory of propellers. Aviation Laboratory was established, as a research institute attached to the Imperial University of Tokyo in 1918. The laboratory, with only a couple of specialists in airplanes, was not active, and, to be worse, its building was collapsed by the Great Kanto earthquake, calamity attacking Tokyo region in 1923. When the Shohwa era began in 1926, Chuzaburou Shiba, the Director of Laboratory, embarked on a project of making an airplane which was able to establish a world record, with a view to publicize the work of the Laboratory, and thereby to convince the laboratory staff of their high ability. This project was launched in the summer of 1931, collecting all the members of Laboratory, and in 1938, their airplane achieved the world record of the longest distance flight. Kawada was a chief researcher reponsible for propellers. The next project of the laboratory was a creation of an airplane for commercial flight from Tokyo to New York. The effort in this direction was suspended with the outbreak of the Second World War in the Pacific in 1941, and the activities of the Japanese aeronautical engineering were completely stopped when Japan surrendered to USA in August 1945. GHQ or GHQ/SCAP (General Headquarters, the Supreme Commander for the Allied Powers) banned the aircraft industry and the related research in Japan for 1945-1953. Kawada waved his route off aeronautics, entered into civil engineering and geophysical fluid mechanics, being featured by environ-ment aspect. In this way, Kawada left the aeronautical engineering and his contribution to the propeller theory lost its connection to the modern development. Aviation industry was almost extinguished when the research ban in aeronautical engineering was lifted in 1953 when the Japan Society of Aeronautical Science got back together. In 1954, Kawada was elected as the president of the society, and devoted himself to reconstructing the society. Theodore von Karman (in his selected papers of 2004) recognized Kawada's contribu-tion to the development of the vortex model of the rotor:“The second step in the develop-ment constitutes a direct application of the Lanchester-Prandtl ideas to rotating bound vortices representing the propeller blades. Helicoidal vortex sheets now replace the free vortex sheet of the Prandtl’s theory. This idea was first carried out mathematically by Sydney Goldstein in his doctor’s thesis at Gottingen University. Goldstein became one of the leading aerodynamics-cists in England ... Two Japanese aerodynamicists, Moriya and Kawada, continued the work of Goldstein ...”This talk recollects Kawada’s theory of propellers (1939) and its relation with his theory of a helical vortex filament (1936) (Fukumoto, Okulov & Wood 2015).

General information

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Helical vorte, Propeller theory, Sandi Kawada
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Laminated Ti-Al composites: Processing, structure and strength

Laminated Ti-Al composite sheets with different layer thickness ratios have been fabricated through hot pressing followed by multi-pass hot rolling at 500 °C. The laminated sheets show strong bonding with intermetallic interface layers of nanoscale thickness between the layers of Ti and Al. The mechanical properties of the composites with different volume fractions of Al from 10% to 67% show a good combination of strength and ductility. A constraint strain in the hot-rolled laminated structure between the hard and soft phases introduces an elastic-plastic deformation stage, which becomes more pronounced as the volume fraction of Al decreases. Moreover, the thin intermetallic interface layer may also contribute to the strength of the composites, and this effect increases with increasing volume fraction of the interface layer.
Large Wind Turbine Rotor Design using an Aero-Elastic / Free-Wake Panel Coupling Code

Despite the advances in computing resources in the recent years, the majority of large wind-turbine rotor design problems still rely on aero-elastic codes that use blade element momentum (BEM) approaches to model the rotor aerodynamics. The present work describes an approach to wind-turbine rotor design by incorporating a higher-delity free-wake panel aero-elastic coupling code called MIRAS-FLEX. The optimization procedure includes a series of design load cases and a simple structural design code. Due to the heavy MIRAS-FLEX computations, a surrogate-modeling approach is applied to mitigate the overall computational cost of the optimization. Improvements in cost of energy, annual energy production, maximum ap-wise root bending moment, and blade mass were obtained for the NREL 5MW baseline wind turbine.

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Latest Developments of Negative Sequence Extensions for Generic RMS Models of Wind Turbines

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Latest results from the EU project AVATAR: Aerodynamic modelling of 10 MW wind turbines
This paper presents the most recent results from the EU project AVATAR in which aerodynamic models are improved and validated for wind turbines on a scale of 10 MW and more. Measurements on a DU 00-W-212 airfoil are presented which have been taken in the pressurized DNW-HDG wind tunnel up to a Reynolds number of 15 Million. These measurements
are compared with measurements in the LM wind tunnel for Reynolds numbers of 3 and 6 Million and with calculational results. In the analysis of results special attention is paid to high Reynolds numbers effects. CFD calculations on airfoil performance showed an unexpected large scatter which eventually was reduced by paying even more attention to grid independency and domain size in relation to grid topology. Moreover calculations are presented on flow devices (leading and trailing edge flaps and vortex generators). Finally results are shown between results from 3D rotor models where a comparison is made between results from vortex wake methods and BEM methods at yawed conditions.

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Authors: Schepers O. Ceyhan, J. G. (Ekstern), Boorsma, K. (Ekstern), Gonzalez, A. (Ekstern), Munduate, X. (Ekstern), Pires, O. (Ekstern), Serensen, N. N. (Intern), Ferreira, C. M. D. (Intern), Sieros, G. (Ekstern), Madsen, J. (Ekstern), Voutsinas, S. (Ekstern), Lutz, T. (Ekstern), Barakos, G. (Ekstern), Colonia, S. (Ekstern), Heißelmann, H. (Ekstern), Meng, F. (Ekstern), Croce, A. (Ekstern)
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Applied fluid mechanics, Compressible flows; shock and detonation phenomena, General fluid dynamics theory, simulation and other computational methods, Rotational flow, vortices, buoyancy and other flows involving body forces, Wakes, Numerical approximation and analysis, Civil and mechanical engineering computing, Finite element analysis, Mechanical engineering applications of IT, Power and plant engineering (mechanical engineering), Fluid mechanics and aerodynamics (mechanical engineering), Mechanical components, Numerical analysis, aerodynamics, aerospace components, boundary-elements methods, computational fluid dynamics, vortices, wakes, wind turbines, EU project AVATAR, aerodynamic modelling, aerodynamic models, pressurized DNW-HDG wind tunnel, LM wind tunnel, Reynolds numbers, CFD calculations, airfoil performance, grid independency, domain size, grid topology, flow devices, 3D rotor models, vortex wake methods, BEM methods, yawed conditions, power 10 MW

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**LES tests on airfoil trailing edge serration**

In the present study, a large number of acoustic simulations are carried out for a low noise airfoil with different Trailing Edge Serrations (TES). The Ffowcs Williams-Hawkings (FWH) acoustic analogy is used for noise prediction at trailing edge. The acoustic solver is running on the platform of our in-house incompressible flow solver EllipSys3D. The flow solution is first obtained from the Large Eddy Simulation (LES), the acoustic part is then carried out based on the instantaneous hydrodynamic pressure and velocity field. To obtain the time history data of sound pressure, the flow quantities are integrated around the airfoil surface through the FWH approach. For all the simulations, the chord based Reynolds number is around 1.5x106. In the test matrix, the effects from angle of attack, the TE flap angle, the length/width of the TES are investigated. Even though the airfoil under investigation is already optimized for low noise emission, most numerical simulations and wind tunnel experiments show that the noise level is further decreased by adding the TES device.

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Lidar-based maps for flow modeling in complex forested terrain

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Lidar configurations for wind turbine control
Lidar sensors have proved to be very beneficial in the wind energy industry. They can be used for yaw correction, feed-forward pitch control and load verification. However, the current lidars are expensive. One way to reduce the price is to use lidars with few measurement points. Finding the best configuration of an inexpensive lidar in terms of number of measurement points, the measurement distance and the opening angle is the subject of this study. In order to solve the problem, a lidar model is developed and used to measure wind speed in a turbulence box. The effective wind speed measured by the lidar is compared against the effective wind speed on a wind turbine rotor both theoretically and through simulations. The study provides some results to choose the best configuration of the lidar with few measurement points.

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Lidar to lidar calibration

This report presents the result of the lidar to lidar calibration performed for ground-based lidar. Calibration is here understood as the establishment of a relation between the reference lidar wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements. The comparison of the lidar measurements of the wind direction with that from the reference lidar measurements are given for information only.

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Organisations: Department of Wind Energy, Test and Measurements, Meteorology & Remote Sensing
Authors: Georgieva Yankova, G. (Intern), Courtney, M. (Intern)
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DTU Wind Energy LC I-088(EN), LC-I-088, LC-I-088(EN)

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Publication: Research › Report – Annual report year: 2016
Lidar to lidar calibration
This report presents the result of the lidar to lidar calibration performed for ground-based lidar. Calibration is here understood as the establishment of a relation between the reference lidar wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements. The comparison of the lidar measurements of the wind direction with that from the reference lidar measurements are given for information only.

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Organisations: Department of Wind Energy, Test and Measurements
Authors: Fernandez Garcia, S. (Intern), Villanueva, H. (Intern)
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Series: DTU Wind Energy LC I
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Publication: Research › Report – Annual report year: 2016

Lidar to lidar calibration of Ground-based Lidar
This report presents the result of the lidar to lidar calibration performed for ground-based lidar. Calibration is here understood as the establishment of a relation between the reference lidar wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements. The comparison of the lidar measurements of the wind direction with that from the reference lidar measurements are given for information only.

General information
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Organisations: Department of Wind Energy, Test and Measurements
Authors: Fernandez Garcia, S. (Intern), Courtney, M. (Intern)
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Main Research Area: Technical/natural sciences

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Lidar to lidar calibration of Ground-based Lidar
This report presents the result of the lidar to lidar calibration performed for ground-based lidar. Calibration is here understood as the establishment of a relation between the reference lidar wind speed measurements with measurement uncertainties provided by measurement standard and corresponding lidar wind speed indications with associated measurement uncertainties. The lidar calibration concerns the 10 minute mean wind speed measurements. The comparison of the lidar measurements of the wind direction with that from the reference lidar measurements are given for information only.
Load Measurements
The report describes Load measurements carried out on a given wind turbine. The aim of the measurement program regarding the loads on the turbine is to verify the basic characteristics of the wind turbine and loads on the blades, the rotor and the tower, using [Ref 1], [Ref2] and [Ref 3]. Regarding the fatigue loads, the rotor, blades and tower moments are presented. The fatigue loads are evaluated using rainflow counting described in detail in Ref. [1]. The 1Hz equivalent load ranges are calculated at different wind speeds. All information regarding the instrumentation is collected in [ref 4] and [ref 6].
Load Measurements
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General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Kock, C. W. (Intern), Federici, P. (Intern)
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Publication: Research › Report – Annual report year: 2016

Long-Range WindScanner System
The technical aspects of a multi-Doppler LiDAR instrument, the long-range WindScanner system, are presented accompanied by an overview of the results from several field campaigns. The long-range WindScanner system consists of three spatially-separated, scanning coherent Doppler LiDARs and a remote master computer that coordinates them. The LiDARs were carefully engineered to perform user-defined and time-controlled scanning trajectories. Their wireless coordination via the master computer allows achieving and maintaining the LiDARs’ synchronization within ten milliseconds. The long-range WindScanner system measures the wind field by emitting and directing three laser beams to intersect, and then scanning the beam intersection over a region of interest. The long-range WindScanner system was developed to tackle the need for high-quality observations of wind fields on scales of modern wind turbine and wind farms. It has been in operation since 2013.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Leosphere
Authors: Vasiljevic, N. (Intern), Lea, G. (Intern), Courtney, M. (Intern), Cariou, J. (Ekstern), Mann, J. (Intern), Mikkelsen, T. K. (Intern)
Number of pages: 24
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
Journal: Remote Sensing
Volume: 8
Long-term research challenges in wind energy – a research agenda by the European Academy of Wind Energy

The European Academy of Wind Energy (eawe), representing universities and institutes with a significant wind energy programme in 14 countries, has discussed the long-term research challenges in wind energy. In contrast to research agendas addressing short- to medium-term research activities, this eawe document takes a longer-term perspective, addressing the scientific knowledge base that is required to develop wind energy beyond the applications of today and tomorrow. In other words, this long-term research agenda is driven by problems and curiosity, addressing basic research and fundamental knowledge in 11 research areas, ranging from physics and design to environmental and societal aspects. Because of the very nature of this initiative, this document does not intend to be permanent or complete. It shows the vision of the experts of the eawe, but other views may be possible. We sincerely hope that it will spur an even more intensive discussion worldwide within the wind energy community.

General information

State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Fluid Mechanics, Wind Turbine Structures and Component Design, Integration & Planning, Department of Management Engineering, Energy Economics and Regulation, Deff University of Technology, National Renewable Energy Laboratory, Durham University, University of Stuttgart, Wageningen IMARES, University of Oldenburg, Politecnico di Milano, Knowledge Centre Wind turbine Materials and Constructions, Centre for Renewable Energy Sources, Aalborg University, Norwegian University of Science and Technology, Royal Belgian Institute of Natural Sciences
Pages: 1-39
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
Journal: Wind Energy Science
Making space for wind farms: Practices of territorial stigmatisation in rural Denmark

Whilst issues of siting wind farms have mostly revolved around their public acceptance resulting from an unequal distribution of local costs and benefits, the perceived fairness of the planning process and the disruption of places, the challenge of finding adequate locations and getting access to the land for large wind projects in the first place is becoming increasingly significant. This matter becomes particularly relevant in small countries with relatively mature wind energy sectors, such as Denmark. Although the Danish Renewable Energy Act provides unique measures that allow for greater community involvement and ownership of wind farms, access to diminishing spatial resources reflects a key concern for developers, while putting the role of private landowners at the core of successful projects. By drawing on case studies from rural Northern Denmark it will be demonstrated how narratives of territorial stigmatisation are mobilised and aligned by developers and municipalities in order to make space for and legitimise large wind farm projects in rural areas. In doing so, the paper will illustrate how stigmatisation practices are embedded in discourses of rurality as ‘Outskirts-Denmark’ that generate a division between areas of energy production and consumption. In more practical terms, it will be shown that ‘new development practices’ of mapping suitable areas, and purchasing and demolishing properties in marginalised rural areas may not only reflect mechanisms of an evolved wind energy industry, but also allow wind farm developers to avoid conflicts by expediting depopulation.

General information
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Organisations: Department of Wind Energy, Integration & Planning
Authors: Rudolph, D. P. (Intern), Kirkegaard, J. K. (Intern)
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Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2016

Mapping Wind Farm Loads and Power Production - A Case Study on Horns Rev 1

This paper describes the development of a wind turbine (WT) component lifetime fatigue load variation map within an offshore wind farm. A case study on the offshore wind farm Horns Rev I is conducted with this purpose, by quantifying wake effects using the Dynamic Wake Meandering (DWM) method, which has previously been validated based on CFD, Lidar and full scale load measurements. Fully coupled aeroelastic load simulations using turbulent wind conditions are conducted for all wind directions and mean wind speeds between cut-in and cut-out using site specific turbulence level measurements. Based on the mean wind speed and direction distribution, the representative 20-year lifetime fatigue loads are calculated. It is found that the heaviest loaded WT is not the same when looking at blade root, tower top or tower base components. The blade loads are mainly dominated by the wake situations above rated wind speed and the highest loaded blades are in the easternmost row as the dominating wind direction is from West. Regarding the tower components, the highest loaded WTs are also located towards the eastern central location. The turbines with highest power production are, not surprisingly, the ones facing a free sector towards west and south. The power production results of few turbines are compared with SCADA data. The results of this paper are expected to have significance for operation and maintenance planning, where the schedules for inspection and service activities can be adjusted to the requirements arising from the varying fatigue levels. Furthermore, the results can be used in the context of remaining fatigue lifetime assessment and planning of decommissioning.

General information
State: Published
MARE-WINT. New Materials and Reliability in Offshore Wind Turbine Technology
This book provides a holistic, interdisciplinary overview of offshore wind energy, and is a must-read for advanced researchers. Topics, from the design and analysis of future turbines, to the decommissioning of wind farms, are covered. The scope of the work ranges from analytical, numerical and experimental advancements in structural and fluid mechanics, to novel developments in risk, safety & reliability engineering for offshore wind. The core objective of the current work is to make offshore wind energy more competitive, by improving the reliability, and operations and maintenance (O&M) strategies of wind turbines. The research was carried out under the auspices of the EU-funded project, MARE-WINT. The work seeks to bridge the gap between research and a rapidly-evolving industry.

Matrices for natural fiber composites

Measurement System & Calibration report
This Measurement System & Calibration report is describing DTU’s measurement system installed at a specific wind turbine. A part of the sensors has been installed by others, the rest of the sensors have been installed by DTU. The results of the measurements, described in this report, are only valid for the specific wind turbine.
Measurement System and Calibration report
This Measurement System & Calibration report is describing DTU's measurement system installed at a specific wind turbine. A major part of the sensors has been installed by others (see [1]) the rest of the sensors have been installed by DTU. The results of the measurements, described in this report, are only valid for the specific wind turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Kock, C. W. (Intern), Federici, P. (Intern)
Number of pages: 268
Publication date: 2016

Bibliographical note
This is an internal report and therefore not available in full text. Please contact author's or director of author's department for further information.
Publication: Research › Report – Annual report year: 2016
Measurement System and Calibration report
This Measurement System & Calibration report is describing DTU's measurement system installed at a specific wind turbine. A major part of the sensors has been installed by others (see [1]) the rest of the sensors have been installed by DTU. The results of the measurements, described in this report, are only valid for the specific wind turbine.

Method for independent strain and temperature measurement in polymeric tensile test specimen using embedded FBG sensors
A novel method to obtain independent strain and temperature measurements using embedded Fibre Bragg Grating (FBG) in polymeric tensile test specimens is presented in this paper. The FBG strain and temperature cross-sensitivity was decoupled using two single mode FBG sensors, which were embedded in the specimen material with a certain angle between them. It is demonstrated that, during temperature variation, both FBG sensors show the same signal response. However, for any applied load the signal response is different, which is caused by the different levels of strain acting in each sensor. Equations to calculate independently the strain and temperature are presented in the article, together with a measurement resolution study. This multi-parameter measurement method was applied to an epoxy tensile specimen, tested in a unidirectional tensile test machine with a temperature controlled cabinet. A full calibration procedure (temperature and strain) was performed to this material-sensor pair, where a calibration error < 1% was achieved. This was followed by a strain-temperature test case, where multiple two loading/strain stages of ε = 0.30% and ε = 0.50% were applied during a continuous variation of temperature, from 40 C to -10 C. The consistency of the expected theoretical results with the calibration procedure and the experimental validation shows that this proposed method is applicable to measure accurate strain and temperature in polymers during static or fatigue tensile testing. Two different calibration protocols are presented and analysed. © 2016 Elsevier Ltd. All rights reserved.
Methodology for testing subcomponents; background and motivation for subcomponent testing of wind turbine rotor blades

This report aims to provide an overview of the design methodology followed by wind turbine blade structural designers, along with the testing procedure on full scale blades which are followed by testing laboratories for blade manufacturers as required by the relevant standards and certification bodies' recommendations for design and manufacturing verification. The objective of the report is not to criticize the design methodology or testing procedure and the standards thereof followed in the wind energy community, but to identify those items offered by state of the art structural design tools that cannot be verified through the currently followed testing procedures and recommend ways to overcome these limitations. The work is performed within...
Work-Package WP7.1 entitled "Improved and validated wind turbine structural reliability - Efficient blade structure" of the IRPWIND programme. The numerical investigations performed are based on the INNWIND.EU reference 10MW horizontal axis wind turbine [1]. The structural properties and material and layout definition used within IRPWIND are defined in the INNWIND.EU report [2]. The layout of the report includes a review of the structural analysis models used for blade design, highlighting the current state of the art. The review of the full-scale blade testing procedure is performed under Section 3, followed by the discussion on the issues of verification of design and manufacture performed through testing. Finally, methodologies for testing blade subcomponents and blade parts are described in 5. The present report is complemented by all details of the comparison of blade test loads against design loads on the reference blade, as provided in Annex 1. These data will facilitate direct comparisons in fine points of interest along the reference blade for the load cases considered. The recommendations of this report are relevant for the design and testing of wind turbine subcomponents, in order to verify the numerical analysis tools used in the structural design of wind turbine blades.

General information
State: Published
Authors: Antoniou, A. (Ekstern), Branner, K. (Intern), Lekou, D. (Ekstern), Nuin, I. (Ekstern), Nijssen, R. (Ekstern)
Number of pages: 94
Publication date: 2016

Microstructural Analysis of Orientation-Dependent Recovery and Recrystallization in a Modified 9Cr-1Mo Steel Deformed by Compression at a High Strain Rate
The evolution of the microstructure and texture during annealing of a modified ferritic/martensitic 9Cr-1Mo steel compressed by dynamic plastic deformation (DPD) to a strain of 2.3 has been investigated using transmission electron microscopy and electron backscatter diffraction. It is found that the duplex 〈111〉 + 〈100〉 fiber texture formed by DPD is transformed during annealing to a dominant 〈111〉 fiber texture, and that crystalites of the 〈111〉 component have an advantage during both nucleation and growth. Detailed characterization of the microstructural morphology, and estimation of the stored energies in 〈111〉 - and 〈100〉 -oriented regions in deformed and annealed samples, as well as investigations of the growth of recrystallizing grains, are used to analyze the annealing behavior. It is concluded that recrystallization in the given material occurs by a combination of oriented nucleation and oriented growth.

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Organisations: Department of Wind Energy, Materials science and characterization, Department of Mechanical Engineering, Materials and Surface Engineering, Sino-Danish Center for Education and Research, Chinese Academy of Sciences
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Web of Science (2017): Indexed Yes
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Scopus rating (2016): CiteScore 1.91 SJR 1.206 SNIP 1.336
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.267 SNIP 1.407 CiteScore 1.78
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.659 SNIP 1.848 CiteScore 2.06
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.513 SNIP 1.656 CiteScore 1.9
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ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
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Web of Science (2005): Indexed yes
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Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.847 SNIP 1.892
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Bibliographical note
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Microstructure, quantification and control of dislocations in bast-type plant fibres

Bast-type plant fibres are increasingly being used for structural composite applications where high quality fibres with good mechanical properties are required. A central aspect for this application is the existence of dislocations in the cell wall of plant fibres, i.e. regions of misaligned cellulose microfibrils, which are believed to form weak points leading to reduced mechanical properties. In the present study, microstructural observations of dislocations are made using high-magnification scanning electron microscopy. An experimental protocol using polarized optical microscopy and image analysis is presented for the quantification of dislocations in plant fibres. The protocol is evaluated with respect to its robustness, and the uncertainty of the determined content of dislocations. Based on in-situ straining of fibres under the optical microscopy, findings are presented to show that this leads to a reduction in the content of dislocations. This is indicating that dislocations in the cell wall of plant fibres are changeable structures. Preliminary work is presented where plant fibres are exposed to physical treatments involving moisture and mechanical straining in order to change the content of dislocations. The effect of the treatments is evaluated by tensile testing of single fibres.

Mobile network architecture of the long-range WindScanner system

In this report we have presented the network architecture of the long-range WindScanner system that allows utilization of mobile network connections without the use of static public IP addresses. The architecture mitigates the issues of additional fees and contractual obligations that are linked to the acquisition of the mobile network connections with static public IP addresses. The architecture consists of a hardware VPN solution based on the network appliances Z1 and MX60 from Cisco Meraki with additional 3G or 4G dongles. With the presented network architecture and appropriate configuration, we fulfill the requirements of running the long-range WindScanner system using a mobile network such as 3G. This architecture allows us to have the WindScanners and the master computer in different geographical locations, and in general facilitates deployments of the long-range WindScanner system.
Modal dynamics of structures with bladed isotropic rotors and its complexity for 2-bladed rotors
The modal dynamics of structures with bladed isotropic rotors is analyzed using Hill’s method. First, analytical derivation of the periodic system matrix shows that isotropic rotors with more than two blades can be represented by an exact Fourier series with 3/rev as the highest order. For 2-bladed rotors, the inverse mass matrix has an infinite Fourier series with harmonic components of decreasing norm, thus the system matrix can be approximated by a truncated Fourier series of predictable accuracy. Second, a novel method for automatically identifying the principal solutions of Hill's eigenvalue problem is introduced. The corresponding periodic eigenvectors can be used to compute symmetric and anti-symmetric components of the 2-bladed rotor motion, and the additional forward and backward whirling components for rotors with more than two blades. Finally, the generic methods are used on a simple wind turbine model consisting of three degrees of freedom for each blade and seven degrees of freedom for the nacelle and drivetrain. The modal dynamics of a 3-bladed 10MW turbine from previous studies is recaptured. Removing one blade, the larger and higher harmonic terms in the system matrix lead to resonant modal couplings for the 2-bladed turbine that do not exist for the 3-bladed turbine, and that excitation of a single mode of a 2-bladed turbine leads to responses at several frequencies in both the ground-fixed and rotating blade frames of reference which complicates the interpretation of simulated or measured turbine responses.

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Organisations: Department of Wind Energy, Wind turbine loads & control
Authors: Hansen, M. H. (Intern)
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Source-ID: 2342046666
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Modeling dynamic stall on wind turbine blades under rotationally augmented flow fields
This paper presents an investigation of two well-known aerodynamic phenomena, rotational augmentation and dynamic stall, together in the inboard parts of wind turbine blades. This analysis is carried out using the following: (1) the National Renewable Energy Laboratory’s Unsteady Aerodynamics Experiment Phase VI experimental data, including constant as well as continuously pitching blade conditions during axial operation; (2) data from unsteady delayed detached eddy simulations (DDES) carried out using the Technical University of Denmark’s in-house flow solver Ellipsys3D; and (3) data from a reduced order dynamic stall model that uses rotationally augmented steady-state polars obtained from steady Phase VI experimental sequences, instead of the traditional two-dimensional, non-rotating data. The aim of this work is twofold. First, the blade loads estimated by the DDES simulations are compared with three select cases of the N-sequence experimental data, which serves as a validation of the DDES method. Results show reasonable agreement between the two data in two out of three cases studied. Second, the dynamic time series of the lift and the moment polars obtained from the experiments are compared with those from the dynamic stall model. This allowed the differences between the stall phenomenon on the inboard parts of harmonically pitching blades on a rotating wind turbine and the classic dynamic stall representation in two-dimensional flow to be investigated. Results indicated a good qualitative agreement between the model and the experimental data in many cases, which suggests that the current two-dimensional dynamic stall model as used in blade element momentum-based aeroelastic codes may provide a reasonably accurate representation of three-dimensional rotor aerodynamics when used in combination with a robust rotational augmentation model. Copyright © 2015 John Wiley & Sons, Ltd.

General information
State: Published
Organisations: Department of Wind Energy, Aeroelastic Design, National Renewable Energy Laboratory
Authors: Guntur, S. (Ekstern), Sørensen, N. N. (Intern), Schreck, S. (Ekstern), Bergami, L. (Intern)
Number of pages: 15
Pages: 383–397
Publication date: 2016
Modeling of the dynamics of wind to power conversion including high wind speed behavior
This paper proposes and validates an efficient, generic and computationally simple dynamic model for the conversion of the wind speed at hub height into the electrical power by a wind turbine. This proposed wind turbine model was developed as a first step to simulate wind power time series for power system studies. This paper focuses on describing and validating the single wind turbine model, and is therefore neither describing wind speed modeling nor aggregation of contributions from a whole wind farm or a power system area. The state-of-the-art is to use static power curves for the purpose of power system studies, but the idea of the proposed wind turbine model is to include the main dynamic effects in order to have a better representation of the fluctuations in the output power and of the fast power ramping especially because of high wind speed shutdowns of the wind turbine. The high wind speed shutdowns and restarts are represented as on–off switching rules that govern the output of the wind turbine at extreme wind speed conditions. The model uses the concept of equivalent wind speed, estimated from the single point (hub height) wind speed using a second-order dynamic filter that is derived from an admittance function. The equivalent wind speed is a representation of the averaging of the wind speeds over the wind turbine rotor plane and is used as input to the static power curve to get the output power. The proposed wind turbine model is validated for the whole operating range using measurements available from the DONG Energy offshore wind farm Horns Rev 2. Copyright © 2015 John Wiley & Sons, Ltd.
Modelling of volumetric composition and mechanical properties of unidirectional hemp/epoxy composites - Effect of enzymatic fibre treatment

The objective of the present study is to assess the effect of enzymatic fibre treatments on the fibre performance in unidirectional hemp/epoxy composites by modelling the volumetric composition and mechanical properties of the composites. It is shown that the applied models can well predict the changes in volumetric composition and mechanical properties of the composites when differently treated hemp fibres are used. The decrease in the fibre correlated porosity factor with the enzymatic fibre treatments shows that the removal of pectin by pectinolytic enzymes results in a better fibre impregnation by the epoxy matrix, and the mechanical properties of the composites are thereby increased. The effective fibre stiffness and strength established from the modelling show that the enzymatic removal of pectin also leads to increased mechanical properties of the fibres. Among the investigated samples, the composites with hydrothermally pre-treated and enzymatically treated fibres have the lowest porosity factor of 0.08 and the highest mechanical properties. In these composites, the effective fibre stiffness and strength are determined to be 83 GPa and 667 MPa, respectively, when the porosity efficiency exponent is set equal to 2. Altogether, it is demonstrated that the applied models provide a concept to be used for the evaluation of performance of treated fibres in composites.

General information
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Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, Department of Wind Energy, Composites and Materials Mechanics
Authors: Liu, M. (Intern), Thygesen, A. (Intern), Meyer, A. S. (Intern), Madsen, B. (Intern)
Number of pages: 11
Publication date: 2016
Main Research Area: Technical/natural sciences
Modelling of Vortex-Induced Loading on a Single-Blade Installation Setup

Vortex-induced integral loading fluctuations on a single suspended blade at various inflow angles were modeled in the present work by means of stochastic modeling methods. The reference time series were obtained by 3D DES CFD computations carried out on the DTU 10MW reference wind turbine blade. In the reference time series, the flapwise force component, Fx, showed both higher absolute values and variation than the chordwise force component, Fz, for every inflow angle considered. For this reason, the present paper focused on modelling of the Fx and not the Fz whereas Fz would be modelled using exactly the same procedure. The reference time series were significantly different, depending on the inflow angle. This made the modelling of all the time series with a single and relatively simple engineering model challenging. In order to find model parameters, optimizations were carried out, based on the root-mean-square error between the Single-Sided Amplitude Spectra of the reference and modelled time series. In order to model well defined frequency peaks present at certain inflow angles, optimized sine functions were superposed on the stochastically modelled time series. The results showed that the modelling accuracy varied depending on the inflow angle. None the less, the modelled and reference time series showed a satisfactory general agreement in terms of their visual and frequency characteristics. This indicated that the proposed method is suitable to model loading fluctuations on suspended blades.

General information
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Authors: Skrzypinski, W. R. (Intern), Gaunaa, M. (Intern), Heinz, J. C. (Intern)
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BFI conference series: European Academy of Wind Energy : The Science of Making Torque from Wind (5010078)
Multi-fidelity wake modelling based on Co-Kriging method

The article presents an approach to combine wake models of multiple levels of fidelity, which is capable of giving accurate predictions with only a small number of high fidelity samples. The G. C. Larsen and k-ε-fP based RANS models are adopted as ensemble members of low fidelity and high fidelity models, respectively. Both the univariate and multivariate
based surrogate models are established by taking the local wind speed and wind direction as variables of the wind farm power efficiency function. Various multi-fidelity surrogate models are compared and different sampling schemes are discussed. The analysis shows that the multi-fidelity wake models could tremendously reduce the high fidelity model evaluations needed in building an accurate surrogate.

**General information**

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Organisations: Resource Assessment Modelling, Department of Wind Energy, Aerodynamic design, North China Electric Power University
Authors: Wang, Y. M. (Ekstern), Réthoré, P. (Intern), van der Laan, P. (Intern), Murcia Leon, J. P. (Intern), Liu, Y. Q. (Ekstern), Li, L. (Ekstern)
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Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
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ISI indexed (2013): ISI indexed no
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ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.351
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Scopus rating (2009): SJR 0.259 SNIP 0.346
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.264 SNIP 0.301
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.258 SNIP 0.399
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.272 SNIP 0.311
Multi-level hydrodynamic modelling of a scaled 10MW TLP wind turbine

In the present paper the accuracy of three numerical models for a scaled 10MW TLP wind turbine is assessed by comparison with test data. The three models present different levels of complexity, and therefore different degrees of accuracy can be expected. A set of load cases including irregular and focused waves is run in the three models, where only wave loads are considered. The simulation results are compared against the test data, and the numerical models are assessed based on their ability to reproduce the test results. Finally, the possibility of enhancing the simple model by using the advanced models is discussed. (C) 2016 The Authors. Published by Elsevier Ltd.

General information
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Organisations: Department of Wind Energy, Fluid Mechanics
Authors: Pegalajar Jurado, A. M. (Intern), Bredmose, H. (Intern), Borg, M. (Intern)
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Scopus rating (2016): CiteScore 1.16 SJR 0.464 SNIP 0.598
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BFI (2014): BFI-level 1
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BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.42 SNIP 0.778 CiteScore 1.02
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
Scopus rating (2012): SJR 0.411 SNIP 0.55 CiteScore 1.08
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
Scopus rating (2011): SJR 0.877 SNIP 1.45 CiteScore 2.42
ISI indexed (2011): ISI indexed no
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Hydrodynamic modelling, Floating wind turbine, TLP, Tension leg platform, Wave loads, Dynamic response
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One of today’s greatest global challenges is the need for clean, reliable, and renewable sources of energy, and wind energy has a key role in this process. However, in order to compete with other less “green” sources of energy the cost to produce wind made electricity needs to be reduced. One way to achieve this is by improving the reliability of wind turbine components and optimising operation and maintenance strategies. This PhD project is part of the European research project MareWint, where the main objective is to develop an innovative approach for coupled multi physics cosimulation, testing, design and optimisation of offshore wind turbines. The MareWint main scientific objective is to optimise the design of offshore wind turbines, maximise reliability, and minimise maintenance costs. Integrated within the innovative rotor blades work-package, this PhD project is focused on damage analysis and structural health monitoring of wind turbine blades. The work presented sets the required framework to develop a monitoring system based on Fibre Bragg gratings (FBG), which can be applied to the different life stages of a wind turbine blade. In this concept, the different measured physical parameters are used to improve the design process, and the implemented sensor are used to control the manufacturing and operation stage of a wind turbine rotor blade. The FBG sensors measurement principle is analysed from a multi-life-stage (design, material testing, manufacturing, and operation) perspective, and supported/validated by numerical models, software tools, signal post-processing, and experimental validation. The damage in the wind turbine rotor blade is analysed from a material perspective (fibre reinforced polymers) and used as a design property, meaning that damage is accepted in an operational wind turbine as long as it is monitored. Thus, a novel crack/damage detection method using FBG sensors is presented, and software/tools are developed for signal simulation and post-processing. The first part of the thesis is an introduction to the multi-life-stage monitoring system based on FBG sensors and the damage tolerant design of fibre reinforced materials, where the different theory and numerical models used are presented. The second part of the thesis is a compilation of scientific journal papers, in which the use of FBG sensors to monitor the different life-stages of the wind turbine rotor blade is described in more detail. In Paper P1, a methodology for reliable design and maintenance of wind turbine rotor blades based on a damage tolerance and structural health monitoring approach is presented. Paper P2 presents a novel method to obtain independent strain and temperature measurements using embedded FBG sensors in polymeric tensile tests. In paper P3, a novel method for assessing crack growth in fibre reinforced polymer or structural adhesive bonded structures by combining conventional measured parameters with post-processing correction of measurement errors is presented. Paper P4 presents a FBG signal post-processing tool. In paper P5, a software development tool to simulate the FBG signal from a finite element method model is described. Paper P6 fits within the manufacturing stage, describing a residual strain measurement solution based on FBG sensors. In paper P7, the fracture process zone length in double cantilever beam specimens is analysed analytically and numerically.
Multi-objective random search algorithm for simultaneously optimizing wind farm layout and number of turbines

A new algorithm for multi-objective wind farm layout optimization is presented. It formulates the wind turbine locations as continuous variables and is capable of optimizing the number of turbines and their locations in the wind farm simultaneously. Two objectives are considered. One is to maximize the total power production, which is calculated by considering the wake effects using the Jensen wake model combined with the local wind distribution. The other is to minimize the total electrical cable length. This length is assumed to be the total length of the minimal spanning tree that connects all turbines and is calculated by using Prim’s algorithm. Constraints on wind farm boundary and wind turbine proximity are also considered. An ideal test case shows the proposed algorithm largely outperforms a famous multi-objective genetic algorithm (NSGA-II). In the real test case based on the Horn Rev 1 wind farm, the algorithm also obtains useful Pareto frontiers and provides a wide range of Pareto optimal layouts with different numbers of turbines for a real-life wind farm developer.

General information
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Organisations: Department of Wind Energy, Fluid Mechanics, Hohai University
Authors: Feng, J. (Intern), Shen, W. Z. (Intern), Xu, C. (Ekstern)
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Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
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BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
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ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.351
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.259 SNIP 0.346
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.264 SNIP 0.301
Multiple vortex structures in the wake of a rectangular winglet in ground effect

Patterns of vorticity in the wake of a single rectangular winglet (vortex generator) embedded in a turbulent boundary layer have been studied using Stereoscopic Particle Image Velocimetry (SPIV). The winglet was mounted normally to a flat surface with an angle to the oncoming flow. A parametric study varying the winglet height (constant aspect ratio) and angle has shown, contrary to the common classical single tip-vortex conception, that the wake generally consists of a complex system of multiple vortex structures. The primary vortex has previously been discovered to contain a direct coupling between the axial and the rotational flow. In the current work, even the longitudinal secondary structures detected from measured streamwise vorticity display similar behavior. A regime map depicting the observed stable far wake states of the multiple vortices as a function of winglet height and angle reveals complex patterns of the flow topologies not only with the primary tip vortex, but with the additional secondary structures as well. A bifurcation diagram shows distinct regimes of the various secondary structures as well as how the primary vortex is in some cases significantly affected by their presence. These data should serve as inspiration in the process of generating longitudinal vortices for enhancement of heat and mass transfer in industrial devices since the multiple vortex regimes can help improve the conditions for these exchanges. Further, these results point to a weakness in existing inviscid models not accounting for the possibility of multiple vortical structures in the wake. © 2015 Elsevier Inc. All rights reserved.

General information
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Organisations: Department of Mechanical Engineering, Fluid Mechanics, Coastal and Maritime Engineering, Department of Wind Energy, Fluid Mechanics
Authors: Velte, C. M. (Intern), Hansen, M. O. L. (Intern), Okulov, V. L. (Intern)
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Main Research Area: Technical/natural sciences

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Scopus rating (2016): CiteScore 3.14 SJR 1.402 SNIP 1.929
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.387 SNIP 1.788 CiteScore 2.58
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.51 SNIP 2.02 CiteScore 2.57
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.287 SNIP 2.068 CiteScore 2.63
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Nacelle power curve measurement with spinner anemometer and uncertainty evaluation

The objective of this investigation was to verify the feasibility of using the spinner anemometer calibration and nacelle transfer function determined on one reference turbine, to assess the power performance of a second identical turbine. An experiment was set up with a met-mast in a position suitable to measure the power curve of the two wind turbines, both...
equipped with a spinner anemometer. An IEC 61400-12-1 compliant power curve was then measured for both turbines using the met-mast. The NTF (Nacelle Transfer Function) was measured on the reference turbine and then applied to both turbines to calculate the free wind speed. For each of the two wind turbines, the power curve (PC) was measured with the met-mast and the nacelle power curve (NPC) with the spinner anemometer. Four power curves (two PC and two NPC) were compared in terms of AEP (Annual Energy Production) for a Rayleigh wind speed probability distribution. For each turbine, the NPC agreed with the corresponding PC within 0.10% of AEP for the reference turbine and within 0.38% for the second turbine, for a mean wind speed of 8 m/s.

**General information**

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Organisations: Meteorology & Remote Sensing, Department of Wind Energy
Authors: Demurtas, G. (Intern), Friis Pedersen, T. (Intern), Wagner, R. (Intern)
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Publication: Research - peer-review › Journal article – Annual report year: 2016

**Nacelle Transfer Function**

The report describes measurements carried out on a given turbine. A comparison between wind speed on the met mast and Nacelle Wind speed are made and the results are presented on graphs and in a table. The data used for the comparison are the data that are same as used for the power curve report. The measurements have been performed using DTU's measurement equipment, the analysis and quality control has been performed by DTU.

**General information**

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Organisations: Department of Wind Energy, Test and Measurements
Authors: Federici, P. (Intern), Kock, C. W. (Intern)
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Publication: Research › Report – Annual report year: 2016

**Nacelle Transfer Function**

The report describes measurements carried out on a given turbine. A comparison between wind speed on the met mast and Nacelle Wind speed are made and the results are presented on graphs and in a table. The data used for the comparison are the data that are same as used for the power curve report. The measurements have been performed using DTU's measurement equipment, the analysis and quality control has been performed by DTU.
Nanomorphology of graphene and CNT reinforced polymer and its effect on damage: Micromechanical numerical study

The effect of morphology, shapes and distribution of nanoscale carbon reinforcement in polymers on their strength and damage resistance is studied using computational micromechanical modeling. A new software and approach were developed for the automatic generation of finite element unit cell models of nanocomposites with inclusions of arbitrary and complex shapes. The effect of curved, zigzagged, snake-like shapes of real carbon nanotubes, as well as re-stacking of graphene on the damage evolution was studied in the computational experiments based on the developed code. The potential of hybrid (carbon nanotubes and graphene) nanoscale reinforcement was studied with view on its effects on the damage resistance. It was demonstrated that idealized, cylinder-like models of carbon nanotubes in polymers lead to an underestimation of the stress concentration and damage likelihood in the nanocomposites. The main damage mechanisms in CNT reinforced polymers are debonding and pull-out/fiber bridging, while in graphene reinforced polymers the main role is played by crack deviation and stack splitting, with following micro-crack merging. The potential of hybrid (carbon nanotubes and graphene) nanoscale reinforcement was studied with view on its effect on damage resistance. (C) 2016 Elsevier Ltd. All rights reserved.
Natural fibre selection for composite eco-design

Natural fibre composites (NFC) are gaining interest in manufacturing because they address some of the environmental problems of traditional composites: use of non-renewable resources, and large impacts related to their production and disposal. Since natural fibres are not yet optimized for composite production, it is crucial to identify the most appropriate applications, and determine the optimal fibre/matrix ratio. A methodology is proposed for early-stage decisions support on selection of bio-composite materials. Results help identify the application with the largest reduction in environmental burden and show that the fibre/matrix combination with the lowest environmental burden also has the best mechanical properties.

General information

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Organisations: Department of Management Engineering, Quantitative Sustainability Assessment, Department of Wind Energy, Composites and Materials Mechanics
Authors: Corona, A. (Intern), Madsen, B. (Intern), Hauschild, M. Z. (Intern), Birkved, M. (Intern)
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Scopus rating (2017): CiteScore 4.09 SJR 2.034 SNIP 2.811
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.93 SJR 2.055 SNIP 3.158
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.088 SNIP 3.294 CiteScore 3.83
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 3.123 SNIP 3.992 CiteScore 4.39
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.598 SNIP 3.818 CiteScore 3.87
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.088 SNIP 4.156 CiteScore 3.04
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
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Scopus rating (2011): SJR 2.117 SNIP 3.46 CiteScore 2.81
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.12 SNIP 3.449
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.652 SNIP 2.219
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.056 SNIP 1.645
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.119 SNIP 1.55
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.892 SNIP 1.96
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.988 SNIP 1.904
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.591 SNIP 2.376
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.142 SNIP 1.823
Web of Science (2003): Indexed yes
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Web of Science (2002): Indexed yes
New direct drive technologies of INNWIND.EU: Superconducting vs. Pseudo Direct Drive

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Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Abrahamsen, A. B. (Intern)
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Presentation

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Oral presentation
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Noise model for serrated trailing edges compared to wind tunnel measurements
A new CFD RANS based method to predict the far field sound pressure emitted from an aerofoil with serrated trailing edge has been developed. The model was validated by comparison to measurements conducted in the Virginia Tech Stability Wind Tunnel. The model predicted 3 dB lower sound pressure levels, but the tendencies for the different configurations were predicted correctly. Therefore the model can be used to optimise the serration geometry. A disadvantage of the new model is that the computational costs are significantly higher than for the Amiet model for a straight trailing edge. However, it is by decades faster than LES methods.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design, Fluid Mechanics, LM Wind Power
Authors: Fischer, A. (Intern), Bertagnolio, F. (Intern), Shen, W. Z. (Intern), Madsen, J. (Ekstern)
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BFI (2018): BFI-level 1
Non-linear ultimate strength and stability limit state analysis of a wind turbine blade

According to the design codes for wind turbine blades, it is sufficient to evaluate the blade’s limit states using solely a linear analysis. This study, however, shows the need of non-linear analyses in blade design. Therefore, a geometrically non-linear structural response of a 34 m blade under flap-wise loading has been compared with a linear response to determine the blade’s resistance in the ultimate strength and stability limit states. The linear analysis revealed an unrealistic failure mechanism and failure mode. Further, it did not capture the highly non-linear response of the blade that was measured in an ultimate full-scale test to failure and determined by a geometrically non-linear analysis. A design evaluation in accordance with the least stringent Germanischer Lloyd (GL) requirements has been compared with non-linear approaches proposed by GL and Eurocode, which require the application of an imperfection. The more realistic non-linear approaches yielded more optimistic results than the mandatory linear bifurcation analysis. Consequently, the investigated blade designed after the lesser requirements was sufficient. Using the non-linear approaches, considering inter-fibre failure as the critical failure mode, yielded still a significant safety margin for the designer (7–28%). The non-linear response was significantly dependent on the scaling of the imperfection. Eurocode's method of applying an imperfection appeared more realistic than the GL method. Since the considered blade withstood 135% of the design load at a full-scale test to failure and the blade has operated successfully in the field, GL’s safety factors combined with the
Normalized performance and load data for the deepwind demonstrator in controlled conditions

Performance and load normalized coefficients, deriving from an experimental campaign of measurements conducted at the large scale wind tunnel of the Politecnico di Milano (Italy), are presented with the aim of providing useful benchmark data for the validation of numerical codes. Rough data, derived from real scale measurements on a three-bladed Troposkien vertical-axis wind turbine, are manipulated in a convenient form to be easily compared with the typical outputs provided by simulation codes. The here proposed data complement and support the measurements already presented in "Wind Tunnel Testing of the DeepWind Demonstrator in Design and Tilted Operating Conditions" (Battisti et al., 2016) [1].

General information

State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control, Meteorology & Remote Sensing, Università di Trento, Politecnico di Milano
Authors: Battisti, L. (Ekstern), Benini, E. (Ekstern), Brighenti, A. (Ekstern), Castelli, M. R. (Ekstern), Dell'Anna, S. (Ekstern), Dossena, V. (Ekstern), Persico, G. (Ekstern), Schmidt Paulsen, U. (Intern), Friis Pedersen, T. (Intern)
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DeepWind Project, Skewed flow, Troposkien rotor, VAWT, Wind tunnel measurements, Wind turbine benchmark data

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Nucleation of recrystallization at selected sites in deformed fcc metals

The objective of this thesis is to explore nucleation of recrystallization at selected sites in selected face-centered-cubic (FCC) metals, namely cold rolled columnar-grained nickel and high purity aluminum further deformed by indenting. Various techniques, including, optical microscopy, electron backscattered diffraction (EBSD), electron channeling contrast (ECC) and synchrotron X-ray technique, differential-aperture X-ray microscopy (DAXM), were used to characterize the microstructures, to explore nucleation sites, orientation relationships between nuclei and deformed microstructures, and nucleation mechanisms. In the cold rolled nickel samples, the preference of triple junctions (TJs) and grain boundaries (GBs) as nucleation sites is observed. The majorities of the nuclei have the same orientations as the surrounding matrix or are twin-related to a surrounding deformed grain. Only a few nuclei are observed with orientations different from the
surrounding matrix. Hardness measurements at TJs in the deformed sample indicate a weak correlation between the difference in hardness among the three grains at the TJs and the potentials of the junctions to form nuclei: the higher the difference, the more likely is nucleation. In the weakly rolled and indented aluminum samples, it is found that hardness indentations lead to large orientation rotations near indentation tips. In initial grains of different crystallographic orientations, the grains with higher stored energy (SE) in the rolled microstructures have higher average hardness values and higher nucleation probabilities. In general, indentations with higher hardness values have higher nucleation potentials. The orientations of the nuclei from different indentations in a given grain are observed not to be randomly distributed, but clustered in limited orientation spaces. The orientation spread observed near the indentation tips in the deformed state covers the orientations of the nuclei observed in the annealed state. Whereas the above results are obtained by the EBSD technique and thus are 2D observation, the nucleation at hardness indentations is also investigated non-destructively by the DAXM technique. By first characterizing the deformation microstructure within a selected gauge volume near a hardness indentation, then annealing the sample and measuring the same volume again, nucleation is directly correlated to the deformation microstructures in the bulk of the sample. It is found that the nuclei evolve from embryonic volumes at areas of high SE below the surface and develop because of an advantage of fast migrating boundaries surrounding the initial embryonic volumes. All nuclei have crystallographic orientations as those present within the embryonic volumes in the deformed state. It is further suggested that boundaries between nuclei and the deformed matrix of less than 5° hinder subsequent growth of the nuclei. For all the observed cases, it is suggested that the nucleation mechanism may be strain induced boundary migration (SIBM), but the boundaries are not those conventionally considered, namely original grain boundaries, but are strain induced dislocation boundaries.

**General information**

State: Published  
Organisations: Department of Wind Energy, Materials science and characterization, Technical University of Denmark, Chongqing University  
Authors: Xu, C. (Ekstern), Juul Jensen, D. (Intern), Wu, G. (Ekstern), Zhang, Y. (Intern)  
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**Numerical study of Wavy Blade Section for Wind Turbines**

The Wavy Blade concept is inspired by the unique flipper of a humpback whale, characterized by the tubercles located at the leading edge. It has been suggested that this shape may have been a result of a natural selection process, since this flipper under some circumstances can produce higher lift than a flipper having a smooth trailing edge and thus could be potentially beneficial when catching food. A thorough literature study of the Wavy Blade concept is made and followed by CFD computations of two wavy blade geometries and a comparison with their baseline S809 airfoil at conditions more relevant for modern wind turbines. The findings in the literature from geometries similar to the hump back whale flipper indicate that the aerodynamic performance can be improved at high angles of attack, but sometimes at the expense of a lower lift slope and increased drag before stall. The numerical results for a blade section based on the S809 airfoil are, however, not as promising as some of the findings reported in the literature for the whale flipper at high angles of attack. These first CFD computations using a thicker airfoil and a higher Reynolds number than the whale flipper indicate that the results may very well depend on the actual airfoil geometry and perhaps also the Reynolds number, and future studies are necessary in order to illuminate this further.

**General information**

State: Published  
Organisations: Department of Wind Energy, Fluid Mechanics, Dong Energy Wind Power A/S  
Authors: Kobæk, C. M. (Ekstern), Hansen, M. O. L. (Intern)  
Number of pages: 6  
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Conference: The Science of Making Torque from Wind , Munich, Germany, 05/10/2016 - 05/10/2016  
BFI conference series: European Academy of Wind Energy : The Science of Making Torque from Wind (5010078)  
Main Research Area: Technical/natural sciences
Numerical study on aerodynamic damping of floating vertical axis wind turbines

Harvesting offshore wind energy resources using floating vertical axis wind turbines (VAWTs) has attracted an increasing interest in recent years. Due to its potential impact on fatigue damage, the aerodynamic damping should be considered in the preliminary design of a floating VAWT based on the frequency domain method. However, currently the study on aerodynamic damping of floating VAWTs is very limited. Due to the essential difference in aerodynamic load characteristics, the aerodynamic damping of a floating VAWT could be different from that of a floating horizontal axis wind turbine (HAWT). In this study, the aerodynamic damping of floating VAWTs was studied in a fully coupled manner, and its
influential factors and its effects on the motions, especially the pitch motion, were demonstrated. Three straight-bladed floating VAWTs with identical solidity and with a blade number varying from two to four were considered. The aerodynamic damping under steady and turbulent wind conditions were estimated using fully coupled aero-hydro-servo-elastic time domain simulations. It is found that the aerodynamic damping ratio of the considered floating VAWTs ranges from 1.8% to 5.3%. Moreover, the aerodynamic damping is almost independent of the rotor azimuth angle, and is to some extent sensitive to the blade number.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design, Norwegian University of Science and Technology
Authors: Cheng, Z. (Ekstern), Aagaard Madsen, H. (Intern), Gao, Z. (Ekstern), Moan, T. (Ekstern)
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Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
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Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed no
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BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
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Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.351
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.259 SNIP 0.346
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.264 SNIP 0.301
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.258 SNIP 0.399
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.272 SNIP 0.311
Web of Science (2006): Indexed yes
This paper summarizes the findings from Phase Ib of the Offshore Code Comparison, Collaboration, Continued with Correlation (OC5) project. OC5 is a project run under the International Energy Agency (IEA) Wind Research Task 30, and is focused on validating the tools used for modelling offshore wind systems through the comparison of simulated responses of select offshore wind systems (and components) to physical test data. For Phase Ib of the project, simulated hydrodynamic loads on a flexible cylinder fixed to a sloped bed were validated against test measurements made in the shallow water basin at the Danish Hydraulic Institute (DHI) with support from the Technical University of Denmark (DTU). The first phase of OC5 examined two simple cylinder structures (Phase Ia and Ib) to focus on validation of hydrodynamic models used in the various tools before moving on to more complex offshore wind systems and the associated coupled physics. Verification and validation activities such as these lead to improvement of offshore wind modelling tools, which will enable the development of more innovative and cost-effective offshore wind designs. (C) 2016 The Authors. Published by Elsevier Ltd.
Offshore DC grids for integration of large scale wind power

The present report summarizes the main findings of the Nordic Energy Research project “DC grids for large scale integration of offshore wind power – OffshoreDC”. The project is been funded by Nordic Energy Research through the TFI programme and was active between 2011 and 2016.

The overall objective of the project was to drive the development of the VSC based HVDC technology for future large scale offshore grids, supporting a standardised and commercial development of the technology, and improving the opportunities for the technology to support power system integration of large scale offshore wind power. This was done by bringing together the key industry stakeholders and competent research organisations in the project.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning, Department of Electrical Engineering, DONG Energy A/S, Norwegian University of Science and Technology, VTT, Chalmers University of Technology
Authors: Cutululis, N. A. (ed.) (Intern), Zeni, L. (Ekstern), Endegnanew, A. G. (Ekstern), Stamatiou, G. (Ekstern), El-Khatib, W. Z. (Intern), Helistö, N. (Ekstern)
Number of pages: 98
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Main Research Area: Technical/natural sciences

Offshore wind power in the Aegean Sea

The wind climate of the Mediterranean Sea has been estimated from atmospheric modelling (Cavaleri 2005, Lavignini et al. 2006) and QuikSCAT (Furevik et al. 2011). The latter shows the Aegean Sea as a promising area for offshore wind power development. According to the Hellenic Wind Energy Association (HWEA), the sites of particular interest for offshore wind energy are located close to the mainland and islands in the Aegean Sea. Wind farm developers aim to select local areas with favorable wind conditions to optimize the annual energy production and the economic profit. In the Aegean Sea, where the spatial variations in wind speed are very high, accurate resource mapping is of great importance as the produced wind power is proportional to the cubed wind speed. It is challenging to model the wind resource and it is costly to measure from the ground at every place of interest. Maps based on Synthetic Aperture Radar (SAR) are expected to prove valuable for the exploitation of the excellent wind resource of the Aegean Sea, to the benefit of the national economy. High-resolution SAR satellite data bring new information for pre-feasibility for instance at the policy planning level. For accurate wind resource mapping from satellite it is necessary to collect many images to reduce the
uncertainty. The 10-year Envisat ASAR archive has been used for wind resource mapping. Wind maps from satellite are
retrieved at 10 m. DTU Wind Energy has developed a method for extrapolation of winds to turbine hub heights at around
100 m using a combination of satellite wind fields and the long-term climate of atmospheric stability from the mesoscale
model (Badger et al. 2016). The result of the mean wind speed at hub-height for the Aegean Sea is shown in Figure 1. The
map shows the stability dependent winds (SDW).
It is planned to combine the Envisat wind fields with Sentinel-1a and Sentinel-1b wind fields to further detail the offshore
wind resource within the New European Wind Atlas. The work is in progress. Sentinel-1a images are processed at DTU
Wind Energy near-real-time and we are updating our wind resource software. A service-based on satellite SAR-derived
winds for wind resource estimation is available at DTU Wind Energy. The project was supported by ESA ResGrow and
satellite data from ESA Envisat and Copernicus Sentinel-1.

General information
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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling
Authors: Hasager, C. B. (Intern), Badger, M. (Intern), Hahmann, A. N. (Intern)
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On Displacement Height, from Classical to Practical Formulation: Stress, Turbulent Transport and Vorticity Considerations
Displacement height (d) is an important parameter in the simple modelling of wind speed and vertical fluxes above
vegetative canopies, such as forests. Here we show that, aside from implicit definition through a (displaced) logarithmic
profile, accepted formulations for d do not consistently predict flow properties above a forest. Turbulent transport can
affect the displacement height, and is an integral part of what is called the roughness sublayer. We develop a more
general approach for estimation of d, through production of turbulent kinetic energy and turbulent transport, and show how
previous stress-based formulations for displacement height can be seen as simplified cases of a more general definition
including turbulent transport. Further, we also give a simplified and practical form for d that is in agreement with the
general approach, exploiting the concept of vortex thickness scale from mixing-layer theory. We assess the new and
previous displacement height formulations by using flow statistics derived from the atmospheric boundary-layer Reynolds-
averaged Navier–Stokes model SCADIS as well as from wind-tunnel observations, for different vegetation types and flow
regimes in neutral conditions. The new formulations tend to produce smaller d than stress-based forms, falling closer to
the classic logarithmically-defined displacement height. The new, more generally defined, displacement height appears to
be more compatible with profiles of components of the turbulent kinetic energy budget, accounting for the combined
effects of turbulent transport and shear production. The Coriolis force also plays a role, introducing wind-speed
dependency into the behaviour of the roughness sublayer; this affects the turbulent transport, shear production, stress,
and wind speed, as well as the displacement height, depending on the character of the forest. We further show how our
practical (‘mixing-layer’) form for d matches the new turbulence-based relation, as well as correspondence to previous
(stress-based) formulations.

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Organisations: Department of Wind Energy, Meteorology
Authors: Sogachev, A. (Intern), Kelly, M. C. (Intern)
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On the aero-elastic design of the DTU 10MW wind turbine blade for the LIFES50+ wind tunnel scale model

This paper illustrates the aero-elastic optimal design, the realization and the verification of the wind tunnel scale model blades for the DTU 10 MW wind turbine model, within LIFES50+ project. The aerodynamic design was focused on the minimization of the difference, in terms of thrust coefficient, with respect to the full scale reference. From the Selig low Reynolds database airfoils, the SD7032 was chosen for this purpose and a proper constant section wing was tested at DTU red wind tunnel, providing force and distributed pressure coefficients for the design, in the Reynolds range 30-250 E3 and for different angles of attack. The aero-elastic design algorithm was set to define the optimal spanwise thickness over chord ratio (t/c), the chord length and the twist to match the first flapwise scaled natural frequency. An aluminium mould for the carbon fibre was CNC manufactured based on B-Splines CAD definition of the external geometry. Then the wind tunnel tests at Politecnico di Milano confirmed successful design and manufacturing approaches.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Politecnico di Milano
Authors: Bayati, I. (Ekstern), Belloli, M. (Ekstern), Bernini, L. (Ekstern), Mikkelsen, R. F. (Intern), Zasso, A. (Ekstern)
Number of pages: 13
Publication date: 2016
Conference: The Science of Making Torque from Wind, Munich, Germany, 05/10/2016 - 05/10/2016
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Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.351
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.259 SNIP 0.346
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.264 SNIP 0.301
On the application of the Jensen wake model using a turbulence-dependent wake decay coefficient: the Sexbierum case

We present a methodology to process wind turbine wake simulations, which are closely related to the nature of wake observations and the processing of these to generate the so-called wake cases. The method involves averaging a large number of wake simulations over a range of wind directions and partly accounts for the uncertainty in the wind direction assuming that the same follows a Gaussian distribution. Simulations of the single and double wake measurements at the Sexbierum onshore wind farm are performed using a fast engineering wind farm wake model based on the Jensen wake model, a linearized computational fluid dynamics wake model by Fuga and a nonlinear computational fluid dynamics wake model that solves the Reynolds-averaged Navier–Stokes equations with a modified k-ε turbulence model. The best agreement between models and measurements is found using the Jensen-based wake model with the suggested post-processing. We show that the wake decay coefficient of the Jensen wake model must be decreased from the commonly used onshore value of 0.075 to 0.038, when applied to the Sexbierum cases, as wake decay is related to the height, roughness and atmospheric stability and, thus, to turbulence intensity. Based on surface layer relations and assumptions between turbulence intensity and atmospheric stability, we find that at Sexbierum, the atmosphere was probably close to stable, although the stability was not observed. We support these assumptions using detailed meteorological observations from the Høvsøre site in Denmark, which is topographically similar to the Sexbierum region. © 2015 The Authors. Wind Energy published by John Wiley & Sons Ltd.

General information
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Organisations: Department of Wind Energy, Meteorology, Aeroelastic Design
Authors: Pena Diaz, A. (Intern), Réthoré, P. (Intern), van der Laan, P. (Intern)
Number of pages: 14
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.37 SJR 1.079 SNIP 2.316
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.201 SNIP 2.165 CiteScore 3.06
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.209 SNIP 3.688 CiteScore 3.42
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
On the peculiar structure of a helical wake vortex behind an inclined prolate spheroid

The self-similarity law for axisymmetric wakes has for the first time been examined and verified in a complex helical vortex in the far part of an asymmetric wake by means of direct numerical simulation (DNS). The helical vortex is the main coherent flow structure in the transitional non-axisymmetric wake behind an inclined 6:1 prolate spheroid at Reynolds number 3000 based on the minor axis. The gradual development of the complex helical vortex structure has been described in detail all the way from its inception at the spheroid and into the far wake. We observed a complex vortex composition in the generation stage, a rare jet-like wake pattern in the near wake and an abrupt change of helical symmetry in the vortex core without an accompanying change in flow topology, i.e. with no recirculation bubble.
On the relative importance of loads acting on a floating vertical axis wind turbine system when evaluating the global system response

Interest in offshore floating wind turbines has been growing over the last decade. While a number of studies have been conducted to model the dynamics of offshore floating HAWT systems (e.g. OC3-Phase IV, OC4-Phase II), relatively few studies have been conducted on floating VAWT systems, despite their potential advantages. Due to the substantial differences between HAWT and VAWT systems, analysis procedures employed for a floating HAWT analyses cannot be extended to use for floating VAWT systems. Here, the main aim is to provide a systematic analysis and comparison of the forces acting on a reference offshore floating VAWT, considering a turbulent wind field and stochastically generated waves, to assess the more critical loads and distinguish them from those with negligible effect, when estimating the global system response. The floating VAWT system considered is comprised of a 5MW rotor supported by the OC4-Phase II semi submersible. Using the coupled model of dynamics for VAWT "FloVAWT", the global response of the system is estimated for a set of load cases, allowing the assessment of the contributions of individual force components. In particular, the simulations allow us to assess the impact of the VAWT aerodynamic forces, the platform hydrodynamic forces, and the mooring forces. The results help evaluate the relative importance of hydrodynamic with respect to aerodynamic forces, depending on the loading condition. A deeper insight into the aerodynamic forces is provided, which shows the impact of a) the roll/pitch inclination and b) the roll/pitch motion velocities on the rotor aerodynamic response and, eventually, on the global response of the platform.
semisubmersible. Using the coupled model of dynamics for VAWT "FloVAWT", the global response of the system is estimated for a set of load cases, allowing the assessment of the contributions of individual force components. In particular, the simulations allow us to assess the impact of the VAWT aerodynamic forces, the platform hydrodynamic forces, and the mooring forces. The results help evaluate the relative importance of hydrodynamic with respect to aerodynamic forces, depending on the loading condition. A deeper insight into the aerodynamic forces is provided, which shows the impact of a) the roll/pitch inclination and b) the roll/pitch motion velocities on the rotor aerodynamic response and, eventually, on the global response of the platform.

**General information**

State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Cranfield University, University of Texas at Austin
Authors: Collu, M. (Ekstern), Borg, M. (Intern), Manuel, L. (Ekstern)
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Conference: ASME 2016 35th International Conference on Ocean, Offshore and Arctic Engineering (OMAE2016), Busan, Korea, Republic of, 19/06/2016 - 19/06/2016
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Source: Findit
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**On the Space-Time Structure of Sheared Turbulence**

We develop a model that predicts all two-point correlations in high Reynolds number turbulent flow, in both space and time. This is accomplished by combining the design philosophies behind two existing models, the Mann spectral velocity tensor, in which isotropic turbulence is distorted according to rapid distortion theory, and Kristensen's longitudinal coherence model, in which eddies are simultaneously advected by larger eddies as well as decaying. The model is compared with data from both observations and large-eddy simulations and is found to predict spatial correlations comparable to the Mann spectral tensor and temporal coherence better than any known model. Within the developed framework, Lagrangian two-point correlations in space and time are also predicted, and the predictions are compared with measurements of isotropic turbulence. The required input to the models, which are formulated as spectral velocity tensors, can be estimated from measured spectra or be derived from the rate of dissipation of turbulent kinetic energy, the friction velocity and the mean shear of the flow. The developed models can, for example, be used in wind-turbine engineering, in applications such as lidar-assisted feed forward control and wind-turbine wake modelling.

**General information**

State: Published
Authors: de Mare, M. T. (Ekstern), Mann, J. (Intern)
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Web of Science (2017): Indexed Yes
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Scopus rating (2016): CiteScore 2.65 SJR 1.525 SNIP 1.325
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.854 SNIP 1.279 CiteScore 2.32
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.802 SNIP 1.785 CiteScore 2.74
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.72 SNIP 1.605 CiteScore 2.4
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.923 SNIP 1.628 CiteScore 2.12
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.378 SNIP 1.345 CiteScore 1.9
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.625 SNIP 1.243
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.953 SNIP 1.356
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.876 SNIP 1.629
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.571 SNIP 1.487
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.765 SNIP 1.368
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.164 SNIP 1.287
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.265 SNIP 1.801
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.86 SNIP 1.396
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.323 SNIP 1.178
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.685 SNIP 1.15
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 1.509 SNIP 1.075
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 1.496 SNIP 0.898

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Earth Sciences, Atmospheric Sciences, Meteorology, Atmospheric Protection/Air Quality Control/Air Pollution, SC7, Sheared turbulence, Spectral velocity tensor, Two-point correlations, Atmospheric Science, Computational fluid dynamics, Kinetic energy, Kinetics, Large eddy simulation, Philosophical aspects, Reynolds number, Shear flow, Turbulence, Velocity, Wind turbines, Isotropic turbulence, Rapid distortion theory, Spacetime structures, Spatial correlations, Turbulent kinetic energy, Two-point correlation, Velocity tensor, Tensors
Open access wind tunnel measurements of a downwind free yawing wind turbine

A series of free yawing wind tunnel experiments was held in the Open Jet Facility (OJF) of the TU Delft. The ≈ 300 W turbine has three blades in a downwind configuration and is optionally free to yaw. Different 1.6m diameter rotor configurations are tested such as blade flexibility and sweep. This paper gives a brief overview of the measurement setup and challenges, and continues with presenting some key results. This wind tunnel campaign has shown that a three bladed downwind wind turbine can operate in a stable fashion under a minimal yaw error. Finally, a description of how to obtain this open access dataset, including the post-processing scripts and procedures, is made available via a publicly accessible website.

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control, Delft University of Technology
Authors: Verelst, D. R. (Intern), Larsen, T. J. (Intern), van Wingerden, J. (Ekstern)
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Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
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Web of Science (2014): Indexed yes
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Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed no
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BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
ISI indexed (2011): ISI indexed no
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Scopus rating (2010): SJR 0.288 SNIP 0.351
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.259 SNIP 0.346
Open Access Wind Tunnel Measurements of a Downwind Free Yawning Wind Turbine

General information
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Organisations: Department of Wind Energy, Wind turbine loads & control, Delft University of Technology
Authors: Verelst, D. R. (Intern), Larsen, T. J. (Intern), van Wingerden, J. (Ekstern)
Number of pages: 19
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Original language: English
Main Research Area: Technical/natural sciences
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Publication: Research › Sound/Visual production (digital) – Annual report year: 2016

Optical Diagnostics of a Gliding Arc Discharge at Atmospheric Pressure

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics, National University of Defense Technology, Lund University
Authors: Zhu, J. (Ekstern), Kusano, Y. (Intern), Li, Z. (Ekstern)
Publication date: 2016

Host publication information
Title of host publication: Atmospheric Pressure Plasmas: Processes, Technology and Applications
Publisher: Nova Science Publishers
Editor: Parker, M.
ISBN (Print): 978-1-63485-180-0
Chapter: 2
Series: Physics Research and Technology
Main Research Area: Technical/natural sciences
**Optimization of pile design for offshore wind turbine jacket foundations**

The aim of this study is to use numerical methods of structural design optimization to design piles for offshore wind turbine jacket foundations. Pile mass is minimized with constraints on axial and lateral capacity. Results indicate that accurate knowledge about soil characteristics can translate into significant cost reductions.

**General information**

State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design, Department of Civil Engineering, Section for Geotechnics and Geology
Authors: Sandal, K. (Intern), Zania, V. (Intern)
Number of pages: 4
Publication date: 2016
Main Research Area: Technical/natural sciences

**Optimization under uncertainty of site-specific turbine configurations**

Uncertainty affects many aspects of wind energy plant performance and cost. In this study, we explore opportunities for site-specific turbine configuration optimization that accounts for uncertainty in the wind resource. As a demonstration, a simple empirical model for wind plant cost of energy is used in an optimization under uncertainty to examine how different risk appetites affect the optimal selection of a turbine configuration for sites of different wind resource profiles. If there is unusually high uncertainty in the site wind resource, the optimal turbine configuration diverges from the deterministic case and a generally more conservative design is obtained with increasing risk aversion on the part of the designer.

**General information**

State: Published
Organisations: Department of Wind Energy, Aerodynamic design, National Renewable Energy Laboratory
Authors: Quick, J. (Ekstern), Dykes, K. (Ekstern), Graf, P. (Ekstern), Zahle, F. (Intern)
Number of pages: 12
Publication date: 2016
Conference: The Science of Making Torque from Wind , Munich, Germany, 05/10/2016 - 05/10/2016
Main Research Area: Technical/natural sciences
Overplanting in offshore wind power plants in different regulatory regimes

Offshore wind power’s journey towards being competitive with other generation technologies relies on technical innovation and maturation, but also on further optimisation of proven and mature solutions. Capacity optimisation or so-called overplanting is one example of optimisation, which is performed by installing a larger wind power capacity than stipulated in the connection agreement with transmission system operators (TSOs). By developing a discounted cash flow (DCF) model, the paper investigates how both regulatory regimes and geographic characteristics of dedicated offshore wind development areas affect the viability of overplanting. The analysis comprises hypothetical scenarios of the distinctive offshore wind markets of the United Kingdom and Denmark and thereby elucidates the key aspects influencing the value of overplanting. This work’s findings show that the UK regulatory framework results more favourable to overplanting. The results indicate that current conceivable offshore wind power plants in the UK can increase their economic value by around 30 mio AC when optimising their capacity setup. In Denmark, current regulations are not suitable for overplanting causing loss of value when optimising the capacity design of wind power plants.

General information
State: Published
Organisations: Department of Management Engineering, Systems Analysis, Department of Wind Energy, Integration & Planning, DONG Energy A/S
Number of pages: 8
Publication date: 2016

Host publication information
Title of host publication: 15th wind Integration workshop - International Workshop on Large-Scale Integration of Wind Power into Power Systems as well as on Transmission Networks for Offshore Wind Power Plants
ISBN (Print): 978-3-9816549-4-3
Main Research Area: Technical/natural sciences
Conference: 15th International Workshop on Large-Scale Integration of Wind Power into Power Systems as well as on Transmission Networks for Offshore Wind Power Plants, Vienna, Austria, 15/11/2016 - 15/11/2016
Electronic versions:
Christoph_Overplanting_conference_paper.pdf
Oxide dispersion-strengthened steel PM2000 after dynamic plastic deformation: nanostructure and annealing behaviour

The microstructure, texture and mechanical properties have been studied in PM2000 compressed via dynamic plastic deformation to a strain of 2.1. It is found that dynamic plastic deformation results in a duplex 〈111〉 + 〈100〉 fibre texture and refines the initial microstructure by nanoscale lamellae, which substantially increases the strength of the material, but decreases its thermal stability. In the as-deformed microstructure, the stored energy density is found to be higher in 〈111〉-oriented regions than in 〈100〉-oriented regions. Recovery during annealing at 715 °C reduces the energy stored in the deformed microstructure. This reduction is more pronounced in the 〈111〉-oriented regions. Orientation-dependent recrystallisation takes place in the recovered microstructure, leading to strengthening of the 〈111〉 fibre texture component at the expense of the 〈100〉 fibre texture component.

General information
State: Published
Organisations: Department of Wind Energy, Materials science and characterization, Department of Mechanical Engineering, Materials and Surface Engineering, Sino-Danish Center for Education and Research, Chinese Academy of Sciences
Authors: Zhang, Z. (Intern), Tao, N. R. (Ekstern), Mishin, O. V. (Intern), Pantleon, W. (Intern)
Pages: 5545-5555
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Materials Science
Volume: 51
Issue number: 11
ISSN (Print): 0022-2461
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.83 SJR 0.807 SNIP 1.064
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.49 SJR 0.769 SNIP 1.072
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.792 SNIP 1.059 CiteScore 2.36
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.963 SNIP 1.388 CiteScore 2.54
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.926 SNIP 1.451 CiteScore 2.36
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.988 SNIP 1.383 CiteScore 2.2
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.935 SNIP 1.377 CiteScore 2.05
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.957 SNIP 1.091
Performance and wake conditions of a rotor located in the wake of an obstacle

Obstacles like forests, ridges and hills can strongly affect the velocity profile in front of a wind turbine rotor. The present work aims at quantifying the influence of nearby located obstacles on the performance and wake characteristics of a downstream located wind turbine. Here the influence of an obstacle in the form of a cylindrical disk was investigated experimentally in a water flume. A model of a three-bladed rotor, designed using Glauert's optimum theory at a tip speed ratio $\lambda = 5$, was placed in the wake of a disk with a diameter close to the one of the rotor. The distance from the disk to the rotor was changed from 4 to 8 rotor diameters, with the vertical distance from the rotor axis varied 0.5 and 1 rotor diameters. The associated turbulent intensity of the incoming flow to the rotor changed 3 to 6% due to the influence of the disk wake. In the experiment, thrust characteristics and associated pulsations as a function of the incoming flow structures were measured by strain gauges. The flow condition in front of the rotor was measured with high temporal accuracy using LDA and power coefficients were determine as function of tip speed ratio for different obstacle positions. Furthermore, PIV measurements were carried out to study the development of the mean velocity deficit profiles of the wake behind the wind turbine model under the influence of the wake generated by the obstacle. By use of regression techniques to fit the velocity profiles it was possible to determine velocity deficits and estimate length scales of the wake attenuation.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Russian Academy of Sciences
Authors: Naumov, I. V. (Ekstern), Kabardin, I. K. (Ekstern), Mikkelsen, R. F. (Intern), Okulov, V. (Intern), Sørensen, J. N. (Intern)
Number of pages: 7
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Physics: Conference Series (Online)
Volume: 753
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Article number: 032051
ISSN (Print): 1742-6596
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BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.351
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Perspectives on Materials Science in 3D

Materials characterization in 3D has opened a new era in materials science, which is discussed in this paper. The original motivations and visions behind the development of one of the new 3D techniques, namely the three dimensional x-ray diffraction (3DXRD) method, are presented and the route to its implementation is described. The present status of materials science in 3D is illustrated by examples related to recrystallization. Finally, challenges and suggestions for the future success for 3D Materials Science relating to hardware evolution, data analysis, data exchange and modeling are discussed.

General information
State: Published
Organisations: Department of Wind Energy, Materials science and characterization
Authors: Juul Jensen, D. (Intern)
Number of pages: 11
Pages: 1-11
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Host publication information
Title of host publication: 1st International Conference on 3D Materials Science, 2012
Publisher: Springer
ISBN (Print): 978-3-319-48573-7
ISBN (Electronic): 978-3-319-48762-5
Main Research Area: Technical/natural sciences
Conference: 1st International Conference on 3D Materials Science, Seven Springs, United States, 08/07/2012 - 08/07/2012
DOIs:
10.1007/978-3-319-48762-5_1
Source: Findit
Source-ID: 2372091967
Publication: Research - peer-review › Article in proceedings – Annual report year: 2017

Phase Angle Calculation Dynamics of Type 4 Wind Turbines in RMS Simulations during Severe Voltage Dips.

In order to conduct power system simulations with high shares of wind energy, standard wind turbine models, which are aimed to be generic rms models for a wide range of wind turbine types, have been developed. As a common practice of rms simulations, the power electronic interface of wind turbines is assumed to be ideally synchronized, i.e. grid synchronization (e.g. PLL) is not included in simplified wind turbine models. As will be shown in this paper, this practice causes simulation convergence problems during severe voltage dips and when the loss of synchronism occurs. In order to provide the simulation convergence without adding complexity to the generic models, a first order filtering approach is
proposed as a phase angle calculation algorithm in the grid synchronization of the rms type 4 wind turbine models. The proposed approach provides robustness for the simulation of large scale power systems with high shares of wind energy.
Physical model tests for floating wind turbines

Floating offshore wind turbines are relevant at sites where the depth is too large for the installation of a bottom fixed substructure. While 3200 bottom fixed offshore turbines have been installed in Europe (EWEA 2016), only a handful of floating wind turbines exist worldwide and it is still an open question which floater concept is the most economically feasible.

The design of the floaters for the floating turbines relies heavily on numerical modelling. While several coupled models exist, data sets for their validation are scarce. Validation, however, is important since the turbine behaviour is complex due to the combined actions of aero- and hydrodynamic loads, mooring loads and blade pitch control.

The present talk outlines two recent test campaigns with a floating wind turbine in waves and wind. Two floaters were tested, a compact TLP floater designed at DTU (Bredmose et al 2015, Pegalajar-Jurado et al 2016) and the recent Triple Spar design of Stuttgart University (Lemmer et al 2016). Both were built at a model scale of 1:60 along with a 1:60 scale version of the DTU 10MW reference wind turbine with a re-designed rotor, applicable to the low wind speeds of the lab. As a new development, the turbine was modified to enable active blade pitch control for the Triple Spar campaign.

The talk presents the scaling considerations and experimental design. The turbine was tested with rotor and floater ID tests and a range of wave conditions spanning from simple regular waves over focused wave groups to misaligned stochastic sea states. The floater and turbine response to combined wind and wave forcing are shown, with focus on aerodynamic damping from the wind and the effect of the controller. The results and analysis of these experiments for a new floater and with enabled pitch control contributes to a better understanding of the dynamics of floating wind turbines and improved validation of the numerical models.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, University of Stuttgart
Authors: Bredmose, H. (Intern), Mikkelsen, R. F. (Intern), Borg, M. (Intern), Pegalajar Jurado, A. M. (Intern), Lemmer, F. (Ekstern)
Number of pages: 1
Publication date: 2016
Main Research Area: Technical/natural sciences
Links:
http://www.sustain.dtu.dk/

Bibliographical note
Sustain Abstract E-4
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2016

PI controller design of a wind turbine: evaluation of the pole-placement method and tuning using constrained optimization

PI/PID controllers are the most common wind turbine controllers. Normally a first tuning is obtained using methods such as pole-placement or Ziegler-Nichols and then extensive aeroelastic simulations are used to obtain the best tuning in terms of regulation of the outputs and reduction of the loads. In the traditional tuning approaches, the properties of different open loop and closed loop transfer functions of the system are not normally considered. In this paper, an assessment of the pole-placement tuning method is presented based on robustness measures. Then a constrained optimization setup is suggested to automatically tune the wind turbine controller subject to robustness constraints. The properties of the system such as the maximum sensitivity and complementary sensitivity functions (Ms and Mt), along with some of the responses of the system, are used to investigate the controller performance and formulate the optimization problem. The cost function is the integral absolute error (IAE) of the rotational speed from a disturbance modeled as a step in wind speed. Linearized model of the DTU 10-MW reference wind turbine is obtained using HAWCStab2. Thereafter, the model is reduced with model order reduction. The trade-off curves are given to assess the tunings of the poles-placement method and a constrained optimization problem is solved to find the best tuning.

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control
Authors: Mirzaei, M. (Intern), Tibaldi, C. (Intern), Hansen, M. H. (Intern)
Number of pages: 7
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Conference: The Science of Making Torque from Wind , Munich, Germany, 05/10/2016 - 05/10/2016
BFI conference series, European Academy of Wind Energy : The Science of Making Torque from Wind (5010078)
Main Research Area: Technical/natural sciences
Wind power plants, Optimisation techniques, Control of electric power systems, Control system analysis and synthesis methods, Stability in control theory, Power and plant engineering (mechanical engineering), Optimisation, Control technology and theory, Elasticity (mechanical engineering), control system synthesis, elasticity, optimisation, PI control, pole assignment, reduced order systems, robust control, wind power plants, wind turbines, wind turbine PI controller design, constrained optimization, PID controller, aeroelastic simulation, load reduction, pole-placement tuning method assessment, robustness constraint, sensitivity function, integral absolute error, IAE, cost function, wind speed, DTU reference wind turbine, HAWCStab2, model order reduction
Possible Improvements for Present Wind Farm Models Used in Optimal Wind Farm Controllers

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning
Authors: Kazda, J. (Intern), Göçmen, T. (Intern), Giebel, G. (Intern), Cutululis, N. A. (Intern)
Number of pages: 7
Publication date: 2016
Event: Paper presented at 15th International Workshop on Large-Scale Integration of Wind Power into Power Systems as well as on Transmission Networks for Offshore Wind Power Plants, Vienna, Austria.
Main Research Area: Technical/natural sciences
Wind farm control, Power maximisation, Wakes, Model improvement
Electronic versions:
WIW16_0107_posterpaper_Kazda.pdf

Bibliographical note
Poster presentation
Source: PublicationPreSubmission
Source-ID: 127806108
Publication: Research - peer-review › Paper – Annual report year: 2016

Possible Power Estimation of Down-Regulated Offshore Wind Power Plants.
The penetration of offshore wind power is continuously increasing in the Northern European grids. To assure safety in the operation of the power system, wind power plants are required to provide ancillary services, including reserve power attained through down-regulating the wind farm from its maximum possible power. Currently, there is neither a standardised regulation by the TSOs nor a verified approach regarding the wind farm scale available power estimation. Here we describe an industrially applicable, validated method for the real-time estimation of the possible power of an offshore wind power plant. The developed procedure, the PossPOW algorithm, can also be used in the wind farm control as it yields a real-time wind farm power curve. The modern wind turbines have a possible power signal at the turbine level and the current state of the art is to aggregate those signals to achieve the wind farm scale production capacity. However, the summation of these individual signals is simply an over-estimation for the wind power plant, due to reduced wake losses during curtailment. The determination of the possible power with the PossPOW algorithm works as follows: firstly the second-wise upstream wind speed is estimated, since it is not affected by any wake. Then the upstream wind is introduced into the wake model, adjusted for the same time resolution, to simulate the power losses that would occur during nominal operation. The PossPOW algorithm uses only 1 Hz turbine data as inputs, namely power, pitch angle, and rotational speed. The method is validated in Horns Rev-I, Lillgrund and Thanet offshore wind farms, together with NREL 5MW simulations. The reduced wake is replaced by the wake model which estimates the velocity deficit for nominal operation. An evaluation of the existing wake models show that the suitable models are tuned for 10-min averaged data. Therefore, the Larsen wake model is re-calibrated for real-time using Thanet data, validated in Horns Rev-I and then implemented in farm scale considering the local turbulence, time delay and meandering. The validation of the algorithm is performed using experiments in Horns Rev-I where two of the upstream turbines are curtailed. The PossPOW algorithm is compared to the current practice and shown to perform significantly better, according to the error scores stipulated in the Danish grid code.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning, Department of Applied Mathematics and Computer Science, Dynamical Systems
Authors: Göçmen, T. (Intern), Giebel, G. (Intern), Sørensen, P. E. (Intern), Poulsen, N. K. (Intern)
Number of pages: 161
Publication date: 2016

Publication information
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Main Research Area: Technical/natural sciences
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Revised_NewCover_TG_PhDThesis_PossPOW.pdf
Publication: Research › Ph.D. thesis – Annual report year: 2016
Power Curve Measurements
The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to Ref. [1]. A site calibration has been carried out; see Ref. [2], and the measured flow correction factors for different wind directions are used in the present analyze of power performance of the turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Gómez Arranz, P. (Intern), Villanueva, H. (Intern)
Number of pages: 88
Publication date: 2016

Publication information
Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy WTT I
Number: 1136(EN)
Main Research Area: Technical/natural sciences
DTU Wind Energy WTT I-1136(EN), WTT-I-1136, WTT-I-1136(EN)

Bibliographical note
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Publication: Research › Report – Annual report year: 2016

Power Curve Measurements
The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to Ref. [1]. A site calibration has been carried out; see Ref. [2], and the measured flow correction factors for different wind directions are used in the present analyze of power performance of the turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Kock, C. W. (Intern), Federici, P. (Intern)
Number of pages: 66
Publication date: 2016

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Original language: English

Series: DTU Wind Energy WTT I
Number: 1140(EN)
Main Research Area: Technical/natural sciences
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Bibliographical note
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Publication: Research › Report – Annual report year: 2016

Power Curve Measurements
The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to Ref. [1]. A site calibration has been carried out; see Ref. [2], and the measured flow correction factors for different wind directions are used in the present analyze of power performance of the turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Federici, P. (Intern), Vesth, A. (Intern)
Number of pages: 62
Publication date: 2016

Publication information
Power Curve Measurements
This report describes the power curve measurements performed with a nacelle LIDAR on a given wind turbine in a wind farm and during a chosen measurement period. The measurements and analysis are carried out in accordance to the guidelines in the procedure “DTU Wind Energy-E-0019” [1]. The reporting format is based on the reference standard [2]. The data has been provided by the customer. The analysis has been performed by DTU.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Gómez Arranz, P. (Intern), Georgieva Yankova, G. (Intern)
Number of pages: 89
Publication date: 2016

Publication information
Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy WTT I
Number: 1142(EN)
Main Research Area: Technical/natural sciences
DTU Wind Energy WTT I-1142(EN), WTT-I-1142, WTT-I-1142(EN)

Bibliographical note
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Publication: Research › Report – Annual report year: 2016
Power Curve Measurements
The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to Ref. [1]. A site calibration has been carried out; see Ref. [2], and the measured flow correction factors for different wind directions are used in the present analyze of power performance of the turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Gómez Arranz, P. (Intern), Villanueva, H. (Intern)
Number of pages: 97
Publication date: 2016

Publication information
Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy WTT I
Number: 1152(EN)
Main Research Area: Technical/natural sciences
DTU Wind Energy WTT I-1152(EN), WTT-I-1152, WTT-I-1152(EN)

Bibliographical note
This is an internal report and therefore not available in full text. Please contact author's or director of author's department for further information.
Publication: Research › Report – Annual report year: 2016

Power Curve Measurements
The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to Ref. [1]. A site calibration has been carried out; see Ref. [2], and the measured flow correction factors for different wind directions are used in the present analyze of power performance of the turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Kock, C. W. (Intern), Federici, P. (Intern)
Number of pages: 66
Publication date: 2016

Publication information
Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy WTT I
Number: 1154(EN)
Main Research Area: Technical/natural sciences
DTU Wind Energy WTT I-1154(EN), WTT-I-1154, WTT-I-1154(EN)

Bibliographical note
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Publication: Research › Report – Annual report year: 2016

Power Curve Measurements
The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to Ref. [1]. A site calibration has been carried out; see Ref. [2], and the measured flow correction factors for different wind directions are used in the present analyze of power performance of the turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Power Curve Measurements
The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to Ref. [1]. A site calibration has been carried out; see Ref. [2], and the measured flow correction factors for different wind directions are used in the present analyze of power performance of the turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Villanueva, H. (Intern), Vesth, A. (Intern)
Number of pages: 67
Publication date: 2016
Power Curve Measurements
The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to Ref. [1]. A site calibration has been carried out; see Ref. [2], and the measured flow correction factors for different wind directions are used in the present analyze of power performance of the turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Kock, C. W. (Intern), Federici, P. (Intern)
Number of pages: 89
Publication date: 2016

Publication information
Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy WTT I
Number: 1172(EN)
Main Research Area: Technical/natural sciences
DTU Wind Energy WTT I-1172(EN), WTT-I-1172, WTT-I-1172(EN)

Bibliographical note
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Publication: Research › Report – Annual report year: 2016

Power Curve Measurements FGW
The report describes power curve measurements carried out on a given wind turbine. The measurements are carried out in accordance to Ref. [1]. A site calibration has been carried out; see Ref. [2], and the measured flow correction factors for different wind directions are used in the present analyze of power performance of the turbine.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Vesth, A. (Intern), Villanueva, H. (Intern)
Number of pages: 51
Publication date: 2016

Publication information
Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy WTT I
Number: 1174(EN)
Main Research Area: Technical/natural sciences
DTU Wind Energy WTT I-1174(EN), WTT-I-1174, WTT-I-1174(EN)

Bibliographical note
This is an internal report and therefore not available in full text. Please contact author's or director of author's department for further information.
Publication: Research › Report – Annual report year: 2016
Power Curve Measurements FGW
This report describes power curve measurements carried out on a given turbine in a chosen period. The measurements are carried out in accordance to IEC 61400-12-1 Ed. 1 and FGW Teil 2.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Gómez Arranz, P. (Intern), Villanueva, H. (Intern)
Number of pages: 68
Publication date: 2016

Power Curve Measurements quantifying the production increase
The purpose of this report is to quantify the production increase on a given turbine with respect to another given turbine. The used methodology is the “side by side” comparison method, provided by the client. This method involves the use of two neighboring turbines and it is based on the assumption that the wind field in front of the tested turbines is statistically the same (i.e. has in average the same mean wind speed conditions in front of both turbines). The method is only used for the evaluation of a relative change in the AEP, not the AEP itself.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Gómez Arranz, P. (Intern), Vesth, A. (Intern)
Number of pages: 38
Publication date: 2016
Power Curve Measurements REWS
This report describes the power curve measurements carried out on a given wind turbine in a chosen period. The measurements were carried out following the measurement procedure in the draft of IEC 61400-12-1 Ed.2 [1], with some deviations mostly regarding uncertainty calculation. Here, the reference wind speed used in the power curve is the equivalent wind speed obtained from lidar measurements at several heights between lower and upper blade tip, in combination with a hub height meteorological mast. The measurements have been performed using DTU’s measurement equipment, the analysis and quality control has been performed by DTU.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Gómez Arranz, P. (Intern), Vesth, A. (Intern)
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Power Curve Measurements REWS
This report describes the power curve measurements carried out on a given wind turbine in a chosen period. The measurements were carried out following the measurement procedure in the draft of IEC 61400-12-1 Ed.2 [1], with some deviations mostly regarding uncertainty calculation. Here, the reference wind speed used in the power curve is the equivalent wind speed obtained from lidar measurements at several heights between lower and upper blade tip, in combination with a hub height meteorological mast. The measurements have been performed using DTU’s measurement equipment, the analysis and quality control has been performed by DTU.

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Power Curve Measurements REWS
This report describes the power curve measurements carried out on a given wind turbine in a chosen period. The measurements were carried out following the measurement procedure in the draft of IEC 61400-12-1 Ed.2 [1], with some deviations mostly regarding uncertainty calculation. Here, the reference wind speed used in the power curve is the equivalent wind speed obtained from lidar measurements at several heights between lower and upper blade tip, in combination with a hub height meteorological mast. The measurements have been performed using DTU's measurement equipment, the analysis and quality control has been performed by DTU.

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Power Curve Measurements REWS
This report describes the power curve measurements carried out on a given wind turbine in a chosen period. The measurements were carried out following the measurement procedure in the draft of IEC 61400-12-1 Ed.2 [1], with some deviations mostly regarding uncertainty calculation. Here, the reference wind speed used in the power curve is the equivalent wind speed obtained from lidar measurements at several heights between lower and upper blade tip, in combination with a hub height meteorological mast. The measurements have been performed using DTU's measurement equipment, the analysis and quality control has been performed by DTU.

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Power Curves in a Wind Turbine Array: A Numerical Study
The impact of measuring a power curve inside a wind turbine array is investigated using computational fluid dynamics. The array consists of five aligned rotors that yaw with the free-stream wind direction. The flow-field in front of a wind turbine array changes with wind direction and hence the individual power output of each turbine. By incorporating the current IEC standards on power performance measurements, the bias in the power performance of turbines in an array over an isolated rotor is determined. The power change depends on the position of the turbine in the array and reaches maximally 9.03% and minimally -0.84%.
Power Oscillation Damping from VSC-HVDC Connected Offshore Wind Power Plants

The implementation of power oscillation damping service on offshore wind power plants connected to onshore grids by voltage-source-converter-based high voltage direct current transmission is discussed. Novel design guidelines for damping controllers on voltage-source converters and wind power plant controllers are derived, using phasor diagrams and a test network model and are then verified on a generic power system model. The effect of voltage regulators is analyzed, which is important for selecting the most robust damping strategy. Furthermore, other often disregarded practical implementation aspects regarding real wind power plants are discussed: 1) robustness against control/communication delays; 2) limitations due to mechanical resonances in wind turbine generators; 3) actual capability of wind power plants to provide damping without curtailing production; and 4) power-ramp rate limiters.
The present article investigates the potential of Active Trailing Edge Flaps (ATEF) in terms of increase in annual energy production (AEP) as well as reduction of fatigue loads. The basis for this study is the DTU 10 MW Reference Wind Turbine (RWT) simulated using the aeroelastic code HAWC2. In an industrial-oriented manner the baseline rotor is upscaled by 5% and the ATEFs are implemented in the outer 30% of the blades. The flap system is kept simple and robust with a single flap section and control with wind speed, rotor azimuth, root bending moments and angle of attack in flap's mid-section being the sensor inputs. The AEP is increased due to the upscaling but also further due to the flap system while the fatigue loads in components of interest (blade, tower, nacelle and main bearing) are reduced close to the level of the original turbine. The aim of this study is to demonstrate a simple and applicable method that can be a technology enabler for rotor upscaling and lowering cost of energy.
In the current experiments, two identical wind turbine models were placed in uniform flow conditions in a water flume. The initial flow in the flume was subject to a very low turbulence level, limiting the influence of external disturbances on the development of the inherent wake instability. Both rotors are three-bladed and designed using blade element/lifting line (BE/LL) optimum theory at a tip speed ratio, $\lambda$, of 5 with a constant design lift coefficient along the span, $CL= 0.8$. Measurements of the rotor characteristics were conducted by strain sensors installed in the rotor mounting. The resulting power capacity has been studied and analyzed at different rotor positions and a range of tip speed ratios from 2 to 8 and a simple algebraic relationship between the velocity deficit in the wake of the front turbine and the power of the second turbine was found, when both rotors have the coaxial position.
Power System Real-Time Monitoring by Using PMU-Based Robust State Estimation Method

Accurate real-time states provided by the state estimator are critical for power system reliable operation and control. This paper proposes a novel phasor measurement unit (PMU)-based robust state estimation method (PRSEM) to real-time monitor a power system under different operation conditions. To be specific, an adaptive weight assignment function to dynamically adjust the measurement weight based on the distance of big unwanted disturbances from the PMU measurements is proposed to increase algorithm robustness. Furthermore, a statistical test-based interpolation matrix H updating judgment strategy is proposed. The processed and resynced PMU information are used as priori information and incorporated to the modified weighted least square estimation to address the measurements imperfect synchronization between supervisory control and data acquisition and PMU measurements. Finally, the innovation analysis-based bad data (BD) detection method, which can handle the smearing effect and critical measurement errors, is presented. We evaluate PRSEM by using IEEE benchmark test systems and a realistic utility system. The numerical results indicate that, in short computation time, PRSEM can effectively track the system real-time states with good robustness and can address several kinds of BD.
Practices and rationales of community engagement with wind farms: awareness raising, consultation, empowerment

In light of the growing emphasis on community engagement in the literature on renewable energy planning, and given the acknowledgement of the complexity of community engagement as a concept, we conducted an empirical review of practice relating to community engagement with onshore wind farms in the UK, exploring what is actually happening in terms of community engagement relating to onshore wind farms, and examining the rationales underpinning approaches to community engagement. We found that a wide range of engagement methods are being used in relation to onshore wind farms across the UK, but that these are predominantly focused at consultation and awareness raising. Developers typically retain considerable – or total – control within such engagement processes. However, the case studies presented in this paper also evidence some innovation in engagement methods. Through this research we develop and test a non-hierarchical classification of community engagement approaches: awareness raising; consultation and empowerment. This provides a useful tool for reflecting on practices and rationales of community engagement. By considering the three approaches non-hierarchically, this model allows for an examination of how such rationales are acted on in practice.
Precision Measurements of Wind Turbine Noise using a Large Aperture Microphone Array

Experiments are described with a large microphone array (40 m scale) recording wind turbine noise. The array comprised 42 purpose-designed low-noise microphones simultaneously sampled at 20 kHz. Very high quality, fast, meteorological profile data was available from nearby 80 m masts and from the turbine nacelle, giving wind speed, wind direction, and turbulence data. A speaker was mounted at the base of the turbine tower, for determining the spatial characteristics of coherence, and for compensating for local wind variations. This speaker emits a continuous dual tone (allowing continuous time-of-flight at each microphone). An experiment was also run recording the sound from a continuous tone speaker mounted near the tip of a turbine blade, allowing testing of signal processing to correct for the very substantial Doppler shift. These various experiments are targeted at obtaining very high spatial and temporal resolution acoustic images of the sound emitted from turbine blades. An overview of some of the first results from this work will be given.

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Presolving and regularization in mixed-integer second-order cone optimization
Mixed-integer second-order cone optimization is a powerful mathematical framework capable of representing both logical conditions and nonlinear relationships in mathematical models of industrial optimization problems. What is more, solution methods are already part of many major commercial solvers including that of MOSEK [72] as well as XPRESS [31], Gurobi [46] and CPLEX [50]. This thesis concerns the performance and reliability of these solvers and makes two contributions; a theoretical one and a practical one.
In the theoretical part of the thesis a fundamental issue with reliability, affecting both continuous and mixed-integer conic optimization in general, is discovered and treated. This part of the thesis continues the studies of facial reduction preceding the work of Borwein and
Wolkowicz [17] in 1981, when the first algorithmic cure for these kinds of reliability issues were formulated. An important distinction to make between continuous and mixed-integer optimization, however, is that the reliability issues occurring in mixed-integer optimization cannot be blamed on the practitioner’s formulation of the problem. Specifically, as shown, the causes for these issues may well lie within the modifications to the formulation performed by the solution method itself. Hence, this calls for native support of facial reduction mechanisms within the commercial solvers to function reliably. In pursuit of such mechanisms, many fast and accurate heuristics are explored, supplementing the main discovery of this thesis that facial reduction can be interleaved with common optimization methods of high efficiency. Finally, a branch-and-bound method utilizing these mechanisms is established.

In the practical part of the thesis, a lack of consensus regarding basic definitions, representations and file formats is found, thereby increasing barriers for benchmarking with decreased market transparency as result. These differences are explored and results in the design of a new file format called The Conic Benchmark Format (CBF). Unlike any other file format for conic optimization, this one is both cross-platform compatible, high performant and future-proof by encompassing other conic extensions. Scripts and tools have moreover been developed to aid parsing (resp. conversion) of the file format in service of software developers (resp. optimization practitioners), and are actively distributed. The functionality of all of this is proven not only by first-class citizenship in the modeling language PICOS [87], but also by The Conic Benchmark Library (CBLIB) where the conversion tools have been used to test its more than a thousand instances with MOSEK and CPLEX. This benchmark library was compiled as part of this thesis in support of studies in performance and reliability, but has yet to be used for the theoretical subjects of this thesis.

Probabilistic model for multi-axial load combinations for wind turbines

The article presents a model describing the joint probability distribution of multiple load components acting on a wind turbine blade cross section. The problem of modelling the probability distribution of load time histories with large periodic components is addressed by dividing the signal into a periodic part and a perturbation term, where each part has a known probability distribution. The proposed model shows good agreement with simulated data under stationary conditions, and a design load envelope based on this model is comparable to the load envelope estimated using the standard procedure for determining contemporaneous loads. Using examples with simulated loads on a 10 MW wind turbine, the behavior of the bending moments acting on a blade section is illustrated under different conditions. The loading direction most critical for material failure is determined using a finite-element model of the blade cross section on which load combinations with different directions but with equal probability are applied. By defining a joint probability distribution and return-period contours for multiple load components, the suggested procedure is applicable to different aspects of the design of wind turbine blades, including the possibility for carrying out reliability analysis on an entire cross section.
Probabilistic stability and "tall" wind profiles: theory and method for use in wind resource assessment

A model has been derived for calculating the aggregate effects of stability and the finite height of the planetary boundary layer upon the long-term mean wind profile. A practical implementation of this probabilistic extended similarity-theory model is made, including its incorporation within the European Wind Atlas (EWA) methodology for site-to-site application. Theoretical and practical implications of the EWA methodology are also derived and described, including unprecedented documentation of the theoretical framework encompassing vertical extrapolation, as well as some improvement to the methodology. Results of the modeling are shown for a number of sites, with discussion of the models' efficacy and the relative improvement shown by the new model, for situations where a user lacks local heat flux information, as well as performance of the new model using measured flux statistics. Further, the uncertainty in vertical extrapolation is characterized for the EWA model contained in standard (i.e., WAsP) wind resource assessment, as well as for the new model. Copyright © 2015 John Wiley & Sons, Ltd.

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Probing NWP model deficiencies by statistical postprocessing

The objective in this article is twofold. On one hand, a Model Output Statistics (MOS) framework for improved wind speed forecast accuracy is described and evaluated. On the other hand, the approach explored identifies unintuitive explanatory value from a diagnostic variable in an operational numerical weather prediction (NWP) model generating global weather forecasts four times daily, with numerous users worldwide. The analysis is based on two years of hourly wind speed time series measured at three locations; offshore, in coastal and flat terrain, and inland in complex topography, respectively. Based on the statistical model candidates inferred from the data, the lifted index NWP model diagnostic is consistently found among the NWP model predictors of the best performing statistical models across sites.

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Provision of enhanced ancillary services from wind power plants - Examples and challenges

Emphasis in this article is on the power system impact of wind power plants capability to provide enhanced ancillary services, i.e. temporary frequency response (TFR) and power oscillation damping (POD). The main objective of the article is to analyze and justify the challenges in the use of TFR and POD from wind power plants (WPPs). The study is conducted with an aggregated wind power plant model which is integrated into a generic power system model, specifically designed to assess the targeted ancillary services in a relatively simple, but still relevant environment. Various case studies with different wind power penetration levels are considered. The study shows that WPPs can provide additional control features such as TFR and POD to enhance the stability of power systems with large share of wind power. Nevertheless, the results illustrate that the power system stability can be potentially degraded without careful coordination between WPPs, simultaneously providing TFR or POD in power systems with large displacement of conventional power plants by WPPs. The article provides to TSO new insights into the need for service coordination between WPPs into future
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Web of Science (2008): Indexed yes
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Web of Science (2007): Indexed yes
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Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.177 SNIP 1.271
Scopus rating (2004): SJR 0.761 SNIP 1.14
Quantitative Characterization of Boundary Roughness in Metals

The boundary migration during recrystallization is by nature a heterogeneous process and local structural variations form on recrystallization boundaries, as revealed from modern techniques such as synchrotron X-rays and advanced electron microscopy. The local structural variations, in the form of protrusions and retrusions, can provide a dragging/driving force due to the local boundary curvature and affect the further migration of recrystallization boundaries through the deformed matrix. In order to develop new understandings and models for boundary migration that take the heterogeneous local structural aspects into account, a detailed characterization is essential of partly recrystallized microstructures focusing on the local shapes of the boundaries, in particular on whether protrusions and retrusions are formed or not. Quantification of the “amount” of boundary roughness in the form of protrusions and retrusions is of importance for statistical investigations into the factors that potentially influence the recrystallization boundary roughening. A method is developed for quantitative characterization of 2-D line features. The area integral invariant (AII) is employed as a morphological variable to obtain information of local structural variations such as protrusions and retrusions formed on recrystallization boundaries. The AII value is direction-independent allowing unbiased characterization of morphological irregularities with both closed and non-closed boundary profiles. The length scale at which the rough features are characterized is determined by a parameter termed sampling radius used to measure the AII values. A number of roughness parameters are developed based on the AII dataset for a boundary or boundary segment, whose local morphological characteristics are represented by individual AII value acquired along the boundary or boundary segment. With the quantified boundary roughness at two length scales: 1 μm and 3 μm, the roughening behaviors of a large number of recrystallization boundaries are statistically analyzed and the effects of several parameters: materials purity, deformation strain, annealing temperature and boundary alignment direction, are evaluated. It is revealed that recrystallization boundaries in general are rough and the roughening behaviors of recrystallization boundaries are affected by the investigated parameters, more significantly at the length scale of 1 μm. It is found that the higher roughness is often associated with the higher migrating rates of recrystallization boundaries. A new method is presented to quantitatively characterize the morphology of graphite nodules in cast iron, as an extended application of the AII method to characterize the 2-D line features. This method develops a morphological variable “dispersion” to obtain information about local morphological characteristics that is subsequently merged into a parameter termed dispersion index, to represent the nodule’s morphology as a whole. The potential of the method is validated by quantifying the morphology of graphite nodules with complicated shape and by measuring the nodularity of an image with many graphite nodules.
Quarter-Century Offshore Winds from SSM/I and WRF in the North Sea and South China Sea

We study the wind climate and its long-term variability in the North Sea and South China Sea, areas relevant for offshore wind energy development, using satellite-based wind data, because very few reliable long-term in-situ sea surface wind observations are available. The Special Sensor Microwave Imager (SSM/I) ocean winds extrapolated from 10 m to 100 m using the Charnock relationship and the logarithmic profile method are compared to Weather Research and Forecasting (WRF) model results in both seas and to in-situ observations in the North Sea. The mean wind speed from SSM/I and WRF differ only by 0.1 m/s at Fino1 in the North Sea, while west of Hainan in the South China Sea the difference is 1.0 m/s. Linear regression between SSM/I and WRF winds at 100 m show correlation coefficients squared of 0.75 and 0.67, standard deviation of 1.67 m/s and 1.41 m/s, and mean difference of −0.12 m/s and 0.83 m/s for Fino1 and Hainan, respectively. The WRF-derived winds overestimate the values in the South China Sea. The inter-annual wind speed variability is estimated as 4.6% and 4.4% based on SSM/I at Fino1 and Hainan, respectively. We find significant changes in the seasonal wind pattern at Fino1 with springtime winds arriving one month earlier from 1988 to 2013 and higher winds in June; no yearly trend in wind speed is observed in the two seas.

General information

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Web of Science (2014): Indexed yes
Scopus rating (2013): SJR 1.127 SNIP 1.973 CiteScore 3.01
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Real time turbulence and wind gust estimation from wind lidar observations using the turbulence reconstruction method

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Recovery Kinetics in Commercial Purity Aluminum Deformed to Ultrahigh Strain: Model and Experiment

A new approach to analyze recovery kinetics is developed from a recent model, and microstructural observations are introduced to supplement hardness measurements. The approach involves two steps of data fitting, and the second step of fitting enables an estimation of the apparent activation energy for recovery. This approach is applied to commercial purity aluminum (AA1050) cold rolled to ultrahigh strain (99.6 pct reduction in thickness) and annealed at temperatures from 413 K to 493 K (140 °C to 220 °C). The annealing data fit the recovery model well, and the analysis shows that the apparent activation energy increases during recovery and approaches 190 kJ/mol at the end of recovery, suggesting that solute drag is an important rate-controlling mechanism. The recovery rate for the highly strained Al is found to be higher than that for Al deformed to a lower strain, an effect which is related to an increase in the stored energy (driving force). These findings form the basis for a discussion of recovery mechanisms and the increase in the apparent activation energy during annealing, suggesting an application of the model when optimizing the structure and strength through annealing of nanostructured materials produced by high strain deformation.

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Recycling of shredded composites from wind turbine blades in new thermoset polymer composites

As the energy produced from wind increases every year, a concern has raised on the recycling of wind turbine blades made of glass fibre composites. In this context, the present study aims to characterize and understand the mechanical properties of polyester resin composites reinforced with shredded composites (SC), and to assess the potential of such recycling solution. A special manufacturing setup was developed to produce composites with a controlled content of SC. Results show that the SC in the composites was well distributed and impregnated. The composite stiffness was well predicted using an analytical model, and fibre orientation parameters for strength modelling were established. The stress-strain curves revealed composite failure at unusual low strain values, and micrographs of the fracture surface indicated poor adhesion between SC and matrix. To tackle this problem, chemical treatment of SC or use of an alternative resin, to improve bonding should be investigated.
Reduced design load basis for ultimate blade loads estimation in multidisciplinary design optimization frameworks

The aim is to provide a fast and reliable approach to estimate ultimate blade loads for a multidisciplinary design optimization (MDO) framework. For blade design purposes, the standards require a large amount of computationally expensive simulations, which cannot be efficiently run each cost function evaluation of an MDO process. This work describes a method that allows integrating the calculation of the blade load envelopes inside an MDO loop. Ultimate blade load envelopes are calculated for a baseline design and a design obtained after an iteration of an MDO. These envelopes are computed for a full standard design load basis (DLB) and a deterministic reduced DLB. Ultimate loads extracted from the two DLBs with the two blade designs each are compared and analyzed. Although the reduced DLB supplies ultimate loads of different magnitude, the shape of the estimated envelopes are similar to the one computed using the full DLB. This observation is used to propose a scheme that is computationally cheap, and that can be integrated inside an MDO framework, providing a sufficiently reliable estimation of the blade ultimate loading. The latter aspect is of key importance when design variables implementing passive control methodologies are included in the formulation of the optimization problem. An MDO of a 10 MW wind turbine blade is presented as an applied case study to show the efficacy of the reduced DLB concept.

General information

State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control
Authors: Pavese, C. (Intern), Tibaldi, C. (Intern), Larsen, T. J. (Intern), Kim, T. (Intern), Thomsen, K. (Intern)
Number of pages: 15
Publication date: 2016
Conference: The Science of Making Torque from Wind, Munich, Germany, 05/10/2016 - 05/10/2016
Main Research Area: Technical/natural sciences

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Web of Science (2017): Indexed yes
Reduction of fatigue loads on jacket substructure through blade design optimization for multimegawatt wind turbines at 50 m water depths

This paper addresses the reduction of the fore-aft damage equivalent moment at the tower base for multi-megawatt offshore wind turbines mounted on jacket type substructures at 50 m water depths. The study investigates blade design optimization of a reference 10 MW wind turbine under standard wind conditions of onshore sites. The blade geometry and structure is optimized to yield a design that minimizes tower base fatigue loads without significant loss of power production compared to that of the reference setup. The resulting blade design is then mounted on a turbine supported by a jacket and placed under specific offshore site conditions. The new design achieves alleviate fatigue damage equivalent loads also in the jacket members, showing the possibility to prolong its design lifetime or to save material in comparison to the reference jacket. Finally, the results suggest additional benefit on the efficient design of other components such as the constituents of the nacelle.
General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design, Wind turbine loads & control, Aerodynamic design
Authors: NJOMO WANDJI, W. (Intern), Pavese, C. (Intern), Natarajan, A. (Intern), Zahle, F. (Intern)
Number of pages: 12
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Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
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Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.351
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.259 SNIP 0.346
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.264 SNIP 0.301
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.258 SNIP 0.399
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.272 SNIP 0.311
Web of Science (2006): Indexed yes
Original language: English
Electronic versions:
Torque_Wandji_Natarajan.pdf
DOI:
10.1088/1742-6596/753/4/042022
Releasable Kinetic Energy-Based Inertial Control of a DFIG Wind Power Plant

Wind turbine generators (WTGs) in a wind power plant (WPP) contain different levels of releasable kinetic energy (KE) because of the wake effects. This paper proposes a releasable KE-based inertial control scheme for a doubly fed induction generator (DFIG) WPP that differentiates the contributions of the WTGs depending on their stored KE. The proposed KE-based gain scheme aims to make use of the releasable KE in a WPP to raise the frequency nadir. To achieve this, two additional loops for the inertial control are implemented in each DFIG controller: the rate of change of frequency and droop loops. The proposed scheme adjusts the two loop gains in a DFIG controller depending on its rotor speed so that a DFIG operating at a higher rotor speed releases more KE. The performance of the proposed scheme was investigated under various wind conditions. The results clearly indicate that the proposed scheme successfully improves the frequency nadir more than the conventional same gain scheme by releasing more KE stored in a WPP, and it helps all WTGs to ensure stable operation during inertial control by avoiding the rotor speed reaching the minimum speed limit.
Remote sensing technologies for measuring offshore wind.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing
Authors: Courtney, M. (Intern), Hasager, C. B. (Intern)
Pages: 59-82
Publication date: 2016

Host publication Information
Title of host publication: Offshore Wind Farms
Publisher: Elsevier
Editors: Ng, C., Ran, L.
ISBN (Print): 9780081007792
Chapter: 4
Main Research Area: Technical/natural sciences
Publication: Research - peer-review › Book chapter – Annual report year: 2016

Renewable Energy Potential of Greenland with emphasis on wind resource assessment
As consumption, of the expensive energy, in the remote Arctic area increases, the demand for alternative energy sources will grow. For Greenland, hydropower is the preferred renewable energy source, but the resource is limited and the investment costs are high, and this moves the focus to other sources, such as wind and solar power. The biggest barriers to implementing these sources are lack of knowledge about the resources and their geographical distribution. In this project, different sources and methods for wind resource assessment are studied, with a focus on their performance in the complex Arctic terrain of Greenland. The energy systems are studied to identify the potential use of renewable energy in the system. Finally, a short description of wind power development in Greenland and some recommendations for further development are provided. The power systems can be split into three categories, based on the type and existing energy source. Small village systems are supplied with diesel generators with limited heat utilization. These generator units have a relatively low efficiency (0.25 - 0.35) because of obsolete technology and low-load factors. To demonstrate the optimization potential for these village systems, the village Sarfannguaq was selected for a detailed study of consumption, saving potential, and renewable energy potential. The saving potential for nonindustrial use was, with only small adjustments, 20% of total consumption, and depending on the definition of Profitable (required returns of investment), more can economically be saved by replacing outdated equipment. The renewable energy potential for both solar and wind was relatively high, with solar radiation above 1000 kWh/m²/year and mean wind speeds of 6.1 m/s at 10 MAG. For a 50 kWp PV installation the 25 year average production cost was estimated to be less than 0.83 DKK/kWh and for a 100kW wind turbine, installed at site 2 (South-west of Sarfannguaq), the 20 year average production cost was estimated to be 0.85 DKK/kWh. Compared to the 2013 cost of goods for the diesel generators of 2.29 DKK/kWh, there is room for system updates to obtain a high RE penetration. In the next category, named diesel cities, a large potential for waste-heat utilization was discovered, and in the city of focus, Nanortalik, updating the diesel generator unit, expanding the district heating grid, and implementing 500-1500 kW wind power were suggested. For the last category, named hydro cities, there is potential for other sources if or when the hydro resources are used up.

For wind resource estimation, various methods of monitoring and modeling of wind resources were studied with a focus on their use in complex Arctic areas. First, the existing ground-based measurements (Climate stations) were studied to determine applicability for wind resource estimation, and for many of the stations, a high local effect, inhomogeneous time series, and deviation from the WMO guidelines were found. The next step was to design a dedicated wind monitoring system usable in the Arctic environment and to test it at different types of sites. The instrument test showed that even the highest quality of equipment failed in harsh climate. An extended test was planned, but due to delays, the test result is not ready yet. Based on the measurements, 10 sites were evaluated, 4 in the Uummannaq district, 5 in Sisimiut district and 1 in the Nanortalik district. Only two of them have a verified resource above 6m/s, but one more has the potential. One of the sites, Nanortalik Dump 1601, was studied in more detail by estimating the in flow angle, BL stability and turbulence distribution. The site class was found to be IEC class III due to raised turbulence levels in some sectors. For wind resource modeling, two types of models were evaluated; micro- and mesoscale models. The validation work showed that the microscale models performed relatively well within a 500m range of the reference site, depending on terrain and metrological conditions. The mesoscale models WRF and Polar WRF were validated against 14 measurement points in an 800x800km domain, and a detailed study of the 3D flow field in a complex fjord system was done. Furthermore, the modeled wind speed distribution was compared to satellite based ocean wind observations. The mesoscale work showed that the surface data available, especially the sea ice concentration and the surface elevation, need to be improved to obtain optimal model performance throughout the domain. In the last part of the thesis, some suggestions for how wind power can be successfully developed in Greenland are given, together with the
experiences gained from the test turbine. The main conclusion in this part is that a high-quality preliminary study (level 1) of available data, such as ocean wind, reanalysis data, inferred pictures of katabatic flow pattern, and station observation, together with good models is the key to a good site selection. To estimate project feasibility, detailed studies of infrastructure, raw materials, and wind resources are needed. Since the unsuccessful introduction of commercial wind turbines in 1983-1986, wind power has not been a part of public systems, but technological development and the fact that verified resources now are available might open the way for Greenlandic wind power. There are still some model problems that need to be solved before a reliable resource map for all Greenland can be made, but with this project, Greenlandic wind power has come one step closer.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics
Authors: Jakobsen, K. R. (Intern), Hansen, M. O. L. (Intern), Vincent, C. L. (Intern)
Number of pages: 237
Publication date: 2016

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Publisher: DTU Wind Energy
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Series: DTU Wind Energy PhD
Number: 0043(EN)
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Renewable Energy Potential of Greenland

Relations
Projects:
Renewable Energy Potential of Greenland with emphasis on wind resource assessment
Publication: Research › Ph.D. thesis – Annual report year: 2016
Report on RUNE’s coastal experiment and first inter-comparisons between measurements systems
Accurate description of the wind energy resource in the coastal zone is crucial for countries developing near-shore wind farms. The RUNE experiment aims to use lidar measurements and mesoscale modelling to study the behaviour of the flow in the coastal zone and find the most effective way to estimate the near-shore wind resource. In this report we document all information regarding the measurement systems and the coastal campaign.

The wind speed is estimated from radial velocities measured by a lidar in sector-scanning mode, from two lidars performing dual-overlapping scans and from five vertical profiling lidars, of which one was operating offshore on a floating platform. All these instruments are inter compared, showing generally good agreement. The availability is best for the vertically profiling lidars, followed by the sector-scan setup, the dual setup and the lidar buoy. We have also reference measurements from the meteorological mast at Høvsøre some kilometers south of the campaign’s site.

The wind climate during the campaign is characterized by strong westerlies with occasional storms. The measurements from the vertically profiling lidars agree well with those from the meteorological mast and show a decrease of mean wind speed from west to east. Two lidars (a long- and a short-range system) measuring next to each other measured similar winds speeds, although the wind speed from the long-range lidar had a small positive bias. There was also a positive bias in the mean wind speed from the sector-scan at large measuring distances.
Satellite winds from ASCAT, Sentinel-1 and TerraSAR-X were available. ASCAT were of coarse resolution and were not used for any direct comparisons with the lidar measurements. A spatial average of these SAR wind speeds along the coast was compared with coinciding scanning lidar 10 min wind speeds. TerraSAR-X retrieved winds showed a rather large deviation from the lidar wind speed transects extrapolated to 10 m. Sensitivity tests performed on the methods for the wind speed retrieval showed small differences in the statistics for the different combinations of the spatial resolution and the polarisation ratio. For the cases investigated, the wind direction from the model was not differing by more than 15° compared to the dual setup, but the spatial variability was not captured.

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling, Meteorology & Remote Sensing
Authors: Floors, R. R. (Intern), Lea, G. (Intern), Pena Diaz, A. (Intern), Karagali, I. (Intern), Ahsbahs, T. T. (Intern)
Number of pages: 33
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Publisher: DTU Wind Energy
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Research Potentials in Industry seen from a Research Department

General information
State: Published
Organisations: Department of Wind Energy, Management and administration
Authors: Madsen, P. H. (Intern)
Publication date: 2016

Publication information
Original language: English
Main Research Area: Technical/natural sciences
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Power point presentation 8 pages
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Residual Strains and Their Relation to the Fatigue Damage Evolution in Composite Materials
The fatigue performance of uniaxial glass fibre reinforced epoxy is found to be highly dependent on at which curing temperature the composite is manufactured. Performing the curing at 110°C instead of at 40°C is found to reduce the lifetime dramatically with a factor of 10. Even though, the volumetric shrinkage of the epoxy at the two curing cycles is identical, the resulting residual strain in an embedded optical fibre measured using fibre Bragg Grating is found to be increased with a factor of 3. Together with, 3D x-ray tomography of partly fatigued test specimens there is an indication of a link between the measured increased residual strains with the governing fatigue damage mechanism.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Mikkelsen, L. P. (Intern), Pereira, G. F. (Intern), Jespersen, K. M. (Intern)
Number of pages: 2
Publication date: 2016

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BFI conference series: Procedia IUTAM (5010947)
Main Research Area: Technical/natural sciences
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Source: PublicationPreSubmission
Source-ID: 125556130
Publication: Research - peer-review › Article in proceedings – Annual report year: 2016

Results of the AVATAR project for the validation of 2D aerodynamic models with experimental data of the DU95W180 airfoil with unsteady flap
The FP7 AdVanced Aerodynamic Tools for lArge Rotors - Avatar project aims to develop and validate advanced aerodynamic models, to be used in integral design codes for the next generation of large scale wind turbines (10-20MW). One of the approaches towards reaching rotors for 10-20MW size is the application of flow control devices, such as flaps.
In Task 3.2: Development of aerodynamic codes for modelling of flow devices on aerofoils and, rotors of the Avatar project, aerodynamic codes are benchmarked and validated against the experimental data of a DU95W180 airfoil in steady and unsteady flow, for different angle of attack and flap settings, including unsteady oscillatory trailing-edge-flap motion, carried out within the framework of WP3: Models for Flow Devices and Flow Control, Task 3.1: CFD and Experimental Database. The aerodynamics codes are: AdaptFoil2D, Foil2W, FLOWer, MaPFlow, OpenFOAM, Q3UIC,
ATEFlap. The codes include unsteady Eulerian CFD simulations with grid deformation, panel models and indicial engineering models. The validation cases correspond to 18 steady flow cases, and 42 unsteady flow cases, for varying angle of attack, flap deflection and reduced frequency, with free and forced transition. The validation of the models show varying degrees of agreement, varying between models and flow cases.

**General information**

State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Delft University of Technology, Centro Nacional de Energías Renovables, University of Stuttgart, National Technical University of Athens
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Main Research Area: Technical/natural sciences

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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.351
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.259 SNIP 0.346
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.264 SNIP 0.301
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.258 SNIP 0.399
Web of Science (2007): Indexed yes
Review of Defence Plans in Europe: Current Status, Strengths and Opportunities
In recent years the European power system has changed significantly, causing the system to be operated closer to the limits. The transition to more renewable generation is causing power injections at different locations from conventional generation. Secondly the integration of the internal electricity market is causing an increase in flows on interconnections between different areas of the European power system. Furthermore the time needed to construct new infrastructure pushes Transmission System Operators (TSOs) to better utilize the installed infrastructure. As the power system is strongly interconnected, a contingency in one area can affect the whole power system and possibly lead to a wide area black out. Therefore adequate defence plans need to be designed and in place to handle these situations. This paper starts with an overview of the terminology used in defence plans. Subsequently the current status of defence plans in Europe and the preferred sequence of actions to mitigate contingencies, is given based on a survey conducted among several European TSOs. Furthermore his paper gives an overview of how the ongoing changes with renewables, phasor measurement units (PMUs), power flow controlling devices and demand side response can affect the adequacy of defence plans.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning, KU Leuven, Imperial College London, Statnett SF, AIA
Authors: De Boeck, S. (Ekstern), Van Hertem, D. (Ekstern), Das, K. (Intern), Sørensen, P. E. (Intern), Trovato, V. (Ekstern), Turunen, J. (Ekstern), Halat, M. (Ekstern)
Pages: 6-16
Publication date: 2016
Main Research Area: Technical/natural sciences

Review of Z phase precipitation in 9–12 wt-%Cr steels
For high temperature applications, 9–12 wt-%Cr steels in fossil fired power plants rely upon precipitate strengthening from (V,Nb)N MX nitrides for long term creep strength. During prolonged exposure at service temperature, another nitride precipitates: Cr(V,Nb)NZ phase. The Z phases slowly replaceMX, eventually causing a breakdown in creep strength. The present paper reviews the Z phase and its behaviour in 9–12 wt-%Cr steels including thermodynamic modelling, crystal structure, nucleation process and precipitation rate as a function of chemical composition. The influence of Z phase precipitation upon long term creep strength is assessed from several different 9–12wt-%Cr steel grades and alloy design philosophies.

General information
State: Published
Organisations: Department of Wind Energy, Materials science and characterization
Authors: Danielsen, H. K. (Intern)
Ripple Field AC Losses in 10-MW Wind Turbine Generators With a MgB2 Superconducting Field Winding

Superconducting (SC) synchronous generators are proposed as a promising candidate for 10-20-MW direct-drive wind turbines because they can have low weights and small sizes. A common way of designing an SC machine is to use SC wires with high current-carrying capability in the dc field winding and the ac armature winding is made with copper conductors. In such generators, the dc field winding is exposed to ac magnetic field ripples due to space harmonics from the armature. In generator design phases, the ac loss caused by these ripple fields needs to be evaluated to avoid local overheating and an excessive cooling budget. To determine the applicability of different design solutions in terms of ac losses, this paper estimates the ac loss level of 10-MW wind generator designs employing a MgB2 SC field winding. The effects on ac losses are compared between nonmagnetic and ferromagnetic teeth with different numbers of slots per pole per phase. The necessity of an electromagnetic shield is then discussed based on the obtained loss levels. The results show that the total ac loss is so small that ferromagnetic teeth can be applied in the generator design without using an electromagnetic shield.

General information

State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design, Delft University of Technology, SINTEF
Authors: Liu, D. (Ekstern), Polinder, H. (Ekstern), Magnusson, N. (Ekstern), Schellevis, J. (Ekstern), Abrahamsen, A. B. (Intern)
Number of pages: 5
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Web of Science (2017): Indexed yes
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Scopus rating (2016): CiteScore 1.42 SJR 0.398 SNIP 1.145
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BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.403 SNIP 1.06 CiteScore 1.27
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.478 SNIP 1.13 CiteScore 0.83
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.443 SNIP 1.156 CiteScore 1.32
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
Roadmap to the multidisciplinary design analysis and optimisation of wind energy systems

A research agenda is described to further encourage the application of Multidisciplinary Design Analysis and Optimisation (MDAO) methodologies to wind energy systems. As a group of researchers closely collaborating within the International Energy Agency (IEA) Wind Task 37 for Wind Energy Systems Engineering: Integrated Research, Design and Development, we have identified challenges that will be encountered by users building an MDAO framework. This roadmap comprises 17 research questions and activities recognised to belong to three research directions: model fidelity, system scope and workflow architecture. It is foreseen that sensible answers to all these questions will enable to more easily apply MDAO in the wind energy domain. Beyond the agenda, this work also promotes the use of systems engineering to design, analyse and optimise wind turbines and wind farms, to complement existing compartmentalised research and design paradigms.

General information

State: Published
Organisations: Resource Assessment Modelling, Department of Wind Energy, Aerodynamic design, Delft University of Technology, Technical University of Munich, National Renewable Energy Laboratory, SINTEF
Authors: Sanchez Perez-Moreno, S. (Ekstern), Zaaijer, M. B. (Ekstern), Bottasso, C. L. (Ekstern), Dykes, K. (Ekstern), Merz, K. O. (Ekstern), Réthoré, P. (Intern), Zahle, F. (Intern)
Number of pages: 13
Publication date: 2016
Conference: The Science of Making Torque from Wind, Munich, Germany, 05/10/2016 - 05/10/2016
BFI conference series: European Academy of Wind Energy: The Science of Making Torque from Wind (5010078)
Main Research Area: Technical/natural sciences
Roughness Effects on Wind-Turbine Wake Dynamics in a Boundary-Layer Wind Tunnel

Increasing demand in wind energy has resulted in increasingly clustered wind farms, and raised the interest in wake research dramatically in the last couple of years. To this end, the present work employs an experimental approach with scaled three-bladed wind-turbine models in a large boundary-layer windtunnel. Time-resolved measurements are carried out with a three-component hot-wire anemometer in the mid-vertical plane of the wake up to a downstream distance of eleven turbine diameters. The major issue addressed is the wake dynamics i.e. the flow and turbulence characteristics as well as spectral content under two different neutral boundary-layer inflow conditions. The wind tunnel is arranged with and
without roughened surfaces in order to mimic moderately rough and smooth conditions. The inflow characterization is carried out by using all three velocity components, while the rest of the study is focused on the streamwise component’s evolution. The results show an earlier wake recovery, i.e. the velocity deficit due to the turbine is less persistent for the rough case due to higher incoming turbulence levels. This paves the way for enhanced mixing from higher momentum regions of the boundary layer towards the centre of the wake. The investigation on the turbulent shear stresses is in line with this observation as well. Moreover, common as well as distinguishing features of the turbulent-scales evolution are detected for rough and smooth inflow boundary-layer conditions. Wake meandering disappears for rough inflow conditions but persists for smooth case with a Strouhal number similar to that of a solid disk wake.
Satellite data used in the New European Wind Atlas

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling
Authors: Hasager, C. B. (Intern), Badger, M. (Intern), Karagali, I. (Intern), Hahmann, A. N. (Intern), Astrup, P. (Intern),
Hahmann, A. N. (Intern), Volker, P. (Intern), Larsén, X. G. (Intern), Mann, J. (Intern)
Number of pages: 37
Publication date: 2016

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Main Research Area: Technical/natural sciences
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Publication: Research › Sound/Visual production (digital) – Annual report year: 2016

Scale Adaptive Simulation Model for the Darrieus Wind Turbine
Accurate prediction of aerodynamic loads for the Darrieus wind turbine using more or less complex aerodynamic models is still a challenge. One of the problems is the small amount of experimental data available to validate the numerical codes. The major objective of the present study is to examine the scale adaptive simulation (SAS) approach for performance analysis of a one-bladed Darrieus wind turbine working at a tip speed ratio of 5 and at a blade Reynolds number of 40,000. The three-dimensional incompressible unsteady Navier-Stokes equations are used. Numerical results of aerodynamic loads and wake velocity profiles behind the rotor are compared with experimental data taken from literature. The level of agreement between CFD and experimental results is reasonable.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Warsaw University of Technology
Authors: Rogowski, K. (Ekstern), Hansen, M. O. L. (Intern), Maroński, R. (Ekstern), Lichota, P. (Ekstern)
Number of pages: 11
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Scanflow: High-resolution full-scale wind field measurements of the ECN's 2.5 MW aerodynamic research wind turbine using DTU's 3D WindScanner and SpinnerLidar for IRPWind's and EERA's benchmark
Scanning lidars for atmospheric boundary-layer research

Sea Surface Temperature Climate Data Record for the North Sea and Baltic Sea

A 30-yr climate data record (CDR) of sea surface temperature (SST) has been produced with daily gap-free analysis fields for the North Sea and the Baltic Sea region from 1982 to 2012 by combining the Pathfinder AVHRR satellite data record with the Along-Track Scanning Radiometer (ATSR) Reprocessing for Climate (ARC) dataset and with in situ observations. A dynamical bias correction scheme adjusts the Pathfinder observations toward the ARC and in situ observations. Largest Pathfinder-ARC differences are found in the summer months, when the Pathfinder observations are up to 0.4 °C colder than the ARC observations on average. Validation against independent in situ observations shows a very stable performance of the data record, with a mean difference of -0.06 °C compared to moored buoys and a 0.46 °C standard deviation of the differences. The mean annual biases of the SST CDR are small for all years, with a negligible temporal trend when compared against drifting and moored buoys. Analysis of the SST CDR reveals that the monthly anomalies for the North Sea, the Danish straits, and the central Baltic Sea regions show a high degree of correlation for interannual and decadal time scales, whereas the monthly variability differs from one region to another. The linear trends of the 1982-2012 SST anomaly time series range from 0.037 °C yr⁻¹ for the North Sea to 0.041 degrees C yr⁻¹ for the Baltic Sea.
**Segmentation of individual fibres in a uni-directional composite from 3D X-ray computed tomography data**

**General information**

State: Published

Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Department of Wind Energy, Composites and Materials Mechanics

Authors: Emerson, M. J. (Intern), Jespersen, K. M. (Intern), Dahl, A. B. (Intern), Conradsen, K. (Intern), Mikkelsen, L. P. (Intern)

Number of pages: 1

Publication date: 2016


Main Research Area: Technical/natural sciences

Electronic versions:
poster3DMS_monj.pdf

**Simulation of electricity generation by marine current turbines at Istanbul Bosphorus Strait**

In this work, several simulations and analyses are carried out to investigate the feasibility of generating electricity from underwater sea currents at Istanbul Bosphorus Strait. Bosphorus is a natural canal which forms a border between Europe and Asia by connecting Black Sea and Marmara Sea. The differences in elevation and salinity ratios between these two seas cause strong marine currents. Depending on the morphology of the canal the speed of the flow varies and at some specific locations the energy intensity reaches to sufficient levels where electricity generation by marine current turbines becomes economically feasible. In this study, several simulations are performed for a 10 MW marine turbine farm/cluster whose location is selected by taking into account several factors such as the canal morphology, current speed and passage of vessels. 360 different simulations are performed for 15 different virtual sea states. Similarly, 8 different configurations are analyzed in order to find the optimum spacing between the turbines. Considering the spatial variations in the current speed within the selected region, the analyses are performed for three different flow speeds corresponding to +/- 10% change in the average value. For each simulation the annual energy yield and cluster efficiency are calculated.

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**General information**

State: Published

Organisations: Department of Wind Energy, Istanbul Bilgi University

Authors: Yazicioglu, H. (Intern), Tunc, K. M. M. (Ekstern), Ozbek, M. (Ekstern), Kara, T. (Ekstern)

Number of pages: 10

Pages: 41-50

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Main Research Area: Technical/natural sciences

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- Web of Science (2018): Indexed yes
- BFI (2017): BFI-level 2
- Scopus rating (2017): CiteScore 5.6 SJR 1.99 SNIP 1.923
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 2
- Scopus rating (2016): CiteScore 5.17 SJR 1.974 SNIP 1.823
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 2
- Scopus rating (2015): SJR 2.22 SNIP 2.037 CiteScore 5.03
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 2
Simulations of the Flow past a Cylinder Using an Unsteady Double Wake Model

In the present work, the in-house UnSteady Double Wake Model (USDWM) is used to simulate flows past a cylinder at subcritical, supercritical, and transcritical Reynolds numbers. The flow model is a two-dimensional panel method which uses the unsteady double wake technique to model flow separation and its dynamics. In the present work the separation location is obtained from experimental data and fixed in time. The highly unsteady flow field behind the cylinder is analyzed in detail, comparing the vortex shedding characteristics under the different flow conditions.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics
Authors: Ramos García, N. (Intern), Sarlak Chivaee, H. (Intern), Andersen, S. J. (Intern), Sørensen, J. N. (Intern)
Simulations of wind turbine rotor with vortex generators
This work presents simulations of the DTU 10MW wind turbine rotor equipped with vortex generators (VGs) on the inner part of the blades. The objective is to study the influence of different VG configurations on rotor performance and in particular to investigate the radial dependence of VGs, i.e. how VGs at one section of the blade may affect the aerodynamic characteristics at other radial positions. Furthermore, the performance of different sections on the blade is compared to their corresponding performance in 2D flow.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design
Authors: Sørensen, N. N. (Intern), Zahle, F. (Intern), Sørensen, N. N. (Intern)
Number of pages: 10
Publication date: 2016
Conference: The Science of Making Torque from Wind, Munich, Germany, 05/10/2016 - 05/10/2016
BFI conference series: European Academy of Wind Energy : The Science of Making Torque from Wind (5010078)
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Physics: Conference Series (Online)
Volume: 753
Article number: 022057
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BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.351
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.259 SNIP 0.346
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.264 SNIP 0.301
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.258 SNIP 0.399
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.272 SNIP 0.311
Web of Science (2006): Indexed yes
Site assessment

This report describes the site assessment of a given position in a given site, for a wind turbine with a well-defined hub height and rotor diameter. The analysis is carried out in accordance to IEC 61400-12-1 [1], and both an obstacle assessment and a terrain assessment are performed.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Villanueva, H. (Intern), Gómez Arranz, P. (Intern)
Number of pages: 23
Publication date: 2016

Publication information
Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy WTT I
Number: 1151(EN)
Main Research Area: Technical/natural sciences
DTU Wind Energy WTT I-1151(EN), WTT-I-1151, WTT-I-1151(EN)

Bibliographical note
This is an internal report and therefore not available in full text. Please contact author's or director of author's department for further information.
Publication: Research › Report – Annual report year: 2016

Site calibration

Performing site calibration using two Ground-based lidars and REWS method

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Gómez Arranz, P. (Intern), Villanueva, H. (Intern)
Number of pages: 118
Publication date: 2016

Publication information
Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy WTT I
Number: 1176(EN)
Main Research Area: Technical/natural sciences
DTU Wind Energy WTT I-1176(EN), WTT-I-1176, WTT-I-1176(EN)

Bibliographical note
This is an internal report and therefore not available in full text. Please contact author's or director of author's department for further information.
Publication: Research › Report – Annual report year: 2016
Sizing and control of trailing edge flaps on a smart rotor for maximum power generation in low fatigue wind regimes: Control of trailing edge flaps on a smart rotor for maximum power generation

An extension of the spectrum of applicability of rotors with active aerodynamic devices is presented in this paper. Besides the classical purpose of load alleviation, a secondary objective is established: optimization of power capture. As a first step, wind speed regions that contribute little to fatigue damage have been identified. In these regions, the turbine energy output can be increased by deflecting the trailing edge (TE) flap in order to track the maximum power coefficient as a function of local, instantaneous speed ratios. For this purpose, the TE flap configuration for maximum power generation has been using blade element momentum theory. As a first step, the operation in non-uniform wind field conditions was analysed. Firstly, the deterministic fluctuation in local tip speed ratio due to wind shear was evaluated. The second effect is associated with time delays in adapting the rotor speed to inflow fluctuations caused by atmospheric turbulence. The increase in power generation obtained by accounting for wind shear has been demonstrated with an increase in energy production of 1%. Finally, a control logic based on inflow wind speeds has been devised, and the potential of enhanced power generation has been shown by time-domain simulations. Copyright © 2015 John Wiley & Sons, Ltd.

General information
State: Published
Organisations: Department of Wind Energy, Aeroelastic Design, Delft University of Technology
Authors: Smit, J. (Ekstern), Bernhammer, L. O. (Ekstern), Navalkar, S. T. (Ekstern), Bergami, L. (Intern), Gaunaa, M. (Intern)
Pages: 607–624
Publication date: 2016
Main Research Area: Technical/natural sciences

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Journal: Wind Energy
Volume: 16
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BFI (2018): BFI-level 2
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BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.18 SJR 1.051 SNIP 1.834
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.37 SJR 1.079 SNIP 2.316
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.201 SNIP 2.165 CiteScore 3.06
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.209 SNIP 3.688 CiteScore 3.42
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.235 SNIP 2.486 CiteScore 2.75
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.062 SNIP 2.297 CiteScore 2.36
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.892 SNIP 2.582 CiteScore 2.49
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.364 SNIP 2.026
Web of Science (2010): Indexed yes
Social contention in Denmark over alternative wind power development paths
Through a case-study on the development of a contested wind farm project in the Northern part of Jutland in Denmark, this paper builds on an STS-approach to shed light on the contested acceptability of wind farm development, which has produced controversy and social contention over energy justice.

Wind energy projects on land in Denmark are increasingly subject to social contention. Research and policy are mostly directed towards understanding how 'public acceptance' of current market-driven ways of wind power development can be supported and less on exploring the potentiality of alternative paths or understanding processes of coalition formation and reasons for social contention that underlie socio-technical controversies over sustainable transitions. In this paper, we draw on case-study research, inquiring into the contested translation of a Danish wind farm site in the rural area of Narrekaer Enge in Jutland. The paper traces protracted negotiations between a large energy company acting as wind farm developer who bought up dwellings to make space for extending an existing wind farm, land-owners, a farmers'
association, and municipalities, as well as with an emergent coalition of citizens and a humanitarian foundation, which proposed an alternative locally owned project. Combining ANT with theories of place attachment (TPA) and theory of the Commons, we map the unfolding controversy, which entails struggles over what entities should be included in and excluded from the project and over energy justice. Through this theoretical lens, we illuminate the contested 'acceptability' of wind energy, contributing to STS-literature, as the paper sheds light on cognitive frames and diversity of interests in 'just' development of wind power. In turn, this opens up for disentangling potential ways in which wind energy is part of Denmark's future energy system and societal development, including aspects of ownership, distribution of economic benefits and contribution to local development.

General information
State: Published
Organisations: Department of Management Engineering, Technology and Innovation Management, Department of Wind Energy, Integration & Planning, University of Copenhagen
Authors: Nyborg, S. (Intern), Kirkegaard, J. K. (Intern), Clausen, L. T. (Ekstern), Jørgensen, M. S. (Intern), Rudolph, D. P. (Intern)
Publication date: 2016
Main Research Area: Technical/natural sciences
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2016

Socio-economic Impacts—Offshore Activities/Energy
The energy sector has a strong presence in the North Sea and in the surrounding coastal areas. Commercial extraction of offshore oil and gas and related activities (exploration, transportation and distribution; pipelines; oil refining and processing) constitutes the single most important economic sector and renewable electricity generation—mainly from offshore wind—is increasing. Energy and offshore activities in the North Sea are critically vulnerable to climate change along the full supply chain. The major vulnerabilities for offshore installations like rigs, offshore wind energy and pipelines concern wind storms and extreme wave heights, whereas on land coastal installations and transportation may also be adversely affected by flooding. Future renewable energy potentials in the North Sea are also susceptible to climate change. Whereas the hydropower potential is expected to increase, it is highly uncertain how much the future potential of other renewable energy sources such as wind, solar, terrestrial biomass, or emerging technologies like wave, tidal or marine biomass could be positively or negatively affected. Due to the different national energy supply mixes the vulnerability to climate-related impacts will vary among North Sea countries. To ensure safe and reliable future operations comprehensive and systematic risk assessments are therefore needed which account for, for example, the high integration of power systems in the region.

General information
State: Published
Organisations: Department of Management Engineering, Systems Analysis, Department of Wind Energy, Integration & Planning
Authors: Halsnæs, K. (Intern), Drews, M. (Intern), Clausen, N. (Intern)
Number of pages: 7
Pages: 409-415
Publication date: 2016

Host publication information
Title of host publication: North Sea Region Climate Change Assessment
Publisher: Springer
ISBN (Print): 978-3-319-39743-6
ISBN (Electronic): 978-3-319-39745-0
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Series: Regional climate studies
Main Research Area: Technical/natural sciences
Electronic versions:
10.1007_2F978_3-319_39745_0_14.pdf
DOIs:
10.1007/978-3-319-39745-0_14
Source: FindIt
Source-ID: 2372552432
Publication: Research - peer-review › Book chapter – Annual report year: 2017

Spatio-temporal analysis of regional PV generation
Photovoltaic (PV) power is growing in importance worldwide and hence needs to be represented in operation and planning of power system. As opposed to traditional generation technologies, it is characterized by exhibiting both a high variability and a significant spatial dependence. This paper presents a fundamental analysis of regional solar generation time series,
aiming to potentially facilitate large-scale solar integration. It will focus on characterizing the underlying dependence structure at the system level as well as describing both statistical and temporal properties of regional PV generation.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning
Authors: Nuño Martinez, E. (Intern), Cutululis, N. A. (Intern)
Number of pages: 7
Publication date: 2016

Host publication information
Title of host publication: Proceedings of 6th International Workshop on Integration of Solar Power into Power (SIW 2016)
Publisher: Energynautics GmbH
ISBN (Electronic): 978-3-9816549-3-6
Main Research Area: Technical/natural sciences
Source: PublicationPreSubmission
Source-ID: 127659244
Publication: Research - peer-review › Article in proceedings – Annual report year: 2016

Special Section on HVDC Systems for Large Offshore Wind Power Plants

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning, University of Manchester, Cardiff University, Polytechnic University of Catalonia, KU Leuven
Authors: Gomis-Bellmunt, O. (Ekstern), Liang, J. (Ekstern), Van Hertem, D. (Ekstern), Barnes, M. (Ekstern), Cutululis, N. A. (Intern)
Number of pages: 2
Pages: 767-768
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
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BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 2.211 SJR 1.814 CiteScore 4.52
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.47 SJR 1.634 SNIP 2.536
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.788 SNIP 2.587 CiteScore 3.96
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.508 SNIP 2.631 CiteScore 3.4
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.412 SNIP 2.769 CiteScore 3.51
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.222 SNIP 2.577 CiteScore 3.28
ISI indexed (2012): ISI indexed yes
Spectral broadening of acoustic tones generated by unmanned aerial vehicles in a turbulent atmosphere

The acoustic spectrum emitted by unmanned aerial vehicles (UAVs) and other aircraft can be distorted by propagation through atmospheric turbulence. Since most UAVs are propeller-based, they generate a series of acoustic tones and harmonics. In this paper, spectral broadening of these tones due to atmospheric turbulence is studied. The broadening results from the combined Doppler effect of multiply scattered acoustic signals propagating in a non-stationary turbulent atmosphere. It can be assessed as a Fourier transform of the temporal coherence function of a monochromatic signal propagating in an atmosphere with spatial-temporal fluctuations in temperature and wind velocity. This temporal coherence was recently investigated [V. E. Ostashev, D. K. Wilson, S. N. Vecherin, and S. L. Collier, J. Acoust. Soc. Am. 136 (5), 2414–2431 (2014)] for the model of locally frozen turbulence. Based on these results, spectral broadening is calculated and analyzed for typical meteorological regimes of the atmospheric boundary layer and different flight trajectories of UAVs. Experimental results are presented and compared with theoretical predictions. Spectral broadening might also provide a means for remotely sensing atmospheric turbulence. © 2016 Acoustical Society of America
Statistics of LES simulations of large wind farms
Numerous large eddy simulations are performed of large wind farms using the actuator line method, which has been fully coupled to the aero-elastic code, Flex5. The higher order moments of the flow field inside large wind farms is examined in order to determine a representative reference velocity. The statistical moments appear to collapse and hence the turbulence inside large wind farms can potentially be scaled accordingly. The thrust coefficient is estimated by two different reference velocities and the generic CT expression by Frandsen. A reference velocity derived from the power production is shown to give very good agreement and furthermore enables the very good estimation of the thrust force using only the steady CT-curve, even for very short time samples. Finally, the effective turbulence inside large wind farms and the equivalent loads are examined.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Uppsala University
Authors: Andersen, S. J. (Intern), Sørensen, J. N. (Intern), Mikkelsen, R. F. (Intern), Ivanell, S. (Ekstern)
Number of pages: 11
Publication date: 2016
Conference: The Science of Making Torque from Wind, Munich, Germany, 05/10/2016 - 05/10/2016
BFI conference series: European Academy of Wind Energy: The Science of Making Torque from Wind (5010078)
Main Research Area: Technical/natural sciences

Publication information
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Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.351
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.259 SNIP 0.346
BFI (2008): BFI-level 1
Steady State Comparisons HAWC2 v12.2 vs HAWCStab2 v2.12

General information
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Organisations: Department of Wind Energy, Wind turbine loads & control
Authors: Verelst, D. R. (Intern), Hansen, M. H. (Intern), Pirrung, G. (Intern)
Number of pages: 29
Publication date: 2016

Publication information
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Volume: 0122
Main Research Area: Technical/natural sciences
Electronic versions:
steady_state_h2_vs_hs2.pdf
Source: PublicationPreSubmission
Source-ID: 12345474
Publication: Research - peer-review › Report – Annual report year: 2016

Stochastic dynamic response analysis of a floating vertical-axis wind turbine with a semi-submersible floater: Analysis of a floating vertical-axis wind turbine
Floating vertical-axis wind turbines (FVAWTs) provide the potential for utilizing offshore wind resources in moderate and deep water because of their economical installation and maintenance. Therefore, it is important to assess the performance of the FVAWT concept. This paper presents a stochastic dynamic response analysis of a 5MW FVAWT based on fully coupled nonlinear time domain simulations. The studied FVAWT, which is composed of a Darrieus rotor and a semi-submersible floater, is subjected to various wind and wave conditions. The global motion, structural response and mooring line tension of the FVAWT are calculated using time domain simulations and studied based on statistical analysis and frequency-domain analysis. The response of the FVAWT is compared under steady and turbulent wind conditions to investigate the effects of turbulent wind. The advantage of the FVAWT in reducing the 2P effect on the response is demonstrated by comparing the floating wind turbine with the equivalent land-based wind turbine. Additionally, by comparing the behaviour of FVAWTs with flexible and rigid rotors, the effect of rotor flexibility is evaluated. Furthermore, the FVAWT is also investigated in the parked condition. The global motions and structural responses as a function of the azimuthal angle are studied. Finally, the dynamic response of the FVAWT in selected misaligned wind and wave conditions is analysed to determine the effects of wind-wave misalignment on the dynamic response.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Norwegian University of Science and Technology
Authors: Wang, K. (Ekstern), Moan, T. (Ekstern), Hansen, M. O. L. (Intern)
Pages: 1853–1870
Publication date: 2016
Main Research Area: Technical/natural sciences

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Journal: Wind Energy
Volume: 19
Issue number: 10
ISSN (Print): 1095-4244
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BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.18 SJR 1.051 SNIP 1.834
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.37 SJR 1.079 SNIP 2.316
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.201 SNIP 2.165 CiteScore 3.06
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.209 SNIP 3.688 CiteScore 3.42
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.235 SNIP 2.486 CiteScore 2.75
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.062 SNIP 2.297 CiteScore 2.36
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.892 SNIP 2.582 CiteScore 2.49
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.364 SNIP 2.026
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 0.885 SNIP 1.439
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.743 SNIP 1.555
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.942 SNIP 1.42
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.586 SNIP 1.653
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.273 SNIP 0.827
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.525 SNIP 0.845
Web of Science (2004): Indexed yes
Web of Science (2003): Indexed yes
Web of Science (2002): Indexed yes
Web of Science (2001): Indexed yes
Web of Science (2000): Indexed yes
Stress and strain gradient in the deformed metallic surface

General information
State: Published
Organisations: Department of Wind Energy, Materials science and characterization
Authors: Zhang, X. (Intern)
Number of pages: 21
Publication date: 2016

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
Stress_and_strain_gradient_in_the_deformed_metallic_surface_Xiaodan_Zhang.pdf
Source: PublicationPreSubmission
Source-ID: 124074834
Publication: Research - peer-review › Sound/Visual production (digital) – Annual report year: 2016

Strong and light-weight materials made of reinforced honeycomb sandwich structures

In the transport sector, new strong and light-weight materials can reduce the weight of airplanes, cars and containers. This will lead to a reduction in CO2 emissions as less weight needs to be transported. The requirements for these light-weight materials are that they need to be strong and have a low cost, in order for them to compete with conventionally used materials like steel or aluminum. A great candidate for a material that can fulfill these requirements of being light, strong and low cost is a sandwich material. A sandwich material is a material that is made of a light-weight core with a thin layer of steel or fibre composite on top and bottom of the core. The core in a sandwich material is typically made of a honeycomb structure. Honeycomb structures have been used for more than 50 years. Until now honeycombs have been expensive to produce. However, with a new production method it is now possible to produce honeycombs structures at a low cost. In a large collaborative European project called INCOM, the possibility of reinforcing the honeycomb structure is investigated. The honeycomb structure is reinforced with sustainable fibres as the fibres are extracted from saw dust.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Mikkelsen, L. P. (Intern), Madsen, B. (Intern)
Number of pages: 1
Publication date: 2016
Main Research Area: Technical/natural sciences
Links:
http://www.sustain.dtu.dk/

Bibliographical note
Sustain Abstract M-2
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2016

Strong winds and waves offshore

This report is prepared for Statoil, with the intention to introduce DTU Wind Energy's ongoing research activities on offshore extreme wind and wave conditions. The purpose is to share our recent findings and to establish possible further collaboration with Statoil. The focus of this report is on the meteorological and environmental conditions related to storm winds and waves over the North Sea. With regard to the offshore wind energy application, the parameters addressed here include: extreme wind and extreme waves, storm wind and waves and turbulence issues for offshore conditions.
Structural health monitoring tools for late and end of life management of offshore wind turbines

The late and end of life stages in an offshore wind turbines (OWT) life cycle have unique features that must be considered. The initial focus on risks associated with start-up issues due to design, manufacturing or process elements gives way to a stable period of operation and maintenance optimisation and service condition monitoring. However, as with other structures, in time the issues of "wear and tear" and remaining life assessment become increasingly prevalent. The dynamics of operating an offshore wind farm varies considerably from existing oil & gas structures. With lower operating margins and the predominance of low redundancy structures, accurate structural health monitoring can play a strong role in safe management and enable increased operating time at end of life and decommissioning. Late life operations of offshore wind farms can pose significant challenges, balancing the potential for rising operations and maintenance costs with the ability to generate significant profitability from increased reliability and longer operations. Improvements in SHM can lead to corresponding improvements in the availability and management of offshore structures. The ability to accurately gather data on damage states and thus remaining life results in significant reduction in repair costs and the determination of cost effective decommissioning plans. Under given scenarios for end of life management and decommissioning there will be various structural systems that will provide hard limits on the viable economic lifetime of OWT and their associated farms. Using a risk based review of age and decommissioning related issues a breakdown of common damage and its causes can be presented, and from this both available and developing SHM techniques to address these late life issues are identified.
Structures and Strength of Gradient Nanostructures

A recent study [1] has shown that a microstructure can be refined to a record low of 5 nm and that dislocation glide is still a controlling mechanism at this length scale. The nanostructure was produced in Cu by applying a very high strain in friction. The stress and strain decrease with increasing distance from the surface forming a gradient structure. In this study [2], by shot peening of a low carbon steel a gradient structure has been produced extending to about 1 mm below the surface. A number of strengthening mechanisms have been analyzed as a basis for a calculation of the stress and strain as a function of the distance from the surface. The results are evaluated by a finite element investigation of shot peening.

General information
State: Published
Organisations: Department of Wind Energy, Materials science and characterization
Authors: Hansen, N. (Intern), Zhang, X. (Intern), Huang, X. (Intern)
Number of pages: 1
Publication date: 2016
Event: Abstract from TMS 2016 145th ANNUAL MEETING & EXHIBITION, Nashville, United States.
Main Research Area: Technical/natural sciences
Electronic versions:
Abstract.pdf

Bibliographical note
Source: PublicationPreSubmission
Source-ID: 124074645
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2016

Study on offshore wind farm wakes based on Envisat ASAR, Radarsat-2 and Sentinel-1

Downstream of operating wind farms the mean wind speed is reduced as compared to the upwind conditions. In the offshore environment it is of particular interest to quantify the wind farm wake because turbine arrays are often located in the vicinity of other wind farms. The wakes reduce the annual energy production in clustered wind farms. Envisat ASAR, Radarsat-2 and Sentinel-1 are used in the study covering wind farms in the North Sea and Kattegat Strait. Three types of analysis are performed. The first is a case based on a Radarsat-2 Scan-SAR wide VV scene (30th April 2013 at 17:41 UTC) with winds around 8-9 m/s from the northeast and eight operating wind farms all showing long wind farm wakes. The longest wake is around 55 km. The case has been modelled using an industry-standard engineering microscale wake model (PARK) and using mesoscale model (WRF) including a parametrization for wind farm wake. Both models reproduce the observed very long wind farm wakes convincingly regarding their direction and extent. The second analysis is based on 835 Envisat ASAR wide-swath-mode scenes from 2003 to 2012 (Hasager et al. 2015a) covering the Horns Rev-1 wind farm near the Danish North Sea coast. The wind farm covers an area of around 4 km by 5 km and three concentric circles centered at the wind farm are used for extraction of results. The selected radii are 6, 10 and 13 km. The mean wind speeds in each of the three circles (geo-collocated) quantify the coastal wind speed gradient. Next step is rotation of the data such that all scenes are aligned with inflow and downstream (wake region) based on the wind direction in the wind field maps. The rotation is done at 1 degree intervals. The data from rotated circles (not geo-collocated) are normalized with the winds at the side-lobes. Side-lobes are regions expected to be undisturbed by the wind farm wake. The key result of the analysis is the significant wind wake deficit at the inner circle, decreasing at outer circles, as expected. The SAR-based results strongly support the wake model results based on PARK and WRF (Hasager et al. 2015b). The third analysis is based on Sentinel-1 covering the Anholt wind farm located 56.6 °N, 11.25 °E in the Kattegat Strait. The 111 wind turbines, each 3.6 MW, are positioned in irregular lay-out with most turbines at the outer rim. Figure 1 shows Sentinel-1 on 11th September 2015 at 05:32 GMT with winds around 11-12 m/s from the southeast and wind farm wake west of the park with winds around 10 m/s. The wind turbines are visible as hard targets. Cases with winds from 6 to 14 m/s are under investigation. The potential of synergetic use of Sentinel-1a and Radarsat-2 with only few minutes time lag and the forthcoming Sentinel-1b with around 6 hour will increase sampling rate.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling , Fluid Mechanics, National Space Institute, Geodynamics, CLS
Authors: Hasager, C. B. (Intern), Badger, M. (Intern), Badger, J. (Intern), Pena Diaz, A. (Intern), Volker, P. (Intern), Hansen, K. S. (Intern), Di Bella, A. (Intern), Vincent, P. (Ekstern), Husson, R. (Ekstern), Mouche, A. (Ekstern)
Number of pages: 1
Publication date: 2016
Main Research Area: Technical/natural sciences
Additional files:
Subcomponent testing of trailing edge panels in wind turbine blades
This paper proposes a static subcomponent test method designed to check the compressive strength of the trailing edge region in wind turbine blades under a simplified loading. The paper presents numerical simulations using the proposed subcomponent test method and discusses its ability to be used for checking the compressive strength of the trailing edge region in wind turbine blades.

Support of Wind Resource Modeling Using Earth Observation—A European Perspective on the Status and Future Options

Swell impact on wind stress and atmospheric mixing in a regional coupled atmosphere-wave model
Over the ocean, the atmospheric turbulence can be significantly affected by swell waves. Change in the atmospheric turbulence affects the wind stress and atmospheric mixing over swell waves. In this study, the influence of swell on atmospheric mixing and wind stress is introduced into an atmosphere-wave-coupled regional climate model, separately and combined. The swell influence on atmospheric mixing is introduced into the atmospheric mixing length formula by adding a swell-induced contribution to the mixing. The swell influence on the wind stress under wind-following swell, moderate-range wind, and near-neutral and unstable stratification conditions is introduced by changing the roughness length. Five year simulation results indicate that adding the swell influence on atmospheric mixing has limited influence, only slightly increasing the near-surface wind speed; in contrast, adding the swell influence on wind stress reduces the near-surface wind speed. Introducing the wave influence roughness length has a larger influence than does adding the swell influence on mixing. Compared with measurements, adding the swell influence on both atmospheric mixing and wind stress gives the best model performance for the wind speed. The influence varies with wave characteristics for different sea basins. Swell occurs infrequently in the studied area, and one could expect more influence in high-swell-frequency areas (i.e., low-latitude ocean). We conclude that the influence of swell on atmospheric mixing and wind stress should be considered when developing climate models.
Synthetic Aperture Radar for wind energy applications: potential and challenges at high wind speeds

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling, Meteorology & Remote Sensing
Number of pages: 22
Publication date: 2016

Publication information
Media of output: Power Point Presentation
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
Exeter_MereteBadger_et_al.pdf
Publication: Research > Sound/Visual production (digital) – Annual report year: 2016

Projects:

Advanced Test Methods and Generic Models for Wind Energy
Department of Wind Energy
Period: 15/08/2018 → 14/08/2021
Number of participants: 3
Phd Student:
Nouri, Behnam (Intern)
Supervisor:
Göksu, Ömer (Intern)
Main Supervisor:
Sørensen, Poul Ejnar (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Offentlig finansiering
Project: PhD

Enhanced Frequency Control Capabilities from Wind Turbine and Plant
Department of Wind Energy
Period: 15/08/2018 → 14/08/2021
Number of participants: 4
Phd Student:
Lu, Liang (Intern)
Supervisor:
Larsen, Gunner (Ekstern)
Sørensen, Poul Ejnar (Intern)
Main Supervisor:
Cutululis, Nicolaos Antonio (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Offentlig finansiering
Project: PhD

Cluster supervisory control of large offshore wind power plants
Department of Wind Energy
Period: 01/08/2018 → 31/07/2021
Number of participants: 4
Phd Student:
Kavimandan, Anup (Intern)
Supervisor:
Das, Kaushik (Intern)
Hansen, Anca Daniela (Intern)
Main Supervisor:
Cutululis, Nicolaos Antonio (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Marie Curie (EU-stipendium)
Project: PhD

Advanced Wind Turbine Converter Control in HVDC-Connected Wind Power Plants
Department of Wind Energy
Period: 15/05/2018 → 14/05/2021
Number of participants: 3
Phd Student:
Arasteh, Amir (Intern)
Supervisor:
Göksu, Ömer (Intern)
Main Supervisor:
Cutululis, Nicolaos Antonio (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Improved Diurnal Variability of Ocean Surface Temperature through Community Modelling
One of the 18 successful Copernicus Marine Service Evolution Call 2. The aim is to support and advance the provision of products from earth observation to the European citizens and support activities related to climate monitoring, risk and disaster management and mitigation.

Department of Wind Energy
Meteorology & Remote Sensing
Danish Meteorological Institute
Period: 16/04/2018 → ...
Number of participants: 1
Acronym: DIVOST-COM
**Tendering sustainable energy transitions**

The overall objective of the project is to contribute to a transition toward sustainability in the energy sector of emerging economies, including sustainable development of local communities and local industries. The project will analyse the developmental implications of the Renewable Energy Independent Power Producers Procurement Programme (REIPPPP) implemented in South Africa (SA) with a focus on the effects of wind power projects on local industrial development and socioeconomic development in local communities. The project will contribute to enhance the research capacity of the younger researchers involved. It will build upon and contribute to significantly advance the literature on sustainability transitions in developing countries through an innovative combination of complementary perspectives on institutional change, global value chains and infant industry development. It will draw on in-depth fieldwork carried out in SA based on qualitative research methods, such as interviews, documents, direct observations and project inventories. Through direct engagement with key policy makers and stakeholders, the project will seek to ensure that local developmental impacts are prioritized and ensured in renewable energy tendering schemes currently being implemented in SA, other countries in Sub-Saharan Africa (SSA) and internationally.

The project will contribute to socially inclusive models of implementation by private companies involved in large-scale wind power projects by cooperating with the wind industry associations in Denmark and SA and through direct consultations. Finally, the project serves as a pilot research for a subsequent five year research programme, which will be up-scaled to include solar PV, concentrated solar power (CSP) and hydro-power, and additional countries in SSA, such as Ethiopia, Kenya, Ghana and Malawi.

Department of Management Engineering

UNEP DTU Partnership

Systems Analysis

Department of Wind Energy

Integration & Planning

Danish Institute for International Studies

University of Cape Town

University of Stellenbosch

Period: 01/04/2018 → 30/09/2020

Number of participants: 5

Acronym: TENTRANS

Project participant:

Hansen, Ulrich Elmer (Intern)

Schaer, Caroline (Intern)

Kitzing, Lena (Intern)

Cronin, Tom (Intern)

Project Manager, academic:

Nygaard, Ivan (Intern)

Project

**Verification of Structural Properties for Bend-Twist Coupled Wind Turbine Blades**

Department of Wind Energy

Period: 01/03/2018 → 28/02/2021

Number of participants: 4

PhD Student:

Tiedemann, Mareen Melissa (Intern)

Supervisor:

Bode, Johannes (Ekstern)

Chen, Xiao (Intern)

Main Supervisor:

Branner, Kim (Intern)

**Financing sources**

Source: Internal funding (public)
RECAST: Reduced Assessment Time

Every wind farm project requires accurate resource assessments to evaluate the energy yield and profitability, but for projects in hilly, mountainous or forested areas the measurement campaigns can be lengthy and expensive. For such projects, RECAST aims to reduce the measurement time by up to 50%, increase the bankability through increased accuracy and improve the annual energy production through optimised wind farm layout design.

RECAST will reach these goals by use of modern but presently commercially immature scanning lidars (WindScanner) instead of conventional met masts. By combining lidar measurements with numerical flow models, RECAST will reduce measurement time without sacrificing accuracy, or if desired instead, achieve higher accuracy for the same campaign duration.

RECAST has the following objectives:

1. to increase the technology readiness level of the WindScanner system to a user-friendly instrument;
2. to integrate multi-point measurements in the WAsP microscale flow model;
3. to develop a decision tool that helps the wind farm developer choose the measurement campaign that best suits his needs.

At the end of the project, the RECAST method, combining all three items, will have been proven and demonstrated at a new wind farm site and is expected to be ready for commercialisation shortly after that.

Department of Wind Energy
Resource Assessment Modelling
Meteorology & Remote Sensing
Test and Measurements
VESTAS Wind Systems A/S
RES
EMD International A/S
Period: 01/02/2018 → 01/03/2020
Number of participants: 14
Acronym: RECAST
Project participant:
Réthoré, Pierre-Elouan (Intern)
Badger, Jake (Intern)
Floors, Rogier Ralph (Intern)
Nielsen, Morten (Intern)
Hahmann, Andrea N. (Intern)
Vasiljevic, Nikola (Intern)
Courtney, Michael (Intern)
Vignaroli, Andrea (Intern)
Zamanbin, Arezoo (Intern)
Peña, Alfredo (Intern)
De Azevedo Santos, Pedro Alvim (Intern)
Svensson, Elin (Intern)
Project Manager, organisational:
Bechmann, Andreas (Intern)
Wagner, Rozenn (Intern)
Project

Blackstart and Islanding Capabilities of Wind Turbines
Department of Wind Energy
Period: 01/02/2018 → 31/01/2021
Number of participants: 4
Phd Student:
Jain, Anubhav (Intern)
Supervisor: Das, Kaushik (Intern)
Göksu, Ömer (Intern)
Main Supervisor: Cutululis, Nicolaos Antonio (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Marie Curie (EU-stipendium)
Project: PhD

Wind power system support in future distribution networks
Department of Wind Energy
Period: 15/01/2018 → 14/01/2021
Number of participants: 5
Phd Student: Pediaditis, Panagiotis (Intern)
Supervisor: Altin, Müfit (Intern)
Das, Kaushik (Intern)
Koivisto, Matti Juhani (Intern)
Main Supervisor: Hansen, Anca Daniela (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Superconducting thin-film neutron detector
Jonas Bertelsen
Department of Energy Conversion and Storage
Electrofunctional materials
Department of Wind Energy
Wind Turbine Structures and Component Design
Imaging and Structural Analysis
Period: 02/01/2018 → 20/06/2018
Number of participants: 4
Neutron detector, Superconducting thin film, Coated conductor, Thermal properties
Project participant: Wulff, Anders Christian (Intern)
Bertelsen, Jonas Lundholm (Ekstern)
Abrahamsen, Asger Bech (Intern)
Kuhn, Luise Theil (Intern)

Wind Atlas for South Africa (Phase 3)
Capacity development and research cooperation through the development of wind resource mapping for the remaining parts of the Northern Cape Province and for the rest of South Africa.

Phase 1 of the project ended in 2014.
Phase 2 of the project ended in 2018.
Department of Wind Energy
Integration & Planning
Resource Assessment Modelling
Council for Scientific and Industrial Research
University of Cape Town
South African Weather Service
South African National Energy Development Institute
Period: 01/01/2018 → 31/12/2020
Number of participants: 4
Acronym: WASA3
Project participant:
Mortensen, Niels Gylling (Intern)
Hahmann, Andrea N. (Intern)
Larsén, Xiaoli Guo (Intern)
Project Manager, organisational:
Hansen, Jens Carsten (Intern)

Related projects:
Wind Atlas for South Africa (Phase 1)
Wind Atlas for South Africa (Phase 2)

New Satellite Products for Wind Energy
Department of Wind Energy
Meteorology & Remote Sensing
Integration & Planning
Period: 01/01/2018 → 21/12/2018
Number of participants: 5
Acronym: NESA
Project participant:
Karagali, Ioanna (Intern)
Maule, Petr (Intern)
Badger, Merete (Intern)
Hasager, Charlotte Bay (Intern)
Dellwik, Ebba (Intern)

Determination of Remaining Life of Operational Wind Turbines
Department of Wind Energy
Period: 01/01/2018 → 31/12/2020
Number of participants: 3
Phd Student:
Conti, Davide (Intern)
Supervisor:
Dimitrov, Nikolay Krasimirov (Intern)
Main Supervisor:
Natarajan, Anand (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Fluid Structure Interaction for Wind Turbines in Atmospheric Flow
Department of Wind Energy
Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Smart Tip
We will design innovative rotor blade tips for wind turbines with the objectives to increase Annual Energy Production by 8% without exceeding the load envelope, reduce noise, reduce performance degradation, reduce costs and make turbines more adaptable for site-specific conditions. The goal is ambitious, yet looking at all the diversity in wing tip design in both aerospace and nature, it is obvious this area has a huge potential for innovation. The tip region for wind turbines produces the most energy, loads and noise. Yet, it has not received focused attention because the complex flow conditions require sophisticated high-fidelity simulations. DTU wind energy will apply high-fidelity surrogate based optimization, wind tunnel and mechanical testing to develop multiple innovations. Siemens will field test the most promising concept. The Siemens development pipeline for tip innovations will be primed. The new competencies created will allow Siemens to improve turbines for years to come.

Department of Wind Energy
Aerodynamic design
Period: 01/12/2017 → 30/11/2020
Number of participants: 1
Acronym: SmartTip
Project Manager, organisational:
Barlas, Athanasios (Intern)

Large scale atmospheric structures in space-time over flat terrain
Department of Wind Energy
Period: 15/11/2017 → 14/11/2020
Number of participants: 4
Phd Student:
Alcayaga Román, Leonardo Andrés (Intern)
Supervisor:
Kelly, Mark C. (Intern)
Mann, Jakob (Intern)
Main Supervisor:
Larsen, Gunner Chr. (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Villum Center for Advanced Structural and Material Testing
Department of Civil Engineering
Department of Wind Energy
Composites and Materials Mechanics
Section for Structural Engineering
Department of Mechanical Engineering
Solid Mechanics

Wind Turbine Structures and Component Design
Period: 07/11/2017 → …
Number of participants: 17
Acronym: CASMaT
Project participant:
Kleis, Camilla (Intern)
Mikkelsen, Lars Pilgaard (Intern)
Sørensen, Bent F. (Intern)
Toftegaard, Helmuth Langmaack (Intern)
Berggreen, Christian (Intern)
Branner, Kim (Intern)
Michel, Alexander (Intern)
Andreassen, Michael Joachim (Intern)
Luczak, Marcin (Intern)
Chen, Xiao (Intern)
Bjørnbak-Hansen, Jørgen (Intern)
Legarth, Brian Nyvang (Intern)
Waldbjørn, Jacob Paamand (Intern)
Project Manager, organisational:
Stang, Henrik (Intern)
Phd Student:
Bangaru, Ashish Kumar (Intern)
Moncy, Aakash (Intern)
Quinlan, Alex (Intern)

Relations
Related projects:
Fatigue behaviour of polymer matrix at the microstructural scale
Multi-axial fatigue damage laws for composite materials at the macro-scale
Fatigue behaviour of polymer composite materials at the sub-structural and structural scale
Publications:
Uncovering the fatigue damage initiation and progression in uni-directional non-crimp fabric reinforced polyester composite
Statistical validation of individual fibre segmentation from tomograms and microscopy
Fatigue Damage Evolution in Fibre Composites for Wind Turbine Blades
Micromechanical Investigation of Fatigue Damage in Uni-Directional Fibre Composites
Three dimensional fatigue damage evolution in non-crimp glass fibre fabric based composites used for wind turbine blades
Individual fibre segmentation from 3D X-ray computed tomography for characterising the fibre orientation in unidirectional composite materials
Micromechanical Time-Lapse X-ray CT Study of Fatigue Damage in Uni-Directional Fibre Composites
Fatigue damage observed non-destructively in fibre composite coupon test specimens by X-ray CT
Ex-situ X-ray computed tomography data for a non-crimp fabric based glass fibre composite under fatigue loading

Fatigue behaviour of polymer matrix at the microstructural scale

Department of Wind Energy
Period: 01/11/2017 → 31/10/2020
Number of participants: 5
Phd Student:
Bangaru, Ashish Kumar (Intern)
Supervisor:
Legarth, Brian Nyvang (Intern)
Michel, Alexander (Intern)
Mikkelsen, Lars Pilgaard (Intern)
Main Supervisor:
Sørensen, Bent F. (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Rain climate and erosion of wind turbine blades
Department of Wind Energy
Period: 15/10/2017 → 14/10/2020
Number of participants: 3
PhD Student:
Tilg, Anna-Maria (Intern)
Supervisor:
Veien, Flemming (Ekstern)
Main Supervisor:
Hasager, Charlotte Bay (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Characterization of wind turbine siting parameters in complex terrain using remote sensing
Department of Wind Energy
Period: 01/10/2017 → 30/09/2020
Number of participants: 3
PhD Student:
De Azevedo Santos, Pedro Alvim (Intern)
Supervisor:
Vasiljevic, Nikola (Intern)
Main Supervisor:
Mann, Jakob (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansierede - Virksomhed
Project: PhD

Performance optimization of wind farms using model-based data analysis
Department of Wind Energy
Period: 01/10/2017 → 30/09/2020
Number of participants: 5
PhD Student:
Schröder, Laura (Intern)
Supervisor:
Mirzaei, Mahmood (Intern)
Sørensen, John Aasted (Intern)
Verelst, David Robert (Intern)
Main Supervisor:
Dimitrov, Nikolay Krasimirov (Intern)

Financing sources
New industrial paradigm for design of wind turbine blades - tip and root optimization for increasing power performance

Industrial PhD

Department of Wind Energy

Aerodynamic design
Period: 15/09/2017 → 14/09/2020
Number of participants: 2
Supervisor:
Zahle, Frederik (Intern)
Main Supervisor:
Bak, Christian (Intern)

Advanced meteorological modeling across scales

Department of Wind Energy
Period: 15/09/2017 → 14/09/2020
Number of participants: 3
Phd Student:
Imberger, Marc (Intern)
Supervisor:
Davis, Neil (Intern)
Main Supervisor:
Larsén, Xiaoli Guo (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: New industrial paradigm for design of wind turbine blades - tip and root optimization for increasing power performance

New industrial paradigm for design of wind turbine blades - tip and root optimization for increasing power performance

Department of Wind Energy
Period: 15/09/2017 → 14/09/2020
Number of participants: 4
Phd Student:
Lønbæk, Kenneth (Ekstern)
Supervisor:
Madsen, Jens Ingemann (Ekstern)
Zahle, Frederik (Intern)
Main Supervisor:
Bak, Christian (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: New industrial paradigm for design of wind turbine blades - tip and root optimization for increasing power performance

High Reynolds Number Rotor Aerodynamics and Design

Department of Wind Energy
Period: 01/09/2017 → 31/08/2020
Number of participants: 4
Phd Student:
Kiefer, Janik (Intern)
Supervisor:
Bak, Christian (Intern)
Supporting sustainable mini-grid development and local production of wind turbines using the case of Kenya
With the long-term objective to reduce poverty, stimulate economic growth and increased sustainable energy supply, the project aims to develop a market for low-cost, partly locally produced kW wind turbines for rural electrification. The project will demonstrate the technical, social and economic feasibility of integrating a kW wind turbine into a smart solar-powered mini-grid in Kenya, and aims to develop this concept into a viable business for the private companies involved, having the technical, economic and management capacity to exploit it. The expected long term impact of the project are (i) local jobs in production, installation, O&M of low cost kW turbines in mini-grids; and (ii) reduced cost of electricity provided by minigrids, benefitting disadvantaged communities. The project will bring together communities, public institutions and commercial companies.

Department of Management Engineering
UNEP DTU Partnership
Department of Wind Energy
Integration & Planning
Department of Civil Engineering
Section for Building Energy
Sustainable energy
Kenya Climate Innovation Centre
Period: 01/09/2017 → 01/09/2022
Number of participants: 5
Acronym: Kenya Miniwind
Project participant:
Hansen, Ulrich Elmer (Intern)
Cronin, Tom (Intern)
Nørgaard, Jørgen (Intern)
Other:
Hansen, Jens Carsten (Intern)
Project Coordinator:
Nygaard, Ivan (Intern)
Project

Design and optimization of electrical infrastructures in offshore wind power clusters
Department of Wind Energy
Period: 15/05/2017 → 14/05/2020
Number of participants: 4
PhD Student:
Pérez-Rúa, Juan-Andrés (Intern)
Supervisor:
Das, Kaushik (Intern)
Sørensen, Poul Ejnar (Intern)
Main Supervisor:
Cutululis, Nicolaos Antonio (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD
Large scale offshore wake impact on the Danish power system
ForskEL project from 2017: Offshore wind farm clusters are expanding. Considering the expected capacity on the order of 1 – 2 GW, it is important to understand wind power variability caused by neighbouring large wind farm wake (WFW) impact. Here we integrate calculation of WFW and important sea surface conditions to one modeling system to dynamically calculate the flow inside and around the wind farm clusters, as input to power calculation. The outputs serve farm planning and forecasting.

Department of Wind Energy
Resource Assessment Modelling
Integration & Planning
Meteorology & Remote Sensing

Vattenfall AB
Period: 01/05/2017 → 30/04/2020
Number of participants: 10
Offshore wind, wind to power, farm wakes, sea conditions
Acronym: OffshoreWake
Project ID: EUDP / ForskEL (64017-0017 / 12521
Number of related Ph.D. students: 1
Project participant:
Larsén, Xiaoli Guo (Intern)
Du, Jianting (Intern)
Imberger, Marc (Intern)
Giebel, Gregor (Intern)
Sørensen, Poul Ejnar (Intern)
Hasager, Charlotte Bay (Intern)
Badger, Jake (Intern)
Volker, Patrick (Intern)
Hahmann, Andrea N. (Intern)
Imberger, Marc (Intern)

Innovation for Global Wind Energy Exploitation on Land using Satellites
Funded by Innovation Fund Denmark

Department of Wind Energy
Meteorology & Remote Sensing
Resource Assessment Modelling
Period: 01/04/2017 → 31/03/2020
Number of participants: 8
Acronym: InnoWind
Project participant:
Hasager, Charlotte Bay (Intern)
Karagali, Ioanna (Intern)
Dellwik, Ebba (Intern)
Bechmann, Andreas (Intern)
Hahmann, Andrea N. (Intern)
Floors, Rogier Ralph (Intern)
Davis, Neil (Intern)
Project Manager, academic:
Badger, Merete (Intern)

An experimental assessment of how trees affect the wind field
Department of Wind Energy
Period: 01/04/2017 → 31/03/2020
Number of participants: 3
Phd Student:
Angelou, Nikolas (Intern)
Supervisor:
Mann, Jakob (Intern)
Main Supervisor:
Dellwik, Ebba (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

Wind Farm Control Trials
Offshore demonstration project of wind farm control optimisation (induction & wake steering)

Department of Wind Energy
Meteorology & Remote Sensing
Integration & Planning
Test and Measurements
Period: 01/03/2017 → 31/12/2020
Number of participants: 6
wake steering, windfarm control, scanning lidar, optimization
Acronym: WFCT
Project participant:
Simon, Elliot (Intern)
Hasager, Charlotte Bay (Intern)
Giebel, Gregor (Intern)
Kazda, Jonas (Intern)
Cutululis, Nicolaos Antonio (Intern)
Courtney, Michael (Intern)

Advanced Accurate and Computationally Efficient Numerical Methods for Wind Turbine Rotor Blade Design

Department of Wind Energy
Period: 15/02/2017 → 14/02/2020
Number of participants: 4
Phd Student:
Bertolini, Paola (Intern)
Supervisor:
Eder, Martin Alexander (Ekstern)
Lindby, Torben (Ekstern)
Main Supervisor:
Stolpe, Mathias (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Industrial PhD
Project: PhD

Aero-acoustic wind tunnel tests

Department of Wind Energy
Period: 01/02/2017 → 31/01/2020
Number of participants: 4
Phd Student:
Lylloff, Oliver Ackermann (Intern)
Marine Renewable Infrastructure Network for Enhancing Technologies 2
Integrating activities planned under MaRINET 2 build upon the achievements of the advanced community created in MaRINET FP7. MaRINET 2 will ensure the continued integration and enhancement of all leading European research infrastructure and facilities specialising in research, development and testing of offshore renewable energy systems including electrical sub systems and grid integration through a range of TRLs (1-7).

Department of Wind Energy
Resource Assessment Modelling
Period: 01/01/2017 → 31/12/2020
Number of participants: 1
Offshore Energy, infrastructure
Acronym: MaRINET2
Project participant: Sempreviva, Anna Maria (Intern)

Relations
Related projects:
EU ORECCA: Off-shore Renewable Energy Conversion platforms – Coordination Action
Integrated Research Programme in Wind Energy
Activities:
MARINET2. A European network of marine renewables infrastructures
Project

MARINET2
H2020 project
Department of Wind Energy
Meteorology & Remote Sensing
Resource Assessment Modelling
Fluid Mechanics
Period: 01/01/2017 → 30/06/2021
Number of participants: 10
Acronym: MARINET2
Project participant:
Badger, Merete (Intern)
Hasager, Charlotte Bay (Intern)
Karagali, Ioanna (Intern)
Sempreviva, Anna Maria (Intern)
Mikkelsen, Torben Krogh (Intern)
Bredmose, Henrik (Intern)
Madsen, Freddy Johannes (Intern)
Vasiljevic, Nikola (Intern)
Svensson, Elin (Intern)
Salnaja, Alma (Intern)
Project
Satellite Wind and Wave Atlas
The objective of WWAtlas is to create a service for quick and easy distribution of satellite-based wind and wave atlases using the existing Global Wind Atlas (GWA) map server and web interface.

Department of Wind Energy
Meteorology & Remote Sensing
Integration & Planning

Resource Assessment Modelling
Period: 01/01/2017 → 22/12/2017
Number of participants: 6
Acronym: WWAt
Project ID: UK10
Project participant:
Maule, Petr (Intern)
Davis, Neil (Intern)
Volker, Patrick (Intern)
Hasager, Charlotte Bay (Intern)
Badger, Merete (Intern)
Project Manager, organisational:
Karagali, Ioanna (Intern)

Wind turbine dynamics
Department of Wind Energy
Period: 01/01/2017 → 31/12/2019
Number of participants: 3
Phd Student:
Gözcü, Ozan (Intern)
Supervisor:
Hansen, Anders Melchior (Intern)
Main Supervisor:
Stolpe, Mathias (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Conceptual research of a multi megawatt downwind turbine
Department of Wind Energy
Period: 15/12/2016 → 14/12/2019
Number of participants: 5
Phd Student:
Wanke, Gesine (Ekstern)
Supervisor:
Buhl, Thomas (Intern)
Hansen, Morten Hartvig (Intern)
Madsen, Jens Ingemann (Ekstern)
Main Supervisor:
Larsen, Torben J. (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Industrial PhD
Project: PhD
Modelling of renewable energy under stressed power system stability conditions

Department of Wind Energy
Period: 15/11/2016 → 14/11/2019
Number of participants: 5
Phd Student:
Sarkar, Moumita (Intern)
Supervisor:
Altin, Müfit (Intern)
Hansen, Anca Daniela (Intern)
Jóhannsson, Hjörtur (Intern)
Main Supervisor:
Sørensen, Poul Ejnar (Intern)
Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Vind i ROSkilde
Vind i ROSkilde (VIROS) projektet vil undersøge om man kan benytte en vindkraftstrategi, som er baseret på mellemstørrelses møller under 100 m totalhøjde og som dermed kan opstilles i mange flere områder end 125-150 m møller tidligere undersøgt for Roskilde kommune. Samtidigt undersøges det, om vindmøllerne via placering og udfoming kan bruges som en ”grøn” kunst installation på lige fod med forbrændingsanlægget for derved at signalere Roskildes grønne aftryk og udvikling. VIROS kommer med tre forslag til, hvorledes lokalt placeret vindkraft kan bidrage til energiforsyningen og dermed til reduktionen af CO2-udledningen i Roskilde kommune. 1) Mellemstore møller nær infrastruktur, hvor eksempelvis 10 møller placeres langs kommunens infrastruktur i form af motorvej, jernbane eller industri, 2) Erstatning af gamle møller med mellemstore møller (repowering) og 3) Mellemstore møller placeret i landzoner. Disse forslag er i overensstemmelse med Roskilde kommunes strategiske energiplan for 2015-2020 med overvejelser for vindkraft med borgere i centrum. For at øge medejerskabet af møllerne vil der blive arrangeret en informationsmøde i samarbejde med Roskilde Festival og Musicon, hvor interesserede partnere i kommunen vil blive inviteret. Projektet vil til sidst evaluere om en vindstrategi baseret på møller af mellemstørrelse er en mulighed for Roskilde og skitsere hvordan den i givet fald kan implementeres

Department of Wind Energy
Meteorology & Remote Sensing
Test and Measurements
Integration & Planning
Musicon
EMD International A/S
Period: 01/11/2016 → 31/01/2018
Number of participants: 7
Acronym: VIROS
Project participant:
Kock, Carsten Weber (Intern)
Clausen, Niels-Erik (Intern)
Kjær, Tyge (Ekstern)
Sander, Mikkel (Ekstern)
Hermansen, Søren (Ekstern)
Project Manager, organisational:
Dellwik, Ebba (Intern)
Project Manager, academic:
Abrahamsen, Asger Bech (Intern)
Financing sources
Source: Other public support (public)
Name of research programme: Klimafonden Roskilde Kommune
Web address: http://roskilde.dk/klimafond
Amount: 110,000.00 Danish Kroner
Year of approval: 2016
Ground clearance and power performance v2
The influence of the hub height on the power of a wind turbine and wind farm is investigated using Computational Fluid Dynamics

Department of Wind Energy
Aerodynamic design

Dong Energy Wind Power A/S
Period: 01/11/2016 → 01/01/2017
Number of participants: 1
Project participant:
van der Laan, Paul (Intern)

Documents:
Report_Gound_Clearance_public_2017-08-31

Copernicus Evolution and Applications with Sentinel Enhancements and Land Effluents for Shores and Seas
H2020 project

Department of Wind Energy
Meteorology & Remote Sensing
Resource Assessment Modelling
Period: 01/11/2016 → 31/10/2019
Number of participants: 4
Acronym: CEASELESS
Project participant:
Badger, Merete (Intern)
Larsén, Xiaoli Guo (Intern)
Du, Jianting (Intern)
Karagali, Ioanna (Intern)

Transition Modeling for Wind Turbine Rotors/TRMOD

Department of Wind Energy
Period: 01/11/2016 → 31/10/2019
Number of participants: 4
Phd Student:
Özçakmak, Özge Sinem (Intern)
Supervisor:
Aagaard Madsen , Helge (Intern)
Sørensen, Jens Nørkær (Intern)
Main Supervisor:
Sørensen, Niels N. (Intern)
Lindebjergskolens CO2 fodastryk

Projektet ”Lindebjergskolens CO2 fodastryk” har som formål at skabe et undervisningsmateriale, der kan bruges i folkeskolen til at undervise i hvorfor CO2 er klades en drivhusgas og om de mulige løsninger på klimaudfordringerne med CO2 fra energiforsyning.

Materialer sigter på at gøre udfordringen med drivhusgassen CO2 så konkret som mulig ved at udregne CO2 fodastrykket fra Lindebjergskolen ud fra el og naturgas forbruget i 2014. Det undersøges om CO2 fodastrykket på 111 tons CO2 i 2014 er stort eller lille og hvad der kan gøres for at reducere det med enten solceller eller en husstands vindmølle.

Materialet består af en række slides, et regne ark til udregning af CO2 fodastrykket og en rapport som forklarer indholdet af slides og regneark.

Forfatterne håber at materialer kan give inspiration til elever og lærer på Lindebjergskolen samt andre skoler i Roskilde kommune, som vil prøve at udregne deres CO2 fodastryk. Vi modtager gerne CO2 fodastryk udregninger som kan sammenlignes med Lindebjergskolens.

Department of Wind Energy
Wind Turbine Structures and Component Design
Lindebjergskolen
Gundsølillehallen A.m.b.a
Period: 01/10/2016 → 01/08/2017
Number of participants: 3
Acronym: LindebjergCO2
Project participant:
Abrahamsen, Asger Bech (Intern)
Thingstrup, Thomas (Ekstern)
Christensen, Allan (Ekstern)
Documents:
LindebjergCO2Fodastryk_Abrahamsen_19April2018
Lindebjergskolens CO2 fodastryk _ABAbrahamson25Sep2016_Opdateret_5Marts2018
LindebjergskolensCO2Fodastryk_Energi_ForbrugSolVind&Varme_8Aug2016
EnergiFraVindMelleVedLindebjergskolen_SWP25kW_6Marts2018
Invitation LegDigKlog 18.4. 2018
Project

Control and stability of meshed offshore grids with diode rectifiers and VSC HVDC

Department of Wind Energy
Period: 01/10/2016 → 30/09/2019
Number of participants: 5
Phd Student:
Bidadfar, Ali (Intern)
Supervisor:
Akhmatov, Vladislav (Intern)
Altin, Müfit (Intern)
Cutululis, Nicolaos Antonio (Intern)
Main Supervisor:
Sørensen, Poul Ejnar (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Anden EU-finansiering
Project: PhD
Doppler lidar scanning of flow over complex terrain
Department of Wind Energy
Period: 01/10/2016 → 01/12/2019
Number of participants: 3
Phd Student: Menke, Robert (Intern)
Supervisor: Vasiljevic, Nikola (Intern)
Main Supervisor: Mann, Jakob (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

High Fidelity CFD-based Shape Optimization of Wind Turbine Blades
Department of Wind Energy
Period: 15/09/2016 → 14/09/2019
Number of participants: 4
Phd Student: Madsen, Mads Holst Aagaard (Intern)
Supervisor: Andersen, Søren Juhl (Intern)
Sørensen, Niels N. (Intern)
Main Supervisor: Zahle, Frederik (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Control and operation of offshore wind power plants connected via HVDC
Department of Wind Energy
Period: 01/09/2016 → 31/08/2019
Number of participants: 5
Phd Student: Saborío-Romano, Oscar (Intern)
Supervisor: Göksu, Ömer (Intern)
Sørensen, Poul Ejnar (Intern)
Zeni, Lorenzo (Intern)
Main Supervisor: Cutululis, Nicolaos Antonio (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Nationwide accurate wind prospecting models for Denmark & Turkey
To develop a new wind modelling concept and apply it nationwide to Denmark and Turkey. These nationwide models are proofs-of-concept and allow prediction of accurate long-term wind climate series and associated uncertainties any place in Denmark or Turkey. The model concept integrates three existing model components in a novel setup including large amounts of observational data; production data from >4000 wind turbines in Denmark and wind measurements from hundreds of masts in Turkey.

Department of Wind Energy
Backup from the local communities is essential for the expansion of renewable energy (RE) in Denmark – a key condition for the country to reach its climate goals.

Although the Danes generally support the green transition, actual plans to establish RE facilities are often met with local resistance, resulting in project delays. Local communities are often worried about how the new facility will impact their local area.

Environmental Impact Assessments (EIA) – a central instrument
In Denmark, the EIA is an important and well-established tool for evaluating and reducing environmental and social risks of larger construction projects. EIAs include technical analyses as well as public hearings in the local community.

However, there is a need to change the way social impacts are evaluated and discussed in the context of RE projects. Researchers and practitioners agree that this may often be vital in facilitating local communities to embrace RE.

Key project objectives
The project’s direct objective is to develop knowledge and tools enabling professionals to:
1) Elucidate and address social impact of RE facilities, and
2) Facilitate a constructive dialogue with local citizens about possible social impacts.

A thorough and systematic elucidation of social impacts will provide a better basis for constructive dialogue with the local communities.

For example, this will enable the professional team to integrate approaches that minimize or compensate for negative impacts early in the planning process. In addition, developers and consultants will have better options for highlighting and strengthening positive social impacts.

Our thesis is that a systematic and proactive approach to social impacts in the planning phase will lead to enhanced local support to RE projects.
NSON-DK - North Sea Offshore Network - Denmark
The focal point of the NSON-DK project is how the future massive offshore wind power and the associated offshore grid development will affect the Danish power system in the transition towards a future sustainable energy system. NSON-DK is a Danish part of the North Sea Offshore and Storage Network (NSON) project framework, which has emerged from the European Energy Research Alliance (EERA) as a pioneer project framework joining nationally funded research according to the European Commission’s Berlin model.

The objective of the NSON-DK project is to study how the future massive offshore wind power and the associated offshore grid development will affect the Danish power system on short term, medium term and long term towards of the transition towards a future sustainable energy system.

The following research questions will have special attention in the project:
- How will the offshore wind power development affect the variability and uncertainty of variable renewable generation in the Danish power system and neighboring systems?
- How will this increased variability and uncertainty from the offshore wind power development together with onshore renewable generation development influence the balancing and need for reserves in the Danish power system?
- How will the offshore wind power and offshore grid development influence the electricity markets in future systems with large scale energy storage and coordination of the electricity system with other energy systems (mainly heat and transport)?
- How will the scale and architecture of the offshore grid development influence the adequacy and security of supply in the Danish power system?
- Which policy instruments should be applied to support an effective and cost-efficient transition of the Danish power system combining the offshore development with energy storage and coordination between energy systems?

Department of Wind Energy
Integration & Planning

Department of Management Engineering
Energy Economics and Regulation
EA Energy Analysis A/S

Period: 01/04/2016 → 31/03/2020
Number of participants: 5
Wind power, Power systems, Offshore wind, Ancillary services, Variability, Renewables
Acronym: NSON-DK
Project participant:
Das, Kaushik (Intern)
Koivisto, Matti Juhani (Intern)
Pade, Lise-Lotte (Intern)
Skytte, Klaus (Intern)

Project Coordinator:
Sørensen, Poul Ejnar (Intern)

Relations
Related projects:
TWENTIES - Transmission system operation with large penetration of Wind and other renewable Electricity sources in Networks by means of innovative Tools and Integrated Energy Solutions
SIMBA - Simulation of balancing
Publications:
A Statistical Model for Hourly Large-Scale Wind and Photovoltaic Generation in New Locations
Multi-terminal Offshore Grid for the North Sea Region for 2030 and 2050 Scenarios
NSON-DK energy system scenario
Impacts of offshore grid developments in the North Sea region on market values by 2050: How will offshore wind farms and transmission lines pay?

Project

Security Assessment of Renewable Power Systems

Department of Electrical Engineering
Center for Electric Power and Energy
Electric Power Systems
Department of Wind Energy
Integration & Planning
Period: 01/04/2016 → 31/03/2020
Number of participants: 5
Acronym: SARP
Project participant:
Sørensen, Poul Ejnar (Intern)
Phd Student:
Karatas, Bahtiyar Can (Intern)
Sarkar, Moumita (Intern)
Jørgensen, Christina Hildebrandt Lüthje (Intern)
Project Coordinator:
Jóhannsson, Hjörtur (Intern)

Relations
Related projects:
Voltage Stability in RES based power systems
Modelling of renewable energy under stressed power system stability conditions
Secure Operation of Sustainable Power Systems
High Performance Algorithms Enabling Real-Time Security Assessment of Sustainable Electric Power Systems

Project

Integrated Baltic offshore wind electricity grid development
The offshore wind energy sector in the Baltic Sea requires coordinated transnational grid planning to realise its full growth potential. Baltic InteGrid promotes the meshed grid approach by creating a professional network for the exchange of expertise and state-of-the-art interdisciplinary research.

Department of Management Engineering
Energy Economics and Regulation
Department of Wind Energy
Integration & Planning
Period: 01/03/2016 → 30/09/2019
Number of participants: 5
Acronym: Baltic InteGrid
Project participant:
Pade, Lise-Lotte (Intern)
Bergaentzlé, Claire (Intern)
The use of wind power capabilities to improve the operation of the distribution network

NetVind aims toward the green transition in Denmark, by rethinking the way of using wind power plants in distribution systems. NetVind analyses and demonstrates in a large experimental facility, which technical and financial potentials exist to improve the operation of distribution systems by using wind power plants support control capabilities.

The goal of NetVind is to improve the operation of distribution systems with high wind power penetration by using the wind power plants grid support capabilities. This is accomplished through:

- Digitizing the communication between grid devices (i.e. wind turbine’s inverter) and the net monitoring system in relation to IEC 61850.
- Minimizing grid losses in MV distribution systems with high wind power penetration by optimizing the reactive power flow.
- Making optimal use of the existing net and obtain a benefit of the green transition by using regulation rather than to reinforce the net.
- Exploring which business model can be applied between players.
- Testing the IT security infrastructure for data communication in accordance with IEC 62351.
- Building up know-how on modelling the condition of the MV net.
- Contributing to improvement and qualification of future technical regulations which are under preparation at Energinet.dk and which should bind together the political, technical and financial interests.

The project seeks to achieve effective integration of renewable energy, considering the overall system security by optimizing the wind power transmission upwards in the system so that unnecessary losses due to new production/consumption scenarios are minimized and optimized by using the control capabilities of power electronics in wind turbines.

Bio4Self

Department of Wind Energy

Integration & Planning

EnergiMidt A/S
Period: 01/03/2016 → 01/10/2018
Number of participants: 5
Acronym: NetVind
Project participant:
Hansen, Anca Daniela (Intern)
Sørensen, Poul Ejnar (Intern)
Das, Kaushik (Intern)
Altin, Müfit (Intern)
Project Manager, organisational:
Thybo, Gitte Wad (Ekstern)

PROMOTioN - PROgress on Meshed HVDC Offshore Transmission Networks

The goal of the PROMOTioN project is to develop and demonstrate three key Technologies: diode rectifier offshore converters; multi-vendor high-voltage direct current (HVDC) grid protection system and the full power testing of HVDC circuit breakers. Furthermore, a regulatory and financial framework will be developed for the coordinated planning,
DTU is mainly involved in R&D on the first technology using diode rectifiers as offshore converters. DTU leads a work package on Wind turbine - converter interaction studies and a work package on harmonization towards standards and best practices. DTU is also involved in several other work packages.

Department of Wind Energy
Integration & Planning
Period: 01/01/2016 → 31/12/2019
Number of participants: 6
Acronym: PROMOTioN
Project ID: H2020 Grant Agreement-691714
Project participant:
Cutululis, Nicolaos Antonio (Intern)
Serensen, Poul Ejnar (Intern)
Göksu, Ömer (Intern)
Altin, Müfit (Intern)
Phd Student:
Saborío-Romano, Oscar (Intern)
Bidadfar, Ali (Intern)

Relations
Related projects:
Control and stability of meshed offshore grids with diode rectifiers and VSC HVDC
Control and operation of offshore wind power plants connected via HVDC
Publications:
Connection of OWPPs to HVDC networks using VSCs and Diode Rectifiers: an Overview

Lidar detection of wakes for wind turbine and farm control
Department of Wind Energy
Period: 01/01/2016 → 31/12/2018
Number of participants: 4
Phd Student:
Held, Dominique Philipp (Ekstern)
Supervisor:
Hu, Qi (Intern)
Mirzaei, Mahmood (Intern)
Main Supervisor:
Mann, Jakob (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Industrial PhD
Project: PhD

Microstructure and Fatigue Properties of Railway Steels for Switches and Crossings
Department of Wind Energy
Period: 15/12/2015 → 14/12/2018
Number of participants: 3
Phd Student:
Dhar, Somrita (Intern)
Supervisor:
Juul Jensen, Dorte (Intern)
Main Supervisor:
Danielsen, Hilmar Kjartansson (Intern)

Financing sources
Multi-objective wind farm control

Department of Wind Energy
Period: 15/12/2015 → 14/12/2018
Number of participants: 3
Phd Student:
Kazda, Jonas (Intern)
Supervisor:
Courtney, Michael (Intern)
Main Supervisor:
Cutululis, Nicolaos Antonio (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Wave Load Response on Offshore Wind Turbine Structures

Department of Wind Energy
Period: 15/12/2015 → 14/12/2018
Number of participants: 4
Phd Student:
Wang, Shaofeng (Intern)
Supervisor:
Bredmose, Henrik (Intern)
Kim, Taeseong (Intern)
Main Supervisor:
Larsen, Torben J. (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Experimental and modelling study of the composite piltrusion process for manufacturing of pre-fabricated elements for wind turbine blades

Department of Wind Energy
Period: 01/12/2015 → 30/11/2018
Number of participants: 4
Phd Student:
Miranda Maduro, Marco Aurelio (Intern)
Supervisor:
Almdal, Kristoffer (Intern)
Legstrup Andersen, Tom (Intern)
Main Supervisor:
Madsen, Bo (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Grundforskningsfonden
Project: PhD

Development of an Applied Measurement System for Short Term Power Forecasting and Gust/Ramp Prediction

Department of Wind Energy
Advanced CFD computation of breaking wave loads on offshore wind turbine structures

Department of Wind Energy
Period: 01/11/2015 → 31/10/2018
Number of participants: 2
Phd Student:
Ghadirian, Amin (Intern)
Main Supervisor:
Bredmose, Henrik (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Coastal Offshore Winds, Ocean Waves and Current using Remote Sensing

Department of Wind Energy
Period: 01/11/2015 → 01/12/2018
Number of participants: 5
Phd Student:
Ahsbahs, Tobias Torben (Intern)
Supervisor:
Karagali, Ioanna (Intern)
Kim, Sung Yong (Ekstern)
Larsén, Xiaoli Guo (Intern)
Main Supervisor:
Badger, Merete (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Flex4RES - Flexible Nordic Energy Systems

The Flex4RES project investigates how an intensified interaction between coupled energy markets, supported by coherent regulatory frameworks, can facilitate the integration of variable renewable energy (VRE) in turn ensuring stable, sustainable and cost-efficient Nordic energy systems.

The primary objective of Flex4RES is to identify and assess regulatory and technical pathways towards coherent Nordic energy systems in 2050 based on strong interaction between different energy markets that ensure resilience, sustainability and efficiency.

Energy Economics and Regulation
Project: Flex4RES

Acronym: Flex4RES
Project ID: 82511

Project participant:
- Kitzing, Lena (Intern)
- Karlsson, Kenneth Bernard (Intern)
- Pizarro Alonso, Amalia Rosa (Intern)
- Balyk, Oleandr (Intern)
- Bolwig, Simon (Intern)
- Pade, Lise-Lotte (Intern)
- Soysal, Emilie Rosenlund (Intern)
- Katz, Jonas (Intern)
- Olsen, Ole Jess (Intern)
- Bergaentzlé, Claire (Intern)
- Sneum, Daniel Møller (Intern)
- Ravn, Hans V. (Intern)
- Boscán Flores, Luis Rafael (Intern)
- Koivisto, Matti Juhani (Intern)
- Serensen, Poul Ejnar (Intern)
- Jensen, Ida Græsted (Intern)
- Phd Student: Vasileiou, Tryfon (Intern)
- Project Manager, academic: Skytte, Klaus (Intern)

Relations

Activities:
- Smart Cities and Energy: District Energy Innovation
- CampusEnergy2018
- Energy, Disaster, and Resilience Workshop
- Panel discussion: Results and take-home messages from Sustainable Energy Systems 2050
- Intraday Market Asymmetries
- District energy in North-eastern universities – greener and more flexible
- Norwegian University of Life Sciences
- Smart regulatory framework conditions for smart energy systems? Incentives for flexible district heating in the Nordic countries
Evaluation of regulation for flexibility – a methodology
Energy Policy in the Nordic Electricity Market: A power system with high penetration of wind energy
Danish case combining resilience, renewables, and district energy
Design of tariffs for power-to-heat generation to increase system flexibility
Flexibility for Variable Renewable Energy Integration in the Nordic Energy System: Danish & Nordic perspectives
Flexibility in district energy systems
A power system with high penetration of intermittent energy: how to regulate the marked
A simplistic method for representing renewable gasses and fuels in an energy systems optimisation model
FlexEm 2050 - Flexible Electricity Markets for Decarbonized Systems
Publications:
Can diverging regulatory approaches hinder the deployment of renewable energy? The case of offshore wind in Europe
Integrated energy systems modelling
District heating as a source of flexibility in the Nordic electricity market
Regulatory Barriers for Flexible Coupling of the Nordic Power and District Heating Markets
Barriers for district heating as a source of flexibility for the electricity system
Smart grid Transitions: System solutions and consumer behaviour
Market Prices in a Power Market with more than 50% Wind Power
The Future of Flexible Energy Systems - Flex4RES intro
From passive to active actors in the power market - Increasing the value of wind
Use of electric vehicles or hydrogen in the Danish transport sector in 2050?
Flexibility-friendly support policies:
Design of grid tariffs in electricity systems with variable renewable energy and power to heat
Regulatory barriers for activating flexibility in the Nordic-Baltic electricity market
Intraday market asymmetries — A Nordic example
Flexible electricity markets for a decarbonised energy system
Decarbonising the Finnish Transport Sector by 2050: Electricity or Biofuels?
Flex4RES status
Project

Optimal Design of Wind Turbine Blades for Additive Manufacturing Techniques

Department of Wind Energy
Period: 01/10/2015 → 30/09/2018
Number of participants: 4
Phd Student:
Fernandez Perez, Miguel (Intern)
Supervisor:
Andersen, Peter Bjørn (Intern)
Blasques, José Pedro Albergaria Amaral (Intern)
Main Supervisor:
Bak, Christian (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Industrial PhD
Project: PhD

Quantifying leading edge roughness on wind turbine blades

Department of Wind Energy
Period: 01/10/2015 → 31/03/2019
Number of participants: 4
Phd Student:
Kruse, Emil Krog (Ekstern)
Supervisor:
Bentzen, Thomas Ruby (Ekstern)
Cascaded design tools for 10MW offshore wind turbine floaters

Department of Wind Energy
Period: 15/09/2015 → 14/09/2018
Number of participants: 4
Phd Student:
Pegalajar Jurado, Antonio Manuel (Intern)
Supervisor:
Borg, Michael (Intern)
Mikkelsen, Robert Flemming (Intern)
Main Supervisor:
Bredmose, Henrik (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Ansat eksternt
Project: PhD

Full scale demonstration of an active flap system for wind turbines

The overall objective of the project is to demonstrate the system integration, the functioning, the performance and the value of an active flap system by full scale turbine tests. A further objective is to establish a detailed risk assessment of the system and a well described business case for the application of the system.

Department of Wind Energy
Aerodynamic design
Period: 01/07/2015 → 30/06/2018
Number of participants: 2
Acronym: INDUFLAP2
Project participant:
Barlas, Athanasios (Intern)
Project Manager, organisational:
Aagaard Madsen, Helge (Intern)

System adequacy and reserve margins with increasing levels of variable generation

The project aims at investigating system adequacy and reserve margins with increasing levels of variable generation (wind and photovoltaic mainly) in South Africa

Department of Electrical Engineering
Center for Electric Power and Energy
Distributed Energy Resources
Department of Wind Energy
Meteorology
Wind Energy Systems
EA Energy Analysis A/S
Period: 01/07/2015 → 31/08/2016
Number of participants: 4
wind power, Photovoltaic, large scale
Cost-effective strategies for Wind farm O&M

Department of Wind Energy
Period: 01/07/2015 → 30/09/2018
Number of participants: 6
PhD Student:
Colone, Lorenzo (Intern)
Supervisor:
Dimitrov, Nikolay Krasimirov (Intern)
Main Supervisor:
Natarajan, Anand (Intern)
Examiner:
Larsen, Gunner Chr. (Intern)
Cheng, Po Wen (Ekstern)
Manuel, Lance (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Marie Curie (EU-stipendium)
Project: PhD

New European Wind Atlas

A New European Wind Atlas will be developed to be used as a standard for site assessment. The new Atlas, based on improved modelling competencies on atmospheric flow, together with the guidelines and best practices for the use of data, should become a key tool not only for manufacturers and developers, but also for public authorities and decision-makers, by reducing overall uncertainties in determining wind conditions.

Department of Wind Energy
Meteorology & Remote Sensing
Resource Assessment Modelling
Period: 01/04/2015 → 31/03/2020
Number of participants: 15
Acronym: NEWA
Project participant:
Karagali, Ioanna (Intern)
Hasager, Charlotte Bay (Intern)
Badger, Merete (Intern)
Vasiljevic, Nikola (Intern)
Dellwik, Ebba (Intern)
Menke, Robert (Intern)
Hahmann, Andrea N. (Intern)
Badger, Jake (Intern)
Cavar, Dalibor (Intern)
Olsen, Bjarke Tobias (Intern)
Volker, Patrick (Intern)
Davis, Neil (Intern)
De Azevedo Santos, Pedro Alvim (Intern)
Peña, Alfredo (Intern)
Project Manager, academic:
Mann, Jakob (Intern)
Intelligent Quality Assessment of Railway Switches and Crossings

This project aims at significantly improving the safety, reliability and operational lifetime of the 3500 switches and crossings (S&Cs) in the Danish railway network. The project is a close cooperation between the Technical University of Denmark (DTU), the Danish rail infrastructure provider Rail Net Denmark and four affiliated European partners with significant expertise within this field. An inter-disciplinary scientific effort is employed to obtain enhanced rail transport reliability and regularity simultaneously with significant savings in S&Cs maintenance costs. The project results will make maintenance based on intelligent fault prediction tools, instead of the presently used regular planned inspections, and it will provide sophisticated tools to prevent hidden faults from developing to failure in the future. In a novel approach, the project will install state-of-the-art sensor technology in selected S&Cs and correlate dynamic parameters during train passage with static geometry data from conventional measurement vehicles. Monitoring of the dynamic responses will provide diagnosis of patterns that indicate when components or ballast begin to deviate from fully functional conditions. Modelling of dynamics will identify root causes to signs of degradation. Damage assessment of components identified by anomalous readings will be done by metallurgical examinations. Data and results will be processed by a holistic model that can produce Maintenance Performance Indicators (MPI) for the S&C condition. The correlation of sensor data to measuring vehicle data will allow existing data to be used reliably as input for the MPI model. It is expected that this project will enable optimisation of maintenance procedures, by which appropriate maintenance can be predicted in advance, thus avoiding unscheduled repairs and delays in the railway traffic.

Department of Wind Energy
Materials science and characterization

Department of Electrical Engineering
Automation and Control

Department of Mechanical Engineering
Solid Mechanics

Department of Applied Mathematics and Computer Science
Statistics and Data Analysis

Banedanmark

Period: 01/03/2015 → 28/02/2019
Number of participants: 14

Acronym: INTELLISWITCH
Number of related Ph.D. students: 1

Project participant:
Galeazzi, Roberto (Intern)
Blanke, Mogens (Intern)
Hansen, Søren (Intern)
Barkhordari, Pegah (Intern)
Asadzadeh, Seyed Mohammad (Intern)
Santos, Ilmar (Intern)
Tejada, Alejandro de Miguel (Intern)
Danielsen, Hilmar Kjartansson (Intern)
Dhar, Somrita (Intern)
Ersbøll, Bjarne Kjær (Intern)
Kulahci, Murat (Intern)
Thyregod, Camilla (Intern)
Hovad, Emil (Intern)

Project Manager, academic:
Juul Jensen, Dorte (Intern)

Financing sources
Source: Public research council
Name of research programme: Innovationsfonden
Web address: http://innovationsfonden.dk/da
Amount: 12,700,000.00 Danish Kroner
Year of approval: 2014
Project
Intelligent Quality Assessment of Railway Switches and Crossings (INTELLISWITCH)
Department of Electrical Engineering
Department of Mechanical Engineering
Department of Applied Mathematics and Computer Science
Statistics and Data Analysis
Department of Wind Energy
Materials science and characterization
Banedanmark
Period: 01/03/2015 → 31/12/2019
Number of participants: 3
Project participant:
Thyregod, Camilla (Intern)
Ersbøll, Bjarne Kjær (Intern)
Project Manager, organisational:
Juul Jensen, Dorte (Intern)

Financing sources
Source: Public research council
Name of research programme: Innovation Fund Denmark
Amount: 12.70 Danish Kroner

Reducing uncertainty of near-shore wind resource estimates using onshore lidars
RUNE aims at reducing the uncertainty of near-shore wind resource estimates by using onshore scanning lidar technology combined with ocean and satellite information

Department of Wind Energy
Meteorology
Test and Measurements
DONG Energy A/S
DHI Denmark
Fraunhofer Institute for Wind Energy and Energy System Technology
Period: 01/02/2015 → 31/03/2016
Number of participants: 13
Acronym: RUNE
Project ID: 12263
Project participant:
Courtney, Michael (Intern)
Vasiljevic, Nikola (Intern)
Lea, Guillaume (Intern)
Hasager, Charlotte Bay (Intern)
Hummelsøj, Poul (Intern)
Floors, Rogier Ralph (Intern)
Ejsing Jørgensen, Hans (Intern)
Hahmann, Andrea N. (Intern)
Mann, Jakob (Intern)
Badger, Merete (Intern)
Hansen, Kristoffer schröder (Intern)
Karagali, Ioanna (Intern)
Project Coordinator:
Peña, Alfredo (Intern)
Financing sources
Source: Public research council
Name of research programme: ForskEL
Web address: https://www.forskel.dk/Pages/default.aspx
Documents:
D1p1_final
D1p2_final
D1p3_final
D2p1_final
D2p2_final
D3p1_final
D3p3_final
Project

Inflow Characterization based on Remote Sensing using Pitot Tubes
Department of Wind Energy
Period: 01/02/2015 → 08/06/2018
Number of participants: 8
Phd Student:
Pedersen, Mads Mølgaard (Intern)
Supervisor:
Larsen, Gunner Chr. (Intern)
Aagaard Madsen, Helge (Intern)
Schmidt Paulsen, Uwe (Intern)
Main Supervisor:
Larsen, Torben J. (Intern)
Examiner:
Dellwik, Ebba (Intern)
Kragh, Knud Abildgaard (Intern)
Riziotis, Vasilis A. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)

Relations
Publications:
Inflow measurements from blade-mounted flow sensors: Flow analysis, application and aeroelastic response
Project: PhD

Advancing Materials
DTU Wind Energy's cross sectional project called Advancing Materials within a special task on Using the Right Materials focusing on material identification to use in structural optimization
Department of Wind Energy
Wind Turbines
Period: 14/01/2015 → …
Number of participants: 1
Project participant:
Weldeyesus, Alemseged Gebrehiwot (Intern)

Ancillary services from renewable power plants
RePlan project is a frontrunner for the integration of large share of renewable energy in the Danish power system. RePlan aims at rethinking the way of using renewable generation resources, as it focuses on enabling a resilient power system by providing ancillary services in a jointly coordinated manner.
The overall objective of this project is to contribute to the integration of large share of renewable energy in the Danish power system and thus to enable a resilient power system in the future by developing technical solutions for the provision of ancillary services by renewable power plants. RePlan focuses on WP and PV plants since they are expected to jointly produce the lion’s share of renewable energy generation capacity needed to reach the Danish government 2050 targets.
With respect to renewable generation (ReGen) plants, investigation of ancillary services, coordinated control, fast communication and forecast of available power are crucial stepping stones on the route toward a future resilient power system.

The ability to provide ancillary services from ReGen plants depends on the communication and the forecast of availability power. In this respect, RePlan develops controllers for the delivery of ancillary services, incorporating communication properties in the control loops of the ReGen plant model and using state-of-the-art methods for simulation of renewable generation patterns and wind power forecast methods. Based on both simulation models and verification in laboratory facilities, this project intends to address this challenge: What is the impact of communication and power availability forecast error in providing coordination and ancillary services from ReGen plants?

The novelty of RePlan consists in the investigation and verification of the ancillary services provision from wind and photovoltaic power plants and of the suitability to coordinate their services provision to power system operator. In this respect, RePlan strives to identify and analyze the strengths and limitations of WP and PV plants, anticipating new challenges and exploring some of the more complex issues and uncertainties related to the coordination of their ancillary services. The services with great concerns in the future include: voltage, frequency and rotor angular stability support.

Department of Wind Energy

Wind Energy Systems
Period: 01/01/2015 → 31/12/2017
Number of participants: 1
Acronym: RePlan
Project Manager, organisational:
Hansen, Anca Daniela (Intern)

Relations
Publications:
Technical Feasibility of Ancillary Services provided by ReGen Plants

Fatigue strength of composite wind turbine blade structures

Department of Wind Energy
Period: 01/01/2015 → 08/06/2018
Number of participants: 6
Phd Student:
Castro Ardila, Oscar Gerardo (Intern)
Supervisor:
Brøndsted, Povl (Intern)
Main Supervisor:
Branner, Kim (Intern)
Examiner:
Mikkelsen, Lars Pilgaard (Intern)
Burchardt, Claus (Ekstern)
Varna, Janis (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering

Relations
Publications:
Fatigue strength of composite wind turbine blade structures
Project: PhD

More accurate mesoscale to microscale downscaling for determining wind conditions at complicated sites

Department of Wind Energy
Period: 15/12/2014 → 16/06/2018
Number of participants: 8
Phd Student:
Olsen, Bjarke Tobias (Intern)
Supervisor:
Cavar, Dalibor (Intern)
Hahmann, Andrea N. (Intern)
Mann, Jakob (Ekstern)
Main Supervisor:
Badger, Jake (Intern)
Examiner:
Sørensen, Niels N. (Intern)
Lundquist, Julie Kay (Ekstern)
Wilson, Clive (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet

Relations
Publications:
Mesoscale to microscale coupling for determining site conditions in complex terrain
Project: PhD

Measuring Turbulence using Commercial Wind Lidars

Department of Wind Energy
Test and Measurements
Number of participants: 2
Project participant:
Sathe, Ameya (Intern)
Vignaroli, Andrea (Intern)

Financing sources
Source: Private funding (private)
Name of research programme: Carbon Trust, UK
Amount: 508,636.00 Danish Kroner
Year of approval: 2011

Impact of wind power uncertainty on electric power system reliability

Department of Wind Energy
Period: 15/11/2014 → 14/11/2017
Number of participants: 6
Phd Student:
Nuño Martínez, Edgar (Intern)
Supervisor:
Sørensen, Poul Ejnar (Intern)
Main Supervisor:
Cutululis, Nicolaos Antonio (Intern)
Examiner:
Giebel, Gregor (Intern)
Kariniotakis, George (Ekstern)
van Hertem, Dirk (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet

Relations
Publications:
Impact of renewable energy uncertainty on electric power system reliability
Project: PhD
Probabilistic Design of Wind Turbines Structures
Department of Wind Energy
Period: 15/11/2014 → 16/04/2018
Number of participants: 7
Phd Student:
NJOMO WANDJI, Wilfried (Intern)

Supervisor:
Buhl, Thomas (Intern)
Dimitrov, Nikolay Krasimirov (Intern)
Main Supervisor:
Natarajan, Anand (Intern)
Examiner:
Bredmose, Henrik (Intern)
Bhattacharya, Subhamaoy (Ekstern)
Muskulus, Michael (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet

Relations
Publications:
Probabilistic Design of Wind Turbine Structures: Design Studies and Sensitivities to Model Parameters
Project: PhD

Development of an advanced noise propagation model for noise optimization in wind farm
Department of Wind Energy
Period: 01/11/2014 → 06/03/2018
Number of participants: 7
Phd Student:
Barlas, Emre (Intern)

Supervisor:
Sørensen, Jens Nørkær (Intern)
Zhu, Wei Jun (Intern)
Main Supervisor:
Shen, Wen Zhong (Intern)
Examiner:
Aagaard Madsen, Helge (Intern)
Burdinso, Ricardo (Ekstern)
Sendergaard, Bo (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet

Relations
Publications:
Development of an advanced noise propagation model for noise optimization in wind farm
Project: PhD

Fracture mechanics approach to probabilistic inspection planning of offshore foundation structures for wind turbines
Department of Wind Energy
Period: 01/11/2014 → 08/06/2018
Number of participants: 9
Phd Student:
Ruiz-Munoz, Gustavo-Adolfo (Ekstern)

Supervisor:
Eder, Martin Alexander (Intern)
Niordson, Christian Frithiof (Intern)
Sørensen, John Dalsgaard (Intern)
Østergaard, Thomas (Ekstern)
Main Supervisor:
Stolpe, Mathias (Intern)
Examiner:
Mikkelsen, Lars Pilgaard (Intern)
Gao, Zhen (Ekstern)
Skallerud, Bjørn Helge (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Ansat eksternt

Relations
Publications:
Fracture mechanics approach to optimize inspection planning of offshore welds for wind turbines
Project: PhD

Improved testing methods for fibre composites used in wind turbine blades
Department of Wind Energy
Period: 01/11/2014 → 31/08/2015
Number of participants: 3
Phd Student:
Kristiansen, Morten Fogtmann (Intern)
Supervisor:
Brøndsted, Povl (Intern)
Main Supervisor:
Mikkelsen, Lars Pilgaard (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Modeling of Wind Turbine Inflow
The overall aim of the project is to numerically model the wind turbine inflow in any kind of terrain. Therefore a thorough understanding of the upstream flow modification through the presence of a wind turbine is needed. This will be achieved by applying various numerical simulation methods, ranging from simple potential flow over to computational fluid dynamics, to various wind turbine designs with different control algorithms. In this context the influence of aeroelasticity will also be examined. All numerical methods will be supported and validated through extensive lidar measurement data, that will be acquired during various measurement campaigns.

The project can be split into three major milestones:
- Modelling the blockage effect of the rotor in flat terrain
- Accessing the impact of the topography on the inflow
- Relate the near flow field to the free wind speed

Department of Wind Energy
Aeroelastic Design

Meteorology
Period: 01/09/2014 → 31/08/2017
Number of participants: 4
CFD, lidar, UniTTe, WindScanner, nacelle lidars, power performance, loads assessment, inflow, induction, Uncertainty Quantification
Acronym: PhD
Project ID: 1305-00024B
Phd Student:
Meyer Forsting, Alexander (Intern)
Supervisor:
Réthoré, Pierre-Elouan (Intern)
Bechmann, Andreas (Intern)
Main Supervisor:
Troldborg, Niels (Intern)

Financing sources
Source: Public research council
Name of research programme: Innovation Fund Denmark
Web address: http://innovationsfonden.dk/da

Relations
Parent project:
Unified testing procedures for wind turbines through inflow characterisation using nacelle lidars
Activities:
A Probabilistic Approach to CFD Model Validation with Field Measurements in Wind Energy
Perdigao NEWA meeting
11th EAWE PhD seminar on Wind Energy in Europe
A Probabilistic Approach to CFD Validation with Field Measurements in Wind Energy
Modelling lidar volume-averaging and its effect on wake measurements
ECCOMAS Congress 2016
Predicting free-stream wind speed in complex terrain with lidar measurements
Publications:
Modelling Wind Turbine Inflow: The Induction Zone

Adhesive Joints in Wind Turbine Blades
Department of Wind Energy
Period: 01/09/2014 → 06/03/2018
Number of participants: 6
Phd Student:
Jørgensen, Jeppe Bjørn (Intern)
Supervisor:
Kildegaard, Casper (Ekstern)
Main Supervisor:
Sørensen, Bent F. (Intern)
Examiner:
Mikkelsen, Lars Pilgaard (Intern)
Caro, Alberto Barroso (Ekstern)
Jensen, Henrik Myhre (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Industrial PhD

Relations
Publications:
Adhesive Joints in Wind Turbine Blades
Project: PhD

Scholarship associated with DSF project UniTTe
Department of Wind Energy
Period: 01/09/2014 → 07/12/2017
Number of participants: 8
Phd Student:
Meyer Forsting, Alexander (Intern)
Supervisor:
Bechmann, Andreas (Intern)
Aagaard Madsen, Helge (Intern)
Réthoré, Pierre-Elouan (Intern)
Main Supervisor:
Troldborg, Niels (Intern)
Examiner:
Sørensen, Jens Nørkær (Intern)
Barthelmie, Rebecca Jane (Intern)
Schlipf, David (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering

Relations
Activities:
Modelling lidar volume-averaging and its effect on wake measurements
Project: PhD

Controversies on wind power Wind2050
Energy Systems Analysis
Department of Wind Energy
Department of Management Engineering
Technology and Innovation Management
Systems Analysis
Energy Systems Analysis
Aalborg University
University of Copenhagen
Danish Institute for Governmental Research
CONCITO
Queen's University Belfast
Period: 14/08/2014 → 14/08/2017
Number of participants: 3
Acronym: Wind2050
Number of related Ph.D. students: 3
Project participant:
Nyborg, Sophie (Intern)
Klinge Jacobsen, Henrik (Intern)
Project Manager, academic:
Borch, Kristian (Intern)

Relations
Press / Media items:
Vindmølle-forsker: Genialt at Vattenfall køber landejendomme
Forsker: Vindmøllekonflikter skyldes misundelse
Vindmølle-modvind skal vendes til medvind
Ja tak til vindenærgi - bare ikke lige her

Cost-Effective mass production of Universal Foundations for large offshore wind park
Department of Wind Energy
Wind Turbines
Period: 09/08/2014 → …
Number of participants: 1
Project participant:
Design Optimization of Jacket Structures for Mass Production

Department of Wind Energy

Wind Turbines
Period: 01/08/2014 → …
Number of participants: 1
Project participant:
Sandal, Kasper (Intern)

Design Optimization of Jacket Structures for Mass Production

Department of Wind Energy
Period: 01/08/2014 → 02/11/2017
Number of participants: 6
Phd Student:
Sandal, Kasper (Intern)
Supervisor:
Bredmose, Henrik (Intern)
Main Supervisor:
Stolpe, Mathias (Intern)
Examiner:
Pedersen, Niels Leergaard (Intern)
Duysinx, Pierre (Intern)
Rolfes, Raimund (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet

Relations
Publications:
Design optimization of jacket structures for mass production
Project: PhD

Dynamic Response Optimal Design of Jacket Structures under Many Loads

Department of Wind Energy
Period: 01/08/2014 → 30/11/2014
Number of participants: 3
Phd Student:
Courtney, William Tucker (Intern)
Supervisor:
Natarajan, Anand (Intern)
Main Supervisor:
Stolpe, Mathias (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Using nacelle-mounted lidars in wind turbine power and load measurements

Department of Wind Energy
Period: 01/06/2014 → 21/09/2017
Number of participants: 6
Phd Student:
Borraccino, Antoine (Intern)
Supervisor:
Wagner, Rozenn (Intern)
Main Supervisor:
Courtney, Michael (Intern)
Examiner:
Hansen, Kurt Schaldemose (Intern)
Clifton, Andrew J. (Ekstern)
Gottschall, Julia (Intern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering

**Relations**
Activities:
ISARS2016
Publications:
Remotely measuring the wind using turbine-mounted lidars: Application to power performance testing
Project: PhD

**Coupling atmospheric and wave models for storm conditions**
Department of Wind Energy
Period: 15/04/2014 → 07/09/2017
Number of participants: 7
Phd Student:
Du, Jianting (Intern)
Supervisor:
Kelly, Mark C. (Intern)
Larsen, Søren Ejling (Intern)
Main Supervisor:
Larsen, Xiaoli Guo (Intern)
Examiner:
Bredmose, Henrik (Intern)
Bidlot, Jean Raymond (Ekstern)
Rutgersson, Anna (Ekstern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet

**Relations**
Publications:
Coupling atmospheric and ocean wave models for storm simulation
Project: PhD

**Fatigue damage evolution in fibre composites for wind turbine blades**
Department of Wind Energy
Period: 15/04/2014 → 07/09/2017
Number of participants: 7
Phd Student:
Jespersen, Kristine Munk (Intern)
Supervisor:
Hansen, Jens Zangenberg (Intern)
Main Supervisor:
Mishnaevsky, Leon (Intern)
Examiner:
Wind Farm Layout Optimization in Complex Terrain
The overall objective of the project is to develop and provide new reliable tools for designing wind farms located in complex terrain through full scale measurements in wind farms. For wind farms located in flat terrain, the performance of the wind turbines is significantly influenced by the upstream wind turbines and slightly influenced by the ground. For wind farms located in complex terrain the ground effects are relatively more pronounced, as such effects may bend the wakes created by the upstream turbines significantly. The goal of the present Sino-Danish project is to further develop Danish wind farm technology by using measured wind farm data from complex terrain wind farms in China, which is convenient, as Denmark does not have complex terrain that can be used for developing/validating such technology. To improve the wind turbines’ performance within wind farms in complex terrain, there are basically three important steps: (1) develop reliable CFD tools for predicting flow in complex terrain with and without wind turbines; (2) develop simplified flow models for predicting wind turbine performance in complex terrain; and (3) design high efficiency wind turbine parks in complex terrain.
Branlard, Emmanuel Simon Pierre (Intern)
Main Supervisor:
Gaunaa, Mac (Intern)
Documents:
Fast vortex method for large scale wind energy simulations

Probabilistic wind characterization and wind turbine design
Department of Wind Energy
Period: 01/04/2014 → 28/10/2018
Number of participants: 4
Phd Student:
Hannesdóttir, Ásta (Intern)
Supervisor:
Natarajan, Anand (Intern)
Mann, Jakob (Intern)
Main Supervisor:
Kelly, Mark C. (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Wind Atlas for South Africa (Phase 2)
Capacity development and research cooperation through the development of wind resource mapping for the remaining parts of the Eastern Cape, KwaZulu-Natal and parts of the Free State Province.
Phase 1 of the project ended in 2014.
Department of Wind Energy
Wind Energy Systems
Meteorology
Test and Measurements
Council for Scientific and Industrial Research
University of Cape Town
South African Weather Service
South African National Energy Development Institute
Period: 01/04/2014 → 31/12/2018
Number of participants: 9
Acronym: WASA2
Project participant:
Mortensen, Niels Gylling (Intern)
Hahmann, Andrea N. (Intern)
Badger, Jake (Intern)
Volker, Patrick (Intern)
Larsen, Xiaoli Guo (Intern)
Enevoldsen, Karen (Intern)
Sørensen, Steen Arne (Intern)
Cronin, Tom (Intern)
Project Manager, organisational:
Hansen, Jens Carsten (Intern)

Relations
Activities:
Interpreting wind energy resource visualisations for South Africa
Wind resource error estimation from mesoscale modeling for the Wind Atlas for South Africa
WASA 2 Application for planning purposes
WASA 2 Microscale modelling and validation
Wind resource error estimation from mesoscale modeling for the Wind Atlas for South Africa

Coordinated control of wind power plants in offshore HVDC grids
Department of Wind Energy
Period: 15/03/2014 → 06/03/2018
Number of participants: 7
Phd Student:
Sakamuri, Jayachandra Naidu (Intern)
Supervisor:
Hansen, Anca Daniela (Intern)
Sørensen, Poul Ejnar (Intern)
Main Supervisor:
Cutululis, Nicolaos Antonio (Intern)
Examiner:
Nielsen, Arne Hejde (Intern)
Liang, Jun (Ekstern)
Uhlen, Kjetil (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Marie Curie (EU-stipendium)
Project: PhD

Integrated Research Programme in Wind Energy
Department of Wind Energy
Resource Assessment Modelling
Period: 01/03/2014 → 28/02/2018
Number of participants: 1
Wind Energy, wind resources, open data, mobility of researchers
Acronym: IRPWIND
Project participant:
Sempreviva, Anna Maria (Intern)

Relations
Activities:
EGU General Assembly 2017
Wind energy open data web portal: Metadata and Taxonomy for data search
Building wind energy taxonomy for FAIR data: how to organize and find web distributed data

WAsP e-learning courses
Development and teaching of on-line WAsP e-learning courses. The 9-week course is intended for engineers, scientists and others, primarily working within the field of wind energy, who require a working knowledge of the WAsP program. Aspects of the theories underlying the program are presented, but the course stresses practical experience and examples on the use of WAsP.

Department of Wind Energy
Meteorology
Period: 10/02/2014 → 31/12/2018
Number of participants: 10
Project participant:
Mortensen, Niels Gylling (Intern)
Rathmann, Ole Steen (Intern)
Alliance for Imaging and Modelling of Energy Applications
The CINEMA research alliance will develop unique 3D micro-structural characterization methods, which make it possible to investigate components under realistic conditions and in real time. This will enable correlation between performance and local changes in the microstructure.

Department of Energy Conversion and Storage
Imaging and Structural Analysis
Department of Physics
Neutrons and X-rays for Materials Physics
Department of Wind Energy
Composites and Materials Mechanics
Department of Applied Mathematics and Computer Science
Image Analysis & Computer Graphics
Scientific Computing
Mixed Conductors
Statistics and Data Analysis
University of Copenhagen
Northwestern University
University of Manchester
MaxLab
LM Wind Power
Haldor Topsoe AS
Xnovo Technology ApS
Rockwool International

Amminex Emissions Technology A/S
Period: 01/01/2014 → 31/12/2018
Number of participants: 26
Acronym: CINEMA
Project participant:
Mikkelsen, Lars Pilgaard (Intern)
Sørensen, Bent F. (Intern)
Bowen, Jacob R. (Intern)
Kuhn, Luise Theil (Intern)
Larsen, Rasmus (Intern)
Hansen, Per Christian (Intern)
Frandsen, Henrik Lund (Intern)
Gundlach, Carsten (Intern)
Dahl, Anders Bjorholm (Intern)
Yang, Shu-Yi (Intern)
Poulsen, Stefan Othmar (Intern)
Lyckegaard, Allan (Intern)
Lauridsen, Erik Mejdal (Intern)
Sørensen, Henning Osholm (Ekstern)
Project Manager, organisational:
Sørensen, Hanne (Intern)
Phd Student:
Jespersen, Kristine Munk (Intern)
Beil, Johannes (Ekstern)
Andersen, Michael (Intern)
Emerson, Monica Jane (Intern)
De Angelis, Salvatore (Intern)
Birkelund, Klaus (Ekstern)
Jacobsen, Hjalte Sylvest (Intern)
Chapelle, Lucie (Intern)
Supervisor:
Frandsen, Henrik Lund (Intern)
Project Manager, academic:
Andreasen, Jens Wenzel (Intern)
Project Coordinator:
Poulsen, Henning Friis (Intern)

Relations
Activities:
DTU Energy Conversion 2nd International PhD Summer School
Wilson K. S. Chiu
High resolution Ptychographic tomography of soft matter
Gerardina Carbone
Sample Design and Preparation Techniques for Dynamic Microstructural Studies of High Temperature Electrochemical Cells
DTU Energy Conversion 2nd International PhD Summer School
Publications:
Fatigue damage evolution in fibre composites for wind turbine blades
Micromechanical Time-Lapse X-ray CT Study of Fatigue Damage in Uni-Directional Fibre Composites
Improving organic tandem solar cells based on water-processed nanoparticles by quantitative 3D nanoimaging
Micromechanical Investigation of Fatigue Damage in Uni-Directional Fibre Composites
Dictionary Based Segmentation in Volumes
3D X-Ray Computed Tomography (XCT) of Fatigue Damage Evolution in UD Glass Fibre Composite
Enabling Flexible Polymer Tandem Solar Cells by 3D Ptychographic Imaging
Project

ABYSS: Advancing BeYond Shallow waterS - Optimal design of offshore wind turbine support structures
ABYSS is a four year research project funded by the Danish Council for Strategic Research. ABYSS develops novel mathematical models, reliable numerical optimization techniques and software for optimal design of cost effective bottom-fixed offshore wind turbine support structures for all relevant water depths including deep waters in excess of 50m.

Department of Wind Energy
Wind Turbines
Fluid Mechanics
Department of Civil Engineering
Section for Geotechnics and Geology
FE-Design GmbH
Norwegian University of Science and Technology
Unified testing procedures for wind turbines through inflow characterisation using nacelle lidars

UniTTTe addresses the question of how best to characterise the wind when measuring the power and loads on modern wind turbines.

Current international standards require us to measure the wind from a mast, far in-front of the rotor and at the rotor centre height (hub-height). UniTTTe proposes a radical change so that in the future we will measure with a lidar (laser anemometer) mounted on the nacelle, measure quite close to the rotor and measure over a range of heights. The advantages will be significant: avoiding erecting high masts (hugely expensive offshore), getting better correlation between the wind and the power and loads and achieving universal procedures that work equally well both offshore and in mountains.

UniTTTe - Unified Turbine Testing

Department of Wind Energy

Test and Measurements

Department of Electrical Engineering

Aeroelastic Design

Residual Resource Engineering

Wind Turbines

Period: 01/01/2014 → 31/12/2017

Number of participants: 11

nacelle lidars, power performance, loads assessment, inflow, induction

Acronym: UniTTTe

Number of related Ph.D. students: 2

Project participant:

Friis Pedersen, Troels (Intern)

Trolldborg, Niels (Intern)

Meyer Forsting, Alexander (Intern)

Bechmann, Andreas (Intern)

Courtney, Michael (Intern)
Relations
Related projects:
Modeling of Wind Turbine Inflow
Activities:
EWEA Technology Workshop
Wind Europe Summit 2016
Perdigao NEWA meeting
11th EWEA PhD seminar on Wind Energy in Europe
Power curve measurement using \( V^\infty \) estimates from nacelle lidars and its uncertainty
ISARS2016
12th German Wind Energy Conference DEWEK 2015
ECCOMAS Congress 2016
Predicting free-stream wind speed in complex terrain with lidar measurements
Power curve measurement using \( \tilde{V}^\infty \) estimates from nacelle lidars and its uncertainty
Publications:
Calibration report for Avent 5-beam Demonstrator lidar
Calibration report for ZephIR Dual Mode lidar (unit 351)
Generic methodology for calibrating profiling nacelle lidars

Nucleation of recrystallization at selected sites in deformed fcc metals
Department of Wind Energy
Period: 01/01/2014 → 20/04/2017
Number of participants: 7
Phd Student:
Xu, Chaoling (Ekstern)
Supervisor:
Wu, Gulin (Ekstern)
Zhang, Yubin (Intern)
Main Supervisor:
Juul Jensen, Dorte (Intern)
Examiner:
Huang, Xiaoxu (Intern)
Quey, Romain (Ekstern)
Zhang, Hongwang (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Stipendie fra udlandet
Project: PhD

Light Weight Rotor Design - Combined passive and active control methods
Department of Wind Energy
Period: 15/12/2013 → 20/04/2017
Number of participants: 7
Phd Student:
Pavese, Christian (Intern)
Supervisor:
Henriksen, Lars Christian (Intern)
Larsen, Torben J. (Intern)
Main Supervisor:
Kim, Taeseong (Intern)
Examiner:
Bak, Christian (Intern)
Kallesøe, Bjarne Skovmose (Intern)
Palacios, Rafael (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Uncertainty Quantification of Wind Farm Flow Models

Department of Wind Energy
Period: 15/12/2013 → 23/03/2017
Number of participants: 7
Phd Student:
Murcia Leon, Juan Pablo (Intern)
Supervisor:
Natarajan, Anand (Intern)
Serensen, John Dalsgaard (Intern)
Main Supervisor:
Réthoré, Pierre-Elouan (Intern)
Examiner:
Larsen, Gunner Chr. (Intern)
Barthelmie, Rebecca Jane (Intern)
Manuel, Lance (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet

Relations
Publications:
Uncertainty quantification in wind farm flow models
Project: PhD

Parallelization of vortex methods
Parallelization of vortex methods using GPU, openMP, MPI, AVX vectorization.

Department of Wind Energy
Aeroelastic Design

Department of Applied Mathematics and Computer Science
Period: 01/12/2013 → 01/04/2015
Number of participants: 2
Project participant:
Branlard, Emmanuel Simon Pierre (Intern)
Serensen, Hans Henrik Brandenborg (Intern)

Modeling of low frequency noise from wind turbines

Department of Wind Energy
Period: 01/12/2013 → 31/05/2017
Number of participants: 7
Phd Student:
Debertshäuser, Harald (Intern)
Supervisor:
Sørensen, Jens Nørkær (Intern)
Zhu, Wei Jun (Intern)
Main Supervisor:
Shen, Wen Zhong (Intern)
Examiner:
Bertagnolio, Franck (Intern)
Cotté, Benjamin (Ekstern)
Kaltenbach, Hans-Jakob (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

European Clusters for Offshore Wind Servicing
ECOWindS' objective is to pave the way for new research and knowledge of how the costs of offshore wind energy can be driven down through better services. The objective is reached by establishing cross-regional cooperation, intensifying the relationship between research, the European offshore wind servicing (OWS) sector and the offshore wind industry. The actions in the project include mapping of regional capabilities, search of RDI projects and building a Joint Action Plan for regional and international co-operation. ECOWindS is funded from the EU FP7.

Department of Management Engineering
Technology and Innovation Management
Wind Energy Systems
Wind Turbines
Offshoreenergy.dk
Period: 01/11/2013 → 31/10/2015
Number of participants: 5
Offshore wind, Roadmap, Foresight, Offshore wind services
Acronym: ECOWindS
Project participant:
Piirainen, Kalle A. (Intern)
Andersen, Per Dannemand (Intern)
Clausen, Niels-Erik (Intern)
Buhl, Thomas (Intern)
Cronin, Tom (Intern)
Relations
Publications:
The GRIP method for collaborative roadmapping workshops
Towards a Joint Action Plan for Research and Development in the Offshore Wind Service Industry
Cluster strategies for the North Sea the offshore wind service sector. A sectoral innovation system foresight.
ECOWindS Joint Action Plan - Guidelines for Implementation
ECOWindS Joint Action Plan
ECOWindS Evaluation and Adaptation Report
Technological competence mapping in the North Sea region
Smart Specialization and Capabilities for Offshore Wind Services around the North Sea
Offshore wind energy developments
Smart Specialisation: ‘All roads lead to Rome’
Towards a Joint Action Plan for Research and Development in the Offshore Wind Service Industry

Press / Media items:
Simulatorbransjen satsar på vind

Design of Large wind turbines using fluid-structure coupling technique
Department of Wind Energy
Period: 01/11/2013 → 16/02/2017
Number of participants: 7
Phd Student:
Sessarego, Matias (Intern)
Supervisor:
Ramos Garcia, Néstor (Intern)
Serensen, Jens Nørkaer (Intern)
Main Supervisor:
Shen, Wen Zhong (Intern)
Examiner:
Aagaard Madsen , Helge (Intern)
Madsen, Jesper (Ekstern)
Schepers, Gerard (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Development of Large Eddy Simulation Tools for Simulation of Atmospheric Boundary Layers in Wind Farms
Department of Wind Energy
Period: 01/11/2013 → 07/12/2017
Number of participants: 7
Phd Student:
Dag, Kaya Onur (Intern)
Supervisor:
Shen, Wen Zhong (Intern)
Serensen, Niels N. (Intern)
Main Supervisor:
Serensen, Jens Nørkaer (Intern)
Examiner:
Berg, Jacob (Intern)
Churchfield, Matthew J. (Ekstern)
Meyers, Johan (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Offentlig finansiering
Relations
Publications:
Combined pseudo-spectral / actuator line model for wind turbine applications
Project: PhD

Cost-Effective mass production of Universal Foundations for large offshore wind park
Department of Wind Energy
Wind Turbines
Period: 01/10/2013 → 30/09/2016
Number of participants: 2
Acronym: HTF-CEUF
Project participant:
Buhl, Thomas (Intern)
Stolpe, Mathias (Intern)

Performance Measurements with the use of Spinner Anemometry
Department of Wind Energy
Period: 01/10/2013 → 25/11/2016
Number of participants: 7
PhD Student:
Demurtas, Giorgio (Intern)
Supervisor:
Moiritsen, Seren (Intern)
Wagner, Rozen (Intern)
Main Supervisor:
Fris Pedersen, Troels (Intern)
Examiner:
Hansen, Kurt Schaldemose (Intern)
Eecen, Pieter Jan (Ekleen)
Gottschall, Julia (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: 1/3 FUU, 1/3 inst 1/3 Andet

Relations
Publications:
Wind turbine power performance measurement with the use of spinner anemometry
Project: PhD

GARPUR - Generally Accepted Reliability Principle with Uncertainty modelling and through probabilistic Risk assessment
Power system reliability management aims to maintain power system performance at a desired level, while minimizing the socio-economic costs of keeping the power system at that performance level.

Historically in Europe, network reliability management has been lying on the so-called “N-1” criterion: in case of fault of one relevant element (e.g. one transmission system element, one significant generation element or one significant distribution network element), the elements remaining in operation must be capable of accommodating the new operational situation without violating the network’s operational security limits.

Today, the increasing uncertainty of generation due to intermittent energy sources, combined with the opportunities provided e.g. by demand-side management and energy storage, call for imagining new reliability criteria with a better balance between reliability and costs.

The GARPUR project designs, develops, assesses and evaluates such new reliability criteria to be progressively implemented over the next decades at a pan-European level, while maximising social welfare.

Risø National Laboratory for Sustainable Energy
Windtrust
The project aims to improve the competitiveness of the Wind energy by enhancing the reliability of key components of 2MW size Wind turbines and by reducing noise emission of this turbines class with blade add-ons.

Statistical characterization of metal microstructures

Blade Dragon 2.0
Analyze & improve Liftra’s Blade Dragon single blade installation system to be able to do single blade installation in higher Wind speeds than today’s approx. 8m/s.
Extreme winds and waves for offshore turbines - Coupling atmosphere and wave modeling for design and operation in coastal zones

The X-WiWa project was motivated by Denmark's long term vision for offshore wind energy and the many technical and scientific challenges in existing methodologies for assessing the design parameters, for both winds and waves.

X-WiWa succeeded in developing a most up-to-date modeling system for wind modeling for offshore wind farms. This modeling system consists of the atmospheric Weather Research and Forecasting (WRF) model, the wave model SWAN and an interface the Wave Boundary Layer Model WBLM, within the framework of coupled-ocean-atmosphere-wave-sediment transport modeling system COAWST (Hereinafter the WRF-WBLM-SWAN model). WBLM is implemented in SWAN, and it calculates stress and kinetic energy budgets in the lowest atmospheric layer where the wave-induced stress is introduced to the atmospheric modeling. WBLM ensures consistent calculation of stress for both the atmospheric and wave modeling, which was considered a major improvement to previous attempts in the literature. This methodology thus provides an option to avoid the parametrization of an often used interface parameter, the roughness length. Many parametrization schemes for the roughness length have brought diverse estimates and associated uncertainties to the modelled wind speed. Data validation using measurements from the Baltic Sea and North Sea around Denmark suggests that the coupled modeling system WRF-WBLM-SWAN outperforms the non-coupled, no-wave, WRF modeling of wind; an improvement by 10% or more is present at strong winds, which can affect the choice of the offshore wind turbine type.

X-WiWa examined various methodologies for wave modeling. The offline coupling system using atmospheric data such as WRF or global reanalysis wind field to the MIKE 21 SW model has been improved with considerations of stability, air density, currents and new wind drag relations. X-WiWa suggests that, implementation of an online coupling technology does not necessarily provide better estimation of the waves, if the physics have not been properly described. This is supported by the comparisons of the modeled wave data between offline MIKE 21 SW modeling and the WRF-WBLM-SWAN modeling. The two provide comparably good wave calculations for coastal areas but the latter underestimates the wave height for far offshore areas, which is speculated to be related to the dissipation description in the wave source functions, where further improvement is seen necessary.

X-WiWa puts modeling efforts on storms that are defined to be contributors to the extreme wind and extreme significant wave height through the annual maximum method. Thus for 23 years from 1994 to 2016, 429 storm days are simulated for the extreme wind, and for 1994 to 2014, 932 storm days are simulated for the extreme significant wave height. The 50-year winds at 10 m, 50 m and 100 m over the waters around Denmark are calculated and validated and agreement is satisfactory. The 50-year significant wave height for the Danish waters and surrounding North Sea and Baltic Sea are presented from the online and offline systems.

The modeling systems, data, analysis, results and publications are introduced and provided on www.xwiwa.dk. These outputs are expected to be useful for general offshore wind and wave applications such as Operation and Maintenance, Forecasting, and Design.
Extreme winds, Extreme wave, wind-wave coupled modeling, storms
Acronym: X-WiWa
Number of related Ph.D. students: 1
Project participant:
Larsén, Xiaoli Guo (Intern)
Du, Jianting (Intern)
Badger, Jake (Intern)
Imberger, Marc (Intern)
Karagali, Ioanna (Intern)
Badger, Merete (Intern)
Kelly, Mark C. (Intern)
Hahmann, Andrea N. (Intern)
Larsen, Søren Ejling (Intern)

New optimal design tools for future wind turbine blades
The object of this project is to develop and study new methods for optimal structural and aerodynamic design of wind turbine blades based on high-fidelity beam models and topology optimization techniques. The ability to reduce the cost of wind energy through an increase in the size of wind turbine rotor blades has motivated the ongoing trend of “bigger is better”. However, as the size of wind turbine blades increases, new structural and aerodynamic design challenges emerge, such as, self-weight and gravity induced fatigue damage. Addressing these issues has become a cornerstone for the realization of larger wind turbine blades. This project suggests the development of new numerical optimization tools for wind turbine blade design to specifically tackle these new challenges. Achieving to do so will render the design of larger wind turbine blades feasible and consequently allow for the continuing reduction in the cost of wind energy.

Department of Wind Energy
Wind Turbines
Period: 01/06/2013 → 31/05/2015
Number of participants: 1
Project participant:
Blasques, José Pedro Albergaria Amaral (Intern)

Relations
Activities:
Optimal design of laminated composite beams with mass, stiffness, and frequency constraints

Optimal design of adaptive wind turbine blades
Department of Wind Energy
Period: 15/05/2013 → 16/02/2017
Number of participants: 7
Phd Student:
Stäblein, Alexander (Intern)
Supervisor:
Branner, Kim (Intern)
Kim, Taeseong (Intern)
Main Supervisor:
Hansen, Morten Hartvig (Intern)
Examiner:
Hansen, Martin Otto Laver (Intern)
Nielsen, Søren R. K. (Ekstern)
Riziotis, Vasilis A. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Marie Curie (EU-stipendium)
Project: PhD
Mechanical properties of stone wool products after chemical and mechanical ageing

Department of Wind Energy
Period: 01/05/2013 → 30/09/2016
Number of participants: 7
Phd Student:
Chapelle, Lucie (Intern)
Supervisor:
Kusano, Yukihiro (Intern)
Larsen, Dorthe (Intern)
Main Supervisor:
Brøndsted, Povl (Intern)
Examiner:
Madsen, Bo (Intern)
Gamstedt, Kristofer (Ekstern)
Neagu, Cristian (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: ErhvervsPhD-ordningen VTU
Project: PhD

Multi-terminal DC grid for offshore wind
A DC grid based on multi-terminal voltage-source converters is a newly emerging technology, which is particularly suitable for the connection of offshore wind farms. The achievements from the project will contribute to integrating offshore wind power into the onshore AC grids in European countries and for the European offshore grid.

The MEDOW network will share complementary expertise, infrastructure and facilities for the training of the next generation of top-quality researchers in this field.

Department of Wind Energy
Wind Energy Systems
Risø National Laboratory for Sustainable Energy
Cardiff University
Katholieke Universiteit
Elia (TSO Belgium)
Universitat Politècnica de Catalunya
University of Porto
Alstom Wind
Period: 01/05/2013 → 31/03/2017
Number of participants: 1
Offshore grids, HVDC, wind power, Control System
Acronym: MEDOW
Number of related Ph.D. students: 1
Project participant:
Cutululis, Nicolaos Antonio (Intern)

Financing sources
Source: EU research programme (public)
Name of research programme: FP7-PEOPLE

Relations
Publications:
MEDOW - Multi-terminal DC Grid for Offshore Wind, Final report
Integration of wind power and other renewables in power system defence plans

Department of Wind Energy
Period: 01/04/2013 → 04/07/2016
Number of participants: 8
Phd Student:
Das, Kaushik (Intern)
Supervisor:
Abildgaard, Hans (Ekstern)
Hansen, Anca Daniela (Intern)
Margaris, Ioannis (Intern)
Main Supervisor:
Sørensen, Poul Ejnar (Intern)
Examiner:
Nielsen, Arne Hejde (Intern)
Iov, Florin (Ekstern)
Uhlen, Kjetil (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Anden EU-finansiering

Relations
Publications:
Integration of Renewable Generation in Power System Defence Plans
Project: PhD

Reliabilities of composite materials for wind turbine blades

Department of Wind Energy
Period: 01/04/2013 → 04/07/2016
Number of participants: 7
Phd Student:
Pereira, Gilmar Ferreira (Intern)
Supervisor:
McGugan, Malcolm (Intern)
Sørensen, Bent F. (Intern)
Main Supervisor:
Mikkelsen, Lars Pilgaard (Intern)
Examiner:
Legarth, Brian Nyvang (Intern)
Güemes, Alfredo (Ekstern)
Ogin, Stephen L. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Marie Curie (EU-stipendium)

Relations
Publications:
Multi-life-stage monitoring system based on fibre bragg grating sensors for more reliable wind turbine rotor blades:
Experimental and numerical analysis of deformation and failure in composite materials
Project: PhD

PhD scholarship in Turbulent Atomspheric Flow with Relevance for Wind Energy

Department of Wind Energy
Period: 01/03/2013 → 29/09/2016
Number of participants: 6
Phd Student:
Lange, Julia (Intern)
**ESA ResGrow**

RESGrow (ESA: Ongoing) is a collaborative project funded by European Space Agency. Techworks Marine Ltd. are responsible for the overall project management and are also responsible for the Wave and Tidal Energy sector. The aim of the RESGrow project is the provision of statistical information on environmental conditions to support the planning of new renewable energy infrastructure as well as the provision of nowcast and forecast information to optimise short- to medium-term operations planning. Within the context of this activity, renewable energy refers to the following sectors:

In Phase 1:
- Offshore wind energy
- Hydropower
- Solar Energy
- Tidal and wave energy
- Biomass

In Phase 2:
- Offshore wind energy
- Solar Energy
- Tidal and wave energy

The main goal of the project is expanding the market for earth observation based information services in renewable energy sector.

Project in two phases 1 and 2.

Department of Wind Energy

Meteorology

Wind Energy Systems

TechWorks Marine

German Aerospace Center

Transvalor

Period: 07/02/2013 → 30/09/2015

Number of participants: 5

Acronym: ESA ResGrow

Project participant:
- Astrup, Poul (Intern)
- Badger, Merete (Intern)
- Giebel, Gregor (Intern)
- Hahmann, Andrea N. (Intern)

Project Manager, organisational:
- Hasager, Charlotte Bay (Intern)
Sino-Danish project: ORES: Study on offshore wind resource assessment based on satellite data and modelling

Objective: To develop a practical, reliable and robust method for offshore wind resource assessment that can be applied for other potential offshore wind farm sites in China and elsewhere.

Department of Wind Energy
Meteorology
Chinese Academy of Meteorological Sciences
Period: 01/02/2013 → 31/12/2014
Number of participants: 4
Acronym: ORES
Project participant:
Badger, Merete (Intern)
Astrup, Poul (Intern)
Larsen, Xiaoli Guo (Intern)

Project Manager, organisational:
Hasager, Charlotte Bay (Intern)

Relations
Activities:
Ocean winds from satellites – applications for offshore wind energy

Project

Sea Surface Temperature Diurnal Variability: Regional Extent - Implications in Atmospheric Modelling

Postdoctoral Research Project funded from the European Space Agency (ESA) - Support to Science Element (STSE)

Department of Wind Energy
Meteorology
European Space Agency
Danish Meteorological Institute
Period: 15/01/2013 → 15/01/2015
Number of participants: 2
Satellite remote sensing, Sea Surface Temperature, Atmospheric Modelling
Acronym: SSTDV: REX - IMAM
Contact person:
Hasager, Charlotte Bay (Intern)
Project applicant:
Karagali, Ioanna (Intern)

Relations
Activities:
ESA SciNet 2014
The 15th GHRSST Science Team Meeting
IOVWST Meeting 2015
Documents:
ESA Support to Science Element Project proposal

Project

Standardiserede Power Packs til forbedret aerodynamik i vindmøller - PowerPack

Department of Wind Energy
Aeroelastic Design

Liftra
Period: 01/01/2013 → 31/12/2015
Number of participants: 3
Acronym: PowerPack
Online WAsP
The objective of the project is to develop an inexpensive and user-friendly tool for energy yield calculations of small wind turbines.

Department of Wind Energy
Aeroelastic Design
Meteorology
Test and Measurements
Wind Energy Systems
Wind Turbines

EMD International A/S
Period: 01/01/2013 → 31/12/2015
Number of participants: 14
WAsP, wind resources, urban, small wind turbine

Project participant:
Troen, Ib (Intern)
Hansen, Brian Ohrbeck (Intern)
Peña, Alfredo (Intern)
Sørensen, Steen Arne (Intern)
Maule, Petr (Intern)
Fris, Peggy (Intern)
Rathmann, Ole Steen (Intern)
Kelly, Mark C. (Intern)
Nielsen, Rikke Anne (Intern)
Ejsing Jørgensen, Hans (Intern)
Astrup, Poul (Intern)
Mortensen, Niels Gylling (Intern)
Nielsen, Morten (Intern)

Project Coordinator:
Bechmann, Andreas (Intern)

Relations
Activities:
Sådan kan man regne på husstands møller
Seminar on small turbines
Seminar on small turbines

Future Technologies for Wind Energy: Blade materials, Turbine reliability, Computation tools, and Experimental methods
International Network Programme - USA & India

Department of Wind Energy
Composites and Materials Mechanics

Department of Electrical Engineering
Period: 01/01/2013 → 31/12/2013
Number of participants: 3
Wind Energy
Project ID: 12-132723
Project participant:
**Power Pack**
The project will develop standardized aerodynamic devices, e.g. vortex generators and Gurney flaps, called Power Packs, to improve wind turbine blades and thereby increase power production by up to 6%.

*Department of Wind Energy*

*Aeroelastic Design*

*Sander Plast*

*Liftra*

**Period:** 01/01/2013 → 31/12/2015  
**Number of participants:** 5  
**Acronym:** 43176-4610  
**Project participant:**  
Gaunaa, Mac (Intern)  
Skrzypinski, Witold Robert (Intern)  
Zahle, Frederik (Intern)  
Sørensen, Niels N. (Intern)  
**Project Manager, academic:**  
Bak, Christian (Intern)  
**Project**

**AVATAR**
The overall objective of the AVATAR project is to evaluate, improve and validate aerodynamic and aeroelastic tools to ensure applicability for large optimized Wind turbines.

*Department of Wind Energy*

*Aeroelastic Design*

*Fluid Mechanics*

**Period:** 01/01/2013 → 31/10/2017  
**Number of participants:** 9  
**Project participant:**  
Aagaard Madsen, Helge (Intern)  
Zahle, Frederik (Intern)  
Rasmussen, Flemming (Intern)  
Heinz, Joachim Christian (Intern)  
Henriksen, Lars Christian (Intern)  
Troldborg, Niels (Intern)  
Sørensen, Jens Nørkaer (Intern)  
Barlas, Athanasios (Intern)  
**Project Manager, academic:**  
Sørensen, Niels N. (Intern)  
**Project**

**Possible Power of Downregulated Offshore Wind power plants**

*Department of Wind Energy*

**Period:** 15/12/2012 → 07/04/2016  
**Number of participants:** 7  
**Phd Student:**  
Göçmen, Tuhfe (Intern)  
**Supervisor:**  
Poulsen, Niels Kjølstad (Intern)
Sørensen, Poul Ejnar (Intern)
Main Supervisor:
Giebel, Gregor (Intern)
Examiner:
Sørensen, Jens Nørkær (Intern)
Apt, Jay (Ekstern)
Johansen, Knud (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Offentlig finansiering
Project: PhD

Innovative wind conversion systems (10-20MW) for offshore applications
This is the largest ongoing wind energy research project in Europe with 27 participating organizations and coordinated by DTU Wind Energy.
The objectives of the Innwind.EU project are high performance innovative design of beyond-state-of-the-art 10-20MW offshore wind turbines and hardware demonstrators of its critical components.

Department of Wind Energy
Wind Turbines
Wind Energy Systems
Aeroelastic Design
Fluid Mechanics
Period: 01/11/2012 → 31/10/2017
Number of participants: 9
Innovative offshore wind turbines
Acronym: INNWIND.EU
Project participant:
Natarajan, Anand (Intern)
Jensen, Peter Hjuler (Intern)
Buhl, Thomas (Intern)
Abrahamsen, Asger Bech (Intern)
Aagaard Madsen, Helge (Intern)
Hanis, Tomas (Intern)
Stolpe, Mathias (Intern)
Sørensen, Jens Nørkær (Intern)
Barlas, Athanasios (Intern)

Relations
Publications:
Effects of an electromagnetic shield and armature teeth on the short-circuit performance of a direct drive superconducting generator for 10 MW wind turbines
Comparison of 10 MW superconducting generator topologies for direct-drive wind turbines
Project

Pan European Climate Data
ENTSO-E funded project aimed at evaluating photovoltaic and wind hourly production on regional scale in the whole Europe

Department of Electrical Engineering
Center for Electric Power and Energy
Distributed Energy Resources
Department of Wind Energy
Wind Energy Systems
Meteorology
Period: 01/11/2012 → 31/07/2014
Number of participants: 3
Photovoltaic, Wind Energy
Acronym: PECD
Project participant:
Marinelli, Mattia (Intern)
Cutululis, Nicolaos Antonio (Intern)
Hahmann, Andrea N. (Intern)

Combinatorial Optimization over Second-Order and Industrial Applications
Department of Wind Energy
Period: 01/10/2012 → 04/07/2016
Number of participants: 7
Phd Student:
Friberg, Henrik Alsing (Intern)
Supervisor:
Andersen, Kent Høj (Ekstern)
Andersen, Erling D. (Intern)
Main Supervisor:
Stolpe, Mathias (Intern)
Examiner:
Andersen, Martin Skovgaard (Intern)
Pataki, Gábor (Ekstern)
Terlaky, Tamás (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: ErhvervsPhD-ordningen VTU

Relations
Publications:
Presolving and regularization in mixed-integer second-order cone optimization
Project: PhD

Mathematical programming methods for large-scale structural topology optimization
Department of Wind Energy
Period: 01/09/2012 → 28/01/2016
Number of participants: 6
Phd Student:
Rojas Labanda, Susana (Intern)
Supervisor:
Sigmund, Ole (Intern)
Main Supervisor:
Stolpe, Mathias (Intern)
Examiner:
Jensen, Jakob Søndergaard (Intern)
Evgrafov, Anton (Intern)
Stingl, Michael Walter (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Eksternt finansieret virksomhed

Relations
Activities:
DCAMM 14th Internal Symposium
National Wind Tunnel
To design and establish a national Wind tunnel, which is a national research infrastructure able mainly to test 2D airfoils up to Re=7 mio aerodynamically and aero-acoustically and in alater phase be able to measure model rotors and wakes.

Department of Wind Energy
Aeroelastic Design
Fluid Mechanics
Meteorology
Period: 15/08/2012 → 31/12/2016
Number of participants: 6
Acronym: 44525-4610
Project participant:
Fischer, Andreas (Intern)
Gaunaa, Mac (Intern)
Mikkelsen, Robert Flemming (Intern)
Mann, Jakob (Intern)
Barlas, Athanasios (Intern)
Project Manager, academic:
Bak, Christian (Intern)

IEA Wind 29 Mexnext-II
The purpose of participation in the IEA Annex 29 Mexnext II is to validate and improve a variety of aerodynamic and aeroelastic calculation models used in both research institutions and industry.

Department of Wind Energy
Aeroelastic Design
Period: 01/08/2012 → 31/12/2014
Number of participants: 2
Acronym: 43144-4610
Project participant:
Sørensen, Niels N. (Intern)
Project Manager, academic:
Aagaard Madsen , Helge (Intern)

EUDP LEX
To clarify the reason of leading edge blade damages and demonstrate efficient solutions to the problem.

Department of Wind Energy
Aeroelastic Design
Period: 08/07/2012 → 30/06/2016
Number of participants: 2
Acronym: 43199
Project participant:
Hansen, Anders Melchior (Intern)
Project Manager, academic:
Larsen, Torben J. (Intern)

Aerodynamic and structural design of wind turbine blades
Department of Wind Energy
Assessment of extreme design loads for modern wind turbines using the probabilistic approach

Department of Wind Energy
Period: 01/05/2012 → 24/08/2015
Number of participants: 6
PhD Student:
Abdallah, Imad (Intern)
Supervisor:
Sørensen, John Dalsgaard (Intern)
Main Supervisor:
Natarajan, Anand (Intern)
Examiner:
Larsen, Gunner Chr. (Intern)
Manuel, Lance (Ekstern)
Riziotis, Vasilis A. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: ErhvervsPhD-ordningen VTU
Project: PhD

Ultimate strength of wind turbine blade structures under multi axial loading

Department of Wind Energy
Period: 01/05/2012 → 25/02/2016
Number of participants: 7
PhD Student:
Haselbach, Philipp Ulrich (Intern)
Supervisor:
Berggreen, Christian (Intern)
Bitsche, Robert (Intern)
Main Supervisor:
Branner, Kim (Intern)
Examiner:
Mikkelsen, Lars Pilgaard (Intern)
Lindgaard, Esben (Ekstern)
Trujillo, Juan-José (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: 1/3 FUU, 1/3 inst 1/3 Andet
Project: PhD

Research and Development of optimal Wind turbine rotors under offshore wind conditions in China

The scientific objectives of the project are to develop new aerodynamic and structural design tools, and control techniques for optimizing wind turbine rotors for offshore wind energy applications in China. During the past five years, DTU has
established a strong research collaboration network with Chinese universities and research institutes in the area of wind energy. The present proposal will further strengthen the collaboration. To develop wind technology under offshore wind conditions in China, it demands the insights of the physics of wind turbine flows under local wind conditions and the development of novel computational techniques that are capable to design and predict the performance of wind turbines. The goal is to make offshore wind energy production more competitive through fundamental insights into the interaction between atmospheric turbulence and wind turbines. Further, wind turbines under offshore conditions in China can be operated optimally through the design of efficient control systems.

Department of Wind Energy

Fluid Mechanics

Aerodynamic design
Period: 01/04/2012 → 30/06/2017
Number of participants: 4
Acronym: OffWindChina
Project ID: IFD-0603-00506B
Number of related Ph.D. students: 4
Project Manager, organisational:
Sørensen, Jens Nørkær (Intern)
Project Manager, academic:
Zhu, Wei Jun (Intern)
Aagaard Madsen, Helge (Intern)
Project Coordinator:
Shen, Wen Zhong (Intern)

Optimizing wind energy: Investigation of atmospheric turbulence using lidars

Risø National Laboratory for Sustainable Energy
Department of Wind Energy

Test and Measurements
Period: 01/04/2012 → 31/03/2015
Number of participants: 1
Project participant:
Sathe, Ameya (Intern)

Economic grid support from variable renewables

REServices (Economic grid support from variable renewables) is the first study to investigate wind and solar based grid support services at EU level. It will provide technical and economic guidelines and recommendations for the design of a European market for ancillary services, as well as for future network codes within the Third Liberalisation Package.

Risø National Laboratory for Sustainable Energy
Department of Wind Energy
Wind Energy Systems
European Wind Energy Association
VTT - Technical Research Centre of Finland
Fraunhofer Institute for Wind Energy and Energy System Technology
3E
EPIA
University College Dublin
Acciona S.A.
Mainstream Renewables
GE
Period: 01/04/2012 → 01/10/2014
Number of participants: 1
Ancillary services, Renewable, Wind, PV, Economic, Grid support
Acronym: REServiceS
Project participant:
Cutululis, Nicolaos Antonio (Intern)

Financing sources
Source: EU research programme (public)
Name of research programme: IEE
Project

Wind Turbine Aerodynamics and Aeroelasticity using Vortex Based Methods

Department of Wind Energy
Period: 01/04/2012 → 22/06/2015
Number of participants: 5
PhD Student:
Branlard, Emmanuel Simon Pierre (Intern)
Main Supervisor:
Gaunaa, Mac (Intern)
Examiner:
Sørensen, Jens Nørkær (Intern)
Hjort, Søren (Intern)
van Kuik, Gijs A. M. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Eksternt finansieret virksomhed
Project: PhD

Electromechanical Drivetrain Simulation

Department of Wind Energy
Period: 15/03/2012 → 24/08/2015
Number of participants: 8
PhD Student:
Gallego Calderon, Juan Felipe (Intern)
Supervisor:
Branner, Kim (Intern)
Hansen, John Michael (Intern)
Cutululis, Nicolaos Antonio (Intern)
Main Supervisor:
Natarajan, Anand (Intern)
Examiner:
Juul Jensen, Dorte (Intern)
Bottasso, Carlo L. (Ekstern)
Muljadi, Eduard (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

Offshore Wind Turbine Foundation Design Loads Mitigation

Department of Wind Energy
Period: 15/03/2012 → 15/01/2013
Number of participants: 2
PhD Student:
Jiwinangun, Randi Gusto (Intern)
Main Supervisor:
Natarajan, Anand (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut, samfinansiering
Project: PhD

Experimental Stereo Vision Studies of Flow and Structural Effects on Wind Turbines

Department of Wind Energy
Period: 01/03/2012 → 30/11/2015
Number of participants: 7
Phd Student:
Najafi, Nadia (Intern)
Supervisor:
Sjöholm, Mikael (Intern)
Mann, Jakob (Intern)
Main Supervisor:
Schmidt Paulsen, Uwe (Intern)
Examiner:
Georgakis, Christos T. (Intern)
Griffith, D. Todd (Ekstern)
Tcherniak, Dmitri (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut/centerfinansieret

Relations
Publications:
Experimental Vision Studies of Flow and Structural Effects on Wind Turbines
Project: PhD

Low-cost semiconductor laser wind sensors
Our objective is to develop, demonstrate and validate prototype laser wind sensors that measure wind speed and direction based on low-cost, compact semiconductor lasers and new optical methods we have recently devised and patented. These wind sensor prototypes will represent the next-generation of compact, rugged and inexpensive laser-based wind sensors for wind energy research and turbine industry.

Department of Photonics Engineering
Optical Sensor Technology
Meteorology
Department of Wind Energy

Test and Measurements
Windar Photonics A/S and Opdi Technologies A/S
Period: 01/03/2012 → 28/02/2014
Number of participants: 5
Project ID: 70720
Project participant:
Pedersen, Christian (Intern)
Dellwik, Ebba (Intern)
Mann, Jakob (Intern)
Sjöholm, Mikael (Intern)
Project Manager, academic:
Rodrigo, Peter John (Intern)

Financing sources
Source: Forskningsprojekter - Andre ministerier og styrelser

Project approved under “International Network Program” with India – 360,000DKK

**Scientific Network Activities [planned jointly with Indian Universities]:**

1. Indo-Danish Workshop on “Future Composites Technologies for Wind Turbine Blades” October 8-9, 2012, Indian Institute of Technology, New Delhi, India

http://indodanish.iitd.ac.in/


http://www.wemep2012.com/

**Demonstration of Partial Pitch 2-bladed Wind Turbine**

Department of Wind Energy

Aeroelastic Design

Test and Measurements

Envision Energy ApS

Period: 01/01/2012 → 31/12/2014

Number of participants: 9

Acronym: Demonstration PP-2B

Project participant:

Larsen, Torben J. (Intern)

Zahle, Frederik (Intern)

Sørensen, Niels N. (Intern)

Yde, Anders (Intern)

Pedersen, Mads Melgaard (Intern)

Kock, Carsten Weber (Intern)

Verelst, David Robert (Intern)

Trolleborg, Niels (Intern)

Project Manager, organisational:

Kim, Taeseong (Intern)
**EUDP Envision PP2B**
To demonstrate the cost saving potential of the Partial Pitch 2-bladed wind turbine technology and through a measurements campaign to verify analysis and development tools for the technology.

Department of Wind Energy
Aeroelastic Design
Period: 01/01/2012 → 31/12/2014
Number of participants: 5
Acronym: 43118 4610
Project participant:
Larsen, Torben J. (Intern)
Yde, Anders (Intern)
Zahle, Frederik (Intern)
Sørensen, Niels N. (Intern)
Project Manager, academic:
Kim, Taeseong (Intern)

**WakesBench**
The objective is to reach international consensus and establish guidelines on operation of Wind farm flow models through a collaborative research work.

Department of Wind Energy
Aeroelastic Design
Period: 01/01/2012 → 31/12/2014
Number of participants: 2
Acronym: 43114-4610
Project participant:
Bechmann, Andreas (Intern)
Project Manager, academic:
Réthoré, Pierre-Elouan (Intern)

**Poseidon 3**
To further develop the concept of a floating platform that combines both wave and Wind energy with focus of basin test of a scale model of P-80.

Department of Wind Energy
Aeroelastic Design
Floating Power Plant
Period: 01/01/2012 → 31/12/2014
Number of participants: 3
Acronym: 43180 95 X-1
Project participant:
Yde, Anders (Intern)
Larsen, Torben J. (Intern)
Verelst, David Robert (Intern)

**EERA DTOC: European Energy Research Alliance Design Tools for Offshore wind farm Clusters**
The project is funded by the EU – Seventh Framework Programme (FP7) – and runs from January 2012 to June 2015. It is coordinated by the Technical University of Denmark - DTU Wind Energy.

The EERA-DTOC project combines expertise to develop a multidisciplinary integrated software tool for an optimized design of offshore wind farms and clusters of wind farms.

Charlotte Bay Hasager is the daily manager of the project.
Peter Hauge Madsen is coordinator.
Department of Wind Energy
Meteorology
Department of Applied Mathematics and Computer Science
Wind Energy Systems
Aeroelastic Design
Risø National Laboratory for Sustainable Energy

Fluid Mechanics
Period: 01/01/2012 → 30/06/2015
Number of participants: 15
Offshore wind, wind clusters, design, optimization
Acronym: EERA-DTOC
Project participant:
Giebel, Gregor (Intern)
Réthoré, Pierre-Elouan (Intern)
Cutululis, Nicolaos Antonio (Intern)
Badger, Merete (Intern)
Hahmann, Andrea N. (Intern)
Peña, Alfredo (Intern)
Badger, Jake (Intern)
Volker, Patrick (Intern)
Karagali, Ioanna (Intern)
Maule, Petr (Intern)
vanderLaan, Paul (Intern)
Cutululis, Nicolaos Antonio (Intern)
Hansen, Kurt Schaldemose (Intern)
Project Manager, academic:
Hasager, Charlotte Bay (Intern)
Project Coordinator:
Madsen, Peter Hauge (Intern)

Relations
Activities:
Ocean winds from satellites – applications for offshore wind energy
Publications:
Shadowing effects of offshore wind farms - an idealised mesoscale study
Energy Yield Prediction of Offshore Wind Farm Clusters at the EERA-DTOC European Project
EERA DTOC wake results offshore
EERA Design Tool for Offshore wind farm Cluster (DTOC)
Offshore winds mapped from satellite remote sensing
Wind Farm Wake: The Horns Rev Photo Case
Transmission of wave energy through an offshore wind turbine farm

EU MERMAID: Innovative Multi-purpose offshore platforms: planning, design and operation
In the near future, the European oceans will be subjected to a massive development of marine infrastructures. The most obvious structures include offshore wind farms, constructions for marine aquaculture and the exploitation of wave energy.

The development of these facilities will increase the need for marine infrastructures to support their installation and operation and will unavoidably exert environmental pressures on the oceans and marine ecosystems. It is therefore crucial that the economic costs, the use of marine space and the environmental impacts of these activities remain within acceptable limits. Hence, offshore platforms that combine multiple functions within the same infrastructure offer significant economical and environmental benefits.

MERMAID will develop concepts for the next generation of offshore platforms which can be used for multiple purposes, including energy extraction, aquaculture and platform related transport. The project does not envisage building new platforms, but will theoretically examine new concepts, such as combining structures and building new structures on
representative sites under different conditions.

The 28 partner institutes forming MERMAID are Universities (11), Research institutes (8), Industries (5) and Small and Medium Enterprises (4 SME's), from many regions in EU. The group represents a broad range of expertise in hydraulics, wind engineering, aquaculture, renewable energy, marine environment, project management as well as socio-economics.

MERMAID is one of three EU-FP7 funded projects selected for funding in response to Ocean 2011 on multi-use offshore platforms (FP7-OCEAN.2011-1 "Multi-use offshore platforms"). This project shall have a cost of 7.4 million euro. The European Union has granted a financial contribution of 5.5 million euro.

MERMAID is lead by Professor Erik Damgaard Christensen at DTU MEK.

Charlotte Bay Hasager at DTU Wind Energy is responsible for the offshore wind assessment.

Department of Wind Energy
Meteorology
Period: 01/01/2012 → 31/05/2016
Number of participants: 4
Acronym: MERMAID
Project participant:
Badger, Merete (Intern)
 Larsén, Xiaoli Guo (Intern)
 Bingöl, Ferhat (Intern)
Project Manager, organisational:
Hasager, Charlotte Bay (Intern)

Relations
Activities:
European Maritime Day
Publications:
Numerical simulation of wave-induced scour and backfilling below submarine pipelines
Influence of clay content on wave-induced liquefaction
Flow-structure-seabed interactions in coastal and marine environments
D5.3 Interaction between currents, wave, structure and subsoil
D5.2 Numerical tools
D5.4 Guidelines for interaction between seabed and support structure

iTesla - Innovative Tools for Electrical System Security within Large Areas
The purpose of the iTESLA project is to develop a toolbox which will support the future operation of the pan-European electricity transmission network. This toolbox shall bring forward a major innovation: carry out operational dynamic simulations in the frame of a full probabilistic approach, thus going further that the current “N-1” approach and optimizing the transit capacities of the grid at different spatial (national, regional, Pan-European) and time (two-days ahead, day-ahead, intra-day, real-time) scales.

The iTesla project is lead by RTE (the French TSO). The total iTesla budget is M€ 19.5. DTUs total budget is M€ 1.1.

The main roles of DTU in iTesla are
- Work Package Leader of WP6: Defence and Restoration (Poul Sørensen)
- PhD in Integration of wind power and other renewables in power system defence plans (Kaushik Das, see related projects)
- Task Leader for Task 3.4. Aggregated dynamic models of variable generation sources (PV and Wind farms) and loads.

Department of Wind Energy

Wind Energy Systems
RTE (TSO France)
Elia (TSO Belgium)
NGC (TSO UK)
REN (TSO Portugal)
Statnett SF
IPTO (TSO Greece)
Regional coordination service center
AIA
Artilyys
Bull
Pepite
Quinary
Imperial College of Science, Technology and Medicine
Instituto de Engenharia de Sistemas e Computadores do Porto
KTH - Royal Institute of Technology
Katholieke Universiteit
Ricerca Sistema Energetico SpA
Tractebel
Period: 01/01/2012 → 31/12/2015
Number of participants: 6
Acronym: iTesla
Project participant:
Sørensen, Poul Ejnar (Intern)
Altin, Müfit (Intern)
Hansen, Anca Daniela (Intern)
Göksu, Ömer (Intern)
Margaris, Ioannis (Intern)
Phd Student:
Das, Kaushik (Intern)

Financing sources
Source: EU research programme (public)
Name of research programme: FP7-ENERGY-2011-1

Relations
Publications:
Aggregated wind power plant models consisting of IEC wind turbine models
Wind Turbine and Wind Power Plant Modelling Aspects for Power System Stability Studies
Understanding IEC standard wind turbine models using SimPowerSystems
Primary reserve studies for high wind power penetrated systems
Adequacy of operating reserves for power systems in future european wind power scenarios
Aspects of Relevance of Wind Power in Power System Defense Plans

Micro-Scale Experiments and Models for Composite Materials with Materials Research
Department of Wind Energy
Period: 01/01/2012 → 30/10/2015
Number of participants: 7
Phd Student:
Zike, Sanita (Intern)
Supervisor:
Sørensen, Bent F. (Intern)
Tvergaard, Viggo (Intern)
Main Supervisor:
Mikkelsen, Lars Pilgaard (Intern)
Examiner:
Legarth, Brian Nyvang (Intern)
Jensen, Henrik Myhre (Intern)
Thouless, Michael (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

Development of Efficient Turbulence Models for CFD Wake Simulations
Department of Wind Energy
Period: 15/12/2011 → 24/04/2015
Number of participants: 8
Phd Student:
van der Laan, Paul (Intern)
Supervisor:
Kelly, Mark C. (Intern)
Réthoré, Pierre-Elouan (Intern)
Mann, Jakob (Intern)
Main Supervisor:
Sørensen, Niels N. (Intern)
Examiner:
Mikkelsen, Robert Flemming (Intern)
Madsen, Jens Ingemann (Ekstern)
Masson, Christian (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Two-dimensional rotor plane wind data retrieval - HTF Wind Lidar
Department of Wind Energy
Period: 15/12/2011 → 24/09/2015
Number of participants: 6
Phd Student:
Foroughi Abari, Farzad (Intern)
Supervisor:
Sjöholm, Mikael (Intern)
Main Supervisor:
Mann, Jakob (Intern)
Examiner:
Courtney, Michael (Intern)
Cariou, Jean-Pierre (Ekstern)
Water, Willem van de (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Wind Power Plant System Services
Department of Wind Energy
Period: 15/12/2011 → 19/03/2015
Number of participants: 7
Phd Student:
INDUFLAP
To transfer a flap technology, tested in the laboratory. To an industrial manufacturing process and test the flap system in a real atmospheric environment on a rotating test rig.

Department of Wind Energy
Aeroelastic Design
Period: 01/11/2011 → 30/06/2014
Number of participants: 4
Acronym: 43031-4610
Project participant:
Bergami, Leonardo (Intern)
Rasmussen, Flemming (Intern)
Barlas, Athanasios (Intern)
Project Manager, academic:
Aagaard Madsen, Helge (Intern)

WAsP CFD
To couple EllipSys and WAsP into WAsP CFD.

Department of Wind Energy
Aeroelastic Design
Test and Measurements
EMD International A/S
Vattenfall AB
Period: 01/11/2011 → 31/01/2014
Number of participants: 5
Acronym: 43087 46-
Project participant:
Sørensen, Niels N. (Intern)
Réthoré, Pierre-Elouan (Intern)
Zahle, Frederik (Intern)
Koblitz, Tilman (Intern)
Project Manager, academic:
Bechmann, Andreas (Intern)

Relations
Activities:
How to use CFD for long-term energy assessments
Aeroservoelastic modeling and stability of wind turbine blades

Department of Wind Energy
Period: 01/11/2011 → 23/02/2015
Number of participants: 6
Phd Student:
Pirring, Georg (Intern)
Supervisor:
Kim, Taeseong (Intern)
Main Supervisor:
Aagaard Madsen, Helge (Intern)
Examiner:
Hansen, Martin Otto Laver (Intern)
Bussel, Gerard J. W. van (Ekstern)
Kallesøe, Bjarne Skovmose (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.

Relations
Publications:
Fast Trailed Vorticity Modeling for Wind Turbine Aerodynamics and its Influence on Aeroelastic Stability
Project: PhD

Concurrent aero-servo-elastic design and optimization of wind turbines

Department of Wind Energy
Period: 01/11/2011 → 21/05/2015
Number of participants: 6
Phd Student:
Tibaldi, Carlo (Intern)
Supervisor:
Henriksen, Lars Christian (Intern)
Main Supervisor:
Bak, Christian (Intern)
Examiner:
Stolpe, Mathias (Intern)
Riziotis, Vasilis A. (Ekstern)
Winther Stærchahl, Jesper (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Multiple Turbine Wakes

Department of Wind Energy
Period: 01/11/2011 → 24/08/2015
Number of participants: 7
Phd Student:
Machefaux, Ewan (Intern)
Supervisor:
Aagaard Madsen, Helge (Intern)
Main Supervisor:
Mann, Jakob (Intern)
Examiner:
Sørensen, Jens Nørkær (Intern)
Ivanell, Stefan S. A. (Ekstern)
Voutsinas, Spyros (Ekstern)

**Financing sources**
Source: Internal funding (public)  
Name of research programme: Forskningsrådsfinansiering  
Project: PhD

**Flow over complex forested terrain**
Department of Wind Energy  
Period: 15/10/2011 → 24/08/2015  
Number of participants: 6  
Phd Student: Boudreault, Louis-Etienne (Intern)  
Supervisor: Bechmann, Andreas (Intern)  
Main Supervisor: Dellwik, Ebba (Intern)  
Examiner: Mann, Jakob (Intern)  
Edward Garrett, Patton (Ekstern)  
Neil Ross, Andrew (Ekstern)

**Financing sources**
Source: Internal funding (public)  
Name of research programme: Offentlig finansiering  
Project: PhD

**Theoretical analysis, design and virtual testing of biocompatibility and mechanical properties of titanium-based nanomaterials**
EU FP7 Project Coordinator “Virtual Nanotitanium” (Theoretical analysis, design and virtual testing of biocompatibility and mechanical properties of titanium-based nanomaterials) Collaborative Project in Nanosciences NMP  
Department of Wind Energy  
Composites and Materials Mechanics  
Period: 01/10/2011 → 31/03/2014  
Number of participants: 2  
Acronym: VINAT (Virtual Nanotitanium)  
Project participant: Liu, Hongsheng (Intern)  
Project Coordinator: Mishnaevsky, Leon (Intern)

**Relations**
Publications:
Martensitic transformations in nanostructured nitinol: Finite element modeling of grain size and distribution effects

**Communication and control in clusters of wind power plants connected to HVDC offshore grids**
Department of Wind Energy  
Period: 01/10/2011 → 22/06/2015  
Number of participants: 7  
Phd Student: Zeni, Lorenzo (Intern)  
Supervisor: Hansen, Anca Daniela (Intern)  
Kjaer, Philip C. (Ekstern)  
Main Supervisor: Sørensen, Poul Ejnar (Intern)
Examiner:
Rasmussen, Tonny Wederberg (Intern)
Liang, Jun (Ekstern)
Petersson, Andreas (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Ansat eksternt
Project: PhD

Integrated Wind Power Planning Tool
Department of Wind Energy
Period: 01/10/2011 → 24/08/2015
Number of participants: 6
Phd Student:
Rosgaard, Martin Haubjerg (Intern)
Supervisor:
Madsen, Henrik (Intern)
Main Supervisor:
Hahmann, Andrea N. (Intern)
Examiner:
Pinson, Pierre (Intern)
Nissen, Jesper Nielsen (Intern)
Wilson, Clive George (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Ansat eksternt
Project: PhD

Nanostructuring of oxide dispersion strengthened ferritic steels by plastic deformation
Department of Wind Energy
Period: 01/10/2011 → 24/04/2015
Number of participants: 7
Phd Student:
Zhang, Zhenbo (Intern)
Supervisor:
Mishin, Oleg (Intern)
Tao, Nairong (Ekstern)
Main Supervisor:
Pantleon, Wolfgang (Intern)
Examiner:
Danielsen, Hilmar Kjartansson (Intern)
Petrov, Roumen Hristov (Ekstern)
Sauvage, Xavier (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Programbevilling
Project: PhD

Offshore Wind Turbine Foundation Design
Department of Wind Energy
Period: 01/10/2011 → 22/06/2015
Number of participants: 7
Phd Student:
Passon, Patrik Alexander (Ekstern)
Virtual Campus Hub
Four technical universities in Europe work together in this EU-funded project to lower the barriers for collaboration across borders.

Universities have an increasing number of and increasingly diverse relations with the outside world but Information and Communications Technology (ICT) is still inward looking. Virtual Campus Hub aims to support a number of activities that are common today for international cooperation in the field of education, research and innovation.

Project partners:
Technical University of Denmark (DTU)
Kungliga Tekniska högskolan, Sweden (KTH)
Politecnico di Torino, Italy (Polito)
Eindhoven University of Technology, Netherlands (TU/e)

Department of Wind Energy
Meteorology
Aeroelastic Design
Wind Energy Systems

Office for Study Programmes and Student Affairs
Period: 01/10/2011 → 30/09/2013
Number of participants: 24
Acronym: VCH

Project participant:
Karagali, Ioanna (Intern)
Larsen, Søren Ejling (Intern)
Bingöl, Ferhat (Intern)
Badger, Jake (Intern)
Nielsen, Morten (Intern)
Peña, Alfredo (Intern)
Gryning, Sven-Erik (Intern)
Berg, Jacob (Intern)
Bergami, Leonardo (Intern)
Cronin, Tom (Intern)
Hansen, Brian Ohrbeck (Intern)
Jowitt, William Richard (Intern)
Ejsing Jørgensen, Hans (Intern)
Kelly, Mark C. (Intern)
Mortensen, Niels Gylling (Intern)
Lundtang Petersen, Erik (Intern)
Rathmann, Ole Steen (Intern)
Verelst, David Robert (Intern)
Nielsen, Rikke Anne (Intern)
Relations
Activities:
Virtual Campus Hub
E-learning activities at DTU Wind Energy
Publications:
Dissemination and Exploitation Strategy
The Virtual Campus Hub Concept
Press / Media items:
Universiteterne mødes på nettet: E-system. Fire tekniske universiteter er forbundet via den europæiske e-infrastruktur eduGAIN.
International students get single sign-on for wind energy training: A Danish university avoids unnecessary hassles with user management by exchanging student data in an international identity federation.
Den europæiske internetstruktur Géant styrker universiteters samarbejde
Harnessing the power of wind with a learning platform

DOE Great Lakes: An Integrated approach to offshore wind energy assessment: Great Lakes 3D wind experiment
Project Goals: The datasets to be collected within the project will be (i) linked to existing resource estimates, (ii) used in a closure (instrument inter-comparison) analysis based in part on the in situ observations, (iii) used to evaluate meteorological and wind farm models (iv) analyzed to characterize meteorological conditions in the coastal Great Lakes region where highly resolved observations are currently lacking, and (v) used to develop best-practice strategies and documentation for each measurement type focused on its application to wind energy.

Principal Investigator: R.J. Barthelmie, Croll Fellow and Professor
Indiana University/Cornell University.

Department of Wind Energy
Meteorology
Clarkson University
Indiana University-Purdue
Cornell University
Case Western Reserve University
Sgurr Energy
Arizona State University
EDP Renewables
Period: 30/09/2011 → 30/09/2015
Number of participants: 3
Acronym: Great Lakes 3D
Project participant:
Hasager, Charlotte Bay (Intern)
Karagali, Ioanna (Intern)
Badger, Merete (Intern)

Validated loads prediction models for offshore wind turbines for enhanced component reliability

Department of Wind Energy
**Enhanced Ancillary Services from Wind Power Plants**

The project vision is to provide wind power with similar grid system interaction characteristics as the conventional generation units. The new technical solutions developed in this project will expand the global wind power market, as they will assist in integrating more wind power in high voltage grids. Bringing wind power technology to this level will assist Vestas in remaining both technology and market leader in the global wind industry.

We pursue the vision by developing and demonstrating control features for primary, secondary and tertiary reserve and response provided by wind power plants. In this way the capability of wind farms to provide system services and thus their ability to actively support the power system in a similar way as the conventional power plants is increased. With these new control features the grid operators can allow a large scale penetration of wind power into the power system while increasing the security and reliability of power supply during the transition period from fossil to renewable based power production.

Risø National Laboratory for Sustainable Energy

Department of Wind Energy

Wind Energy Systems

Aalborg University

VESTAS Wind Systems A/S

Period: 01/09/2011 → 31/08/2014

Number of participants: 3

Acronym: EASEWIND

Project participant:

Cutululis, Nicolaos Antonio (Intern)

Hansen, Anca Daniela (Intern)

Altin, Müfit (Intern)

**Optimal Design of Composite Structures under Manufacturing Constraints**

Department of Wind Energy

Period: 01/08/2011 → 05/11/2014

Number of participants: 7

Phd Student:

Marmaras, Konstantinos (Intern)

Supervisor:

Lund, Erik (Ekstern)

Mikkelsen, Lars Pilgaard (Intern)

Main Supervisor:

Stolpe, Mathias (Intern)

Examiner:

Branner, Kim (Intern)

Duysinx, Pierre (Intern)
**Forecasting Wind Turbine Icing Conditions**

Department of Wind Energy  
**Period:** 01/06/2011 → 05/11/2014  
**Number of participants:** 7  
**PhD Student:** Davis, Neil (Intern)  
**Supervisor:** Clausen, Niels-Erik (Intern)  
**Zagar, Mark (Ekstern)**  
**Main Supervisor:** Hahmann, Andrea N. (Intern)  
**Examiner:**  
Giebel, Gregor (Intern)  
Andersson, Annika (Ekstern)  
Haupt, Sue Ellen (Ekstern)  

**Financing sources**  
Source: Internal funding (public)  
Name of research programme: Forskningsrådsfinansiering  
Project: PhD

**Development of commercially viable wind power system in Nepal**

Department of Wind Energy  
**Composites and Materials Mechanics**  
**Period:** 31/05/2011 → 30/06/2013  
**Number of participants:** 1  
**Project Manager, academic:**  
Mishnaevsky, Leon (Intern)  
**Project**

**High reliability of large wind turbines via computational micromechanics based enhancement of materials performances**  
(Danish Council for Strategic Research, in collaboration with the Ministry of Science and Technology of China)

Department of Wind Energy  
**Composites and Materials Mechanics**  
**Period:** 01/05/2011 → 31/07/2015  
**Number of participants:** 2  
**Project participant:**  
Dai, Gaoming (Intern)  
**Project Manager, academic:**  
Mishnaevsky, Leon (Intern)  
**Project**

**Wind turbine tip-loss corrections**

The focus of this study is the use of a lifting-line free wake vortex code to derive tip-loss corrections that could be implemented in Blade Element Momentum (BEM) codes. The different theories and three dimensional effects that are related to tip-losses are progressively introduced: lifting-line concepts, wake dynamics and its vortex modeling, far-wake analysis. The different tip-loss corrections found in the literature are reviewed with a focus on the main theories, namely the work of Betz, Prandtl, Goldstein and Theodorsen, and the different implementations in BEM codes found in the literature are presented. The method of Okulov to compute Goldstein’s factor at a reasonable computational cost is provided with details. The computation of Goldstein’s factor being accessible, a method to use this factor in the BEM method is presented. Various form of Prandtl’s tip-loss factor are also listed for reference. Tip-losses are investigated
using a free wake vortex code and with Computational Fluid Dynamics (CFD), and results from both approaches are compared and discussed. For the use of CFD data, the question of definition of the local induction factor on the blade is risen and different method to define it are investigated. The author introduces the naming of "performance tip-loss" factor, which is a correction to the airfoil coefficients due to the tri-dimensionality of the flow at the tip. A preliminary model for the performance tip-loss function is introduced. For the representation of various circulation shapes, a new method using the formulation of Bézier curves is described and developed. Such method can be widely used to describe curves such as lift, circulation or chord distribution. Last, a method to determine tip-losses using a vortex code is described and implemented. From this method, a new tip-loss model is implemented in a BEM code in order to reproduce the 3D effects inherently present in a vortex code.

Department of Wind Energy
Aeroelastic Design
Period: 16/04/2011 → 30/09/2011
Number of participants: 1
Project participant:
Branlard, Emmanuel Simon Pierre (Intern)

Relations
Publications:
An improved tip-loss correction based on vortex code results
Vortex methods to answer the need for improved understanding and modelling of tip-loss factors
Documents:
Branlard-2011-TipLosses_MscThesis_Public

TURBOPT
The project aims to develop the calculation of energy production and loads on wind turbines by develop and optimize Integrated models, which is able to handle the multi-scale phenomena in complex terrain.

Department of Wind Energy
Aeroelastic Design
Fluid Mechanics

Chinese Academy of Sciences
Period: 01/04/2011 → 30/06/2014
Number of participants: 4
Acronym: 43033-4610
Project participant:
Henriksen, Lars Christian (Intern)
Fischer, Andreas (Intern)
Shen, Wen Zhong (Intern)
Project Manager, academic:
Aagaard Madsen, Helge (Intern)

The impact of non-neutral atmosphere on offshore wind turbines
Department of Wind Energy
Period: 15/03/2011 → 24/09/2015
Number of participants: 7
Phd Student:
de Mare, Martin Tobias (Intern)
Supervisor:
Larsen, Gunner Chr. (Intern)
Veldkamp, Dick (Ekstern)
Main Supervisor:
Mann, Jakob (Intern)
 Examiner:
Berg, Jacob (Intern)
Bossanyi, Ervin Ashoka (Ekstern)
George, William K (Intern)

**Financing sources**
- **Source:** Internal funding (public)
- **Name of research programme:** ErhvervsPhD-ordningen VTU
- **Project:** PhD

**OffshoreDC - DC grids for integration of large scale wind power**

Department of Wind Energy  
Wind Energy Systems  
Risø National Laboratory for Sustainable Energy  
Department of Electrical Engineering  
Center for Electric Power and Energy  
Energinet.dk  
DONG Energy A/S  
Aalborg University  
Norwegian University of Science and Technology  
Chalmers University of Technology  
ABB Carbon AB  
VTT - Technical Research Centre of Finland

**Statnett SF**  
**Period:** 01/02/2011 → 31/01/2016  
**Number of participants:** 6  
**Offshore wind, Offshore grids, Wind power, HVDC, Control**  
**Acronym:** OffshoreDC  
**Number of related Ph.D. students:** 4  
**Project participant:**  
Sørensen, Poul Ejnar (Intern)  
Hansen, Anca Daniela (Intern)  
Zeni, Lorenzo (Intern)  
El-Khatib, Walid Ziad (Intern)  
Holbøll, Joachim (Intern)

**Project Coordinator:**  
Cutululis, Nicolaos Antonio (Intern)

**Financing sources**
- **Source:** Public research programme (public)
- **Name of research programme:** Nordic Energy Research  
- **Web address:** [http://www.nordicenergy.org/](http://www.nordicenergy.org/)  
- **Amount:** 2,500,000.00 Euro  
- **Year of approval:** 2010

**Relations**

**Publications:**
- OffshoreDC DC grids for integration of large scale wind power  
- Active Power Control with Undead-Band Voltage & Frequency Droop for HVDC Converters in Large Meshed DC Grids  
- Active power control with undead-band voltage & frequency droop applied to a meshed DC grid test system  
- Influence of current limitation on voltage stability with voltage sourced converter HVDC  
- Voltage margin control for offshore multi-use platform integration  
- Coordinated system services from offshore wind power plants connected through HVDC networks  
- HVDC Connected Offshore Wind Power Plants: Review and Outlook of Current Research  
- An Assessment of Converter Modelling Needs for Offshore Wind Power Plants Connected via VSC-HVDC Networks  
- Dynamic Active Power Control with Improved Undead-Band Droop for HVDC Grids
Alternatives for Primary Frequency Control Contribution from Wind Power Plants Connected to VSC-HVDC Intertie
Generic Models of Wind Turbine Generators for Advanced Applications in a VSC-based Offshore HVDC Network
Modular Multilevel Converter Modelling, Control and Analysis under Grid Frequency Deviations
DC grids for integration of large scale wind power

**Wind Farm**
The project will develop a model that describes the turbine wake and how it affects Down Wind turbines. The model can provide a better basis for determining relative positions of turbines, and thereby optimize production.

Department of Wind Energy
Aeroelastic Design
DONG Energy A/S
VESTAS Wind Systems A/S
Period: 01/02/2011 → 31/12/2014
Number of participants: 3
Acronym: 43032 4610-EUDP
Project participant:
Troldborg, Niels (Intern)
Larsen, Torben J. (Intern)
Project Manager, academic:
Larsen, Gunner Chr. (Intern)

**Simulation of flows past a wind turbine with wind shear using Navier-Stokes based sliding mesh technique**

Department of Wind Energy
Period: 01/02/2011 → 29/09/2014
Number of participants: 7
Phd Student:
Kolmogorov, Dmitry (Intern)
Supervisor:
Sørensen, Jens Nørkær (Intern)
Zhu, Wei Jun (Intern)
Main Supervisor:
Shen, Wen Zhong (Intern)
Examiner:
Zahle, Frederik (Intern)
Bijl, Hester (Ekstern)
Madsen, Jens Ingemann (Ekstern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

**REWIND - Knowledge based engineering for improved reliability of critical wind turbine components**
Department of Mechanical Engineering
Manufacturing Engineering
Solid Mechanics
Materials and Surface Engineering
Department of Wind Energy
Materials science and characterization
Wind Turbines
Aalborg University

Magma Gießereitechnologie GmbH

Michigan State University
Period: 01/01/2011 → 31/12/2016
Number of participants: 6
Acronym: REWIND
Project ID: 76142
Number of related Ph.D. students: 8
Project participant:
Tvergaard, Viggo (Intern)
Somers, Marcel A. J. (Intern)
Fæster, Søren (Intern)
Natarajan, Anand (Intern)
Klit, Peder (Intern)
Project Manager, academic:
Hattel, Jesper Henri (Intern)

WTopt
Design and testing of thick airfoils, 3D correction of airfoil data, 360 degree airfoil data standstill vibration, design of blades with bend twist coupling.

Department of Wind Energy

Aeroelastic Design

Wind Turbines
Period: 01/01/2011 → 30/06/2014
Number of participants: 8
Acronym: 43109
Project participant:
Troldborg, Niels (Intern)
Kim, Taeseong (Intern)
Skrzypinski, Witold Robert (Intern)
Fischer, Andreas (Intern)
Sørensen, Niels N. (Intern)
Heinz, Joachim Christian (Intern)
Fedorov, Vladimir (Intern)
Project Manager, academic:
Zahle, Frederik (Intern)

Development of a carbon neutral luminaire for the urban environement

Department of Photonics Engineering

Rise National Laboratory for Sustainable Energy
Wind Energy Division
Diode Lasers and LED Systems
Gate 21
Arkitektfirmaet Ark-Unica
FAKTOR 3
Philips Lighting A/S
Københavns Kommune
Albertslund kommune
Egedal kommune
Period: 01/01/2011 → 31/12/2012
Number of participants: 19
Project ID: 70673
Project participant:
Sandholt, Hanne (Ekstern)
Levholt, Kenneth (Ekstern)
Lundgaard, Jacob (Ekstern)
Dam-Hansen, Carsten (Intern)
Poulsen, Peter Behrens-Dorff (Intern)
Hansen, Søren Stentoft (Intern)
Jensen, Peter (Intern)
Bak, Christian (Intern)
Harboe, René Kirstein (Ekstern)
Bentzen, Barbara (Ekstern)
Kähler, Rikke (Ekstern)
Falk, Lars (Ekstern)
Maare, Thomas (Ekstern)
Halden, Steen (Ekstern)
Bluhme, Niels Carsten (Ekstern)
Fristrøm, Erik (Ekstern)
Thorseth, Anders (Intern)
Project Manager, organisational:
Bluhme, Niels Carsten (Ekstern)
Seerup, Einar (Ekstern)

Financing sources
Source: Forsk. Private danske - Andre
Name of research programme: Forsk. Private danske - Andre
Amount: 1,599,658.00 Danish Kroner

Relations
Related projects:
The PV LED Engine – a new generation of intelligent solar powered LED lighting
Publications:
CopenHybrid – Development of a CO2 neutral hybrid street lighting system for the Danish municipalities’ illumination classes
Den selvforsynende gadelampe
Wind Turbines on CO2 Neutral Luminaries in Urban Areas
Udvikling af CO2 neutrale byrumsarmatur
Press / Media items:
Metropol: Grøn Teknologi
Gadelygten skal være selvforsynende med strøm

Project
Simulation and Modelling of Wakes and Wake Interaction in Offshore Wind Farms
Department of Wind Energy
Period: 01/01/2011 → 25/08/2014
Number of participants: 7
Phd Student:
Sarlak Chivae, Hamid (Intern)
Supervisor:
Mikkelsen, Robert Flemming (Intern)
Shen, Wen Zhong (Intern)
Main Supervisor:
Sørensen, Jens Nørkær (Intern)
Free Material Optimization of Wind Turbine Blades

Department of Wind Energy
Period: 15/12/2010 → 03/12/2014
Number of participants: 6
Phd Student: Weldeyesus, Alemseged Gebrehiwot (Intern)
Supervisor: Lund, Erik (Ekstern)
Main Supervisor: Stolpe, Mathias (Intern)
Examiner: Mikkelsen, Lars Pilgaard (Intern)
Kocvara, Michal (Intern)
Stingl, Michael Walter (Ekstern)

Icing Problems of Wind Turbine Blades in Cold Climates

Department of Wind Energy
Period: 15/11/2010 → 26/05/2014
Number of participants: 7
Phd Student: Hudecz, Adriána (Intern)
Supervisor: Battisti, Lorenzo (Ekstern)
Villumsen, Arne (Intern)
Main Supervisor: Hansen, Martin Otto Laver (Intern)
Examiner: Meyer, Knud Erik (Intern)
Johansen, Jeppe (Intern)
Oleskiw, Myron M. (Ekstern)

Numerical modelling of the boundary-layer wind profile

Department of Wind Energy
Period: 15/10/2010 → 21/02/2014
Number of participants: 6
Phd Student: Pedersen, Jesper Grønnegaard (Intern)
Future Deep Sea Wind Turbine Technologies
DeepWind is a 4 year project, funded by FP7 - Future Emerging Technologies, and runs from 1 October 2010 to 30 September 2014.

Offshore wind energy will play a steadily increasing role and calls for dedicated technology rather than being based on onshore technology that in principle just is transported to sea environments. The hypothesis of this project is that a new wind turbine concept developed specifically for offshore application has potentials for better cost efficiency than existing offshore technology. Based on this hypothesis the project has the overall objective to explore the technologies needed for development of a new and simple floating offshore concept with a vertical axis rotor and a floating and rotating foundation. Additionally, the objective is to develop calculation and design tools for development and evaluation of very large wind turbines based on this concept.

Department of Electrical Engineering
Department of Wind Energy
Test and Measurements
Risø National Laboratory for Sustainable Energy
Wind Energy Division
Period: 01/10/2010 → 30/09/2014
Number of participants: 1
Acronym: DEEPWIND
Project Coordinator:
Schmidt Paulsen, Uwe (Intern)

Relations
Activities:
VAWTs for offshore applications
Retrospective aspects of DeepWind (ANFSCD) by Uwe Schmidt Paulsen

Publications:
A novel concept for floating offshore wind turbines

**Light Rotor**
The project seeks to create an Integrated design process composed of: Advanced airfoil design taking into account both aerodynamic and structural objectives/constraints, Aero-servo-elastic blade optimization etc.

Department of Wind Energy
Aeroelastic Design
Period: 01/10/2010 → 31/05/2014
Number of participants: 7
Acronym: 43028 4610
Project participant:
Zahle, Frederik (Intern)
Kim, Taeseong (Intern)
Yde, Anders (Intern)
Sørensen, Niels N. (Intern)
Gaunaa, Mac (Intern)
Skrzypinski, Witold Robert (Intern)
Project Manager, academic:
Bak, Christian (Intern)

**Cost efficient deep water foundation for large offshore wind turbines**

Wind Turbines
Wind Energy Division
Risø National Laboratory for Sustainable Energy
Period: 01/10/2010 → 01/10/2014
Number of participants: 1
Project Manager, organisational:
Buhl, Thomas (Intern)

**Financing sources**
Source: Forskningsprojekter - Andre ministerier og styrelser
Name of research programme: Forskningsprojekter - Andre ministerier og styrelser
Amount: 7,930,000.00 Danish Kroner

**PSO Poseidon 2**
Department of Wind Energy
Aeroelastic Design
Test and Measurements
Floating Power Plant
Contech Automatic
DONG Energy A/S
Period: 01/10/2010 → 31/12/2013
Number of participants: 5
Acronym: 43030 46-PSO
Project participant:
Larsen, Torben J. (Intern)
Wake effects of large offshore wind farms - a study of mesoscale atmosphere and ocean feedbacks

Department of Wind Energy
Period: 01/10/2010 → 28/04/2014
Number of participants: 6
PhD Student:
Volker, Patrick (Intern)
Supervisor:
Badger, Jake (Intern)
Main Supervisor:
Hahmann, Andrea N. (Intern)
Examiner:
Réthoré, Pierre-Elouan (Intern)
Barstad, Idar (Ekstern)
Gayle Nygaard, Nicolai (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Marie Curie (EU-stipendium)
Project: PhD

Aerodynamic modelling

Department of Wind Energy
Period: 15/09/2010 → 27/01/2014
Number of participants: 5
PhD Student:
Guntur, Srinivas (Intern)
Supervisor:
Sørensen, Niels N. (Intern)
Main Supervisor:
Hansen, Martin Otto Laver (Intern)
Examiner:
Johansen, Jeppe (Intern)
Echarri, Xabier Munduate (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Marie Curie (EU-stipendium)
Project: PhD

Boundary-layer wind profile, measurements and theory

Department of Wind Energy
Period: 15/09/2010 → 27/01/2014
Number of participants: 6
PhD Student:
Floors, Rogier Ralph (Intern)
Supervisor:
Peña, Alfredo (Intern)
Main Supervisor:
Gryning, Sven-Erik (Intern)
Examiner:
Larsen, Søren Ejling (Intern)
The ICEWIND project is funded by The Nordic Top-level research program http://www.toppforskningsinitiativet.org/en/programmer-1/program-4/prosjekter/icewind/

- Overall budget 20.8 mill NOK
- Financial support TFI 12.3 mill NOK
- Ekstern finansiering 8.5 mill NOK
- Partners: 13

The project objectives address cold climate aspects and will include the production of icing atlas for Sweden and Iceland based on long term meteorological statistics.

A main issue is the development and validation of short-term forecast of icing by use of numerical weather prediction models and different cloud and hydrometeor-parameterization schemes and include offshore sea spray icing. The final objective is development of an engineering tool for production loss calculation of large wind turbine installations in northern latitudes.

The project objectives related to offshore wind include resource mapping near Iceland and improved land-wind resource map such that the following objectives can be achieved: Full-scale studies on the integration of hydro and wind power in Iceland. The objectives are to identify and enumerate several potential future location scenarios for wind farms and identify location specific cost - benefit measures regarding investment and operations cost with timing and expansion assumptions for these scenarios. Furthermore, to estimate wind energy production when integrated with other resources and to identify transmission capacity restrictions and transmission loss measures for the range of locations and finally to design a market driven short term simulation system using optimization models.

Large-scale integration of wind power objectives include improved forecasting for 1) each wind farm, 2) the entire grid on energy production data and wake loss, 3) icing loss, and 4) offshore operation and cost effective maintenance, tools for optimising the choice of vessel types in different wave climates and providing specialized forecasts for accessibility will be addressed. The site conditions and forecasting results will be combined in analysis of the implications to the power system in the Nordic countries assuming increased amount of cold climate and offshore wind farms.

The objectives of the ICEWIND project aim to support the European targets for the high amount of renewable integration of the power systems in 2020, with the inevitable move towards offshore waters. The project outcomes are expected to be relevant for other cold climate areas of the world.

Niels-Erik Clausen is coordinating the project.
Gregor Giebel is Work Package leader.
Charlotte Bay Hasager is project participant and contributes to the offshore wind atlas for Iceland.
Giebel, Gregor (Intern)
Project Manager, organisational:
Clausen, Niels-Erik (Intern)

Relations
Activities:
Ocean winds from satellites – applications for offshore wind energy
Publications:
Mapping Offshore Winds Around Iceland Using Satellite Synthetic Aperture Radar and Mesoscale Model Simulations
Project

Nysted 2, Wakes
The objective of this project in on basis of simple turbine measurements in a wind farm to identify, model and verify the basic mechanisms driving the increased loading experienced by turbines operating in offshore Wind farm.
Department of Wind Energy
Aeroelastic Design
Department of Applied Mathematics and Computer Science
Test and Measurements
Grontmij A/S
Period: 01/06/2010 → 30/06/2014
Number of participants: 4
Acronym: 43026 4610-PSO
Project participant:
Pedersen, Mads Mølgaard (Intern)
Aagaard Madsen, Helge (Intern)
Larsen, Torben J. (Intern)
Project Manager, academic:
Larsen, Gunner Chr. (Intern)
Project

CFD Modelling of non-Neutral ABL Conditions
Department of Wind Energy
Period: 01/06/2010 → 12/12/2013
Number of participants: 7
Phd Student:
Koblitz, Tilman (Intern)
Supervisor:
Bechmann, Andreas (Intern)
Sogachev, Andrey (Intern)
Main Supervisor:
Sørensen, Niels N. (Intern)
Examiner:
Hahmann, Andrea N. (Intern)
Madsen, Jens Ingemann (Ekstern)
Palma, José Manuel L. M. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Marie Curie (EU-stipendium)
Project: PhD

Flow measurements in complex terrain using a 3D LIDAR Windscanner
Department of Wind Energy
Period: 01/06/2010 → 30/09/2014
Number of participants: 6
Phd Student:
Vasiljevic, Nikola (Intern)
Supervisor:
Mann, Jakob (Intern)
Main Supervisor:
Courtney, Michael (Intern)
Examiner:
Ejsing Jørgensen, Hans (Intern)
Margulis, Michael S. (Ekstern)
Rankers, Adrian M. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Marie Curie (EU-stipendium)
Project: PhD

Simulation and prediction of wakes and wake interaction in wind farms
Department of Wind Energy
Period: 01/06/2010 → 27/01/2014
Number of participants: 7
Phd Student:
Andersen, Søren Juhl (Intern)
Supervisor:
Mikkelsen, Robert Flemming (Intern)
Shen, Wen Zhong (Intern)
Main Supervisor:
Sørensen, Jens Nørkær (Intern)
Examiner:
Mann, Jakob (Intern)
Ivanell, Stefan S. A. (Ekstern)
Meyers, Johan (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Fatigue and extreme wave loads on bottom fixed offshore wind turbines
Department of Wind Energy
Period: 01/05/2010 → 12/12/2013
Number of participants: 6
Phd Student:
Schlee, Signe (Intern)
Supervisor:
Mikkelsen, Robert Flemming (Intern)
Main Supervisor:
Bredmose, Henrik (Intern)
Examiner:
Aagaard Madsen, Helge (Intern)
Krokstad, Jørgen Ranum (Ekstern)
Manuel, Lance (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD
Atmospheric turbulence and wind energy
Department of Wind Energy
Period: 15/04/2010 → 20/09/2013
Number of participants: 5
Phd Student:
Chougule, Abhijit S. (Intern)
Supervisor:
Kelly, Mark C. (Intern)
Main Supervisor:
Mann, Jakob (Intern)
Examiner:
Sørensen, Jens Nørkær (Intern)
Cheng, Po Wen (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut, samfinansiering
Project: PhD

The effects of fibre architecture on fatigue life-time of composite materials
Department of Wind Energy
Period: 15/04/2010 → 30/09/2013
Number of participants: 6
Phd Student:
Hansen, Jens Zangenberg (Intern)
Supervisor:
Østergaard, Rasmus Christian (Intern)
Main Supervisor:
Brøndsted, Povl (Intern)
Examiner:
Mikkelsen, Lars Pilgaard (Intern)
Adolphs, Georg (Ekstern)
Varna, Janis (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: ErhvervsPhD-ordningen VTU
Project: PhD

Danish Centre for Composites Structures and Materials for Wind Turbines
Some of the most critical components of a wind turbine are the rotor blades, which are usually made of polymer matrix composites and are the largest rotating components of a wind turbine. Different types of damage can develop at different length scales in wind turbine rotor blades. Therefore, the Danish Centre for Composite Structures and Materials for Wind Turbines (DCCSM) aims to develop a coherent, multiscale-based understanding of the mechanical behaviour of composite materials and structures for wind turbine blades. The length scale goes from nano- and microscale (materials) to product scale (the whole blade, which currently can be more than 60 meters in length), and covers manufacturing, materials design, damage detection, modelling and prediction of damage evolution in wind turbine blades. A coherent multiscale understanding of composite materials and structures will enable full optimisation, viz., optimisation at all length scales. The Centre aims for the creation of new knowledge (e.g. material models), new experimental methods and new modeling methods. The Centre spans wide thematically and disciplinarily. The specific PhD, Post Doc and research projects funded by DCCSM (Core and Shell activities) are focused at smaller, well-defined topics. Therefore, the Centre will coordinate the research activities in Denmark in the area of composite structures and materials for wind turbines. That includes the Core and Shell activities of DCCSM and research projects that are not funded by the DSF funds but are thematically covered by the Centre. Such projects are called "Crust" projects.

DSF Strategic Research Centre (sags. nr. 09-067212).
Department of Wind Energy
Composites and Materials Mechanics
Department of Micro- and Nanotechnology
Amphiphilic Polymers in Biological Sensing
Wind Turbines
Solid Mechanics
Department of Mechanical Engineering
Department of Civil Engineering
Section for Structural Engineering
Period: 01/04/2010 → 31/03/2017
Number of participants: 11
Acronym: DCCSM
Project participant:
Almdal, Kristoffer (Intern)
Mikkelsen, Lars Pilgaard (Intern)
Branner, Kim (Intern)
Mishnaevsky, Leon (Intern)
Legarth, Brian Nyvang (Intern)
Berggreen, Christian (Intern)
Stang, Henrik (Intern)
PhD Student:
Zike, Sanita (Intern)
Hansen, Jens Zangenberg (Intern)
Ashouri Vajari, Danial (Intern)
Approving authority:
Sørensen, Bent F. (Intern)

Relations
Publications:
From Measurements Errors to a New Strain Gauge Design
Micro-Scale Experiments and Models for Composite Materials with Materials Research
Correction of Gauge Factor for Strain Gauges Used in Polymer Composite Testing
Fatigue damage propagation in unidirectional glass fibre reinforced composites made of a non-crimp fabric
Determination of the minimum size of a statistical representative volume element from a fibre-reinforced composite based on point pattern statistics
Quantitative study on the statistical properties of fibre architecture of genuine and numerical composite microstructures
Methodology for characterisation of glass fibre composite architecture
Design of a fibrous composite preform for wind turbine rotor blades
The effects of fibre architecture on fatigue life-time of composite materials
A numerical study of the influence of microvoids in the transverse mechanical response of unidirectional composites

Transmission system operation with large penetration of Wind and other renewable Electricity sources in Networks by means of innovative Tools and Integrated Energy Solutions
A group of Transmission System Operators from Belgium, Denmark, France, Germany, Spain, The Netherlands, have linked with two generator companies, three power technology manufacturers, two wind turbine manufacturers and research and development organisations, in order to bring answers by 2015 to the following questions:

What are the valuable contributions that intermittent generation and flexible load can bring to system services?
What should the network operators implement to allow for off-shore wind development?
How to give more flexibility to the transmission grid?
Overall: how scalable and replicable are the results within the entire pan-European electricity system?

These four intertwined overarching goals have been split into a set of 6 high level demonstration objectives, two replication objectives and one dissemination objective.

Department of Wind Energy
TWENTIES - Transmission system operation with large penetration of Wind and other renewable Electricity sources in Networks by means of innovative Tools and Integrated Energy Solutions

A group of 6 Transmission System Operators (Belgium, Denmark, France, Germany, The Netherlands and Spain) with 2 generator companies, 5 manufacturers and research organisations, propose 6 demonstration projects to remove, in 3 years, several barriers which prevent the electric system from welcoming more wind electricity, and wind electricity from contributing more to the electric system. The full scale demonstrations aim at proving the benefits of novel technologies (most of them available from manufacturers) coupled with innovative system management approaches. The contribution of wind energy to the system will show how aggregated wind farms can provide system services (voltage and frequency control) in Spain. The aggregation of wind farms with flexible generation and loads will be demonstrated in Denmark using a scalable IT platform developed by a generator. Increasing the flexibility of transmission networks will be tested in Belgium (existing sensors and coordinated power flow control devices avoiding possible large scale instabilities induced by wind farms in the CWE region) and in Spain (dynamic wind power evacuation capacity using real-time computations based on short-term generation forecasts and use of a mobile Overload Line Controller). Off-shore wind farms are addressed from a security viewpoint. Secure HVDC meshed networks will be validated in France using simulations and full scale experiments of two different HVDC circuit breaker technologies. Off-shore wind farm shut downs under stormy conditions will be demonstrated in Denmark using the world largest off-shore wind farm with balancing power provided by the Norwegian hydro capacities through a HVDC link. The experimental results will be integrated into European impact analyses to show the scalability of the solutions: routes for replication will be provided with benefits for the pan European transmission network and the European electricity market as soon as 2014, in line with the SET plan objectives.
Assessment of storm forecast
Offshore wind power integration in TWENTIES and beyond
Managing Critical Weather Conditions in a Large-Scale Wind Based European Power System - The TWENTIES Project

**Design af bæredygtige energisystemer i Grønland**

 Department of Wind Energy  
 Period: 01/04/2010 → 28/04/2016  
 Number of participants: 6  
 Phd Student:  
 Jakobsen, Kasper Rønnow (Intern)  
 Supervisor:  
 Vincent, Claire Louise (Intern)  
 Main Supervisor:  
 Hansen, Martin Otto Laver (Intern)  
 Examiner:  
 Abrahamsen, Asger Bech (Intern)  
 Ivanell, Stefan S. A. (Ekstern)  
 Walløe Hansen, Aksel (Ekstern)  

**Financing sources**
Source: Internal funding (public)  
Name of research programme: Institut stipendie (DTU) Samf.

**Relations**
Publications:  
Renewable Energy Potential of Greenland with emphasis on wind resource assessment  
Project: PhD

**Highly flexible wind turbine rotor design**

 Department of Wind Energy  
 Period: 01/04/2010 → 30/09/2013  
 Number of participants: 7  
 Phd Student:  
 Verelst, David Robert (Intern)  
 Supervisor:  
 Aagaard Madsen , Helge (Intern)  
 Wingerden, Jan-Willem van (Ekstern)  
 Main Supervisor:  
 Larsen, Torben J. (Intern)  
 Examiner:  
 Bak, Christian (Intern)  
 Bottasso, Carlo L. (Ekstern)  
 Schepers, Gerard (Ekstern)  

**Financing sources**
Source: Internal funding (public)  
Name of research programme: Marie Curie (EU-stipendium)  
Project: PhD

**Studies of 3D microscale damage evolution in composites materials for wind turbines**

 Department of Wind Energy  
 Period: 01/04/2010 → 27/01/2014  
 Number of participants: 6  
 Phd Student:  
 Martyniuk, Karolina (Intern)  
 Supervisor:
Offshore wind energy has enormous potential, and its production is highly cost efficient compared to other renewable energy sources. The European Commission has therefore identified offshore wind energy to be of strategic importance with regard to the EU energy targets and reducing dependence on energy imports.

With the worldwide energy and climate challenge becoming more acute than ever, the importance of renewable energy resources has risen to a new level. In recent years offshore wind energy (OWE) has become a competitive alternative to fossil fuel, and the European Commission has consequently identified OWE to be of strategic importance for meeting the demands of the Kyoto protocol while reducing dependence on energy imports and ensuring long-term energy security. The South Baltic Region with its favourable natural and geographical setting, economic preconditions and workforce potential has the unique chance to position itself as one of the EU's premier OWE regions. However, if the South Baltic Region wants to become a major player in OWE, it is crucial to overcome existing bottlenecks in the supply chain as well as legislative and societal barriers. Public awareness and acceptance of OWE must be raised, and skills development in the sector needs improvement.

Ten partners from Denmark, Germany, Poland, Lithuania and Sweden will tackle these challenges within the “South Baltic OFF.E.R” project by building up a vital network to promote coherence of policies. Moreover, the project will develop standard-setting approaches in order to increase efficiency and to speed up the development of a highly competitive offshore wind industry in the South Baltic Region. The Rostock Business and Technology Development mbH (Germany) as “Lead Beneficiary” is the responsible partner for the overall project management and public relations.

There will be a close cooperation with the “sister projects” POWER cluster (direct successor of POWER project) dealing with offshore wind energy in the North Sea Region and WEBSR 2 dealing with wind energy in the Baltic Sea Region.

The project runs between 1st March 2010 and 28th February 2013 within the framework of the South Baltic Cross-border Cooperation Programme 2007-2013 and is part-financed by the European Union (European Regional Development Fund).

Niels-Erik Clausen is coordinating the contribution from DTU Wind Energy that includes a wind atlas for South Baltic and promotional and educational activities including a summer school in 2011.

Charlotte Bay Hasager is project participant and has coordinated the wind atlas task.


Office for Study Programmes and Student Affairs
Department of Wind Energy
Wind Energy Systems
Meteorology

Period: 01/03/2010 – 28/02/2013
Number of participants: 7
Project participant:
Clausen, Niels-Erik (Intern)
Hasager, Charlotte Bay (Intern)
Relations
Publications:
Future wind energy
Economics - do subsidies help developing offshore wind energy?
Rare materials - can we compete for them on the global market?
Construction - offshore wind farm design
Offshore wind energy in Denmark
How to deal with the public in relation to offshore wind energy investments?

Documents:
South_Baltic_OFFER.pdf

**EU ORECCA: Off-shore Renewable Energy Conversion platforms – Coordination Action**
The goals of the ORECCA project (Off-shore Renewable Energy Conversion platforms – Coordination Action) are to create a framework for knowledge sharing and to develop a roadmap for research activities in the context of offshore renewable energy that are a relatively new and challenging field of interest. In particular, the project will stimulate collaboration in research activities leading towards innovative, cost efficient and environmentally benign offshore renewable energy conversion platforms for wind, wave and other ocean energy resources, for their combined use as well as for the complementary use such as aquaculture e.g. biomass and fishes and monitoring of the sea environment e.g. marine mammals, fish and bird life. The objectives of the ORECCA project are to:

1. improve the information exchange and promotion of specific research cooperation in this field between academia and industry, public and private actors;
2. create an efficient and focused framework for knowledge sharing;
3. involve and stimulate all the relevant stakeholder groups in Europe to define the framework for future exploitation of renewable energy sources in the offshore;
4. develop roadmap studies for the research, deployment and regulatory activities in the field of offshore renewable energy.

Department of Wind Energy
Meteorology
Period: 01/03/2010 → 31/08/2011
Number of participants: 2
Acronym: EU ORECCA
Project participant:
Karagali, Ioanna (Intern)
Sempreviva, Anna Maria (Intern)

**Performance enhancement and load reduction on wind turbines using inflow measurements**
Department of Wind Energy
Period: 01/03/2010 → 25/06/2013
Number of participants: 7
Phd Student:
Kragh, Knud Abildgaard (Intern)
Supervisor:
Larsen, Torben J. (Intern)
Mikkelsen, Torben Krogh (Intern)
Main Supervisor:
Hansen, Morten Hartvig (Intern)
Examiner:
Poulsen, Niels Kjølstad (Intern)
Financing sources
Source: Internal funding (public)
Name of research programme: Institut, samfinansiering
Project: PhD

Optimization of vortex generators on wind turbine blades
Experimental/theoretical optimization and model construction for the wake induced by vortex generators.

Department of Mechanical Engineering
Fluid Mechanics, Coastal and Maritime Engineering
Department of Wind Energy
Fluid Mechanics
Aeroelastic Design

LM Glasfiber A/S
Period: 01/02/2010 → 31/07/2013
Number of participants: 5
Project ID: 76031
Project participant:
Veite, Clara Marika (Intern)
Hansen, Martin Otto Laver (Intern)
Okulov, Valery (Intern)
Sørensen, Niels N. (Intern)
Fuglsang, Peter (Intern)

Predicting durability of composite structures during cyclic loading

Department of Wind Energy
Period: 15/01/2010 → 06/10/2015
Number of participants: 4
Phd Student:
Wahlgren, Søren (Intern)
Supervisor:
Jacobsen, Torben Krogsdal (Intern)
Lundsgaard-Larsen, Christian (Intern)
Main Supervisor:
Sørensen, Bent F. (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: ErhvervsPhD-ordningen VTU
Project: PhD

DANAERO MW II: Indflydelse af atmosfære- og kølvandsturbulens på MW møllers ydeevne, last og stabilitet

Department of Wind Energy
Aeroelastic Design
Test and Measurements
VESTAS Wind Systems A/S
LM Wind Power
Siemens Wind Power A/S
**SIMBA - Simulation of balancing**

SimBa is based on Danish principles for balancing. Simba models the power system analytically and can therefore model a future power system. SimBa is expected to be able to investigate other market structures for ancillary services. Gives valuable information on how to balance the system in the future.

Department of Wind Energy

Wind Energy Systems

Risø National Laboratory for Sustainable Energy

Energinet.dk

Period: 01/01/2010 → 31/12/2014

Number of participants: 4

Acronym: SIMBA

Project participant:

- Sørensen, Poul Ejnar (Intern)
- Cutululis, Nicolaos Antonio (Intern)
- Litong-Palima, Marisciel (Intern)
- Maule, Petr (Intern)

**ComWind (Flowcenter) AED**

The project concerns the mutual interaction between wind turbine aerodynamics, turbine wakes, terrain affected flow and atmospheric turbulence, which is not accounted for in state of the art modelling.

Department of Wind Energy

Aeroelastic Design

Fluid Mechanics

Test and Measurements

Period: 01/01/2010 → 31/12/2016

Number of participants: 7

Acronym: 43081-4610

Project participant:

- Sørensen, Niels N. (Intern)
- Trolldborg, Niels (Intern)
- Réthoré, Pierre-Elouan (Intern)
- Bechmann, Andreas (Intern)
- Zahle, Frederik (Intern)
- Larsen, Gunner Chr. (Intern)

Project Manager, academic:

- Sørensen, Jens Nørkær (Intern)
EU MARINA PLATFORM: Marine renewable integrated application platform

MARINA is a European project dedicated to bringing offshore renewable energy applications closer to the market by creating new infrastructures for both offshore and ocean energy converters. MARINA is a European project dedicated to bringing offshore renewable energy applications closer to the market by creating new infrastructures for both offshore wind and ocean energy converters. It addresses the need for creating a cost-efficient technology development basis to kick-start growth of the nascent European marine renewable energy (MRE) industry in the deep offshore a major future global market. The project combines deep-water engineering experience from European oil & gas developments during the last 40 years, state-of-the-art concepts for offshore wind energy, and the most promising concepts in today’s R&D pipeline on wave energy and other marine renewables. The MARINA project is designed to capitalise on the vast body of proven marine technological knowledge gained in one of the world’s most hostile off-shore operating environments: the Northern European seas. MARINA will bolt this practical technology skill set onto the research base of the emerging but still marginal EU MRE industry and ensure its continued world-leading role. The MARINA project is therefore of major strategic significance for Europe. The FP7 EU project MARINA: Marine Renewable Integrated Application Platform. The MARINA project is lead by ACCIONA http://www.renewable-energy-sources.com/2010/02/10/acciona-leads-a-consortium-of-17-european-organizations-to-research-the-integration-of-different-marine-energy-sources/ The MARINA project is a pan-European project dedicated to bringing offshore renewable energy applications closer to the market by creating new infrastructures for both offshore wind and ocean energy converters. It addresses the need for creating a cost-efficient technology development basis to kick-start growth of the nascent European marine renewable energy (MRE) industry in the deep offshore – a major future global market. The project combines deep-water engineering experience from European oil and gas developments during the last 40 years, state-of-the-art concepts for offshore wind energy and the most promising concepts in today’s R&D pipeline on wave energy and other marine renewable. The total project is 12,8 million euro. The European Union has granted 8,7 million euro. Grant 241402. https://www.marine.ie/home/research/ProjectsDatabase/CurrentProjects/MARINA+Platform+Marine+Renewable+Integrated+Application+Platform.htm Charlotte Bay Hasager, Xiaoli Guo Larsén and Ioanna Karagali are responsible for site conditions wind and waves for combined wind-wave energy converters.

Department of Wind Energy
Aeroelastic Design
Meteorology
Fraunhofer Gesellschaft
University of Edinburgh
National Technical University of Athens
DONG Energy A/S
Statoil Hydro
Period: 01/01/2010 → 30/06/2014
Number of participants: 10
Acronym: 43019 4610-EU-Marina Platform
Project participant:
Hasager, Charlotte Bay (Intern)
Larsén, Xiaoli Guo (Intern)
Astrup, Poul (Intern)
Peña, Alfredo (Intern)
Floors, Rogier Ralph (Intern)
Gryning, Sven-Erik (Intern)
Yde, Anders (Intern)
Kallesøe, Bjarne Skovmose (Intern)
Bingöl, Ferhat (Intern)
Project Manager, academic:
Hansen, Anders Melchior (Intern)
Project

Adaptive Trailing Edge Flap, control for enhanced load alleviation

Department of Wind Energy
Period: 01/01/2010 → 27/08/2013
Number of participants: 7
Phd Student:
Test Facility for grid connection characteristics of wind power plants - Phase 1

Requirements to wind turbines aiming to support the integration of wind power plants into power systems are becoming increasingly important in R&D and design of new wind turbines. As a consequence, there is a growing need for test and validation of the interaction between wind turbines and grid. This project deals with test facilities, i.e. equipment which can be applied to emulate specific grid conditions on the terminals of a wind turbine in order to test the wind turbine response to such conditions.

Dedicated tests of wind turbines Low Voltage Ride Through (LVRT) capabilities have been common practice for several years, and are required in most grid codes. Such tests are also included in the wind turbine power quality test standard IEC 61400-21. However, the standard LVRT test equipment using impedances to provide voltage dips at the turbine terminals is dedicated to this specific type of test, but there are many other grid conditions which are relevant to test. A power converter test facility offers a very high degree of freedom in terms of possible grid conditions to emulate. The present report mainly considers these two options for test equipment, but also discusses other options.

The aim of the project was to find the right technical solution for the test facility, together with an establishment and operational budget. Furthermore, the possible funding options and operational organisations were to be investigated, culminating in implementation plan.

Risø National Laboratory for Sustainable Energy
Department of Wind Energy
Aalborg University
VESTAS Wind Systems A/S
Siemens Wind Power A/S
ABB Energi & Industri A/S
Siemens A/S

Period: 01/01/2010 → 30/06/2011
Number of participants: 2
Project participant:
Cronin, Tom (Intern)

Project Coordinator:
Sørensen, Poul Ejnar (Intern)

Financing sources
Source: Public research programme (public)
Name of research programme: EUDP-2009-II
Amount: 1,024,760.00 Danish Kroner
Year of approval: 2010
Period: 01/01/2010 → 20/06/2014
Number of participants: 6
Phd Student:
Kidmose, Jacob (Intern)
Supervisor:
Winther, Grethe (Intern)
Main Supervisor:
Huang, Xiaoxu (Intern)
Examiner:
Mikkelsen, Lars Pilgaard (Intern)
Nielsen, Karl Brian (Ekstern)
Tsuji, Nobuhiro (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut, samfinansiering
Project: PhD

Kinetics of coarsening during annealing
Department of Wind Energy
Period: 01/12/2009 → 24/04/2013
Number of participants: 6
Phd Student:
Lin, Fengxiang (Intern)
Supervisor:
Pantleon, Wolfgang (Intern)
Main Supervisor:
Juul Jensen, Dorte (Intern)
Examiner:
Huang, Xiaoxu (Intern)
Delannay, Laurent (Ekstern)
Rollett, Anthony David (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Grundforskningsfonden
Project: PhD

Performance of biodegradable polymers used in mechanically loaded implants
Department of Wind Energy
Period: 01/12/2009 → 28/10/2013
Number of participants: 6
Phd Student:
Andersen, Lonnie Ulrich (Intern)
Supervisor:
Lauritzen, Jes Bruun (Intern)
Main Supervisor:
Brøndsted, Povl (Intern)
Examiner:
Madsen, Bo (Intern)
Hansen, Ulrich N. (Ekstern)
Solgaard, Søren (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD
Dynamic wake model for load calculations of wind turbines

Department of Wind Energy
Period: 01/11/2009 → 27/05/2013
Number of participants: 6
Phd Student:
Keck, Rolf-Erik (Ekstern)
Supervisor:
Larsen, Gunner Chr. (Intern)
Main Supervisor:
Aagaard Madsen, Helge (Intern)
Examiner:
Hansen, Martin Otto Laver (Intern)
Madsen, Jens Ingemann (Ekstern)
Riziotis, Vasilis A. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: ErhvervsPhD-ordningen VTU
Project: PhD

Coupling of a CFD Solver with a Multibody Structural Model Applied to Trailing Edge Flaps

Department of Wind Energy
Period: 01/10/2009 → 27/08/2013
Number of participants: 6
Phd Student:
Heinz, Joachim Christian (Intern)
Supervisor:
Zahle, Frederik (Intern)
Main Supervisor:
Serensen, Niels N. (Intern)
Examiner:
Mikkelsen, Robert Flemming (Intern)
Johansen, Jeppe (Intern)
Voutsinas, Spyros (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut, samfinansiering
Project: PhD

Meso-scale modelling with focus on the water vapour profile

Department of Wind Energy
Period: 01/10/2009 → 20/09/2013
Number of participants: 7
Phd Student:
Nielsen, Joakim Refslund (Intern)
Supervisor:
Bagh, Eva (Ekstern)
Hahmann, Andrea N. (Intern)
Main Supervisor:
Dellwik, Ebba (Intern)
Examiner:
Badger, Jake (Intern)
Nielsen, Niels Woetmann (Ekstern)
Verhoef, Anne (Ekstern)

Financing sources
Source: Internal funding (public)
Aeroelastic optimization of MW turbines

Aeroelastic Design

Wind Energy Division

Risø National Laboratory for Sustainable Energy
Period: 01/09/2009 → 31/08/2011
Number of participants: 1
Project ID: 1110073-01
Project Manager, organisational:
Buhl, Thomas (Intern)

Financing sources
Source: Unknown
Name of research programme: Ukendt
Amount: 6,112,768.00 Danish Kroner

Computationally Efficient Methods for Reliability Based Design of Wind Turbine Blades

Department of Wind Energy
Period: 01/09/2009 → 27/08/2013
Number of participants: 7
Phd Student:
Dimitrov, Nikolay Krasimirov (Intern)
Supervisor:
Friis-Hansen, Peter (Intern)
Staerdahl, Jesper (Ekstern)
Main Supervisor:
Berggreen, Christian (Intern)
Examiner:
Nishijima, Kazuyoshi (Intern)
Straub, Daniel (Ekstern)
Sørensen, John Dalsgaard (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: ErhvervsPhD-ordningen VTU

Integriert Aeroservoelastisk Analyse og Design af Vindmøller

Department of Wind Energy
Period: 01/09/2009 → 20/09/2013
Number of participants: 5
Phd Student:
Sønderby, Ivan Bergquist (Intern)
Main Supervisor:
Hansen, Morten Hartvig (Intern)
Examiner:
Poulsen, Niels Kjølstad (Intern)
Kanev, Stoyan (Ekstern)
Riziotis, Vasilis A. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut, samfinansiering
Project: PhD
Structural and textural control in high strength dual phase steels

Department of Wind Energy
Period: 01/09/2009 → 24/04/2013
Number of participants: 6
Phd Student:
Azuma, Masafumi (Intern)
Supervisor:
Winther, Grethe (Intern)
Main Supervisor:
Huang, Xiaoxu (Intern)
Examiner:
Juul Jensen, Dorte (Intern)
Furuhara, Tadashi (Ekstern)
Withers, Philip John (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Eksternt finansieret virksomhed
Project: PhD

3D virtual testing of composites for wind energy applications: Computational mesomechanics approach

Department of Wind Energy
Composites and Materials Mechanics
Period: 01/05/2009 → 31/05/2011
Number of participants: 1
Project Coordinator:
Mishnaevsky, Leon (Intern)

Pre-standardisation of wind power modelling
The purpose of the project is to support the standardisation work in IEC Technical Committee 88 (TC88) Working Group 27 (WG27) on electrical simulation models for wind power generation. This work is done in cooperation between DTU and industry partners. The role of DTU has been to implement the IEC models in Power Factory, and in cooperation with industry to parametrise and validate the models against test results

Department of Wind Energy
Wind Energy Systems
Department of Electrical Engineering
Center for Electric Power and Energy
Period: 01/05/2009 → 30/06/2013
Number of participants: 4
Project participant:
Margaris, Ioannis (Intern)
Hansen, Anca Daniela (Intern)
Wu, Qiuwei (Intern)
Project Manager, academic:
Sørensen, Poul Ejnar (Intern)

Relations
Activities:
IEC TC88 WG27: Wind Turbines - Electrical Simulation Models (External organisation)

Publications:
Implementation of IEC Standard Models for Power System Stability Studies
Implementation of IEC Generic Model Type 1A using RTDS
Wind turbine standard models
Modular structure of wind turbine models in IEC 61400-27-1
IEC work on modelling - generic model development. IEC 61400-27 - expected outcome
IEC 61400-27 standard on electrical simulation models for wind power generation
IEC 61400-27. Electrical simulation models for wind power generation

Structure and mechanical properties of aligned natural fibre composites
Department of Wind Energy
Period: 01/04/2009 → 31/01/2013
Number of participants: 6
Phd Student:
Rask, Morten (Intern)
Supervisor:
Lauridsen, Erik Mejdal (Intern)
Madsen, Bo (Intern)
Main Supervisor:
Sørensen, Bent F. (Intern)
Examiner:
Mikkelsen, Lars Pilgaard (Intern)
Spearing, Simon Mark (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Anden EU-finansiering
Project: PhD

Offshore Wind Energy: Wind and Sea Surface Temperature from Satellite Observations
Department of Wind Energy
Period: 01/03/2009 → 24/08/2012
Number of participants: 7
Phd Student:
Karagali, Ioanna (Intern)
Supervisor:
Badger, Merete (Intern)
Høyer, Jacob L. (Ekstern)
Main Supervisor:
Hasager, Charlotte Bay (Intern)
Examiner:
Larsen, Søren Ejling (Intern)
Fensholt, Rasmus (Ekstern)
Furevik, Birgitte R. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut, samfinansiering
Project: PhD

EO-LAND-WATER
EO-LAND-WATER: Implementing Earth observations, advanced satellite based atmospheric sounders and distributed temperature sensing for effective land surface representation in water resource modelling

In order to predict future freshwater availability and the vulnerability of ecosystems and society to floods and droughts, hydrological model tools are needed that are capable of accurately representing climate, land use and land cover at different spatial scales. The purpose of the current project is to develop model tools capable of quantifying the relative effects of site-specific land use change and climate variability at different scales.

Boegh, Eva (Project Coordinator)Dellwik, Ebba, Risø-DTU, Denmark (Project participant)Hasager, Charlotte, Risø-DTU, Denmark (Project participant)Hahmann, Andrea, Risø-DTU, Denmark (Project participant)Rosbjerg, Dan, DTU-Environment, Denmark (Project participant)Refslund Nielsen, Joakim, Risø-DTU, Denmark (Project participant)
The Department of Environmental, Social and Spatial Change

In order to predict future freshwater availability and the vulnerability of ecosystems and society to floods and droughts, hydrological model tools are needed that are capable of accurately representing climate, land use and land cover at different spatial scales. The purpose of the current project is to develop model tools capable of quantifying the relative effects of site-specific land use change and climate variability at different scales.

Status: Current

Period: 01-02-09 → 01-07-12

URL: http://www.upscalehydrology.ruc.dk

Financing source: Public research council

Research programme: Forskningsrådet for Teknologi og Produktion (FTP)

Short description:

Climate, land cover and land use are changing, thereby imposing changes to the hydrological cycle which are affecting the access to water resources and increasing the frequency of extreme hydrological events, such as floods and droughts. In order to predict future freshwater availability and the vulnerability of ecosystems and society to floods and droughts, hydrological model tools are needed that are capable of accurately representing climate, land use and land cover at different spatial scales.

The purpose of the current project is to develop model tools capable of quantifying the relative effects of site-specific land use change and climate variability at different scales.

Evaluating impacts of site-specific changes in land use and land cover on catchment processes is significantly complicated by spatial heterogeneity and the long and variable time lags between precipitation and the responses of soil, streams and groundwater. To address the research objectives, new data- and model- based technologies will be combined. This includes the use of a Distributed Temperature System (DTS) for measuring spatial variations in stream temperature. The DTS system uses a long (1-2 km) fiber-optic cable to provide temperature measurements with 1 meter resolution. The system will be used to identify and model lateral inflows to the stream in relation to the spatial characteristics of the upland contributing land areas which are represented as multiple (cumulative) sub-catchments. At the larger scales (all Sjælland), Earth observations will be used for land surface hydrology modeling, and effective land surface representation schemes will be developed. Impact of effective spatial land surface hydrology representation will be analyzed and verified using new satellite based atmospheric sounders (AIRS, IASI) which are providing high vertical resolution information of atmospheric properties (ie. air temperature, air humidity and CO2). For this purpose the land surface scheme will be used in a next-generation regional climate model. The impact of land surface hydrology and heterogeneity on the atmospheric boundary layer development will then be analyzed and verified using the (3-D) observed variations in atmospheric condition from AIRS and IASI.

Keywords: Satellite data, land use, water resources, distributed temperature sensing, hydrological modelling

Department of Wind Energy

Meteorology

Period: 01/02/2009 → 01/07/2012

Number of participants: 4

Acronym: EO-LAND-WATER

Project participant:

Hasager, Charlotte Bay (Intern)

Sogachev, Andrey (Intern)

Nielsen, Joakim Refslund (Intern)

Project Manager, organisational:

Dellwik, Ebba (Intern)

Project

Floating offshore wind turbines - 3D hydrodynamics coupled to an advanced aero-elastic code

Department of Wind Energy

Period: 01/02/2009 → 27/05/2013

Number of participants: 7

Phd Student:

Kumari Ramachandran, Gireesh Kumar Vasanta (Intern)

Supervisor:

Bredmose, Henrik (Intern)
Jensen, Jørgen Juncher (Intern)
Main Supervisor: Sørensen, Jens Nørkær (Intern)
Examiner: Bingham, Harry B. (Intern)
Nielsen, Finn Gunnar (Ekstern)
Veldkamp, Dick (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Eksternt finansieret virksomhed
Project: PhD

Integrated design of wind power systems
Department of Wind Energy
Period: 01/02/2009 → 18/06/2012
Number of participants: 8
Phd Student: Barahona Garzón, Braulio (Intern)
Supervisor: Hansen, Anca Daniela (Intern)
Hansen, Anders Melchior (Intern)
Cutululis, Nicolaos Antonio (Intern)
Main Supervisor: Sørensen, Poul Ejnar (Intern)
Examiner: Larsen, Gunner Chr. (Intern)
Carlson, Ola (Ekstern)
Iov, Florin (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut, samfinansiering
Project: PhD

Analysis and modeling of unsteady aerodynamics with application to wind turbine blade vibration at standstill conditions
Department of Wind Energy
Period: 15/12/2008 → 23/05/2012
Number of participants: 7
Phd Student: Skrzypinski, Witold Robert (Intern)
Supervisor: Bak, Christian (Intern)
Bertagnolio, Franck (Intern)
Main Supervisor: Gaunaa, Mac (Intern)
Examiner: Mikkelsen, Robert Flemming (Intern)
Riziotis, Vasilis A. (Ekstern)
Wedel-Heinen, Jens Jakob (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut, samfinansiering
Project: PhD

New data assimilation techniques for short-term wind energy forecast models with a rapid update cycle
Department of Wind Energy
Period: 15/12/2008 → 25/06/2012
Number of participants: 7
Phd Student: 
Draxl, Caroline (Intern)
Supervisor: 
Hahmann, Andrea N. (Intern)
Monache, Luca Delle (Ekstern)
Main Supervisor: 
Giebel, Gregor (Intern)
Examiner: 
Larsen, Xiaoli Guo (Intern)
Kaas, Eigil (Ekstern)
Lundquist, Julie Kay (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut, samfinansiering
Project: PhD

Sensor Design and Control Algorithm for Flaps on Wind Turbine Blades
Department of Wind Energy
Period: 01/12/2008 → 23/05/2012
Number of participants: 6
Phd Student: 
Castaignet, Damien Bruno (Intern)
Supervisor: 
Poulsen, Niels Kjølstad (Intern)
Wedel-Heinen, Jens Jakob (Ekstern)
Main Supervisor: 
Buhl, Thomas (Intern)
Examiner: 
Knudsen, Torben (Ekstern)
vandam, C. P. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Ansat eksternt
Project: PhD

Strukturelt design af fremtidens store vinger under kombineret last
Department of Wind Energy
Period: 01/12/2008 → 15/09/2012
Number of participants: 4
Phd Student: 
Bialas, Zuzana (Intern)
Supervisor: 
Bak, Christian (Intern)
Berggreen, Christian (Intern)
Main Supervisor: 
Branner, Kim (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut, samfinansiering
Project: PhD
Unsteady Flow Modeling and Experimental Verification of Active Flow Control Concepts for Wind Turbine Blades

Department of Wind Energy
Period: 01/12/2008 → 02/05/2012
Number of participants: 6
Phd Student:
Bæk, Peter (Ekstern)
Supervisor:
Korsgaard, John (Ekstern)
Main Supervisor:
Gaunaa, Mac (Intern)
Examiner:
Hansen, Martin Otto Laver (Intern)
Bottasso, Carlo L. (Ekstern)
van Kuik, G. A. M. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: ErhvervsPhD-ordningen VTU
Project: PhD

Wind Atlas for South Africa (Phase 1)
Capacity development and research cooperation through development of wind resource mapping for the Western Cape and areas of Northern and Eastern Cape.

Phase 2 of the project starts in 2014.

Department of Wind Energy
Wind Energy Systems
Meteorology
Test and Measurements
Council for Scientific and Industrial Research
University of Cape Town
South African Weather Service
South African National Energy Development Institute
Period: 01/11/2008 → 31/03/2014
Number of participants: 10
Acronym: WASA
Project participant:
Mortensen, Niels Gylling (Intern)
Hahmann, Andrea N. (Intern)
Badger, Jake (Intern)
Volker, Patrick (Intern)
Larsén, Xiaoli Guo (Intern)
Kelly, Mark C. (Intern)
Enevoldsen, Karen (Intern)
Sørensen, Steen Arne (Intern)
Cronin, Tom (Intern)
Project Manager, organisational:
Hansen, Jens Carsten (Intern)

Relations
Related projects:
Wind Atlas for South Africa (Phase 2)
Publications:
Large-scale, high-resolution wind resource mapping for wind farm planning and development in South Africa
Mesoscale modeling for the Wind Atlas of South Africa (WASA) project
In August 2008 the European project “Northern Seas Wind Index Database” (NORSEWInD) started within the seventh framework programme of the European Union http://www.norsewind.eu/public/index.html.

The aim of the project is to quantify the wind resource for offshore wind power utilisation. In order to truly understand the quality of the wind resource available, the wind regime will be captured using instrumentation installed at offshore locations in the Baltic, Irish and North Seas. Furthermore a small validation area is selected off Portugal in the Atlantic Ocean.

A combination of ground-based remote sensing, satellite-based remote sensing, meteorological masts, computational modelling and forecasting is used in the project. NORSEWInD takes a multi-disciplinary, multi-industrial sector approach to achieve a thorough understanding of offshore wind conditions.

The end-product of the project is a comprehensive wind resource database and an offshore wind atlas for (pre-) feasibility, as well as a suite of techniques that can be translated to any offshore location in the world.

One part of the NORSEWInD project was to collect remote sensing observations from space on ocean surface winds in near-real-time (NRT). The overall aim is to provide new offshore wind climatology map for the entire area of interest based on satellite remote sensing.

Charlotte Bay Hasager coordinated the work at DTU Wind Energy. (and was WP-leader)
Participants: Torben Mikkelsen (WP-leader), Mike Courtney, Alfredo Peña, Merete Badger, Ferhat Bingöl, Andrea Hahmann, Jake Badger, Morten Nielsen, Poul Astrup, Ioanna Karagali, Sven-Erik Gryning, Ameya Sathe, Caroline Draxl, Julia Lange
Hahmann, Andrea N. (Intern)
Karagali, Ioanna (Intern)
Bingöl, Ferhat (Intern)
Nielsen, Morten (Intern)
Astrup, Poul (Intern)
Gryning, Sven-Erik (Intern)
Sathe, Ameya (Intern)
Lange, Julia (Intern)

Relations
Activities:
Ocean winds from satellites – applications for offshore wind energy

Project

Recovery and recrystallisation of nanostructured metals - mechanisms and kinetics
Department of Wind Energy
Period: 01/08/2008 → 23/05/2012
Number of participants: 6
PhD Student:
Yu, Tianbo (Intern)
Supervisor:
Winther, Grethe (Intern)
Main Supervisor:
Huang, Xiaoxu (Intern)
Examiner:
Pantleon, Wolfgang (Intern)
Doherty, Roger D. (Ekstern)
Driver, Julian H. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Risø (Løn)
Project: PhD

Development of Adaptive Trailing Edge Flap (ATEF) system for Wind Turbines
Aeroelastic Design
Wind Energy Division
Risø National Laboratory for Sustainable Energy
Period: 01/04/2008 → 31/12/2011
Number of participants: 1
Project ID: 1110064-01
Project Manager, organisational:
Buhl, Thomas (Intern)

Financing sources
Source: Forskningsprojekter - Andre ministerier og styrelser
Name of research programme: Forskningsprojekter - Andre ministerier og styrelser
Amount: 8,706,852.00 Danish Kroner
Project

EFP07-II, Program for Forskning i Anvendt Aeroelasticitet
Aeroelastic Design
Wind Energy Division
Risø National Laboratory for Sustainable Energy
Period: 01/04/2008 → 31/03/2009
Number of participants: 1
Project ID: 1110065-01
Project Manager, organisational:
Buhl, Thomas (Intern)

Financing sources
Source: Forskningsprojekter - Miljø- og Energiministeriet
Name of research programme: Forskningsprojekter - Miljø- og Energiministeriet
Amount: 4,147,000.00 Danish Kroner

Strukturel modellering af vindmølleblade med passiv kontrol

Department of Wind Energy
Period: 01/03/2008 → 23/11/2012
Number of participants: 7
Phd Student:
Fedorov, Vladimir (Intern)
Supervisor:
Branner, Kim (Intern)
Krenk, Steen (Intern)
Main Supervisor:
Berggreen, Christian (Intern)
Examiner:
Jensen, Jørgen Juncher (Intern)
Hayman, Brian (Intern)
Thomsen, Ole Thybo (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

El til vejtransport, fleksible el-systemer og vindkraft

Centre for Electric Technology
Risø National Laboratory for Sustainable Energy
Systems Analysis Division
Department of Electrical Engineering
Electronics
Wind Energy Division
RAM-lose
Energinet.dk
Dansk Energi
Period: 17/01/2008 → 31/12/2010
Number of participants: 14
Project ID: 55563
Contact person:
Larsen, Esben (Intern)
Hansen, Lars (Ekstern)
Project participant:
Morthorst, Poul Erik (Intern)
Jørgensen, Kaj (Intern)
Meibom, Peter (Intern)
Mesoscale and microscale modelling in China (CMA component)
Capacity building and research cooperation through development of wind resource mapping for northwestern China (Dongbei). Sustainable use of wind energy through knowledge transfer and capacity building at central level and in the three North-eastern provinces of Heilongjiang, Jilin and Liaoning. Implemented as a twinning arrangement between CMA and Risø DTU and divided in four main projects:
1) mesoscale modelling
2) measurements
3) microscale modelling
4) guidelines for application
(Under construction!)

Department of Wind Energy
Wind Energy Systems
Meteorology

Test and Measurements
Period: 01/12/2007 → 31/07/2010
Number of participants: 8
Project participant:
Badger, Jake (Intern)
Larsén, Xiaoil Guo (Intern)
Rathmann, Ole Steen (Intern)
Nielsen, Morten (Intern)
Hummelsøj, Poul (Intern)
Enevoldsen, Karen (Intern)

Project Manager, organisational:
Hansen, Jens Carsten (Intern)
Mortensen, Niels Gylling (Intern)

Relations
Publications:
Mesoscale and microscale modelling in NE China: A new application-ready numerical wind atlas for Dongbei
Meso- and Micro-scale Modelling in China: Wind atlas analysis for 12 meteorological stations in NE China (Dongbei)
Meso- and Micro-scale Modelling in China: Site inspection trip to NE China (Dongbei)
Methods to assess uncertainty of wind resource estimates determined by mesoscale modelling
Mesoscale and microscale modelling in China: Wind measurements at 12 meteorological stations in NE China (Dongbei)
Development of wind energy technologies in Nepal on the basis of natural materials

Department of Wind Energy
Composites and Materials Mechanics
Period: 01/11/2007 → 31/08/2011
Number of participants: 1
Project Manager, academic:
Mishnaevsky, Leon (Intern)

Agentbaserede styringsstrukturer i eisystemer med betydelig decentral produktion : PSO-projekt

Department of Electrical Engineering
Wind Energy Division
Risø National Laboratory for Sustainable Energy
Centre for Electric Technology
Syd Energi, Syd Energi Net A/S,

NESA A/S
Period: 01/03/2007 → 31/03/2010
Number of participants: 6
Project ID: 55388
Project participant:
Nielsen, Arne Hejde (Intern)
Saleem, Arshad (Intern)
Bindner, Henrik W. (Intern)
Andreasen, Jacob (Ekstern)
Nielsen, Lars Bai (Ekstern)
Project Manager, organisational:
Lind, Morten (Intern)

Financing sources
Source: Forskningsprojekter - Andre ministerier og styrelser
Name of research programme: Forskningsprojekter - Andre ministerier og styrelser
Amount: 2,003,000.00 Danish Kroner

VirtuelGalathea3 e-learning (vg3.dk og galathea3.dk)
The VirtuelGalathea3 project provides educational material to pupils in Danish schools from 14 years to 20 years of age about mainly physical and natural sciences. The material is based on the Galathea 3 expedition (1996-1997).

Charlotte Bay Hasager coordinates the project.

The homepage www.virtuelgalathea3.dk or vg3.dk has had more than 1/4 unique visitors since 2008. The monthly visits are above 10,000 people per month.


Formål
Formålet med VirtuelGalathea3 e-learning er at tilbyde et solidt fagligt funderet undervisningsmateriale, der varigt sikrer danske elever web-baseret online adgang til de mange spændende observationer og resultater fra Galathea 3 projekterne til brug i undervisningen i fagene fysik, kemi, matematik, biologi, naturgeografi og historie niveau-delt til klasser i folkeskole og ungdomsuddannelser.

Projektdeltagerne er
Risa DTU Charlotte Bay Hasager (koordinator), Merete Bruun Christiansen, Michael Ole Olsen, Kristian Frederiksen, Lone Als Egebo, Helle Houkjær, Lone Skafte Jespersen
Danmarks Rumcenter – DTU Ole Baltazar Andersen
Danmarks Meteorologiske Institut Jacob L. Høyer
Niels Bohr Institut ved Københavns Universitet Niels Kristian Højerslev
Kort om VirtuelGalathea3 e-learning
Projektet bygges op på hjemmesiden www.virtuelgalathea3.dk i samarbejde med forskningsprojekterne og skoleprojekter på Galathea 3. Erfaringerne fra Dansk Ekspeditionsfond, EMU og medierne vil der blive linket til i bredt omfang, således at det tilgængelige materiale for Galathea 3 kan blive anvendt i videst muligt omfang i de danske skoler i de kommende år.

Department of Wind Energy

Meteorology
Period: 01/01/2007 → 31/12/2015
Number of participants: 1
Acronym: VirtuelGalathea3
Project participant:
Hasager, Charlotte Bay (Intern)

Advanced Load Alleviation for Wind Turbines using Adaptive Trailing Edge Geometry : Sensoring and control
Aeroelastic Design

Wind Energy Division

Rise National Laboratory for Sustainable Energy
Period: 01/06/2006 → 30/06/2009
Number of participants: 1
Acronym: ADAPWING2
Project ID: 1110050-01
Project Manager, organisational:
Buhl, Thomas (Intern)

Financing sources
Source: Forskningsrådene - Andre
Name of research programme: Forskningsrådene - Andre
Amount: 2,740,050.00 Danish Kroner

Satellite Eye for Galathea 3
A Living Atlas showing the highly dynamical processes in the marine, atmospheric and coastal environment along the route of the Galathea 3 expedition ship.

The project is supported by Egmont Fonden with approximately 3.9 mio. DKK over two years from 2006 to 2008.

Goal
The goal of the project ‘Satellite Eye for Galathea 3’ is to contribute with a Living Atlas based on satellite images recorded along the sailing track for Galathea 3. The highly dynamical processes in the marine, atmospheric and coastal environment will be quantified from satellite images and published - in a professionally-based way and in near-real-time - to scientists, students, pupils, the public and to the crew on-board the Galathea 3.

It is a technological challenge to download, archive and distribute the immense amount of data. It is at the same time compelling to order the high-resolution images from the European satellite Envisat’s many instruments well in advance. In agreement with the European Space Agency (ESA), we have in this project secured an agreement with Eduspace/ESA, such that we ensure an optimal use of Envisat in relationship with Galathea 3 as from other satellites.

Eduspace will publish web-based teaching on satellites and Galathea 3 from upper secondary schools. Galathea 3 is a sailing laboratory with instruments on-board that observes a long list of similar parameters as the satellites observe. It is a unique option of international quality to compare and combine the different parameter values. Some will be investigated within this project, others in parallel projects. A close cooperation with scientists from other projects is being established, such that an optimal collection of satellite images will be achieved.

The fantastic development in Earth Observation from satellites is one of the greatest technological advances since Galathea 1 and 2. It is seen as very important to optimized the collection, archiving and publishing these satellite images for the future generations.
12 MW wind turbines: the scientific basis for their operational 70 to 270 m height offshore

Improvement of offshore winds and turbulence predictions based on available remote sensing equipment, wind and turbulence quantification, and modelling.

12 MW wind turbines: the scientific basis for their operational 70 to 270 m height offshore. The 12MW project runs in years 2005 and 2009 with funding from the Danish Research Agency, The Strategic Research Council, Program for Energy and Environment

Background
Wind turbine dimensions have evolved from rapidly 1980 to now. At the moment turbines up to 8 MW can be tested at Høvsøre Test Station, Risø. The size of commercial wind turbine design may grow to 12 MW. The very large turbines will be used offshore. This development puts a strong demand on our understanding of the atmospheric flow and turbulence characteristics at very high heights offshore.

Small turbines operate in the lower part of the atmospheric boundary layer. Here the logarithmic wind profile is valid and turbulence statistics are well known from offshore and coastal masts. Higher up winds are largely unknown due to severe practical offshore measurement difficulties.

The challenge is to improve our knowledge on offshore wind and turbulence characteristics for the next generation of multi-MW wind turbines that will come to operate at heights ranging from 70 to 270 m above sea level.

In the 12MW project we will improve offshore winds and turbulence prediction capabilities at these heights based on available new and proven remote sensing equipment, wind and turbulence quantification, and modelling.

Goal
The goal of the project is to experimentally investigate the wind and turbulence characteristics between 70 and 270 m above sea level and thereby establish the scientific basis relevant for the next generation of huge 12 MW wind turbines operating offshore. This will be done using state of the art wind remote sensing measurement techniques for data collection at an offshore wind farm site in Denmark.

The strategic aim is to supply the wind industry relevant results.

Objective
To establish new wind and turbulence design models for the next generation of 12 MW turbines operating in the offshore marine environment from 70 to 270 m’s height. The design models will be evaluated from observations from Doppler Laser LIDAR, SODAR, backscatter aerosol LIDAR, radiosondes, ceilometer and satellite.

Participants
Risø National Laboratory, Wind Energy Department
Power Fluctuations from Large Offshore Wind Farms

The project has developed and verified simulation and prediction models for power fluctuations in large wind farms. The verification is based on extensive measurements in the two large offshore wind farms in Denmark: Horns Rev and Nysted. The models can also be applied to simulation of wind power fluctuations from wind turbines distributed over a larger area than a wind farm. The advantage of the prediction models is that they can be applied in the operation, but these models require a training period before they work in a new system. On the other hand, the simulation model can simulate power fluctuations with possible future wind power developments, based on information about size and location of the individual wind turbines. Thus, the simulation model is a planning tool.

Department of Wind Energy

Wind Energy Systems

Risø National Laboratory for Sustainable Energy

Department of Applied Mathematics and Computer Science

DONG Energy A/S

Vattenfall A/S

Publications:

Modelling of power fluctuations from large offshore wind farms
Power fluctuations from large offshore wind farms
Analysis of the experimental spectral coherence in the Nysted Wind Farm
Models for assessing power fluctuations from large wind farms
Fluctuations of offshore wind generation: Statistical modelling
Power Fluctuations From Large Wind Farms
Regime-switching modelling of the fluctuations of offshore wind generation
SAT-WIND: Winds from satellites for offshore and coastal wind energy mapping and wind-indexing

Applicability of satellite wind maps derived from passive microwave, altimeter, scatterometer and imaging SAR technologies as tools for wind resources and wind-indexing.

Winds from satellites for offshore and coastal wind energy mapping and wind-indexing.

The SAT-WIND project runs in years 2004 and 2006 with funding from the Danish Technical Research Council (STVF) at the Danish Research Agency.

Background
Planning wind farms offshore are generally based on little knowledge of the wind speeds. It is due to the limited amount of offshore meteorological observations worldwide. This again has put a severe limitation to verification on offshore wind model results. Current practices on the modeling offshore winds therefore introduce significant uncertainties. For wind farm owners the wind power production may deviate from the prospected output and wind-indexing becomes a necessary tool in surveying on-going wind farm projects as well as in recommendations for new offshore wind farm initiatives.

Until now offshore wind observations from satellites have not been used for offshore wind energy purposes even though wind maps from various technologies such as passive microwave, altimeter, scatterometer and imaging synthetic aperture radar (SAR) are available for more than one decade. The two major reasons for not using satellite winds within offshore wind energy are

- satellite wind mapping accuracy (absolute precision, mapping frequency, spatial scale)
- technological methodologies to transfer satellite data to wind energy tools

For selection of the ‘right spots’ for planning offshore and coastal wind farms, just the relative offshore wind speeds would be of importance. In (pre)-feasibility studies where a large region typically is under investigation, a lower absolute accuracy on the wind estimate may be acceptable. The spatial wind variations mapped from satellites may be used for pointing out where to put up the relatively expensive offshore met-masts. In regard to wind-indexing continuous and frequent wind observations are necessary. This now can be provided by satellite wind observations.

Goal
The goal of the project is to verify the applicability of satellite wind maps derived from passive microwave, altimeter, scatterometer and imaging SAR technologies for wind energy tools for wind resources and wind-indexing.

Earth Observation data and study site
The satellite images under study are passive microwave data from SSM/I, scatterometer data from ERS-2 AMI Scat and Quikscat, altimeter data from TOPEX/Poseidon, and imaging synthetic aperture radar (SAR) data from ERS-2 SAR and ENVISAT ASAR covering the North Sea.

Participants
Risø National Laboratory, Wind Energy Department Charlotte Bay Hasager (coordinator), Rebecca Barthelmie, Morten Nielsen, Merete Christiansen, Jørgen Højstrup, Poul Astrup,
Energi- og Miljø data Per Nielsen
Elsam Engineering: Paul Sørensen

Acknowledgements
Satellite scenes are kindly granted at research cost through the ESA EO-1356 project. Charlotte Bay Hasager is the PI

Department of Wind Energy
Meteorology
Period: 01/04/2004 → 30/09/2006
Number of participants: 1
Acronym: SAT-WIND
Project participant:
Hasager, Charlotte Bay (Intern)
Project

Adaptiv vingegeometri til reduktion af vindmøllelaster
Aeroelastic Design
The SAR-WAKE project runs in years 2003 and 2004 with funding from the Danish Technical Research Council (STVF) at the Danish Research Agency.

Background
One of the environmental effects of a large offshore wind farm is that it causes changes in the local wind climate. From theoretical work the effect of a large offshore wind farm is calculated to reach of the order of 5 to 15 km downstream. The wake effect is the shadowing (lee-effect) from one wind turbine to the next and much further downstream. It is known that the wind speed directly downwind of a turbine is decreased (up to 30 %) and the turbulence intensity is increased. A turbine placed downwind of another turbine produces less energy, typically 10-20 % less but in the worst cases where turbines are closely spaced up to 60% less. So far only very few meteorological observations behind single or few wind turbines in a row have been collected offshore. Wake effects at larger scales are poorly understood despite the possibility that higher turbine generated turbulence may impact air-sea interactions.

Goal
The goal of the project is to quantify the horizontal extent and intensity of the wake effect through analysis of Earth Observation (EO) data from Synthetic Aperture Radar (SAR).

Earth Observation data and study site
Observations from the ERS-2 SAR satellite and the ENVISAT ASAR satellite of the European Space Agency (ESA) and airborne ESAR data from German Aerospace Research Establishment (DLR) are collected at the Horns Rev site in the North. Here the world's largest offshore wind farm consisting of 80 wind turbines covering an area of 20 km² in the North Sea is in operation since 12 December 2002. The wind farm is positioned in a trapezoid-grid at a distance more than 16 km from the coastline.

Participants
Risø National Laboratory, Wind Energy Department Charlotte Bay Hasager (coordinator), Rebecca Barthelmie, Merete Christiansen, Jørgen Højstrup
Ørsted -Denmark Technical University: Henning Skriver, Jørgen Dall
Elsam Engineering: Paul Sørensen
Visiting Post.doc. at Risø: Birgitte Furevik from NERSC

Department of Wind Energy
Meteorology
Period: 01/02/2003 → 01/04/2006
Number of participants: 1
Acronym: SAR-WAKE
Project participant:
Hasager, Charlotte Bay (Intern)

EO-WINDFARM: Design and integration of an EO-based mapping service based on end-user demands for geo-information when planning, constructing and operating wind farms.

EO-based information service for WINDFARM management.

The EO-WINDFARM project runs in years 2003 and 2007 with funding from the European Space Agency (ESA), Earth Observation Market Development (EOMD) programme.
Objective
The overall objective of this study is to design and integrate an EO-based mapping service based on end-user demands for geo-information when planning, constructing and operating wind farms.

The service will benefit citizens of Europe, through improved cost-effectiveness pre-siting, constructing and operating wind farms. The service products will be GIS compatible, for easy inclusion in different customer applications.

The focus of this project is on providing an EO-based information service, aiding potential customers. The service will provide different products for different regions, e.g. for offshore sites EO wind mapping will be an important product, while for land sites other EO products such as roughness mapping will be more relevant.

Further information is available at www.nersc.no/EO-WINDFARM

Participants
NERSC, Nansen Environmental and Remote Sensing Center, Norway
Project manager, Ola M. Johannessen
Project co-ordinator, Lasse Pettersson
Risoe National Laboratory, Wind Energy Department, Denmark
Charlotte Bay Hasager (co-ordinator at Risø)
Morten Nielsen
Poul Astrup

Link to ESA news: http://www.eomd.esa.int/stories.php?id=190

Department of Wind Energy
Meteorology
Period: 01/01/2003 → 31/12/2006
Number of participants: 1
Acronym: EO-WINDFARM
Project participant:
Hasager, Charlotte Bay (Intern)

Grid-connected Wind Farm Extension Project in Cape Verde
Under contract with Electra S.A. and the Programa Energia, Água e Saneamento of the Republic of Cape Verde.

Department of Wind Energy
Meteorology
Wind Energy Systems
Period: 31/03/2001 → 30/11/2002
Number of participants: 2
Project participant:
Mortensen, Niels Gylling (Intern)
Project Manager, organisational:
Hansen, Jens Carsten (Intern)

Relations
Publications:
Wind Resource Assessment for Santiago, Sao Vicente and Sal, Cap Verde Islands prepared for Electra S.A. and Programa Energia, Água e Saneamento of the Republic of Cape Verde

EO-FLUX-BUDGET: Earth Observation data for upscaling carbon FLUX and water BUDGET at Zealand
Earth Observation data for upscaling carbon FLUX and water BUDGET at Zealand

A web page is available at www.geogr.ku.dk/projects/eoflux/ with more detailed information.

Measurements of CO2 emission and deposition at Zealand are collected at 5 sites representing major Danish biotypes. While these measurements provide information on the temporal variability of ecosystem fluxes and their longer term trends, EO-FLUX-BUDGET combines Earth Observation (EO) data and a GIS-based soil-vegetation-atmosphere transfer model (DaisyGIS) for the spatial upscaling of such data at Zealand. Spatial extrapolation of ground-based data is essential for the monitoring of regional, national and global biospheric processes. Because of the landscape heterogeneity, the surface conditions which are responsible for the atmospheric fluxes vary with the scale of modeling. In EO-FLUX-BUDGET, "effective" (or aggregate) surface variables are computed directly at the scale of interest using multiple-resolution EO data. The new-generation EO data are important for this purpose because they facilitate improved
estimation of both vegetation quantity and chlorophyll contents which are particular important for evaluating the carbon sink (absorption) on Earth. Maps of CO2 exchange and evapotranspiration rates will be produced and validated in time and space using tower fluxes and air-borne flux measurements. The annual budgets of CO2 and water are calculated for Zealand in two climatologically different years.

Participants

Institute of Geography, University of Copenhagen: Henrik Søgaard (co-ordinator of the project), Eva Bøgh
Wind Energy Department, Risø National Laboratory: Charlotte Bay Hasager (co-ordinator of the Risø part), Niels Otto Jensen, Ebba Døllwik
Plant Research Department, Risø National Laboratory: Kim Pilegaard
Danish Hydraulic Institute (DHI) Water & Environment: Michael Butts, Mette Thorsen
Royal Veterinary and Agricultural University: Søren Hansen

Sponsor
The Danish Research Agency within the ESA følgesforsknings-programme for 1.1.2001-1.1.2004

Department of Wind Energy
Meteorology
Period: 01/01/2001 → 01/01/2004
Number of participants: 1
Acronym: EO-FLUX-BUDGET
Project participant:
Hasager, Charlotte Bay (Intern)

WAsP-Engineering (WEng) Courses
Department of Wind Energy
Resource Assessment Modelling
Risø National Laboratory for Sustainable Energy
Meteorology
Department of Mechanical Engineering
Period: 01/01/2001 → 31/12/2017
Number of participants: 6
Site assessment, wind engineering, wind energy, meteorology, turbulence, extreme winds, site suitability, IEC standards
Acronym: WEng-courses
Project participant:
Nielsen, Morten (Intern)
Kelly, Mark C. (Intern)
Berg, Jacob (Intern)
Sempreviva, Anna Maria (Intern)
Ejsing Jørgensen, Hans (Intern)
Mann, Jakob (Intern)

EU WATERMED: WATer use Efficiency in natural vegetation and agricultural areas by Remote sensing in the MEDiterranean basin
WATERMED project runs from year 2000 to 2002. The project is funded from the European Union 5th Framework Programme within the INCOMED programme.

Objectives
The general objective of the WATERMED project is to develop a comprehensive method for the study of the water use and the resistance to the drought of the natural and irrigated vegetation in the Mediterranean Basin, by means of a combined historical and current space-based remote sensing database, vegetation models and field measurements. The general concept is to integrate all available data of the studied environments.
To carry out a climatology of the study area to distinguish the most fragile areas to the drought and the evolution of the ecozones. The study will map the land cover change in the time period chosen. The study will be made by using NOAA AVHRR satellite data, high resolution imagery, airborne remote sensing measurements and field measurements.

A study of water use efficiency in four specific test areas chosen in the following critical zones:

- the Guadalentin Basin (SE Spain)
- the Ouarzazate province and Marrakech (SE of Morocco)
- the lower Rhone valley (SE France)
- the northern region of the Sinai Peninsula in Egypt.

The contribution from Risø is focussed on the upscaling of surface heat and water vapour fluxes from point scale to a scale of 1 km * 1 km. This is the resolution the NOAA AVHRR satellite data. The study will be based on high resolution satellite data from selected sites. The surface flux modelling will be done with a new version of the microscale aggregation method. Further will the upscaling results be compared to other methodologies.

Charlotte Bay Hasager was partner in the project and contributed a non-linear aggregation model for calculation of surface fluxes based on satellite remote sensing maps for roughness and meteorological data.

Project web page with further details available.

Partners

- University de Valencia, Faculty of Physics, Dept. of Thermodynamics, Spain (Dr. José A. Sobrino co-ordinator)
- Institut National de la Recherche agronomique (INRA) of France (Dr. Albert Olioso)
- Risø National Laboratory of Denmark (Dr. Charlotte Hasager, Dr. Niels Otto Jensen)
- Centre Royal de Télédétection Spatial (CRTS) of Morocco
- University of Marakkech, Faculty of Physics, Morocco
- National Authority for Remote Sensing and Space (NARSS) of Egypt

The WATERMED general web pages are found at http://www.uv.es/~uvalen/eng/index.html

Department of Wind Energy

Meteorology

- Period: 01/01/2000 → 31/12/2002
- Number of participants: 1
- Acronym: EU WATERMED
- Project participant:
  - Hasager, Charlotte Bay (Intern)

**EU-WEMSAR: Wind Energy Mapping using Synthetic Aperture Radar**

The WEMSAR project runs from year 2000 to 2002. The project is funded from the European Union 5th Framework Programme on Research Technology Development and Demonstration within the Energy, Environment and Sustainable Development Programme.

Objective

To develop, validate and demonstrate the potential use of satellite-based Synthetic Aperture Radar (SAR), scatterometer and altimeter data combined with meteorological observations for the mapping of wind resources in off-shore and near-coastal regions.

Satellite SAR data

Currently satellite SAR data are retrieved by the European satellite ERS-2 SAR from the European Space Agency (ESA) and by the Canadian RADARSAT-1. From year 2000 Advanced Synthetic Aperture Radar (ASAR) data from ENVISAT and in year 2001 SAR data from RADARSAT-2 will become available. SAR data has a resolution of about 25 m in the horizontal domain. In the WEMSAR project the SAR data will be regridded to a 400 m resolution.

Satellite altimeter data

Altimeter data are available from ERS-2 Altimeter and TOPEX/POSEIDON from NASA. The footprint is approximately 7
km.

Satellite scatterometer data
Scatterometer data are available from ERS scatterometer from ESA, SeaWinds from QuikScat at the American satellite TITAN II from NASA, SeaWinds at the Japanese satellite ADEOS II and NSCAT at ADEOS I. Global near-real time observations of ocean winds are available from QuikScat. The horizontal resolution is 50 km.

Wind resource mapping
In the WEMSAR project the off-shore wind resources will be calculated at regional and local scale for three sites located in Norway, Denmark and Italy. For the regional scale calculations the Karlsruhe Atmospheric Mesoscale Model (KAMM) will be used and for the local scale calculations WAsP.

Charlotte Bay Hasager coordinated the work at Risø on mapping wind resources from SAR.

Partners
Nansen Remote Sensing Centre (NERSC) in Bergen, Norway (Prof. Ola Johannessen project co-ordinator; Dr. Stein Sandven, Dr. Heidi Espedal, Dr. Birgitte Furevik, Dr. Torill Hamre, Dr. Lasse Pettersson)

Rise National Laboratory, Wind Energy and Atmospheric Physics Dept.(Dr. Charlotte Bay Hasager, Dr. Bo Hoffmann Jørgensen, Dr. Morten Nielsen, Dr. Sara Pryor, Dr. Ole Rathmann, Dr. Rebecca Barthelmie, Dr. Poul Astrup)

NEG-Micon, Randers, Denmark (Lars E. Christensen)

ENEA, Italy (Dr. Gaetano Gaudiosi)

Terra Orbit AS, Norway (Geir Jevne)

Project web-pages at NERSC is available at http://www.nersc.no/main/index2.php

Department of Wind Energy

Meteorology
Period: 01/01/2000 → 31/12/2002
Number of participants: 1
Acronym: EU-WEMSAR
Project participant:
Hasager, Charlotte Bay (Intern)

Konvertering af danske vinddata til "Database on Wind Characteristics"
Formålet er at konvertere en række nye danske meteorologiske vinddata til "Database on Wind Characteristics" hvorved disse målinger bliver gjort generelt tilgængelig for en større kreds af brugere.

Department of Energy Engineering

Wind Energy Division

Department of Electrical Engineering

NEG-Micon

Elsamprojekt A/S
Period: 01/01/2000 → 31/12/2001
Number of participants: 1
Project Manager, organisational:
Hansen, Kurt Schaldemose (Intern)

Financing sources
Source: Unknown
Name of research programme: Ukendt
Amount: 675,000.00 Danish Kroner

SAT-MAP-CLIMATE: SATellite based bio-geophysical parameter MAPping and aggregation modelling for CLIMATE models
SATellite based bio-geophysical parameter MAPping and aggregation modelling for CLIMATE models

Charlotte Bay Hasager is coordinator of the project.
Global climate change and weather forecasting is modelled by the HIRLAM (High Resolution Limited Area Model) atmospheric flow model. This model is developed at the Danish Meteorological Institute in collaboration with other Nordic weather services. HIRLAM currently is used by weather services in many European countries. The exchanges of energy, water vapour and momentum between the land- and ocean surface and the large scale atmospheric circulation are very important dynamical processes in this type of model.

The SAT-MAP-CLIMATE project focus on development on parameterizations of the land surface fluxes mapped by Earth Observation data from satellites. The satellite information is used to cover the Danish land and sea with a high temporal and spatial resolution. Satellite based maps of land surface roughness, land- and sea surface temperatures and vegetation state will be area-averaged from a 30 m * 30 m resolution to the grid cell size of 5 km * 5 km in HIRLAM. The area-averaging is highly non-linear due to the turbulent physical processes involved. Thus the effective surface conditions cannot be obtained by simple averaging but only by a flow model taking horizontal advection into consideration.

Results of using improved surface boundary conditions in the HIRLAM model will be validated from wind and temperature data at synoptic weather stations and surface flux data from land- and ocean meteorological masts in Denmark. The possibility of surface flux climatology mapping will be evaluated. Further will a one-year climate prediction be carried out with the seasonal land surface effects included in the input conditions. This work is basic to improvements in global climate change predictions.

Participants

Wind Energy and Atmospheric Physics Department, Risø National Laboratory: Charlotte Bay Hasager (co-ordinator) and Niels Otto Jensen

Institute of Geography, University of Copenhagen: Henrik Søgaard, Eva Bøgh, Michael Schultz Rasmussen

Danish Meteorological Institute: Niels Woetmann Nielsen and Jens Hesselbjerg Christensen

Sponsor

The Danish Research Agency within the ESA følgeforsknings-programme

References

Hasager, C.B. Nielsen, N.W., Jensen, N.O., Boegh, E., Christensen, J.H, Dellwik, E. and Soegaard, H., 2002 Effective roughness calculated from satellite-derived land cover maps and hedge information used in a weather forecasting model. Boundary-Layer Meteorology


Hasager, C.B., Nielsen, N.W., Soegaard, H., Boegh, E., Christensen, J.H., Jensen, N.O., Rasmussen, M.S., Astrup, P. and Dellwik, E. 2002 SAT-MAP-CLIMATE project results. Risø-R-1350(EN), Roskilde, Denmark. Available at risoe.dk pp. 72

Hasager, C.B., Soegaard, H., Nielsen, N.W., Christensen, J.H., Boegh, E., Jensen, N.O. 2002 Aggregation of satellite remote sensing-based land cover roughness applied to meteorological modelling. 34th COSPAR Assembly Scientific (Committee on Space Research). The second world space congress. Houston, Texas, USA, 10-19 October 2002. See abstract and slide show


Department of Wind Energy
Meteorology
Period: 01/01/1999 → 01/01/2001
Number of participants: 1
Acronym: SAT-MAP-CLIMATE
Project participant: Hasager, Charlotte Bay (Intern)
Wind Atlas for Egypt
Under contract with Danida, Danish Ministry of Foreign Affairs, Danida.

Department of Wind Energy
Meteorology

Wind Energy Systems
Period: 01/01/1997 → 31/12/2006
Number of participants: 2
Project participant:
Mortensen, Niels Gylling (Intern)
Project Manager, organisational:
Hansen, Jens Carsten (Intern)

Relations
Publications:
Meso- and Micro-scale flow modelling in the Gulf of Suez, Arab Republic of Egypt
Wind atlas for the Gulf of Suez. Measurements and modelling 1991-95
Wind atlas for the Gulf of Suez. Measurements and modelling 1991-2001

Project

(and continuation)
This is a continuation (2001-2005) of a Danish project originally running from year 1996 to 2000 within "EARTH OBSERVATION" - an interdisciplinary research programme funded by three Danish Research Councils and the Danish Space Board Committee.

Objectives
Interactions between field and landscape scale Soil-Vegetation-Atmospheric Transport (SVAT) will be investigated from experimental field data combined with information from digital remote sensing images. Focus is on surface fluxes of water vapour, heat and CO2.

The cycles of water, heat and CO2 are important to crop simulation which is relevant for efficient land-use planning, crop management and yield predictions. Expertise on these matters are held by Research Centre Foulum where the field site is located.

The overall objective is to get a better understanding of the processes from the very fine scale (plant/canopy), over homogeneous fields, to landscape mosaics. Previously developed models from five Danish research institutions will be used jointly to pass relevant information from "point" to "area" with the goal of estimating the H2O and CO2 cycles.

Partners
The research project draws on experimental and theoretical expertise from five Danish research institutes. These are the Department of Agricultural Systems at Research Centre Foulum (Foulum) with Kirsten Schelde as project coordinator the Hydrological Modelling Department (HMD) at the Danish Hydraulic Institute (DHI), the Wind Energy and Atmospheric Physics Department (VEA) at Risø National Laboratory (Risø), the Laboratory for Agrohydrology and Bioclimatology (AGSCI) at the Royal Veterinary and Agricultural University (KVL) and the Institute of Geography (GI) at the University of Copenhagen (KU).

Data
Field investigations on soil properties, vegetation state and local meteorological conditions are long-term research objectives at Research Centre Foulum. Likewise has digital remote sensing from airborne and satellite sensors been investigated. A huge database of field data and remote sensing images exists for the test site collected within among other projects, the DANish Multisensor Airborne Campaign project (DANMAC). These data are available for the current project.

New data will be collected during field campaigns to obtain contemporary datasets. Measurements will include for canopy: spectral reflectance, temperature, leaf angle distribution, cover fraction, leaf area index, biomass, light absorption and standard agronomic observations. Measurements for soil will include: water content, temperature and standard soil observations. Measurements for atmosphere will include: wind, temperature, radiation, humidity, rainfall and CO2. A tall meteorological mast will provide data relevant for landscape scale evaluation and smaller masts will provide data for field scale use. At landscape scale digital remote sensing imagery will be obtained.

Analysis
As the data collected will have to be used by all participants a common data base will be created and maintained at
Researchers at Foulum will analyse the relations between spectral data and canopy development as well as conduct inverse modelling of canopy conductance by SVAT-modelling. This demands a broad set of field scale information on soil, canopy and atmosphere. The processing of remote sensing data for larger scale model applications will be carried out by scientists involved in climatology and remote sensing research at Institute of Geography, KU.

The "plant/canopy-scale" soil/plant model DAISY developed at the Royal Veterinary and Agricultural University will be applied and modified by these researchers for use in conjunction with the "catchment scale" MIKE SHE hydrological model. The MIKE SHE model will be applied by researchers from the Danish Hydraulic Institute where this model was developed. The MIKE SHE "landscape scale" flux results will be compared to results from a microscale aggregation model developed at Risø. At Risø the microscale aggregation model is currently being developed from its present state of calculating land surface momentum flux to include scalar surface fluxes such as water vapour, sensible heat and CO2. Model inputs are remote sensing images as well as wind speed and wind direction, air humidity and temperature at one level.

The two "landscape scale" flux results from respectively, the combined DAISY/MIKE SHE model and the scalar microscale aggregation model, will be validated against fluxes of H2O and CO2 measured at a tall meteorological mast run by Risø.

Funding of the RS-project

- The Danish Space Board Committee
- The Danish Agricultural and Veterinary Research Council (SJVF)
- The Danish Natural Science Research Council (SNF)
- The Danish Technical Research Council (STVF)

Charlotte Bay Hasager is partner in the project.

Department of Wind Energy

Meteorology
Period: 01/01/1996 → 31/12/2005
Number of participants: 1
Acronym: RS-model
Project participant:
Hasager, Charlotte Bay (Intern)

WAsP courses and certification

Development and teaching of standard on-site WAsP courses. The 3-day WAsP course is intended for engineers, scientists and others, primarily working within the field of wind energy, who require a working knowledge of the WAsP program. Aspects of the theories underlying the program are presented, but the course stresses practical experience and examples on the use of WAsP. The WAsP course teachers also develop and carry out WAsP certification examinations.

Department of Wind Energy

Meteorology
Period: 01/01/1991 → 31/12/2017
Number of participants: 10
Project participant:
Mortensen, Niels Gylling (Intern)
Rathmann, Ole Steen (Intern)
Nielsen, Morten (Intern)
Kelly, Mark C. (Intern)
Gryning, Sven-Erik (Intern)
Troen, Ib (Intern)
Lundtang Petersen, Erik (Intern)
Peña, Alfredo (Intern)
Hansen, Brian Ohrbeck (Intern)
Larsen, Søren Ejling (Intern)
WAsP development and support
Department of Wind Energy
Meteorology
Aeroelastic Design
Period: 23/07/1987 → 31/12/2018
Number of participants: 8
Project participant:
Mortensen, Niels Gylling (Intern)
Rathmann, Ole Steen (Intern)
Troen, Ib (Intern)
Kelly, Mark C. (Intern)
Nielsen, Morten (Intern)
Lundtang Petersen, Erik (Intern)
Bechmann, Andreas (Intern)
Project Manager, organisational:
Hansen, Brian Ohrbeck (Intern)

Activities:

Inflow characterization using measurements from the SpinnerLidar: the ScanFlow experiment
Period: 20 Jun 2018
Torben Krogh Mikkelsen (Guest lecturer)
Department of Wind Energy
Meteorology & Remote Sensing
Description
Poster presentation by T. Mikkelsen
Inflow characterization using measurements from the SpinnerLidar: the ScanFlow experiment
Alfredo Pena, Mikael Sjöholm, Torben Mikkelsen and Charlotte B. Hasager
DTU Wind Energy, Technical University of Denmark, Risø campus, Roskilde,
Degree of recognition: International
Links:
http://www.torque2018.org/ (Torque 2018)

Related event
Torque 2018: The science of making torque from wind
20/06/2018 → 22/06/2018
Milan, Italy
Activity: Talks and presentations › Conference presentations

Offshore New European Wind Atlas
Period: 20 Jun 2018
Ioanna Karagali (Guest lecturer)
Jakob Mann (Other)
Andrea N. Hahmann (Other)
Charlotte Bay Hasager (Other)
Merete Badger (Other)
Department of Wind Energy
Meteorology & Remote Sensing
Resource Assessment Modelling
Degree of recognition: International
Related event

Torque 2018: The science of making torque from wind
20/06/2018 → 22/06/2018
Milan, Italy
Activity: Talks and presentations › Conference presentations

The Østerild balconies experiment
Period: 20 Jun 2018
Ioanna Karagali (Guest lecturer)
Ebba Dellwik (Other)
Jakob Mann (Other)
Nikola Vasiljevic (Other)
Department of Wind Energy
Meteorology & Remote Sensing

Description
poster presentation
Degree of recognition: International
Documents:
TORQUE_Balcony

Related event

Torque 2018: The science of making torque from wind
20/06/2018 → 22/06/2018
Milan, Italy
Activity: Talks and presentations › Conference presentations

WASA 2 Application for planning purposes
Period: 20 Jun 2018
Niels Gylling Mortensen (Guest lecturer)
Andrea N. Hahmann (Other)
Jens Carsten Hansen (Other)
Department of Wind Energy
Resource Assessment Modelling
Integration & Planning
Degree of recognition: National

Related event

WASA 2 Mid-term Workshop: Wind Atlas for South Africa Workshop
20/06/2018 → 20/06/2018
Cape Town, South Africa
Activity: Talks and presentations › Conference presentations

WASA 2 Microscale modelling and validation
Period: 20 Jun 2018
Niels Gylling Mortensen (Guest lecturer)
Andrea N. Hahmann (Other)
Jens Carsten Hansen (Other)
Department of Wind Energy
Resource Assessment Modelling
Integration & Planning
Degree of recognition: National
Related event

WASA 2 Mid-term Workshop: Wind Atlas for South Africa Workshop
20/06/2018 → 20/06/2018
Cape Town, South Africa
Activity: Talks and presentations › Conference presentations

IEA Wind (Tasks 36 & 32) Joint Workshop on Very-Short Term Forecasting of Wind Power
Period: 12 Jun 2018 → 13 Jun 2018
Elliot Simon (Organizer)
Department of Wind Energy
Meteorology & Remote Sensing
Degree of recognition: International
Links:
https://community.ieawind.org/events/event-description?CalendarEventKey=d9fa9f4fb-f360-4952-a9fb-7c7ca66048fa (IEA event page)
https://www.youtube.com/watch?v=mA1zkqgf38 (YouTube stream - Day 1)
https://www.youtube.com/watch?v=6gmwy4qzCeE (YouTube stream - Day 2)

Related event

IEA Wind (Tasks 36 & 32) Joint Workshop on Very-Short Term Forecasting of Wind Power
12/06/2018 → 13/06/2018
Roskilde, Denmark
Activity: Attending an event › Participating in or organising a conference

IMPROVED DIURNAL VARIABILITY FORECAST OF OCEAN SURFACE TEMPERATURE THROUGH COMMUNITY MODEL DEVELOPMENT (DIVOST-COM)
Period: 5 Jun 2018
Ioanna Karagali (Guest lecturer)
Jacob L. Høyer (Other)
Jun She (Other)
Department of Wind Energy
Meteorology & Remote Sensing
Degree of recognition: International

Related event

19th International GHRSST Science Team Meeting 2018: GHRSST XIX
04/06/2018 → 08/06/2018
Darmstadt, Germany
Activity: Talks and presentations › Conference presentations

The increasing importance of SST for wind energy applications
Period: 4 Jun 2018 → 8 Jun 2018
Ioanna Karagali (Guest lecturer)
Department of Wind Energy
Meteorology & Remote Sensing

Description
poster presentation
Degree of recognition: International
Documents:
GHRSST_poster_Karagali

Related event

19th International GHRSST Science Team Meeting 2018: GHRSST XIX
On the Transition between the Shear-production and the Inertial Subranges in a Strong Shear Turbulent Atmospheric Surface Layer
Period: 22 May 2018 → 25 May 2018
Torben Krogh Mikkelsen (Guest lecturer)
Department of Wind Energy
Meteorology & Remote Sensing

Description
Oral presentation
ISARS 2018
Cologne May 23. 2018
Degree of recognition: International
Documents:
ISARS 2018_ On the Transition between the Shear-production and the Inertial Subranges in a Strong Shear Turbulent Atmospheric Surface Layer
Links:

Related external organisation
University of Cologne
Germany
Activity: Talks and presentations › Conference presentations

Mechanical Systems and Signal Processing (Journal)
Period: 5 Apr 2018 → 2 May 2018
Oliver Ackermann Lylloff (Reviewer)
Acoustic Technology
Department of Wind Energy
Aerodynamic design
Degree of recognition: International

Related journal
Mechanical Systems and Signal Processing
0888-3270
Central database
Activity: Research › Peer review of manuscripts

Innovative measurement techniques for atmospheric turbulence and wind energy
Period: 4 Apr 2018
Torben Krogh Mikkelsen (External examiner)
Department of Wind Energy
Meteorology & Remote Sensing

Description
Examiner PhD Thesis
Degree of recognition: International
Activity: Examinations and supervision › External examination
EERA jp Wind (External organisation)
Period: 1 Apr 2018 → 31 Mar 2021
Nicolaos Antonio Cutululis (Member)
Department of Wind Energy
Integration & Planning

Description
Management Board member; coordinator of sub-program System Integration
Degree of recognition: International
Links:

Related external organisation

EERA jp Wind
Activity: Membership › Membership of research networks or expert groups

Wind Flows at the Kurzeme Coast of the Baltic Proper
Period: 23 Mar 2018
Andrea N. Hahmann (External examiner)
Department of Wind Energy
Resource Assessment Modelling

Description
PhD dissertation
Degree of recognition: International
Activity: Examinations and supervision › External examination

Overview of upcoming lidar wake experiments at DTU
Period: 22 Mar 2018
Elliot Simon (Guest lecturer)
Department of Wind Energy
Meteorology & Remote Sensing
Degree of recognition: International
Documents:
AWAKEN Presentation - Elliot Simon

Related event

AWAKEN - American Wake Experiment
22/03/2018 → …
Boulder, United States
Activity: Talks and presentations › Conference presentations

Noise Quantification with Beamforming Deconvolution: Effects of Regularization and Boundary Conditions
Period: 6 Mar 2018
Oliver Ackermann Lylloff (Speaker)
Acoustic Technology
Department of Wind Energy
Aerodynamic design
Degree of recognition: International

Related event

Berlin Beamforming Conference
05/03/2018 → 06/03/2018
Berlin, Germany
Activity: Talks and presentations › Conference presentations

The DTU Mesoscale Reanalysis System
Period: 5 Mar 2018
Andrea N. Hahmann (Guest lecturer)
Department of Wind Energy
Resource Assessment Modelling

Description
Presentation at the ENTSO-E workshop on Weather Data for Economical Studies

Related external organisation
European Network of Transmission System Operators for Electricity
Avenue de Cortenbergh 100, 1000, Brussels, Belgium
Activity: Talks and presentations › Conference presentations

MARINERG-I Stakeholders Meeting AAU 25. jan 2018
Period: 25 Jan 2018
Torben Krogh Mikkelsen (Organizer)
Department of Wind Energy
Meteorology & Remote Sensing

Description
MARINERG-I Stakeholders Meeting
Degree of recognition: International
Documents:
MARINERG-i Stakeholder meeting Science Case: Real time measurements of wind using lidars

Related event
MARINERG-I Stakeholders Meeting AAU 25. jan 2018
25/01/2018 → 25/01/2018
Ålborg, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Impact on wind turbine loads from different down regulation control strategies EERA DeepWind 2018
Period: 17 Jan 2018 → 19 Jan 2018
Christos Galinos (Other)
Department of Wind Energy
Wind turbine loads & control
Degree of recognition: International
Documents:
DeepWind2018_Poster_Galinos_et_al_A4_v3

Related external organisation
EERA DeepWind'18
Trondheim Norway, Trondheim , Norway
Activity: Talks and presentations › Conference presentations

Mitigating Turbine Mechanical Loads Using Engineering Model Predictive Wind Farm Controller
Period: 17 Jan 2018
Jonas Kazda (Guest lecturer)
Karl Merz (Other)
John Olav Tande (Other)
Nicolaos Antonio Cutululis (Guest lecturer)

Department of Wind Energy
Integration & Planning
Degree of recognition: International

Related event

**EERA Deepwind 2018**
17/01/2018 → 19/01/2018
Trondheim, Norway
Activity: Talks and presentations › Conference presentations

**Advanced meteorological modelling cross scales**
Period: 2017 → 2020
Xiaoli Guo Larsén (Main supervisor)

Department of Wind Energy
Resource Assessment Modelling

Description
PhD project
Degree of recognition: International
Activity: Examinations and supervision › Supervisor activities

**Advances in Science and Research (Journal)**
Period: 2017 → …
Patrick Volker (Reviewer)

Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International
Links:
https://www.adv-sci-res.net/14/227/2017/ (links to published article)

Related journal

**Advances in Science and Research**
1992-0628
Indexed in DOAJ
Central database
Activity: Research › Peer review of manuscripts

**Atmospheric Science Letters (Journal)**
Period: 2017 → …
Sven-Erik Gryning (Reviewer)

Department of Wind Energy
Degree of recognition: International

Related journal

**Atmospheric Science Letters**
1530-261X
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 1.36 SJR 0.87 SNIP 0.579, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Indexed in DOAJ
Central database
Activity: Research › Peer review of manuscripts
Boundary-Layer Meteorology (Journal)
Period: 2017
Jake Badger (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International

Related journal
Boundary-Layer Meteorology
0006-8314
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 2.47 SJR 1.262 SNIP 1.193, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

Boundary-Layer Meteorology (Journal)
Period: 2017 → …
Sven-Erik Gryning (Reviewer)
Department of Wind Energy

Related journal
Boundary-Layer Meteorology
0006-8314
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 2.47 SJR 1.262 SNIP 1.193, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

Boundary-Layer Meteorology (Journal)
Period: 2017 → …
Sven-Erik Gryning (Reviewer)
Department of Wind Energy
Degree of recognition: International

Related journal
Boundary-Layer Meteorology
0006-8314
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 2.47 SJR 1.262 SNIP 1.193, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

Boundary-Layer Meteorology (Journal)
Period: 2017 → …
Sven-Erik Gryning (Reviewer)
Department of Wind Energy
Degree of recognition: International

Related journal
Boundary-Layer Meteorology
0006-8314
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 2.47 SJR 1.262 SNIP 1.193, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Central database
Climate Dynamics (Journal)
Period: 2017 → …
Sven-Erik Gryning (Reviewer)
Department of Wind Energy
Degree of recognition: International

Related journal
Climate Dynamics
0930-7575
Web of Science (2018): Indexed yes

EGU General Assembly 2017
Period: 2017 → …
Anna Maria Sempreviva (Organizer)
Department of Wind Energy
Resource Assessment Modelling

Description
Convener Energy meteorology and spatial modelling of renewable energies

Links:
http://meetingorganizer.copernicus.org/EGU2017/session/22846 (Wind and solar power are the predominant new sources of electrical power in recent years. Solar power reached a milestone of providing 50% of demand in Germany during one hour in 2012, and wind power during one hour in 2015 exceeded 140% of demand in Denmark. By their very nature, wind and solar power, as well as hydro, tidal, wave and other renewable forms of generation are dependent on weather and climate. Modelling and measurement for resource assessment, site selection, long-term and short term variability analysis and operational forecasting for horizons ranging from minutes to decades are of paramount importance. The success of wind power means that wind turbines are increasingly put in sites with complex terrain or forests, with towers extending beyond the strict logarithmic profile, and in offshore regions that are difficult to model and measure. Major challenges for solar power are notably accurate measurements and the short-term prediction of the spatiotemporal evolution of the effects of cloud field and aerosols. For both solar and wind power, the integration of large amounts of renewable energy into the grid is another critical research problem due to the uncertainties linked to their forecast and to patterns of their spatio-temporal variabilities. Of particular interest these days is the relatively new field of urban meteorology applied to the renewable energy sector. There are several “Smart Cities” and “Smart Grids” projects in Europe focusing on urban measurement development for forecasts or high resolution resource mapping. Geographic information systems are well established tools for the identification of potentials and location selection of renewable energies. There is a high and increasing number of studies concerning indicators of resource availability such as the amount of available biomass, average wind speed, cumulated solar radiation and soil temperature. These studies range from the determination of merely theoretical resources potentials to combined technical, economic, environmental and social studies of the suitability of energy generation technologies (e.g. wind parks, photovoltaic installations and biogas/biomass facilities). However, the consideration of the temporal variability of the energy demand and of highly fluctuating sources, such as wind and solar radiation, is a fundamental element that has been addressed only marginally in GIS-based procedures especially considering the temporal dimension. The consideration of these fluctuations would allow the evaluation and design of spatially distributed energy systems with a high share of renewable sources. We invite contributions on all following aspects of weather dependent renewable power generation: • Wind conditions (both resources and loads) on short and long time scales for wind power development, especially in complex environments (e.g. mountains, forests, coastal or urban). • Long term analysis of inter-annual variability of solar resource • Typical Meteorological Year and probability of exceedance for wind and solar power development. • Wind and solar resource and atlases. • Wake effect models and measurements, especially for large wind farms and offshore. • Performance and uncertainties of forecasts of renewable power at different time horizons and in different external conditions. • Forecast of extreme wind events and wind ramps. • Local, regional and global impacts of renewable energy power plants or of large-scale integration. • Dedicated wind
measurement techniques (SODARS, LIDARS, UAVs etc.). • Dedicated solar measurement techniques (pyranometric sensors, sun-photometer, ceilometer, fish-eye cameras, etc.) from ground-based and space-borne remote sensing. • Tools for urban area renewable energy supply strategic planning and control. • Dimension distributed renewable energy systems such as virtual power plants • Analyse interaction and proportions of renewable energy power plants in distributed renewable energy systems • Calculate peak load offsetting and/or output variability reduction alternatives for grid connected and off-grid renewable energy systems • Size and locate decentralized storage facilities • Plan multicarrier systems (heat-electricity, heat-cooling-electricity).

Related event

EGU General Assembly 2017: European Geosciences Union 2017
24/04/2017 → 28/04/2017
Vienna, Austria
Activity: Attending an event › Participating in or organising a conference

Energies (Journal)
Period: 2017 → …
Sven-Erik Gryning (Reviewer)
Department of Wind Energy
Degree of recognition: International

Related journal

Energies
1996-1073
Indexed in DOAJ
Activity: Research › Peer review of manuscripts

Energy for Sustainable Development (Journal)
Period: 2017 → …
Sven-Erik Gryning (Reviewer)
Department of Wind Energy
Degree of recognition: International

Related journal

Energy for Sustainable Development
0973-0626
Central database
Activity: Research › Peer review of manuscripts

Energy Procedia (Journal)
Period: 2017
Anna Maria Sempreviva (Peer reviewer)
Department of Wind Energy
Resource Assessment Modelling

Description
Guest Editor Energy Meteorology session
Degree of recognition: International

Related journal

Energy Procedia
1876-6102
Environmental Research Letters (Journal)
Period: 2017
Andrea N. Hahmann (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Description
Manuscript review

Related journal

Environmental Research Letters
1748-9326
Indexed in DOAJ
Central database
Activity: Research › Peer review of manuscripts

Environmental Research Letters (Journal)
Period: 2017
Andrea N. Hahmann (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Description
Manuscript review

Related journal

Environmental Research Letters
1748-9326
Indexed in DOAJ
Central database
Activity: Research › Peer review of manuscripts

Examination of wave effect in the Wind-Wave-Wake coupled modeling for offshore wind farm
Period: 2017 → 2019
Xiaoli Guo Larsén (Main supervisor)
Department of Wind Energy
Resource Assessment Modelling
Description
Post Doc Task
Degree of recognition: International
Activity: Examinations and supervision › Supervisor activities

Impact of the sea breeze on the vertical wind profile in coastal areas: Comparison between a Mediterranean and a North Sea site
Period: 2017
Anna Maria Sempreviva (Guest lecturer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International
Links:
http://wesc2017.org/

Related event

Wind Energy Science Conference 2017
26/06/2017 → 29/06/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

International Conference on Future Technologies for Wind Energy WindTech 2017
24-26 Oct. 2017
Boulder, United States
Activity: Attending an event › Participating in or organising a conference

Journal of King Saud University - Science (Journal)
Period: 2017 → …
Sven-Erik Gryning (Reviewer)
Department of Wind Energy
Degree of recognition: International
Related journal

Journal of the Air and Waist Management Association (Journal)
Period: 2017 → …
Sven-Erik Gryning (Reviewer)
Department of Wind Energy
Degree of recognition: International
Related journal
Journal of the Atmospheric Sciences (Journal)
Period: 2017 → …
Sven-Erik Gryning (Reviewer)
Department of Wind Energy

Related journal
Journal of the Atmospheric Sciences
0022-4928
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

Journal of Wind Engineering & Industrial Aerodynamics (Journal)
Period: 2017 → …
Xiaoli Guo Larsén (Reviewer)
Department of Wind Energy
Resource Assessment Modelling

Related journal
Journal of Wind Engineering & Industrial Aerodynamics
0167-6105
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 3.42 SJR 1.264 SNIP 2.071, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

Journal of Wind Engineering & Industrial Aerodynamics (Journal)
Period: 2017 → …
Sven-Erik Gryning (Reviewer)
Department of Wind Energy
Degree of recognition: International

Related journal
Journal of Wind Engineering & Industrial Aerodynamics
0167-6105
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 3.42 SJR 1.264 SNIP 2.071, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

MARINET2. A European network of marine renewables infrastructures
Period: 2017
Anna Maria Sempreviva (Speaker)
Department of Wind Energy
Resource Assessment Modelling

Description
PO224
Degree of recognition: International
Links:
https://windeurope.org/confex2017

Related event
Meteorological Applications (Journal)
Period: 2017
Jake Badger (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International

Related journal
Meteorological Applications
1350-4827
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 1.96 SJR 0.654 SNIP 1.025, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

Meteorology and Atmospheric Physics (Journal)
Period: 2017 → …
Sven-Erik Gryning (Reviewer)
Department of Wind Energy
Degree of recognition: International

Related journal
Meteorology and Atmospheric Physics
0177-7971
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 1.25 SJR 0.543 SNIP 0.676, Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

Modeling rough weather over the North Sea - using COAWST for offshore wind energy applications
Period: 2017 → …
Xiaoli Guo Larsén (Main supervisor)
Department of Wind Energy
Resource Assessment Modelling

Description
Master Project
Activity: Examinations and supervision › Supervisor activities

Monthly Weather Review (Journal)
Period: 2017
Andrea N. Hahmann (Reviewer)
Department of Wind Energy
Resource Assessment Modelling

Description
Manuscript review

Related journal
Monthly Weather Review
0027-0644
Central database
Activity: Research › Peer review of manuscripts

**Nature Energy (Journal)**
Period: 2017
Jake Badger (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International

**Related journal**
**Nature Energy**
2058-7546
Central database
Activity: Research › Peer review of manuscripts

**Remote Sensing (Journal)**
Period: 2017 → …
Sven-Erik Gryning (Reviewer)
Department of Wind Energy
Degree of recognition: International

**Related journal**
**Remote Sensing**
2072-4292
Indexed in DOAJ
Central database
Activity: Research › Peer review of manuscripts

**Remote Sensing (Journal)**
Period: 2017 → …
Sven-Erik Gryning (Reviewer)
Department of Wind Energy

**Related journal**
**Remote Sensing**
2072-4292
Indexed in DOAJ
Central database
Activity: Research › Peer review of manuscripts

**Remote Sensing (Journal)**
Period: 2017 → …
Sven-Erik Gryning (Reviewer)
Department of Wind Energy
Degree of recognition: International

**Related journal**
**Remote Sensing**
2072-4029
Indexed in DOAJ
Central database
Activity: Research › Peer review of manuscripts

**Royal Meteorological Society. Quarterly Journal (Journal)**
Period: 2017 → ...
Sven-Erik Gryning (Reviewer)
Department of Wind Energy
Degree of recognition: International

**Related journal**
Quarterly Journal of the Royal Meteorological Society
0035-9009
Central database
Activity: Research › Peer review of manuscripts

**Wind energy open data web portal: Metadata and Taxonomy for data search**
Period: 2017
Anna Maria Sempreviva (Keynote speaker)
Department of Wind Energy
Resource Assessment Modelling

**Description**
Technical University of Denmark, DTU Wind Energy, Roskilde, Denmark, anse@dtu.dk
** ForWind, University of Oldenburg, Oldenburg, Germany, stephan.barth@forwind.de, *** CENER, Sarriguren, Navarra, Spain, jsrodrigo@cener.com, **** SINTEF, Trondheim, Norway, toringe.reigstad@sintef.no, *****ECN, Petten, The Netherlands, j.wagenaar@ecn.nl,

**Abstract**
We present the conceptual scheme for a Wind Energy data portal intended to make data Findable, Accessible, Interoperable and Re-usable, FAIR, adhering to the Open Data strategy of the European Commission H2020 Programme. As a first step, metadata have been suggested and taxonomies for the wind Energy topics and related data have been developed to be used as a common vocabulary for tagging data in the metadata card describing datasets. This effort is within the Open Data roadmap of the European Energy Research Alliance, the Joint Programme on Wind Energy, EERA JP Wind Energy.

**Related event**
International Conference on Future Technologies for Wind Energy
WindTech 2017
24-26 Oct. 2017
24/10/2017 → 26/10/2017
Boulder, United States
Activity: Talks and presentations › Conference presentations

**Wind Energy Science Discussions (Journal)**
Period: 2017
Andrey Sogachev (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Multidisciplinary Design Optimization with HAWTOpt2

**Period:** 15 Dec 2017

Michael McWilliam (Invited speaker)
Frederik Zahle (Other)

Department of Wind Energy

Aerodynamic design

**Documents:**
HAWTOpt2_Dec_15_2017

Coastal Effects on Offshore Wind Calculation

**Period:** 14 Dec 2017

Xiaoli Guo Larsén (Keynote speaker)

Department of Wind Energy

Resource Assessment Modelling

*Related event*

Coastal Effects on Wind Resources and Wind Farm Production

14/12/2017 → …

Activity: Talks and presentations › Conference presentations

Mapping offshore winds in the New European Wind Atlas

**Period:** 12 Dec 2017

Ioanna Karagali (Guest lecturer)
Andrea N. Hahmann (Guest lecturer)
Merete Badger (Guest lecturer)
Charlotte Bay Hasager (Guest lecturer)
Jakob Mann (Guest lecturer)

Department of Wind Energy

Meteorology & Remote Sensing

Resource Assessment Modelling

*Degree of recognition: International*

*Related event*

2017 AGU Fall Meeting

11/12/2017 → 15/12/2017

New Orleans, United States

Activity: Talks and presentations › Conference presentations
The Østerild Balconies Experiment
Period: 12 Dec 2017
Ioanna Karagali (Guest lecturer)
Jakob Mann (Guest lecturer)
Ebba Dellwik (Guest lecturer)
Guillaume Lea (Guest lecturer)
Elliot Simon (Guest lecturer)
Nikola Vasiljevic (Guest lecturer)
Department of Wind Energy
Meteorology & Remote Sensing
Test and Measurements
Degree of recognition: International

Related event
2017 AGU Fall Meeting
11/12/2017 → 15/12/2017
New Orleans, United States
Activity: Talks and presentations › Conference presentations

See continuing education as disruption
Period: 7 Dec 2017
Merete Badger (Speaker)
Department of Wind Energy
Meteorology & Remote Sensing
Degree of recognition: Local

Related event
DTU Efteruddannelsesworkshop
07/12/2017 → 07/12/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

Wind Energy Master - a new online programme
Period: 4 Dec 2017
Merete Badger (Speaker)
Department of Wind Energy
Meteorology & Remote Sensing
Degree of recognition: Local

Related event
DTU Undervisningsseminar
04/12/2017 → 04/12/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

WIND ENERGY DENMARK 2017
Period: 2 Dec 2017
Jake Badger (Chairman)
Department of Wind Energy
Resource Assessment Modelling

Description
Session Chair
Wind Meteorology
Talents of Tomorrow
Degree of recognition: National

Related event

WIND ENERGY DENMARK 2017
02/10/2017 → 03/10/2017
Herning, Denmark
Activity: Attending an event › Participating in or organising a conference

Lightweight rotor design for 10-20 MW Wind turbines
Period: 30 Nov 2017
Flemming Rasmussen (Lecturer)
Department of Wind Energy
Degree of recognition: International

Related event

WindEurope 2017
28/11/2017 → 30/11/2017
Amsterdam, Netherlands
Activity: Talks and presentations › Conference presentations

Power curve measurement using \( \nu \)- estimates from nacelle lidars and its uncertainty
Period: 30 Nov 2017
Antoine Borraccino (Guest lecturer)
Department of Wind Energy
Meteorology & Remote Sensing
Degree of recognition: International
Documents:
PCV_naclidars_Vinfy_ABorraccino_WindEurope2017

Related event

WindEurope 2017
28/11/2017 → 30/11/2017
Amsterdam, Netherlands
Activity: Talks and presentations › Conference presentations

E-learning: Wind Energy Master
Period: 29 Nov 2017
Merete Badger (Other)
Niels-Erik Clausen (Speaker)
Department of Wind Energy
Meteorology & Remote Sensing
Integration & Planning
Degree of recognition: International

Related event

Wind Europe Conference and Exhibition 2018
28/11/2017 → 30/12/2017
Amsterdam, Netherlands
Activity: Talks and presentations › Conference presentations

Kuren mod klimaproblemet - Et bud på løsningen fra et teknisk-videnskabeligt vindenergi-synspunkt
Period: 29 Nov 2017
Mac Gaunaa (Guest lecturer)
Department of Wind Energy
Aerodynamic design

Description
Two presentation for gymnasium-pupils on what we can do to avoid a catastrophic climate... and a bit on what kind of research we do at DTU wind energy
Degree of recognition: Local

Related external organisation
Rysensteen Gymnasium
Tietgensgade 74, 1704, København, Denmark
Activity: Talks and presentations › Talks and presentations in private or public companies and organisations

Building wind energy taxonomy for FAIR data: how to organize and find web distributed data
Period: 28 Nov 2017
Anna Maria Sempreviva (Guest lecturer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International
Links:
https://windeurope.org/confex2017/conference/

Related event
Wind Europe Conference and Exhibition 2018
28/11/2017 → 30/12/2017
Amsterdam, Netherlands
Activity: Talks and presentations › Conference presentations

Online teaching and MOOCs
Period: 28 Nov 2017
Merete Badger (Guest lecturer)
Department of Wind Energy
Meteorology & Remote Sensing
Degree of recognition: Local

Related event
Universitetspædagogik for erfarne undervisere, UP
27/11/2017 → 29/11/2017
Gentofte, Denmark
Activity: Talks and presentations › Conference presentations

The Poul la Cour Tunnel: A new aerodynamic and aeroacoustic wind tunnel dedicated to wind energy
Period: 28 Nov 2017 → 30 Nov 2017
Christian Bak (Other)
Andreas Fischer (Other)
Robert Flemming Mikkelsen (Other)
Anders Smærup Olsen (Other)
Mac Gaunaa (Other)
Efren Fernandez Grande (Other)
Witold Robert Skrzypinski (Other)
Department of Wind Energy
Aerodynamic design
Fluid Mechanics
Department of Electrical Engineering
Acoustic Technology

Description
Poster
Degree of recognition: International

Related event

WindEurope 2017
28/11/2017 → 30/11/2017
Amsterdam, Netherlands
Activity: Talks and presentations › Conference presentations

Mesh Dependence on Shear Driven Boundary Layers in Stable Stratification Generated by Large Eddy-Simulation
Period: 21 Nov 2017
Jacob Berg (Guest lecturer)
Department of Wind Energy
Resource Assessment Modelling

Related event

American Physical Society : Division of Fluid Mechanics
19/11/2017 → 21/11/2017
Denver , United States
Activity: Talks and presentations › Conference presentations

Performance and Equivalent Loads of Wind Turbines in Large Wind Farms
Period: 20 Nov 2017
Søren Juhl Andersen (Speaker)
Department of Wind Energy
Fluid Mechanics
Documents:
APS2017_Presentation

Related external organisation

American Physical Society
United States
Activity: Talks and presentations › Conference presentations

Wind Energy in Denmark & Introduction to DTU Wind Energy
Period: 15 Nov 2017
Xiaoli Guo Larsén (Invited speaker)
Department of Wind Energy
Resource Assessment Modelling

Related event

Introduction of DTU WIND to the Chinese Embassy in Copenhagen
15/11/2017 → …
Activity: Talks and presentations › Conference presentations

Interpreting wind energy resource visualisations for South Africa
Period: 14 Nov 2017
Description
About the variety of ways of applying and interpreting wind resource data, with examples from the WASA project.

Documents:
WindAC2017_Hahmann

Related event

WindAc
14/11/2017 → 15/11/2017
Cape Town, South Africa
Activity: Talks and presentations › Conference presentations

Rui Liu
Start date: 13 Nov 2017 → 1 Nov 2018
Andrey Sogachev (Host)
Department of Wind Energy
Resource Assessment Modelling

Description
High resolution numerical simulations of energy and water exchanges in oasis-desert area

Activity: Hosting a guest lecturer

Specimen design and instrumentation for monitoring fatigue crack growth initiating at ply drops
Period: 8 Nov 2017 → 9 Nov 2017
Stergios Goutianos (Speaker)
Leonardo Di Crescenzo (Speaker)
Malcolm McGugan (Speaker)
Bent F. Sørensen (Speaker)
Department of Wind Energy
Composites and Materials Mechanics
Degree of recognition: International
Documents:
ISMEM2017_gout

Related event

2nd International Symposium on Multiscale Experimental Mechanics: Multiscale Fatigue
08/11/2017 → 09/11/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

Structural degradation of a large composite wind turbine blade in a full-scale fatigue test
Period: 8 Nov 2017
Xiao Chen (Speaker)
Wind Turbines
Department of Wind Energy

Description
Presented at 2nd International Symposium on Multiscale Experimental Mechanics: Multiscale Fatigue
Related organisation

Structural degradation of a large composite wind turbine blade in a full-scale fatigue test
Chen, X. (Speaker)
8 Nov 2017
Activity: Talks and presentations › Conference presentations

Large-scale wake effects of wind turbines
Period: 7 Nov 2017
Patrick Volker (Participant)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International

Related event

Large-scale wake effects of wind turbines
07/11/2017 → 07/11/2017
Berlin, Germany
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Journal of Geophysical Research - Part C - Ocean (Journal)
Period: 2 Nov 2017
Ioanna Karagali (Reviewer)
Department of Wind Energy
Meteorology & Remote Sensing

Related journal

Journal of Geophysical Research - Part C - Ocean
Local database
Activity: Research › Peer review of manuscripts

Environmental Research Letters (Journal)
Period: 1 Nov 2017 → 31 Dec 2017
Patrick Volker (Reviewer)
Department of Wind Energy
Resource Assessment Modelling

Description
manuscript ERL-104523, reject to resubmit
Degree of recognition: International

Related journal

Environmental Research Letters
1748-9326
Indexed in DOAJ
Central database
Activity: Research › Peer review of manuscripts
**Remote Sensing of Environment (Journal)**
Period: 1 Nov 2017
Ioanna Karagali (Reviewer)
Department of Wind Energy
Meteorology & Remote Sensing

**Related journal**

Remote Sensing of Environment
0034-4257
BFI (2018): BFI-level 2, Scopus rating (2017): CiteScore 7.16 SJR 3.121 SNIP 2.5, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

**European Commission (External organisation)**
Period: Oct 2017 → Nov 2017
Andrea N. Hahmann (Participant)
Department of Wind Energy
Resource Assessment Modelling

**Description**
Evaluation of Research Proposals
Degree of recognition: International

**Related external organisation**

European Commission
Belgium
Activity: Membership › Membership in review committee

**Journal of Applied Meteorology and Climatology (Journal)**
Period: Oct 2017 → …
Mark C. Kelly (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International

**Related journal**

Journal of Applied Meteorology and Climatology
1558-8424
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 2.47 SJR 1.408 SNIP 1.042, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

**E-learning: Wind Energy Master**
Period: 30 Oct 2017
Merete Badger (Invited speaker)
Nina Juhl Madsen (Invited speaker)
Department of Wind Energy
Meteorology & Remote Sensing
Degree of recognition: National

**Related event**

Administrativ Efteruddannelse for Universitetsansatte
PhD censor
Period: 25 Oct 2017
Jake Badger (External examiner)
Department of Wind Energy
Resource Assessment Modelling

Description
Managing the Risks of Wind Farms in Forested Areas: Design Principles for Northern Europe
Industrial PhD dissertation: 4135-00033B
Pete Enevoldsen
Degree of recognition: National
Activity: Examinations and supervision › External examination

International Conference on Future Technologies for Wind Energy WindTech 2017
Period: 24 Oct 2017 → 26 Oct 2017
Elliot Simon (Participant)
Department of Wind Energy
Meteorology & Remote Sensing

Description
International Conference on Future Technologies for Wind Energy, WindTech 2017
Degree of recognition: International

Related event

International Conference on Future Technologies for Wind Energy
WindTech 2017
24-26 Oct. 2017
24/10/2017 → 26/10/2017
Boulder, United States
Activity: Attending an event › Participating in or organising a conference

Satellite SAR measurements for offshore wind farm development
Period: 24 Oct 2017 → 26 Oct 2017
Tobias Torben Ahsbahs (Guest lecturer)
Merete Badger (Guest lecturer)
Charlotte Bay Hasager (Guest lecturer)
Kurt Schaldemose Hansen (Guest lecturer)
Patrick Volker (Guest lecturer)
Department of Wind Energy
Meteorology & Remote Sensing
Fluid Mechanics
Resource Assessment Modelling

Description
Satellite SAR wind maps are used to determine wakes and coastal wind speed gradients at the Anholt wind farm.
Degree of recognition: International

Related event
Wind field re-construction of 3D Wake measurements from a turbine-installed scanning lidar

Period: 24 Oct 2017 → 26 Oct 2017
Torben Krogh Mikkelsen (Guest lecturer)
Department of Wind Energy
Meteorology & Remote Sensing

Description
WindTech 2017 International Conference on Future Technologies for Wind Energy
Degree of recognition: International
Documents:
Extended Abstract WindTech 2017 Boulder Oct 24-26 - 3D wind field reconstruction from DTU SpinnerLidar wake measurements at SWIFT

Related event
International Conference on Future Technologies for Wind Energy
WindTech 2017
24-26 Oct. 2017
24/10/2017 → 26/10/2017
Boulder, United States
Activity: Talks and presentations › Conference presentations

Institute of Engineering Thermophysics Chinese Academy of Sciences
Period: 19 Oct 2017
Xiaoli Guo Larsén (Visiting lecturer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International
Activity: Visiting an external institution › Visiting another research institution

Modeling wind conditions for offshore wind farms: implications of layout for wind resource, design conditions and integration
Period: 19 Oct 2017
Xiaoli Guo Larsén (Invited speaker)
Department of Wind Energy
Resource Assessment Modelling

Related external organisation
Chinese Meteorological Administration
Beijing China
Activity: Talks and presentations › Conference presentations

Wind farm design in complex terrain - the FarmOpt methodology
Period: 18 Oct 2017
Ju Feng (Invited speaker)
Wen Zhong Shen (Other)
Department of Wind Energy
Fluent Mechanics

Description
Invited speaker at the conference on 18th October in the session "Wind Farm Micro Siting".
Degree of recognition: International
Documents:
Wind farm design in complex terrain - the FarmOpt methodology _Ju Feng _DTU (2017)

Related event

China Wind Power 2017
17/10/2017 → 19/10/2017
Beijing, China
Activity: Talks and presentations › Conference presentations

Chinese Meteorological Administration
Period: 13 Oct 2017
Xiaoli Guo Larsén (Visiting researcher)
Department of Wind Energy
Resource Assessment Modelling
Activity: Visiting an external institution › Visiting another research institution

Modeling wind conditions for offshore wind farms: implications of layout for wind resource, design conditions and integration
Period: 13 Oct 2017
Xiaoli Guo Larsén (Guest lecturer)
Department of Wind Energy
Resource Assessment Modelling

Related external organisation

Institute of Engineering Thermophysics Chinese Academy of Sciences
China
Activity: Talks and presentations › Conference presentations

Pitch me
Period: 10 Oct 2017 → 11 Oct 2017
Christian Bak (Panel member)
Department of Wind Energy
Aerodynamic design

Description
Judge in a competition about new innovations within blade inspection
Degree of recognition: International

Related event

Blade Inspection Damage and Repair 2017
10/10/2017 → 12/10/2017
Brussels, Belgium
Activity: Talks and presentations › Conference presentations

WIND ENERGY DENMARK 2017
Period: 3 Oct 2017
Flemming Rasmussen (Organizer)
Department of Wind Energy
Aerodynamic design
Degree of recognition: National

Related event

WIND ENERGY DENMARK 2017
02/10/2017 → 03/10/2017
Herning, Denmark
Activity: Attending an event › Participating in or organising a conference

Extreme variance vs. turbulence: What can the IEC cover?
Period: 2 Oct 2017
Ásta Hannesdóttir (Speaker)
Mark C. Kelly (Other)
Nikolay Krasimirov Dimitrov (Other)
Department of Wind Energy
Resource Assessment Modelling
Wind Turbine Structures and Component Design

Description
Here we demonstrate the effect of extreme variance events on wind turbine loads. From ten years of data, we analyze periods with variance exceeding the IEC extreme turbulence prescription. The variance is mainly due to coherent gust-like events, and not turbulence, and these events additionally incur extreme shear. Loads from simulations of these events are compared with the extreme turbulence design load case of the IEC standard, with the latter generally giving higher loads.

Links:
http://www.windenergydenmark.dk/program/presentations.aspx

Related event

WIND ENERGY DENMARK 2017
02/10/2017 → 03/10/2017
Herning, Denmark
Activity: Talks and presentations › Conference presentations

Global Wind Atlas 2.0: Aiming for best value out of high resolution
Period: 2 Oct 2017
Jake Badger (Speaker)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: National

Related event

WIND ENERGY DENMARK 2017
02/10/2017 → 03/10/2017
Herning, Denmark
Activity: Talks and presentations › Conference presentations

Global Wind Atlas 2.0: Aiming for best value out of high resolution global datasets
Period: 2 Oct 2017
Jake Badger (Guest lecturer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: National

Related event
Optimization of jacket design for large wind turbines
Period: 2 Oct 2017
Mathias Stolpe (Invited speaker)
Department of Wind Energy
Wind Turbine Structures and Component Design
Degree of recognition: International
Links:
http://www.windenergydenmark.dk/

Related event

The New European Wind Atlas: Exploring new methods for user access and analysis
Period: 2 Oct 2017
Jake Badger (Guest lecturer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: National

Related event

The Poul la Cour Tunnel & the DTU Research Turbine
Period: 2 Oct 2017
Christian Bak (Guest lecturer)
Department of Wind Energy
Aerodynamic design
Description
Presentation of two aerodynamic and aeroelastic research facilities at DTU
Degree of recognition: National

Related event

Mathias Stolpe (Participant)
Department of Wind Energy
Wind Turbine Structures and Component Design
Degree of recognition: International

Related event

WIND ENERGY DENMARK 2017
02/10/2017 → 03/10/2017
Herning, Denmark
Activity: Attending an event › Participating in or organising a conference

Leonardo Aquino
Start date: Sep 2017 → Dec 2017
Andrea N. Hahmann (Host)
Department of Wind Energy
Resource Assessment Modelling

Description
Visit related to thesis research topic - downscaling for wind energy
Activity: Hosting a guest lecturer

Theoretical and Applied Climatology (Journal)
Period: Sep 2017 → …
Mark C. Kelly (Reviewer)
Department of Wind Energy
Resource Assessment Modelling

Related journal
Theoretical and Applied Climatology
0177-798X
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 2.07 SJR 0.867 SNIP 0.999, ISI indexed (2013): ISI indexed yes, Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

IEA Wind Task 32 workshop
Period: 27 Sep 2017
Antoine Borraccino (Guest lecturer)
Rozenn Wagner (Other)
David Schlipf (Other)
Nicolai Gayle Nygaard (Other)
Department of Wind Energy
Meteorology & Remote Sensing

Description
Workshop on: "Power Performance Measurement Using Nacelle Lidars"
Degree of recognition: International
Documents:
2017_09_27_ABorraccino_IEA_wind32_naclidar_calib
2017_09_27_ABorraccino_IEA_wind32_naclidar_PCV_UntTe

Related event

IEA Wind Task 32 workshop: Power performance measurement using nacelle lidars
27/09/2017 → 27/09/2017
Gentofte, Denmark
Activity: Talks and presentations › Conference presentations
Lidar Measurement for more Accurate Measurements and Higher Energy Yield  
Period: 27 Sep 2017  
Torben Krogh Mikkelsen (Invited speaker)  
Department of Wind Energy  
Meteorology & Remote Sensing  

Description  
Real time measurements of Wind Using Lidars  
Turbine Control  
Turbine Wakes  
Data Basis for Model Comparison  
Degree of recognition: International  

Related event  
3rd International Conference Digital Data Integration & Management From SCADA to Asset Optimization  
26/09/2017 → 28/09/2017  
Activity: Talks and presentations › Conference presentations

Land surface parametrizations for CFD models and WASP in complex forested terrain  
Period: 26 Sep 2017  
Ebba Dellwik (Invited speaker)  
Department of Wind Energy  
Meteorology & Remote Sensing  

Related event  
Expert meeting at OX2, Stockholm  
26/09/2017 → 26/09/2017  
Stockholm, Sweden  
Activity: Talks and presentations › Talks and presentations in private or public companies and organisations

Vindenergi (Wind energy)  
Period: 26 Sep 2017  
Niels-Erik Clausen (Guest lecturer)  
Department of Wind Energy  
Integration & Planning  
Degree of recognition: National  
Documents:  
Clausen Vindenergi Folkeuniversitetet 26 september 2017_red_size  
Links:  
https://fuau.dk/aarhus/program/naturvidenskab-og-teknologi/vedvarende-energi-1721-382 (Series of lectures on renewable energy (in Danish))  

Related external organisation  
Folkeuniversitetet i Aarhus  
Ny Munkegade 118, 8000, Aarhus, Denmark  
Activity: Talks and presentations › Guest lectures, external teaching and course activities at other universities

E-learning master and continuing education  
Period: 21 Sep 2017  
Merete Badger (Invited speaker)  
Department of Wind Energy  
Meteorology & Remote Sensing
Degree of recognition: Local

**Related event**

**DTU Wind Energy Department Day**
21/09/2017 → 21/09/2017
Roskilde, Denmark
Activity: Talks and presentations › Conference presentations

**Remote Sensing of Environment (Journal)**
Period: 21 Sep 2017
Ioanna Karagali (Reviewer)
Department of Wind Energy
Meteorology & Remote Sensing

**Related journal**

Remote Sensing of Environment
0034-4257
Central database
Activity: Research › Peer review of manuscripts

**13th EAWE PhD seminar on Wind Energy in Europe**
Period: 19 Sep 2017 → 22 Sep 2017
Elliot Simon (Organizer)
Department of Wind Energy
Meteorology & Remote Sensing

**Description**
Conference co-organiser and scientific committee chair for DTU
Degree of recognition: International

**Related event**

**13th EAWE PhD seminar on Wind Energy in Europe**
19/09/2017 → 22/09/2017
Cranfield, United Kingdom
Activity: Attending an event › Participating in or organising a conference

**IEC 61400-15 meeting/workshop 12 (Event)**
Period: 19 Sep 2017 → 22 Sep 2017
Mark C. Kelly (Member)
Department of Wind Energy
Resource Assessment Modelling

**Description**
IEC 61400-15 workshop and creation of standard for uncertainty in resource assessment. I am an active author of drafts; wrote/edited more of uncertainty-combination section, and modified/augmented vertical-extrapolation section in this meeting.
Degree of recognition: International

**Related event**

**IEC 61400-15 meeting/workshop 12**
19/09/2017 → 22/09/2017
Madrid, Spain
Activity: Membership › Membership of commitees, commissions, boards, councils, associations, organisations, or similar
Gert-Jan Steeneveld  
Start date: 18 Sep 2017 -- 13 Oct 2017  
Jake Badger (Host)  
Department of Wind Energy  
Resource Assessment Modelling  
Degree of recognition: International  
Activity: Hosting a guest lecturer

Journal of Renewable and Sustainable Energy (Journal)  
Period: 18 Sep 2017 -- 14 Nov 2017  
Ole Steen Rathmann (Reviewer)  
Department of Wind Energy  
Resource Assessment Modelling  
Description  
Peer-review of paper  
Degree of recognition: International  
Related journal  
Journal of Renewable and Sustainable Energy  
1941-7012  
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 1.41 SJR 0.44 SNIP 0.588, ISI indexed (2013): ISI indexed yes,  
Web of Science (2018): Indexed yes  
Central database  
Activity: Research › Peer review of manuscripts

4th Biannual System Engineering Workshop  
Period: 13 Sep 2017 -- 15 Sep 2017  
Michael McWilliam (Chairman)  
Frederik Zahle (Chairman)  
Katherine Dykes (Chairman)  
Department of Wind Energy  
Aerodynamic design  
Degree of recognition: International  
Links:  
http://www.vindenergi.dtu.dk/english/kalender/2017/09/4th-bi-annual-workshop-on-system-engineering?id=c4d8a6e0-106d-4154-be81-d261588b4f87

Related event  
4th Biannual System Engineering Workshop  
13/09/2017 -- 15/09/2017  
Roskilde, Denmark  
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Blind Results for The Aerodynamic Wind Turbine Design Optimization Case Study for the IEA Task 37 on Wind Energy Systems Engineering  
Period: 13 Sep 2017  
Michael McWilliam (Invited speaker)  
Frederik Zahle (Other)  
Katherine Dykes (Other)  
Department of Wind Energy  
Aerodynamic design
**Degree of recognition:** International

**Documents:**

- Aero_Opt_Presentation_Sys_Workshop

**Related event**

**4th Biannual System Engineering Workshop**

13/09/2017 → 15/09/2017

Roskilde, Denmark

Activity: Talks and presentations › Conference presentations

**Higher Fidelity Analysis in Wind Turbine Multi-disciplinary Design Optimization**

Period: 13 Sep 2017

**Michael McWilliam (Invited speaker)**

Department of Wind Energy

Aerodynamic design

**Documents:**

- System_Engineering_Workshop_2017_Higher_Fidelity_in_Optimization

**Related event**

**4th Biannual System Engineering Workshop**

13/09/2017 → 15/09/2017

Roskilde, Denmark

Activity: Talks and presentations › Conference presentations

**J A S A Express Letters (Journal)**

Period: 10 Sep 2017

**Oliver Ackermann Lylloff (Reviewer)**

Acoustic Technology

Aerodynamic design

**Degree of recognition:** International

**Related journal**

**J A S A Express Letters**

1529-7853


Central database

Activity: Research › Peer review of manuscripts

**EMS Annual Meeting: European Conference for Applied Meteorology and Climatology 2017**

Period: 7 Sep 2017

**Sven-Erik Gryning (Chairman)**

Department of Wind Energy

**Degree of recognition:** International

**Related event**

**EMS Annual Meeting: European Conference for Applied Meteorology and Climatology 2017**

04/09/2017 → 08/09/2017

Dublin, Ireland

Activity: Attending an event › Participating in or organising a conference
European Meteorological Society (External organisation)
Period: 7 Sep 2017
Sven-Erik Gryning (Member)
Department of Wind Energy

Description
European Meteorological Society: Programme and Science Committee Meeting
Degree of recognition: International

Related external organisation
European Meteorological Society
Germany
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

EMS Annual Meeting: European Conference for Applied Meteorology and Climatology 2017 (Event)
Period: 6 Sep 2017
Sven-Erik Gryning (Chairman)
Department of Wind Energy

Description
Chairing two sessions
Degree of recognition: International

Related event
EMS Annual Meeting: European Conference for Applied Meteorology and Climatology 2017
04/09/2017 → 08/09/2017
Dublin, Ireland
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

An emerging European Doppler lidar network for meteorological applications
Period: 4 Sep 2017 → 8 Sep 2017
Ewan J. O'Connor (Speaker)
Anne Hirsikko (Other)
Christos Halios (Other)
Sven-Erik Gryning (Other)
Ronny Leinweber (Other)
Antti Manninen (Other)
Tobias Marke (Other)
Nina Petersen (Other)
Jana Preissler (Other)
Eileen Päschke (Other)
Umar Saeed (Other)
Jan Sween (Other)
Yang Shu (Other)
Irene Suomi (Other)
Minttu Tuononen (Other)
Ville Vakkari (Other)
Ludovic Thobois (Other)
Guy Pearson (Other)
Alain Dabas (Other)
Johannes Buehl (Other)
Department of Wind Energy
Degree of recognition: International
Documents:
EMS2017-745
Related event

EMS Annual Meeting: European Conference for Applied Meteorology and Climatology 2017
04/09/2017 → 08/09/2017
Dublin, Ireland
Activity: Talks and presentations › Conference presentations

Doppler lidar horizontal wind retrievals from a meteorological perspective
Period: 4 Sep 2017 → 8 Sep 2017
Ewan O'Connor (Speaker)
Anne Hirsikko (Other)
Christos Halios (Other)
Sven-Erik Gryning (Other)
Ronny Leinweber (Other)
Antti Manninen (Other)
Tobias Marke (Other)
Guðrún Nina Petersen (Other)
Jana Preißler (Other)
Eileen Päschke (Other)
Umar Saeed (Other)
jan schween (Other)
Yang Shu (Other)
Irene Suomi (Other)
Minttu Tuononen (Other)
Ville Vakkari (Other)
Ludovic Thobois (Panel member)
Guy Pearson (Other)
Alain Dabas (Other)
Johannes Buehl (Other)

Department of Wind Energy
Degree of recognition: International
Documents:
EMS2017-763-1

Related event

EMS Annual Meeting: European Conference for Applied Meteorology and Climatology 2017
04/09/2017 → 08/09/2017
Dublin, Ireland
Activity: Talks and presentations › Conference presentations

European Meteorological Society (External organisation)
Period: 4 Sep 2017
Sven-Erik Gryning (Member)

Department of Wind Energy

Description
Member of the EMS Council
Degree of recognition: International

Related external organisation

European Meteorological Society
Germany
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar
Marina wind profiles measured by a wind lidar - ability of WRF to predict marine wind profiles
Period: 4 Sep 2017 → 8 Sep 2017
Ekaterina Batchvarova (Speaker)
Sven-Erik Gryning (Other)
Department of Wind Energy
Degree of recognition: International
Documents:
EMS2017-775

Related event
EMS Annual Meeting: European Conference for Applied Meteorology and Climatology 2017
04/09/2017 → 08/09/2017
Dublin, Ireland
Activity: Talks and presentations › Conference presentations

New methodologies to observe wind gusts: research aircraft and Doppler lidar measurements
Period: 4 Sep 2017 → 8 Sep 2017
Irene Suomi (Speaker)
Timo Vihma (Other)
Sven-Erik Gryning (Other)
Christof Lüpkes (Other)
Jörg Hartmann (Other)
Ewan O'Connor (Other)
Department of Wind Energy
Degree of recognition: International
Documents:
EMS2017-197

Related event
EMS Annual Meeting: European Conference for Applied Meteorology and Climatology 2017
04/09/2017 → 08/09/2017
Dublin, Ireland
Activity: Talks and presentations › Conference presentations

Performance of four PBL schemes in WRF at Villum Research Station, Station Nord, Greenland
Period: 4 Sep 2017 → 8 Sep 2017
Hristina Kirova (Other)
Ekaterina Batchvarova (Speaker)
Sven-Erik Gryning (Other)
Henrik Skov (Other)
Lise-Lotte Sørensen (Other)
Department of Wind Energy
Degree of recognition: International
Documents:
EMS2017-778-2

Related event
EMS Annual Meeting: European Conference for Applied Meteorology and Climatology 2017
04/09/2017 → 08/09/2017
Dublin, Ireland
Activity: Talks and presentations › Conference presentations

Ramp events in the marine boundary-layer investigated by a wind lidar
Period: 4 Sep 2017 → 8 Sep 2017
Sven-Erik Gryning (Speaker)
Ekaterina Batchvarova (Other)
Department of Wind Energy
Degree of recognition: International
Documents:
EMS2017-777

Related event
EMS Annual Meeting: European Conference for Applied Meteorology and Climatology 2017
04/09/2017 → 08/09/2017
Dublin, Ireland
Activity: Talks and presentations › Conference presentations

Geoscientific Model Development (Journal)
Period: 1 Sep 2017 → 1 Dec 2017
Patrick Volker (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International
Links:
https://www.geosci-model-dev.net/10/4229/2017/gmd-10-4229-2017-discussion.html (Review discussion)

Related journal
Geoscientific Model Development
1991-959X
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 4.49 SJR 2.404 SNIP 1.539, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Indexed in DOAJ
Central database
Activity: Research › Peer review of manuscripts

Test of universality of roughness length and displacement height formulations regarding stability
Period: 30 Aug 2017
Andrey Sogachev (Speaker)
Mark C. Kelly (Other)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International
Documents:
ICOS Nordic 2017

Related event
1st Nordic ICOS Symposium
29/08/2017 → 31/08/2017
Copenhagen, Denmark
Activity: Talks and presentations › Conference presentations

Ekaterina Batchvarova
Start date: 8 Aug 2017 → 16 Aug 2017
Sven-Erik Gryning (Host)
Department of Wind Energy

Description
COST STSM
Degree of recognition: International
Activity: Hosting a guest lecturer
Energies (Journal)
Period: 1 Aug 2017 → 1 Sep 2017
Patrick Volker (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Description
Manuscript energies-232250, rejected
Degree of recognition: International
Related journal
Energies
1996-1073
BFI (2018): BFI-level 2, Scopus rating (2017): CiteScore 3.11 SJR 0.67 SNIP 1.34, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Indexed in DOAJ
Central database
Activity: Research › Peer review of manuscripts

Journal of Fluid Mechanics (Journal)
Period: Jul 2017 → Nov 2017
Mark C. Kelly (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International
Related journal
Journal of Fluid Mechanics
0022-1120
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

Accuracy of coastal wind speed gradients from Synthetic Aperture Radar by comparisons with scanning lidars
Period: 26 Jul 2017 → 29 Jul 2017
Tobias Torben Ahsbahs (Speaker)
Merete Badger (Speaker)
Ioanna Karagali (Speaker)
Xiaoli Guo Larsén (Speaker)
Department of Wind Energy
Meteorology & Remote Sensing
Resource Assessment Modelling
Degree of recognition: International
Documents:
presentation_WESC_2017_TTAH

Related event
Wind Energy Science Conference 2017
26/06/2017 → 29/06/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations
**WAsP-ForestGALES: a merged tool for improved forest wind damage prediction**

Period: 19 Jul 2017

Ebba Dellwik (Guest lecturer)
Ducan Heathfield (Guest lecturer)
Barry Gardiner (Guest lecturer)

Department of Wind Energy
Meteorology & Remote Sensing

**Description**
Conference presentation, talk
Degree of recognition: International
Documents:
WAsP-ForestGALES_final

**Related event**

IUFRO Wind and trees conference 2017
17/07/2017 → 20/07/2017
Boulder, United States
Activity: Talks and presentations › Conference presentations

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**Initial results from the Single Tree Experiment**

Period: 17 Jul 2017

Ebba Dellwik (Guest lecturer)
Jakob Mann (Guest lecturer)
Nikolas Angelou (Guest lecturer)
Andrey Sogachev (Guest lecturer)
Niels Trolldborg (Guest lecturer)
Barry Gardiner (Guest lecturer)
Timothy Newson (Guest lecturer)
Horia Hangan (Guest lecturer)

Department of Wind Energy
Meteorology & Remote Sensing

Resource Assessment Modelling
Aerodynamic design

**Description**
Conference presentation, talk
Degree of recognition: International
Documents:
Initial results from the single tree experiment_nofilms

**Related event**

IUFRO Wind and trees conference 2017
17/07/2017 → 20/07/2017
Boulder, United States
Activity: Talks and presentations › Conference presentations

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**Initial results from the Single-Tree Experiment**

Period: 17 Jul 2017

Ebba Dellwik (Speaker)
Jakob Mann (Other)
Nikolas Angelou (Other)
Andrey Sogachev (Other)
Niels Trolldborg (Other)
Barry Gardiner (Other)
Timothy Newson (Other)
Horia Hangan (Guest lecturer)

Department of Wind Energy
Meteorology & Remote Sensing
Resource Assessment Modelling
Aerodynamic design

Description
Conference presentation, Talk
Degree of recognition: International

Related event

IUFRO Wind and trees conference 2017
17/07/2017 → 20/07/2017
Boulder, United States
Activity: Talks and presentations › Conference presentations

Long-term measurements of the dynamic wind loads on an open-grown oak tree
Period: 17 Jul 2017
Nikolas Angelou (Guest lecturer)
Jakob Mann (Guest lecturer)
Ebba Dellwik (Guest lecturer)
Department of Wind Energy
Meteorology & Remote Sensing

Description
Conference presentation, talk
Degree of recognition: International

Related event

IUFRO Wind and trees conference 2017
17/07/2017 → 20/07/2017
Boulder, United States
Activity: Talks and presentations › Conference presentations

Summary of oral and poster presentations
Period: 29 Jun 2017
Sven-Erik Gryning (Speaker)
Department of Wind Energy
Degree of recognition: International

Related event

International Conference on Energy & Meteorology
27/06/2017 → 29/06/2017
Bari, Italy
Activity: Talks and presentations › Conference presentations

Wind Energy (Journal)
Period: 29 Jun 2017
Ioanna Karagali (Reviewer)
Department of Wind Energy
Meteorology & Remote Sensing
Related journal

Wind Energy
1095-4244
Central database
Activity: Research › Peer review of manuscripts

WRF model evaluation based on wind lidar measurements
Period: 29 Jun 2017
Sven-Erik Gryning (Speaker)
Ekaterina Batchvarova (Other)
Department of Wind Energy
Degree of recognition: International
Links:
http://www.wemcouncil.org/wp/icem2017/

Related event

International Conference on Energy & Meteorology
27/06/2017 → 29/06/2017
Bari, Italy
Activity: Talks and presentations › Conference presentations

An Engineering 2D Vortex-based Model for VAWT Aerodynamics
Period: 28 Jun 2017
Mac Gaunaa (Guest lecturer)
Department of Wind Energy
Aerodynamic design

Description
Presentation of a new vortex-based 2D aerodynamic model for Vertical-Axis Wind Turbines
Degree of recognition: International
Links:
http://www.eawe.eu/index.php/wescdocs/

Related event

Wind Energy Science Conference 2017
26/06/2017 → 29/06/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

Improved Roughness Model for 2D Viscous-Inviscid Panel Methods
Period: 28 Jun 2017
Anders Smærup Olsen (Speaker)
Néstor Ramos García (Other)
Christian Bak (Other)
Mac Gaunaa (Other)
Department of Wind Energy
Aerodynamic design
Fluid Mechanics
Degree of recognition: International
Links:
http://www.eawe.eu/index.php/wescdocs/ (Link to presentation)

Related event
Wind Energy Science Conference 2017
26/06/2017 → 29/06/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

Journal of Geophysical Research - Part C - Ocean (Journal)
Period: 28 Jun 2017
Ioanna Karagali (Reviewer)
Department of Wind Energy
Meteorology & Remote Sensing

Related journal

Journal of Geophysical Research - Part C - Ocean
Local database
Activity: Research › Peer review of manuscripts

The Østerild Balconies Experiment
Period: 28 Jun 2017
Ioanna Karagali (Speaker)
Ebba Dellwik (Other)
Guillaume Lea (Other)
Elliot Simon (Other)
Nikola Vasiljevic (Other)
Jakob Mann (Other)
Department of Wind Energy
Meteorology & Remote Sensing

Description
Mini Symposia "Exp. Investigations of Wind Resourced and Siting Parameters"

Related event

Wind Energy Science Conference 2017
26/06/2017 → 29/06/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

CFD prediction of airfoil deep stall performance using Improved Delayed Detached Eddy Simulations
Period: 27 Jun 2017
Niels N. Sørensen (Guest lecturer)
Department of Wind Energy
Aerodynamic design
Documents:
280617-14.20-S08
Links:
http://www.wesc2017.org/

Related organisation

CFD prediction of airfoil deep stall performance using Improved Delayed Detached Eddy Simulations
Sørensen, N. N. (Guest lecturer)
27 Jun 2017
Activity: Talks and presentations › Conference presentations

Chairing session on Forecasting for power-system applications - wind models
Period: 27 Jun 2017
Sven-Erik Gryning (Speaker)
Department of Wind Energy
Degree of recognition: International

Related event

International Conference on Energy & Meteorology
27/06/2017 → 29/06/2017
Bari, Italy
Activity: Talks and presentations › Conference presentations

Inflow conditions and wake effects for wind turbines in forested terrain
Period: 27 Jun 2017
Ebba Dellwik (Invited speaker)
Alkistis Papetta (Other)
Johan Arnqvist (Other)
Morten Nielsen (Other)
Torben J. Larsen (Other)
Department of Wind Energy
Meteorology & Remote Sensing
Resource Assessment Modelling
Wind turbine loads & control
Documents:
abstract - WESC2017-final

Related event

27/06/2017 → 27/06/2017
Copenhagen, Denmark
Activity: Talks and presentations › Conference presentations

Interaction between turbine wakes and complex terrain in large-eddy simulations
Period: 27 Jun 2017
Jacob Berg (Guest lecturer)
Department of Wind Energy
Resource Assessment Modelling

Related event

Wind Energy Science Conference 2017
26/06/2017 → 29/06/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

International Conference on Energy & Meteorology (Event)
Period: 27 Jun 2017
Sven-Erik Gryning (Participant)
Department of Wind Energy

Description
Chair of abstract selection committee
Degree of recognition: International

Related event
Predicting free-stream wind speed in complex terrain with lidar measurements
Period: 27 Jun 2017
Alexander Meyer Forsting (Speaker)
Department of Wind Energy
Aerodynamic design
Degree of recognition: International
Documents:
Wesc17_alrf_presentation

Related event

Wind Energy Science Conference 2017
26/06/2017 → 29/06/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

Simulation of Bayesian Optimization Based Wind Farm Power Maximization Technique Using Dynamic Wake Meandering Model
Period: 27 Jun 2017
Jonas Kazda (Guest lecturer)
Nicolaos Antonio Cutululis (Guest lecturer)
Juan Gratacos (Other)
Department of Wind Energy
Integration & Planning
Degree of recognition: International

Related event

Wind Energy Science Conference 2017
26/06/2017 → 29/06/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

TOPFARM: framework for coupling models to address wind farm optimization challenges
Period: 27 Jun 2017
David Robert Verelst (Speaker)
Frederik Zahle (Other)
Pierre-Elouan Réthoré (Other)
Jennifer Rinker (Other)
Department of Wind Energy
Wind turbine loads & control
Aerodynamic design
Resource Assessment Modelling

Related event

Wind Energy Science Conference 2017
26/06/2017 → 29/06/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations
Turbulence Estimation from a Continuous-Wave Scanning Lidar (SpinnerLidar)
Period: 27 Jun 2017
Torben Krogh Mikkelsen (Guest lecturer)
Department of Wind Energy
Meteorology & Remote Sensing

Description
One of the current challenges using lidars for wind energy measurements is the inability of lidars to accurately measure turbulence. Two important factors affecting lidar measurements of turbulence are:

1) the spatial averaging by the lidars sounding volume leading to smaller eddies being filtered out, and
2) the mixing of velocity co-variances from other components into the line-of-sight variance measurements.

Turbulence measurements based on upwind horizontal rotor plane scanning of the line-of-sight variance measurements combined with ensemble-averaged Doppler spectra width measurements is shown to provide unfiltered, un-truncated line-of-sight turbulence measurements similar to what is achievable from a hub-height installed cup anemometer.

Degree of recognition: International
Documents:
270617 – 1100 – S10
Links:
http://www.eawe.eu/index.php/wescdocs/ (Presentation at WESC2017 uploaded at AEWE public home pages)

Related organisation
Turbulence Estimation from a Continuous-Wave Scanning Lidar (SpinnerLidar)
Mikkelsen, T. K. (Guest lecturer)
27 Jun 2017
Activity: Talks and presentations › Conference presentations

An Advanced Blade Modelling Approach
Period: 26 Jun 2017 → 29 Jun 2017
Philipp Ulrich Haselbach (Other)
Kim Branner (Other)
Department of Wind Energy
Wind Turbine Structures and Component Design
Degree of recognition: International

Related event
Wind Energy Science Conference 2017
26/06/2017 → 29/06/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

Analysis of extreme wind events at Høvsøre and the effect on wind turbine loads
Period: 26 Jun 2017
Ásta Hannesdóttir (Speaker)
Mark C. Kelly (Other)
Jakob Mann (Other)
Anand Natarajan (Other)
Department of Wind Energy
Resource Assessment Modelling
Meteorology & Remote Sensing
Wind Turbine Structures and Component Design
Analysis of extreme wind events at Høvsøre and the effect on wind turbine loads

The IEC 61400-1 standards for wind turbines prescribe a set of requirements to ensure that wind turbines are designed to defined reliability levels. These standards take into consideration extreme wind conditions and various operational turbine load regimes, and specify the damage a wind turbine may withstand over its lifetime. The standards include an extreme turbulence model (ETM), which gives the 50-year extreme ten-minute standard deviation of wind speed as function of ten-minute wind speed at hub height. Herein observations of high wind speed variance events, where the variance exceed the ETM level are analysed.

Inspection of these specific events shows that the measurements often include a sharp increase in wind speed, a ramp or a coherent gust-like structure. These structures give rise to the observed high wind speed variance, which is not resulting from extreme turbulence. The aim of this analysis is to answer the questions:

1. How are the wind-turbine loads affected by these events?
2. What atmospheric parameters give rise to the highest loads?

The data used for the analysis is from a 160 m tall lighting tower in Høvsøre, which is a measurement site approximately 2 km from the west coast of Denmark. The data consists of wind speed measurements from cup anemometers and directional data from wind vanes at 60 m, 100 m and 160 m.

A ten-year period with measurements from the western sector is used to identify events of high wind speed variance that exceed the ETM for a given 10-minute mean wind speed. The events are analysed and factors that might possibly contribute to extreme wind turbine loads, like wind-velocity jump, directional change and wind shear, are identified and quantified.

The wind speed measurements are low pass filtered and simulated with HAWC2, which is an aeroelastic software used to simulate wind turbine response in time domain. The simulations are made for the DTU 10 MW reference wind turbine. Load analysis shows that the maximum tilt moment on the tower yaw bearing correlates well with the wind shear of the measurements. When these loads are compared with the extreme wind shear load case of the IEC standards, it is seen that they are of similar magnitude and in one case even higher.

Related event

Wind Energy Science Conference 2017
26/06/2017 → 29/06/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

Bigger is better! Is it really?
Period: 26 Jun 2017
Andrea N. Hahmann (Speaker)
Department of Wind Energy
Resource Assessment Modelling

Description
Sensitivity experiments with WRF over the North Sea.
Degree of recognition: International

Related event

Wind Energy Science Conference 2017
26/06/2017 → 29/06/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

Large scale wind farm wakes and a wind-wave-wake coupled mesoscale modeling system
Period: 26 Jun 2017
Patrick Volker (Guest lecturer)
Jake Badger (Guest lecturer)
Xiaoli Guo Larsén (Guest lecturer)
Large scale wind farm wakes and a wind-wave-wake coupled mesoscale modeling system
Period: 26 Jun 2017 → 29 Jun 2017
Patrick Volker (Speaker)
Jake Badger (Guest lecturer)
Xiaoli Guo Larsén (Guest lecturer)
Jianting Du (Guest lecturer)
Jesper Nielsen Nissen (Guest lecturer)
Poul Ejnar Sørensen (Guest lecturer)
Department of Wind Energy
Resource Assessment Modelling
Integration & Planning
Degree of recognition: International
Documents:
260617-13:00-M01

Related event
Wind Energy Science Conference 2017
26/06/2017 → 29/06/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

Modelling of high cycle fatigue of coated high strength steel bolts
Period: 26 Jun 2017 → 29 Jun 2017
Philipp Ulrich Haselbach (Other)
Martin Alexander Eder (Other)
Oleg Mishin (Other)
Department of Wind Energy
Wind Turbine Structures and Component Design
Materials science and characterization
Degree of recognition: International

Related event
Wind Energy Science Conference 2017
26/06/2017 → 29/06/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations
Offshore winds from a new generation of European satellites
Period: 26 Jun 2017
Merete Badger (Speaker)
Ioanna Karagali (Other)
Tobias Torben Ahsbahs (Other)
Charlotte Bay Hasager (Other)
Department of Wind Energy
Meteorology & Remote Sensing

Related event

Wind Energy Science Conference 2017
26/06/2017 → 29/06/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

Optimal wind turbine aeroelastic rotor design with active flaps
Period: 26 Jun 2017 → 29 Jun 2017
Michael McWilliam (Speaker)
Athanasios Barlas (Other)
Helge Aagaard Madsen (Other)
Frederik Zahle (Other)
Department of Wind Energy
Aerodynamic design
Degree of recognition: International
Documents:
WESC_2017_Flap_CoDesign_Smart_Blade

Related event

Wind Energy Science Conference 2017
26/06/2017 → 29/06/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

Parameter Uncertainty Reduction of the Re-calibrated Larsen Wake Model
Period: 26 Jun 2017 → 29 Jun 2017
Tuhfe Göçmen (Speaker)
Gregor Giebel (Other)
Department of Wind Energy
Integration & Planning

Description
Presentation at the Wind Energy Science Conference (WESC)
Degree of recognition: International
Documents:
Parameter Uncertainty Reduction of the Re-calibrated Larsen Wake Model

Related event

Wind Energy Science Conference 2017
26/06/2017 → 29/06/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations
Power curve measurement using $V_\infty$ estimates from nacelle lidars and its uncertainty
Period: 26 Jun 2017 → 29 Jun 2017
Antoine Borraccino (Speaker)
Department of Wind Energy
Meteorology & Remote Sensing
Degree of recognition: International
Documents:
AntoineBorraccino_WESC17_presentation_PowerPerf_nacelle_lidars

Related event

Wind Energy Science Conference 2017
26/06/2017 → 29/06/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

Preliminary Results for The Aerodynamic Wind Turbine Design Optimization Case Study for the IEA Task 37 on Wind Energy Systems Engineering
Period: 26 Jun 2017 → 29 Jun 2017
Michael McWilliam (Speaker)
Frederik Zahle (Other)
Katherine Dykes (Other)
Department of Wind Energy
Aerodynamic design
Degree of recognition: International
Documents:
Aero_Opt_Presentation_WESC_2017

Related event

Wind Energy Science Conference 2017
26/06/2017 → 29/06/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

Test possibilities in the Poul la Cour Tunnel
Period: 26 Jun 2017
Christian Bak (Speaker)
Andreas Fischer (Other)
Robert Flemming Mikkelsen (Other)
Anders Smørup Olsen (Other)
Mac Gaunaa (Other)
Witold Robert Skrzypinski (Other)
Efren Fernandez Grande (Other)
Department of Wind Energy
Aerodynamic design
Fluid Mechanics
Department of Electrical Engineering
Acoustic Technology

Description
Oral presentation
Degree of recognition: International

Related event
The wind speed signature of varying sea surface temperature in the mesoscale model WRF
Period: 26 Jun 2017
Ioanna Karagali (Speaker)
Andrea N. Hahmann (Other)
Department of Wind Energy
Meteorology & Remote Sensing
Resource Assessment Modelling
Documents:
Karagali_WESC_2017_SST_WRF

Related event

Wind Energy Science Conference 2017
Period: 26 Jun 2017 → 29 Jun 2017
Lyngby, Denmark
Activity: Attending an event › Participating in or organising a conference

A Probabilistic Approach to CFD Model Validation with Field Measurements in Wind Energy
Period: 20 Jun 2017
Alexander Meyer Forsting (Speaker)
Department of Wind Energy
Aerodynamic design
Degree of recognition: International
Documents:
Links:
https://www.youtube.com/watch?v=YrT7Hy_eGWg (WindScanner & UniTTe | 3D inflow measurement)

Related event

IEA Wind Task 32 (Lidar): Workshop on Elaboration of use cases in wake and complex flow measurements
19/06/2017 → 20/06/2017
Glasgow, United Kingdom
Activity: Talks and presentations › Talks and presentations in private or public companies and organisations

Ocean & Coastal Management (Journal)
Period: 16 Jun 2017 → 6 Jul 2017
Morten Nielsen (Reviewer)
Description
Review of manuscript for the journal
Editors reference: OCMA_2017_56
Title: Selecting sites for co-located wave and wind farms – a more sustainable use of the marine resource
Conclusion: Paper rejected

Related journal
Ocean & Coastal Management
0964-5691
Central database
Activity: Research › Peer review of manuscripts

SAR for Wind Energy
Period: 16 Jun 2017
Merete Badger (Lecturer)
Charlotte Bay Hasager (Other)
Ioanna Karagali (Other)
Tobias Torben Ahsbahs (Guest lecturer)
Xiaoli Guo Larsén (Other)
Alfredo Peña (Other)
Andrea N. Hahmann (Other)
Patrick Volker (Other)
Alessandro Di Bella (Other)
Department of Wind Energy
Meteorology & Remote Sensing
Resource Assessment Modelling
National Space Institute
Geodynamics
Links:
http://www.vindenergi.dtu.dk/english/education/phd/phd-summer-school/charlotte-bay-hasager/phd-summer-school-2017

Related event
PhD Summer School: Remote Sensing for Wind Energy
12/06/2017 → 16/06/2017
Roskilde, Denmark
Activity: Talks and presentations › Conference presentations

A Probabilistic Approach to CFD Validation with Field Measurements in Wind Energy
Period: 15 Jun 2017
Alexander Meyer Forsting (Speaker)
Department of Wind Energy
Aerodynamic design
Degree of recognition: International
Documents:
doc_dtubeamer

Related event
UNCECOMP 2017: 2nd International Conference on Uncertainty Quantification in Computational Sciences and Engineering
IEC 61400-15 meeting/workshop 11 (Event)
Period: 12 Jun 2017 → 16 Jun 2017
Mark C. Kelly (Member)

Department of Wind Energy

Resource Assessment Modelling

Description
IEC 61400-15 workshop and creation of standard for uncertainty in resource assessment. I am an active author of drafts; wrote/edited more of uncertainty-combination section, and modified/augmented vertical-extrapolation section in this meeting.

Degree of recognition: International

Related event

IEC 61400-15 meeting/workshop 11
12/06/2017 → 16/06/2017
Porto, Portugal

Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

PhD Summer School: Remote Sensing for Wind Energy
Period: 12 Jun 2017 → 16 Jun 2017
Merete Badger (Organizer)

Department of Wind Energy

Meteorology & Remote Sensing

Related event

PhD Summer School: Remote Sensing for Wind Energy
12/06/2017 → 16/06/2017
Roskilde, Denmark

Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

12th World Congress of Structural and Multidisciplinary Optimisation
Period: 7 Jun 2017
Kasper Sandal (Participant)
Susana Rojas Labanda (Participant)
Mathias Stolpe (Participant)

Department of Wind Energy

Description
Sizing optimization of an offshore wind turbine jacket under dynamic loads considering stress and eigenfrequency constraints

Related event

12th World Congress of Structural and Multidisciplinary Optimisation
05/06/2017 → 09/06/2017
Braunschweig, Germany

Activity: Attending an event › Participating in or organising a conference

12th World Congress of Structural and Multidisciplinary Optimisation
Period: 7 Jun 2017
Asger Bech Abrahamsen (Participant)
Mathias Stolpe (Participant)
**Description**
Optimal design of a galvanic corrosion protection systems for offshore wind turbine support structures
Degree of recognition: International
Links:
http://www.wcsmo12.org/

**Related event**
12th World Congress of Structural and Multidisciplinary Optimization
05/06/2017 → 09/06/2017
Braunschweig, Germany
Activity: Attending an event › Participating in or organising a conference

**Coastal extreme winds and waves from COAWST-WBLM modelling system**
Period: 7 Jun 2017
Jake Badger (Speaker)
Xiaoli Guo Larsén (Other)
Jianting Du (Other)
Andrea N. Hahmann (Other)
Jacob T. Sørensen (Other)
Patrick Volker (Other)
Marc Imberger (Other)
Rodolfo Bolanos (Other)
Mark C. Kelly (Other)
Merete Badger (Other)
Henrik Kofod-Hansen (Other)
Ioanna Karagali (Other)
Søren Ejling Larsen (Other)
Ole Svenstrup Petersen (Other)
Department of Wind Energy
Resource Assessment Modelling
Meteorology & Remote Sensing
Degree of recognition: International

**Related event**
WindEurope Offshore 2017
08/06/2017 → 08/06/2017
London, United Kingdom
Activity: Talks and presentations › Conference presentations

**Mapping offshore winds in the New European Wind Atlas (NEWA)**
Period: 7 Jun 2017
Ioanna Karagali (Invited speaker)
Charlotte Bay Hasager (Other)
Merete Badger (Other)
Andrea N. Hahmann (Other)
Patrick Volker (Other)
Alfredo Peña (Guest lecturer)
Julia Gottschall (Other)
Eleonora Catalano (Other)
Jakob Mann (Other)
Department of Wind Energy
Meteorology & Remote Sensing
Resource Assessment Modelling

Related event

Offshore Wind Energy 2017
06/06/2017 → 08/06/2017
London, United Kingdom
Activity: Talks and presentations › Conference presentations

Optimal design of a galvanic corrosion protection systems for offshore wind turbine support structures
Period: 7 Jun 2017
Ali Sarhadi (Speaker)
Department of Wind Energy
Degree of recognition: International
Links:
http://www.wcsmo12.org/

Related event

12th World Congress of Structural and Multidisciplinary Optimization
05/06/2017 → 09/06/2017
Braunschweig, Germany
Activity: Talks and presentations › Conference presentations

Sizing optimization of an offshore wind turbine jacket under dynamic loads considering stress and eigenfrequency constraints
Period: 7 Jun 2017
Alexander Verbart (Speaker)
Kasper Sandal (Other)
Susana Rojas Labanda (Other)
Mathias Stolpe (Other)
Department of Wind Energy
Wind Turbine Structures and Component Design

Related event

12th World Congress of Structural and Multidisciplinary Optimisation
05/06/2017 → 09/06/2017
Braunschweig, Germany
Activity: Talks and presentations › Conference presentations

Near-shore wind resource estimation using lidar measurements and modelling
Period: 6 Jun 2017 → 8 Jun 2017
Rogier Ralph Floors (Guest lecturer)
Andrea N. Hahmann (Guest lecturer)
Alfredo Peña (Guest lecturer)
Department of Wind Energy
Resource Assessment Modelling
Meteorology & Remote Sensing

Description
The atmospheric flow in the coastal zone is investigated using (scanning) lidars, mast measurements and the mesoscale WRF model. The WRF model is set-up in 12 different configurations using 2 planetary boundary-layer schemes, 3 horizontal grid spacings and varied sources of land use, and initial and lower boundary conditions.
Documents:
Related event

WindEurope Offshore 2017
06/06/2017 → 08/06/2017
London, United Kingdom
Activity: Talks and presentations › Conference presentations

12th World Congress of Structural and Multidisciplinary Optimisation
Period: 5 Jun 2017
Mathias Stolpe (Participant)
Susana Rojas Labanda (Participant)
José Pedro Albergaria Amaral Blasques (Participant)
Department of Wind Energy

Description
3D structural topology optimization of wind turbine blades with stiffness and frequency constraints
Degree of recognition: International

Related event

12th World Congress of Structural and Multidisciplinary Optimisation
05/06/2017 → 09/06/2017
Braunschweig, Germany
Activity: Attending an event › Participating in or organising a conference

12th World Congress of Structural and Multidisciplinary Optimization
Period: 5 Jun 2017 → 9 Jun 2017
Susana Rojas Labanda (Participant)
Mathias Stolpe (Participant)
Department of Wind Energy
Wind Turbine Structures and Component Design

Description
Simultaneous Analysis and Design formulation for sizing optimization problems under many dynamic loads
Degree of recognition: International

Related event

12th World Congress of Structural and Multidisciplinary Optimisation
05/06/2017 → 09/06/2017
Braunschweig, Germany
Activity: Attending an event › Participating in or organising a conference

3D structural topology optimization of wind turbine blades with stiffness and frequency constraints
Period: 5 Jun 2017
Christian Carstensen (Speaker)
Department of Wind Energy
Degree of recognition: International

Related event

12th World Congress of Structural and Multidisciplinary Optimisation
05/06/2017 → 09/06/2017
Braunschweig, Germany
Activity: Talks and presentations › Conference presentations
**Comparison of fatigue constraints in optimal design of jacket structures for offshore wind turbines**
Period: 5 Jun 2017 → 9 Jun 2017
Kasper Sandal (Speaker)
Department of Wind Energy
Wind Turbine Structures and Component Design
Degree of recognition: International

**Related event**

**12th World Congress of Structural and Multidisciplinary Optimisation**
05/06/2017 → 09/06/2017
Braunschweig, Germany
Activity: Talks and presentations › Conference presentations

**Optimal modular design of jacket structures for offshore wind turbines**
Period: 5 Jun 2017 → 9 Jun 2017
Mathias Stolpe (Speaker)
Kasper Sandal (Speaker)
Department of Wind Energy
Degree of recognition: International

**Related event**

**12th World Congress of Structural and Multidisciplinary Optimisation**
05/06/2017 → 09/06/2017
Braunschweig, Germany
Activity: Talks and presentations › Conference presentations

**Large-Eddy Simulation of turbine wake in complex terrain**
Period: 1 Jun 2017
Jacob Berg (Guest lecturer)
Department of Wind Energy
Resource Assessment Modelling

**Related event**

**Wake Conference 2017**
30/05/2017 → 01/06/2017
Visby, Sweden
Activity: Talks and presentations › Conference presentations

**Wind farm efficiency assessed by WRF with a statistical-dynamical approach**
Period: 1 Jun 2017
Patrick Volker (Speaker)
Jake Badger (Speaker)
Andrea N. Hahmann (Speaker)
Hans Ejring Jørgensen (Speaker)
Department of Wind Energy
Resource Assessment Modelling
Meteorology & Remote Sensing

**Description**
Discussion about large wind farms and their efficiency
Degree of recognition: International
Documents:
abstract_pvol
Related event

**WindFarms 2017, Madrid**
31/05/2017 → 02/06/2017
Madrid, Spain
Activity: Talks and presentations › Conference presentations

**Boundary-Layer Meteorology (Journal)**
Period: May 2017 → Jun 2017
Mark C. Kelly (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International

**Related journal**

**Boundary-Layer Meteorology**
0006-8314
Central database
Activity: Research › Peer review of manuscripts

**Efficiency of large wind farms: investigation of dependency on turbine technology and cluster layout**
Period: 31 May 2017 → 2 Jun 2017
Patrick Volker (Guest lecturer)
Jake Badger (Guest lecturer)
Andrea N. Hahmann (Guest lecturer)
Hans Ejsing Jørgensen (Guest lecturer)
Department of Wind Energy
Resource Assessment Modelling
Meteorology & Remote Sensing
Degree of recognition: International
Documents: presentation

**Related event**

**WindFarms 2017, Madrid**
31/05/2017 → 02/06/2017
Madrid, Spain
Activity: Talks and presentations › Conference presentations

**Modelling lidar volume-averaging and its effect on wake measurements**
Period: 30 May 2017 → 1 Jun 2017
Alexander Meyer Forsting (Speaker)
Department of Wind Energy
Aerodynamic design

**Description**
Wake conference 2017
Degree of recognition: International
Documents: AMeyerForsting

**Related event**

**Wake Conference 2017**
30/05/2017 → 01/06/2017
Visby, Sweden
Activity: Talks and presentations › Conference presentations

Royal Meteorological Society. Quarterly Journal (Journal)
Period: 29 May 2017
Ioanna Karagali (Reviewer)
Department of Wind Energy
Meteorology & Remote Sensing

Related journal
Quarterly Journal of the Royal Meteorological Society
0035-9009
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

Optimal modular design of offshore support structures - modelling and methods
Period: 18 May 2017
Mathias Stolpe (Invited speaker)
Department of Wind Energy
Degree of recognition: International

Related event
Support Structure Optimization - Science or Art?
18/05/2017 → 19/05/2017
Delmenhorst, Germany
Activity: Talks and presentations › Conference presentations

Support Structure Optimization - Science or Art?
Period: 18 May 2017 → 19 May 2017
Mathias Stolpe (Organizer)
Department of Wind Energy
Degree of recognition: International

Related event
Support Structure Optimization - Science or Art?
18/05/2017 → 19/05/2017
Delmenhorst, Germany
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Journal of Geophysical Research: Atmospheres (Journal)
Period: 8 May 2017
Ioanna Karagali (Reviewer)
Department of Wind Energy
Meteorology & Remote Sensing

Related journal
Journal of Geophysical Research: Atmospheres
0148-0227
Web of Science (2018): Indexed yes
Central database
Dynamical downscaling of North Sea winds: Reanalysis and ensemble predictions
Period: 5 May 2017
Andrea N. Hahmann (External examiner)
Department of Wind Energy
Resource Assessment Modelling

Description
PhD dissertation
Degree of recognition: International
Activity: Examinations and supervision › External examination

Energies (Journal)
Period: 1 May 2017 → 1 Aug 2017
Patrick Volker (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International
Links:
http://www.mdpi.com/1996-1073/10/10/1475 (link to article)

Related journal
Energies
1996-1073
Central database
Activity: Research › Peer review of manuscripts

Monthly Weather Review (Journal)
Period: 1 May 2017 → 1 Dec 2017
Patrick Volker (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International
Links:
http://journals.ametsoc.org/doi/abs/10.1175/MWR-D-16-0401.1 (published article)

Related journal
Monthly Weather Review
0027-0644
Central database
Activity: Research › Peer review of manuscripts

Passive/active load alleviation
Period: 27 Apr 2017
Flemming Rasmussen (Lecturer)
Department of Wind Energy
Aerodynamic design
Related event

DTU Seminar - The Application of Smart Structures for Large Wind Turbine Rotor Blades
27/04/2016 → 28/04/2017
Roskilde, Denmark
Activity: Talks and presentations › Conference presentations

Remote Sensing of Environment (Journal)
Period: 24 Apr 2017
Ioanna Karagali (Reviewer)
Department of Wind Energy
Meteorology & Remote Sensing

Related journal

Remote Sensing of Environment
0034-4257
BFI (2018): BFI-level 2, Scopus rating (2017): CiteScore 7.16 SJR 3.121 SNIP 2.5, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

Impact of interfaces for wind and wave modeling - via coupled atmospheric & ocean wave models, with SAR and mast measurements
Period: 21 Apr 2017
Xiaoli Guo Larsén (Guest lecturer)
Department of Wind Energy
Resource Assessment Modelling

Related event

EGU General Assembly 2017: European GEosciences Union 2017
24/04/2017 → 28/04/2017
Vienna, Austria
Activity: Talks and presentations › Conference presentations

Exploring the perspectives in aeroelastic tailoring of blades
Period: 6 Apr 2017
Flemming Rasmussen (Invited speaker)
Department of Wind Energy
Aerodynamic design
Degree of recognition: International

Related event

IQPC Conference 2017 - Advances in Rotor Blades for Wind Turbines
05/04/2017 → 07/04/2017
Bremen, Germany
Activity: Talks and presentations › Conference presentations

Wake Conference 2017 (Event)
Period: Mar 2017 → Apr 2017
Mark C. Kelly (Reviewer)
Department of Wind Energy
Resource Assessment Modelling

Description
Reviewed 2 papers
Degree of recognition: International

Related event

Wake Conference 2017
30/05/2017 → 01/06/2017
Visby, Sweden
Activity: Research › Peer review of manuscripts

Extreme winds
Period: 30 Mar 2017
Merete Badger (Invited speaker)
Xiaoli Guo Larsén (Other)
Jianting Du (Other)
Charlotte Bay Hasager (Other)
Nina Svensson (Other)
Department of Wind Energy
Meteorology & Remote Sensing
Resource Assessment Modelling
Degree of recognition: International

Related event

Baltic from Space Workshop: European Space Agency
29/03/2017 → 31/03/2017
Helsinki, Finland
Activity: Talks and presentations › Conference presentations

SCIENCE OF MAKING TORQUE FROM WIND (Journal)
Period: 30 Mar 2017
Ioanna Karagali (Reviewer)
Department of Wind Energy
Meteorology & Remote Sensing

Related journal

SCIENCE OF MAKING TORQUE FROM WIND
1742-6596
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447, ISI indexed (2013): ISI indexed no, Web of Science (2017): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

Remote Sensing (Journal)
Period: 29 Mar 2017
Ioanna Karagali (Reviewer)
Department of Wind Energy
Meteorology & Remote Sensing

Related journal

Remote Sensing
2072-4292
Seeing the wind with Lidar-based WindScanners  (Lidar-based wind turbine control & wind resource assessment)
Period: 23 Mar 2017
Mikael Sjöholm (Invited speaker)
Department of Wind Energy
Meteorology & Remote Sensing

Description
An invited talk about Lidar-based wind turbine control & wind resource assessment with WindScanners at a workshop about Lidar techniques organized by Dr. Xuerui Mao at the University of Nottingham.

Related event

Workshop on Lidar techniques
23/03/2017 → 23/03/2017
Nottingham, United Kingdom
Activity: Talks and presentations › Conference presentations

Mesoscale Modelling of Wind Farm Wakes: Implications for large-scale planning
Period: 17 Mar 2017
Jake Badger (Guest lecturer)
Patrick Volker (Other)
Andrea N. Hahmann (Other)
Hans Ejsing Jørgensen (Other)
Department of Wind Energy
Resource Assessment Modelling
Meteorology & Remote Sensing
Degree of recognition: International

Related event

WindEurope Resource Assessment Workshop 2017
16/03/2017 → 17/03/2017
Edinburgh, United Kingdom
Activity: Talks and presentations › Conference presentations

Wind resource error estimation from mesoscale modeling for the Wind Atlas for South Africa
Period: 17 Mar 2017
Andrea N. Hahmann (Guest lecturer)
Niels Gylling Mortensen (Guest lecturer)
Patrick Volker (Guest lecturer)
Department of Wind Energy
Resource Assessment Modelling
Documents:
WindEurope-RA17-Poster

Related event

WindEurope Resource Assessment Workshop 2017
16/03/2017 → 17/03/2017
Edinburgh, United Kingdom
Activity: Talks and presentations › Conference presentations
Towards a New European Wind Atlas: WRF Sensitivity Experiments and the Mesoscale-to-Microscale Model Chain
Period: 16 Mar 2017
Andrea N. Hahmann (Guest lecturer)
Alfredo Peña (Guest lecturer)
Rogier Ralph Floors (Guest lecturer)
Xiaoli Guo Larsén (Guest lecturer)
Department of Wind Energy
Meteorology & Remote Sensing
Degree of recognition: International
Documents:
NEWA_WindEurope-TechWorkshop2017_forweb

Related event

WindEurope Resource Assessment Workshop 2017
16/03/2017 → 17/03/2017
Edinburgh, United Kingdom
Activity: Talks and presentations › Conference presentations

Copernicus Training and Information Session in Denmark, Aarhus, 9 Mar 2017
Period: 9 Mar 2017
Merete Badger (Participant)
Department of Wind Energy
Meteorology & Remote Sensing
Degree of recognition: National
Links:

Related event

Copernicus Training and Information Session in Denmark, Aarhus, 9 Mar 2017
09/03/2017 → 09/03/2017
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

SCIENCE OF MAKING TORQUE FROM WIND (Journal)
Period: 3 Mar 2017
Ioanna Karagali (Reviewer)
Department of Wind Energy
Meteorology & Remote Sensing

Related journal

SCIENCE OF MAKING TORQUE FROM WIND
1742-6596
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447, ISI indexed (2013): ISI indexed no, Web of Science (2017): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

Investigation of the flow in a rain erosion tester
Period: 27 Feb 2017
Christian Bak (Speaker)
Niels N. Sørensen (Other)
Anders Smærup Olsen (Other)
Jakob listed Bech (Other)
Mac Gaunaa (Other)
Yukihiro Kusano (Other)

Department of Wind Energy
Aerodynamic design
Composites and Materials Mechanics

Description
Presentation on the workshop about erosion of wind turbine blades
Degree of recognition: National

Related event
Erosion Day Workshop
27/02/2017 → 27/02/2017
Roskilde, Denmark
Activity: Talks and presentations › Conference presentations

CFD for Atmospheric Flows and Wind Engineering
Period: 24 Feb 2017
Niels N. Sørensen (Guest lecturer)
Department of Wind Energy
Aerodynamic design

Description
Lecture Series 2016-2017
Documents:
presentation
Links:
https://www.vki.ac.be/index.php/component/jevents/eventdetail/425/259%7C258%7C257%7C251%7C252%7C256%7C255%7C253%7C254%7C278%7C280/cfd-for-atmospheric-flows-and-wind-engineering?Itemid=329&filter_reset=1

Related external organisation
von Karman Institute for Fluid Dynamics
Belgium
Activity: Talks and presentations › Guest lectures, external teaching and course activities at other universities

Applied Acoustics (Journal)
Period: 10 Feb 2017
Oliver Ackermann Lyloff (Reviewer)
Acoustic Technology
Department of Wind Energy
Aerodynamic design
Degree of recognition: International

Related journal
Applied Acoustics
0003-682X
Central database
Activity: Research › Peer review of manuscripts

Applied Micrometeorology: Resource Assessment (Uni.Stuttgart)
Period: 8 Feb 2017 → 9 Feb 2017
Mark C. Kelly (Guest lecturer)
Department of Wind Energy
Resource Assessment Modelling

Description
Part of Stuttgart Wind Energy course; connect meteorological and industry concepts to application, using WAsP also.

Related external organisation
Universität Stuttgart
Germany
Activity: Talks and presentations › Guest lectures, external teaching and course activities at other universities

Environmental Research Letters (Journal)
Period: 1 Feb 2017 → 1 Aug 2017
Patrick Volker (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International

Related journal
Environmental Research Letters
1748-9326
Indexed in DOAJ
Central database
Activity: Research › Peer review of manuscripts

American Meteorological Society. Bulletin (Journal)
Period: Jan 2017 → Apr 2017
Mark C. Kelly (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International

Related journal
Bulletin of the American Meteorological Society
0003-0007
Central database
Activity: Research › Peer review of manuscripts

3D WindScanner - målinger af vind og turbulens omkring vindmøller, bygninger og broer
Period: 31 Jan 2017
Torben Krogh Mikkelsen (Invited speaker)
Department of Wind Energy
Meteorology & Remote Sensing

Description
Dansk Selskab for Bygningsstatik - medlemsmøde
Tirsdag d. 31. januar 2017, kl. 17:00 – ca. 18:30

Dansk Selskab for Bygningsstatik
Related external organisation

Unknown external organisation
Activity: Talks and presentations › Conference presentations

31761 Renewables in Electricity Markets
Period: 30 Jan 2017 → 8 May 2017
Elliot Simon (Course lecturer)
Department of Wind Energy
Meteorology & Remote Sensing

Description
Graduate Teaching Assistant with Professor Pierre Pinson
Degree of recognition: National
Links:
http://kurser.dtu.dk/course/2014-2015/31761 (Renewables in Electricity Markets Course Description)

Related event

31761 Renewables in Electricity Markets
30/01/2017 → 08/05/2017
Lyngby, Denmark
Activity: Other

Effect of atmospheric boundary layer top and capping inversion properties on mean wind profiles
Period: 30 Jan 2017 → 30 Jun 2017
Mark C. Kelly (Main supervisor)
Jørgen Højstrup (External examiner)
Jacob Berg (Supervisor)
Department of Wind Energy
Resource Assessment Modelling

Description
The thesis studies the inversion capped neutral (conditionally neutral) atmospheric boundary layer. The effect of the potential temperature inversion on the mean wind speed profile is analyzed using the data from seventeen LES simulations. The averaged turbulent quantities profiles are presented, explained and the relevant dimensional groupings to obtain dimensionless functions are investigated. Based on this observations three solutions for the mean speed profile have been obtained: analytic, semi-empirical and from similarity theory. The last is the most reliable and is obtained using Buckingham Pi theorem twice. First, to obtain an expression for the entrainment heat flux based on surface and ABL-top parameters. Then this expression is used in a second similarity theory where the choice of the groupings is analogous to Monin-Obukhov’s with the difference that the heat flux profile is used rather than the surface heat flux. This allows to identify two dimensionless groups. These two groups are related by very similar functions and the existence of a universal function that relates the two groups has been assumed and found. This allows to express the mean wind speed profile as $S(z) = (u^*/B) \ln(z/z_0)+c(z/B)^2$. This formulation ensures maximum errors within 5% percent, up to 80% of the boundary layer height when compared to LES results.
Degree of recognition: National
Activity: Examinations and supervision › Supervisor activities

From gusts to turbulence: vertical structure
Period: 30 Jan 2017 → 21 Jul 2017
Mark C. Kelly (Main supervisor)
Jørgen Højstrup (External examiner)
Joachim Peinke (Supervisor)
Ásta Hannesdóttir (Supervisor)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International
Activity: Examinations and supervision › Supervisor activities
IEC 61400-15 meeting/workshop 10 (Event)
Period: 23 Jan 2017 → 26 Jan 2017
Mark C. Kelly (Member)
Department of Wind Energy
Resource Assessment Modelling

Description
IEC 61400-15 workshop and creation of standard for uncertainty in resource assessment. I am an active author of and contributor to drafts. In this meeting I wrote/edited more of uncertainty-combination section and taught uncertainty combination, helping to create industrial spreadsheet; modified/augmented vertical-extrapolation section, and contributed to VMM section.
Degree of recognition: International

Related event
IEC 61400-15 meeting/workshop 10
23/01/2017 → 26/01/2017
Boulder, United States
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

AMS 97th Annual Meeting
Period: 22 Jan 2017 → 28 Jan 2017
Elliot Simon (Speaker)
Department of Wind Energy
Meteorology & Remote Sensing

Description
AMS2017: Lidar Applications to the Energy Sector
Documents:
AMS-presentation-elliot-simon-final
Elliot-AMS-Presentation-Recording
Links:
https://ams.confex.com/ams/97Annual/webprogram/Paper314118.html (Abstract and recorded presentation)

Related event
AMS 97th Annual Meeting: Eighth Conference on Weather, Climate, Water and the New Energy Economy
22/01/2017 → 27/01/2017
Seattle, United States
Activity: Talks and presentations › Conference presentations

AMS Renewable Energy Committee (External organisation)
Period: 22 Jan 2017 → …
Elliot Simon (Participant)
Department of Wind Energy
Meteorology & Remote Sensing
Degree of recognition: International

Related external organisation
AMS Renewable Energy Committee
45 Beacon Street, 02108, Boston, United States
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

Load conditions for wind turbines based on tall-tower observations at forested sites
Period: 20 Jan 2017 → 30 Jun 2017
Ebba Dellwik (Main supervisor)
Supervision of MSc student

**Conceptual optimal design of jackets**
Period: 18 Jan 2017 → 20 Jan 2017
Kasper Sandal (Speaker)
Department of Wind Energy
Wind Turbine Structures and Component Design
Degree of recognition: International

**Related event**
**EERA DeepWind 2017**
18/01/2017 → 20/01/2017
Trondheim, Norway
Activity: Talks and presentations › Conference presentations

**European perspective on wind energy research aimed at reducing the cost of wind energy through advances in wind plant flow physics, modeling and understanding.**
Period: 10 Jan 2017
Flemming Rasmussen (Invited speaker)
Department of Wind Energy
Aerodynamic design
Degree of recognition: International

**Related event**
**AIASScTech Forum 2017; Wind Energy Symposium**
09/01/2017 → 13/01/2017
Grapevine, United States
Activity: Talks and presentations › Conference presentations

**Multi-fidelity optimization of horizontal axis wind turbines**
Period: 9 Jan 2017
Michael McWilliam (Speaker)
Frederik Zahle (Other)
Christian Pavese (Other)
Department of Wind Energy
Aerodynamic design
Documents:
AIASSA_Presentation_on_AMMF
multi_fidelity_wind_turbine_optimization

**Related event**
**2017 AIASSA Science and Technology Forum and Exposition**
09/01/2017 → 13/01/2017
Grapevine, Texas, United States
Activity: Talks and presentations › Conference presentations

**Energies (Journal)**
Period: 1 Jan 2017 → 1 Feb 2017
Patrick Volker (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International
Links:
http://www.mdpi.com/1996-1073/10/1/125 (link to article)

**Related journal**

**Energies**
1996-1073
Indexed in DOAJ
Central database
Activity: Research › Peer review of manuscripts

**IEC (International Electrotechnical Commission) (External organisation)**
Period: 1 Jan 2017 → 31 Dec 2017
Mark C. Kelly (Member)
Department of Wind Energy
Resource Assessment Modelling

**Description**
I am an active author of content, using research, industrial experience and interaction.

**Related external organisation**

**Journal of Renewable and Sustainable Energy (Journal)**
Period: 1 Jan 2017 → 1 Feb 2017
Patrick Volker (Reviewer)
Department of Wind Energy
Lidar and MCP in wind resource estimations above measurement-mast height

Period: 1 Jan 2017 → 1 Aug 2017

Mark C. Kelly (Main supervisor)
G.J.W. van Bussel (External examiner)
W.A.A.M. Bierbooms (Supervisor)
Niels-Erik Clausen (Internal examiner)
Ardaan Walvis (Supervisor)

Department of Wind Energy

Resource Assessment Modelling
Integration & Planning

Description
Tall wind turbines require assessment of wind resources above typical heights of measurement masts. Lidar is becoming a popular tool for measuring over expected turbine rotor heights, but it is generally not yet feasible to use lidar for more than a few months in industrial wind farm developments. This project focuses on how lidar measurements, in combination with MCP, can be used in wind resource assessment

Degree of recognition: International

Documents:
MSc_Thesis_Final_DTU-NielsWaars

Activity: Examinations and supervision › Supervisor activities
Related external organisation

Unknown external organisation
Activity: Talks and presentations › Conference presentations

EGU General Assembly 2016
Period: 2016
Anna Maria Semperviva (Chairman)
Department of Wind Energy
Resource Assessment Modelling
Description
ERE 3.1 Energy Meteorology Session
Degree of recognition: International

Related event

EGU General Assembly 2016
17/04/2016 → 22/04/2016
Vienna, Austria
Activity: Attending an event › Participating in or organising a conference

Energies (Journal)
Period: 2016 → …
Patrick Volker (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International
Links:
http://www.mdpi.com/1996-1073/9/1/46 (link to published article)

Related journal

Energies
1996-1073
BFI (2018): BFI-level 2, Scopus rating (2017): CiteScore 3.11 SJR 0.67 SNIP 1.34, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Indexed in DOAJ
Central database
Activity: Research › Peer review of manuscripts

Energies (Journal)
Period: 2016 → …
Patrick Volker (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Description
manuscript energies-85687, rejected
Degree of recognition: International

Related journal

Energies
1996-1073
BFI (2018): BFI-level 2, Scopus rating (2017): CiteScore 3.11 SJR 0.67 SNIP 1.34, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Indexed in DOAJ
Central database
IEC 61400-15 and TC-88 (External organisation)
Period: 2016 → …
Mark C. Kelly (Member)
Department of Wind Energy
Resource Assessment Modelling

Description
International electrotechnical commission, standard on uncertainty and site-assessment/suitability plus reporting for wind energy
lead contributor for vertical extrapolation uncertainty subgroup, co-founder of subgroups on uncertainty combination and virtual met-mast

Body type: International
Degree of recognition: International

Related external organisation
IEC 61400-15 and TC-88

I E T Renewable Power Generation (Journal)
Period: 2016 → …
Nicolaos Antonio Cutululis (Editor)
Department of Wind Energy
Integration & Planning

Description
Associate Editor

Related journal
I E T Renewable Power Generation
1752-1416
Central database
Activity: Research › Journal editor

Measnet Site Assessment Working Group (External organisation)
Period: 2016 → 2018
Niels Gylling Mortensen (Participant)
Department of Wind Energy
Resource Assessment Modelling

Description
Working group has produced the following publications in 2016:
Degree of recognition: International
Links:

Related external organisation
Measnet Site Assessment Working Group
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar
PhD course in Advanced Finite Element Simulations using Abaqus

Period: 2016

Philipp Ulrich Haselbach (Lecturer)

Department of Wind Energy

Related external organisation

Unknown external organisation

Activity: Talks and presentations › Conference presentations

PhD representative in DTU Steering Committee for gender equality and diversity (External organisation)

Period: 2016 → 2017

Kasper Sandal (Participant)

Department of Wind Energy

Office for HR

Description

Appointed member by the PhD association at DTU.

Degree of recognition: International

Links:

http://www.dtu.dk/english/About/OFFICE-of-the-PRESIDENT/Editorials/2016-June (DTU editorial describing our gender equality and diversity policy)

Related external organisation

PhD representative in DTU Steering Committee for gender equality and diversity

Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

Royal Meteorological Society. Quarterly Journal (Journal)

Period: 2016 → …

Patrick Volker (Reviewer)

Department of Wind Energy

Resource Assessment Modelling

Degree of recognition: International

Links:


Related journal

Quarterly Journal of the Royal Meteorological Society

0035-9009


Central database

Activity: Research › Peer review of manuscripts

Sådan kan man regne på husstandsmøller

Period: 2016

Andreas Bechmann (Invited speaker)

Department of Wind Energy

Resource Assessment Modelling

Documents:

Temadag 20160909 Sådan kan man regne på husstandsmøller

Related event
Husstandsmøller - Temadag: Danmarks Vindmølleforening
09/09/2016 → …
Fredericia, Denmark
Activity: Talks and presentations › Conference presentations

University of Bergen (External organisation)
Period: 2016 → 2017
Andrea N. Hahmann (Chairman)
Department of Wind Energy
Resource Assessment Modelling

Description
Member of NORCOWE advisory group
Degree of recognition: International

Related external organisation
University of Bergen
Norway
Activity: Membership › Board duties in companies, associations, or public organisations

Wind Energy Denmark 2016
Period: 2016 → …
Kasper Sandal (Speaker)
Department of Wind Energy

Description
Poster and oral presentation at Wind Energy Denmark 2016
Documents:
WED2016_KasperSandal_poster
WED2016_KasperSandal_pp

Related event
Wind Energy Denmark
26/10/2016 → 27/10/2016
Odense, Denmark
Activity: Talks and presentations › Conference presentations

Wind Energy Science (Journal)
Period: 2016
Andrea N. Hahmann (Reviewer)
Department of Wind Energy
Resource Assessment Modelling

Description
Manuscript review

Related journal
Wind Energy Science
2366-7443
Indexed in DOAJ
Central database
Activity: Research › Peer review of manuscripts

Wind Energy Science (Journal)
Period: 2016 → …
Patrick Volker (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International
Links:
https://www.wind-energ-sci.net/1/115/2016/wes-1-115-2016-discussion.html (Link to the peer review discussion)

Related journal

Wind Energy Science
2366-7443
Indexed in DOAJ
Central database
Activity: Research › Peer review of manuscripts

Boundary-Layer Meteorology (Journal)
Period: Dec 2016 → …
Mark C. Kelly (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International

Related journal

Boundary-Layer Meteorology
0006-8314
Central database
Activity: Research › Peer review of manuscripts

Wind and atmospheric stability characteristics over the Baltic Sea
Period: Dec 2016
Xiaoli Guo Larsén (External examiner)
Department of Wind Energy
Resource Assessment Modelling

Description
Licentiate Degree Defense at Uppsala University
Degree of recognition: International
Activity: Examinations and supervision › External examination

Galathea 3-ekspeditionen fejrer 10 års jubilæum: VirtuelGalathea3 e-learning
Period: 14 Dec 2016
Charlotte Bay Hasager (Participant)
Department of Wind Energy
Meteorology & Remote Sensing

Description
Ekspeditionen, som har bidraget til forskningsprojekter og undervisningsmateriale til en lang række områder, fejrer 10 års jubilæum.

Det Kongelige Danske Geografiske Selskab Galathea3 Jubilæumskonference 10 år http://rdgs.dk/galathea-3-jubilaeumskonference/

Activity: Other
VAWTs for offshore applications
Period: 14 Dec 2016
Uwe Schmidt Paulsen (Speaker)
Siri Magrethe Kalvig (Panel member)
Department of Wind Energy
Wind turbine loads & control

Description
keynotes on VAWTs for offshore applications; highlights of key issues to be addressed in combining Aqua industry with FVAWTs for Scandinavian and European applications
Degree of recognition: International
Documents:
Wind Turbine Loads and Control (LAC)a

Related event
Scandinavian Consortium for a small scale floating VAWT
14/12/2016 → 14/12/2016
Stavanger, Norway
Activity: Talks and presentations › Talks and presentations in private or public companies and organisations

Compression Fatigue Testing and Damage in UD Glass Fibre Composites
Period: 12 Dec 2016
Anthony Fraisse (Other)
Povl Brendsted (Speaker)
Department of Wind Energy
Composites and Materials Mechanics

Description
The objective of this project was to optimize the geometry of compression fatigue specimens. FEM, and experimental parametrical study have been performed in order to define a possible geometry. Repeatable and representative results were achieved and damage mechanisms were identified by performing 3D Tomography ex situ study.
Degree of recognition: International
Documents:
3.2.+DTU+Wind+Energy

Related event
Wind Turbine Blade Manufacturer
12/09/2016 → 14/09/2016
Düsseldorf, Germany
Activity: Talks and presentations › Conference presentations

COST Action TOPROF Workshop
Period: 2 Dec 2016
Sven-Erik Gryning (Speaker)
Ekaterina Batchvarova (Other)
Department of Wind Energy
Resource Assessment Modelling

Description
WRF model evaluation based on wind lidar profiles (Sven-Erik Gryning and Ekaterina Batchvarova)

Related event
COST Action TOPROF Workshop: Evaluation and Data Assimilation in Atmospheric Models using Automatic-Lidar-and-Ceilometer Measurements
COST Action TOPROF Workshop
Period: 2 Dec 2016
Sven-Erik Gryning (Speaker)
Department of Wind Energy
Resource Assessment Modelling

Description
WRF model evaluation based on wind lidar profiles (Sven-Erik Gryning and Ekaterina Batchvarova)

Related event
COST Action TOPROF Workshop: Evaluation and Data Assimilation in Atmospheric Models using Automatic-Lidar-and-Ceilometer Measurements
01/12/2016 → 02/12/2016
Paris, France
Activity: Talks and presentations › Conference presentations

O-B analysis for ceilometers
Period: 1 Dec 2016 → 2 Dec 2016
Sven-Erik Gryning (Speaker)
Department of Wind Energy
Resource Assessment Modelling

Description
WRF model evaluation based on wind-lidar profiles

http://www.toprof.imaa.cnr.it/index.php/sub-working-group/56-2016-12-01-swg-1-4-o-b-analysis-for-ceilometers

TOPROF (COST Action ES1303)
Workshop 1-2 December
O-B analysis for ceilometers
Place: IPSL, Paris, France

Related event
O-B analysis for ceilometers
01/12/2016 → 02/12/2016
Paris, France
Activity: Talks and presentations › Conference presentations

Wind Energy at Nygårdsfjæææt - Norway
Period: Nov 2016
Xiaoli Guo Larsén (External examiner)
Department of Wind Energy
Resource Assessment Modelling

Description
PhD defense by Muhammad Bilal from The Arctic University of Norway
Degree of recognition: International
Activity: Examinations and supervision › External examination

Satellite data used in the New European Wind Atlas
Period: 29 Nov 2016
Charlotte Bay Hasager (Lecturer)
Department of Wind Energy
Meteorology & Remote Sensing

Description
Authors: Charlotte Hasager
Merete Badger
Ioanna Karagali
Tobias Ahsbahs
Poul Astrup
Andrea Hahmann
Patrick Volker
Xiaoli Guo Larsén
Jakob Mann

Related event
VindkraftNet: November 2016
Malmö, Sweden
Activity: Talks and presentations › Conference presentations

WEng [WAsP-Engineering] course
Mark C. Kelly (Lecturer)

Department of Wind Energy
Resource Assessment Modelling
Risø National Laboratory for Sustainable Energy
Meteorology

Description
Course on site-assessment and site-suitability (turbulence, extremes, terrain) using WAsP-Engineering [WEng'], for both DTU graduate students and commercial industrial participants.

Related organisation
WEng [WAsP-Engineering] course
Kelly, M. C. (Lecturer)
28 Nov 2016 → 30 Nov 2016
Activity: Talks and presentations › Guest lectures, external teaching and course activities at other universities

Retrospective aspects of DeepWind (ANFSCD) by Uwe Schmidt Paulsen
Period: 23 Nov 2016
Uwe Schmidt Paulsen (Keynote speaker)

Department of Wind Energy
Wind turbine loads & control

Description
This presentation was performed on the initiative and invitation made by the SUPERGEN Wind General Assembly, focusing primarily on the offshore environment and held at Cranfield University Nov 2016. This free event showcases wind energy research carried out by universities within the EPSRC's SUPERGEN Wind Hub Consortium, focussing primarily on the offshore environment. The Hub encourages researchers, commercial and industrial organisations working in the UK to come along and network with other organisations working in wind energy. The presentation highlights on the development process and design of a conceptual 5 MW floating vertical-axis Wind turbine for offshore operations in Deep Sea. The results presented are outcomes from the European Commision financed FP7 project under the program 'future emerging technologies'

Degree of recognition: International
Documents:
Cranfield_v1
Related event

SUPERGEN Wind General Assembly 2016-Topic: Novel Turbines: Deepwind
Cranfield, United Kingdom
Activity: Talks and presentations › Talks and presentations in private or public companies and organisations

EERA Workshop
Period: 22 Nov 2016
Sven-Erik Gryning (Speaker)
Department of Wind Energy
Resource Assessment Modelling

Description
Offshore and coastal Weibull distributions measured with lidars, lesson learnt

Related event

EERA Workshop: Joint Program Wind Energy - Sub-program Wind Conditions
Roskilde, Denmark
Activity: Talks and presentations › Conference presentations

SPICE Edition 1 - Presentation, Analysis and Perspectives
Period: 18 Nov 2016
Franck Bertagnolio (Invited speaker)
Department of Wind Energy
Aerodynamic design

Description
The Sound Propagation International Comparison Exercise aims at comparing various wind turbine noise propagation models. It takes the form of a benchmark for which a pre-defined test case is proposed to the participants. Results are compiled, analysed and presented at the Wind Turbine Sound 2016 technical workshop organized by WindEurope.

DTU Energy was responsible for the analysis of the results and F. Bertagnolio presented the results at the workshop

Related event

Wind Turbine Sound Technology Workshop 2016
17/11/2016 → 18/11/2016
Gdansk, Poland
Activity: Talks and presentations › Conference presentations

Wind-wave coupled mesoscale modelling systems for coastal extreme wind and wave conditions
Period: 17 Nov 2016
Merete Badger (Speaker)
Department of Wind Energy
Meteorology & Remote Sensing

Description
Oral presentation given on behalf of Jianiting Du

Related event
Measuring coastal winds with multiple remote sensing systems: A comparison of SAR wind retrievals and lidar wind measurements
Period: 15 Nov 2016 → 17 Nov 2016
Tobias Torben Ahsbahs (Guest lecturer)
Merete Badger (Other)
Ioanna Karagali (Other)
Xiaoli Guo Larsén (Other)
Alfredo Peña (Other)
Department of Wind Energy
Meteorology & Remote Sensing
Resource Assessment Modelling

Related event
International workshop on measuring high wind speeds over the ocean
15/11/2016 → 17/11/2016
Exeter, United Kingdom
Activity: Talks and presentations › Conference presentations

Synthetic Aperture Radar for wind energy applications: potential and challenges at high wind speeds
Period: 15 Nov 2016
Merete Badger (Speaker)
Department of Wind Energy
Meteorology & Remote Sensing

Description
Oral presentation

Related event
International workshop on measuring high wind speeds over the ocean
15/11/2016 → 17/11/2016
Exeter, United Kingdom
Activity: Talks and presentations › Conference presentations

Danish coast pilot
Period: 11 Nov 2016
Merete Badger (Speaker)
Department of Wind Energy
Meteorology & Remote Sensing

Related event
H2020 CEASELESS: Kick-off meeting
Barcelona, Spain
Activity: Talks and presentations › Conference presentations

ON-SHORE SERVICE AND MAINTENANCE
Period: 8 Nov 2016
Christian Bak (Invited speaker)
Department of Wind Energy

Aerodynamic design

**Related event**

**ON-SHORE SERVICE AND MAINTENANCE**
08/11/2016 → 08/11/2016
Aalborg, Denmark

Activity: Talks and presentations › Guest lectures, external teaching and course activities at other universities

Some experience as an evaluator of Marie Skłodowska-Curie applications
Period: 8 Nov 2016
Sven-Erik Gryning (Lecturer)

Department of Wind Energy

Resource Assessment Modelling

**Related event**

**Hvordan forbereder man-en succesfuld-Marie-Sklodowska-Curie-itn-ansøgning**
08/11/2016 → 08/12/2016
Copenhagen, Denmark

Activity: Talks and presentations › Conference presentations

Approaches to characterize forest structures for wind resource assessment using airborne laser scan data
Period: 1 Nov 2016 → 30 Jun 2017
Ebba Dellwik (Main supervisor)

Department of Wind Energy

Meteorology & Remote Sensing

**Description**
Erasmus+ student
Degree of recognition: International
Activity: Examinations and supervision › Supervisor activities

**European Commission (External organisation)**
Andrea N. Hahmann (Participant)

Department of Wind Energy

Resource Assessment Modelling

**Description**
Evaluation of Research Proposals
Degree of recognition: International

**Related external organisation**

**European Commission**
Belgium
Activity: Membership › Membership in review committee

**Wind resource error estimation from mesoscale modeling for the Wind Atlas for South Africa**
Period: 31 Oct 2016
Andrea N. Hahmann (Guest lecturer)
Patrick Volker (Guest lecturer)
Jens Carsten Hansen (Guest lecturer)

Department of Wind Energy
Resource Assessment Modelling
Integration & Planning
Degree of recognition: International
Documents:
WindAc_2016

Related event

WINDAc Africa 2016
31/10/2016 → 01/11/2016
Cape Town, South Africa
Activity: Talks and presentations › Conference presentations

Wind Energy Denmark
Period: 27 Oct 2016
Christian Bak (Invited speaker)
Department of Wind Energy
Aerodynamic design

Related event

Wind Energy Denmark
26/10/2016 → 27/10/2016
Odense, Denmark
Activity: Talks and presentations › Conference presentations

The use of WindScanners in wind energy – Overview and status of WindScanners technology
Period: 26 Oct 2016
Torben Krogh Mikkelsen (Lecturer)
Department of Wind Energy
Meteorology & Remote Sensing

Description
New remote sensing wind measurement technologies are presented, which take verification of models to a new stage where the difference in physics of the models and measurements can be revealed in much larger detail, potentially making conventional towers obsolete in the future.

Links:

Related event

Wind Energy Denmark
26/10/2016 → 27/10/2016
Odense, Denmark
Activity: Talks and presentations › Conference presentations

Wind Energy Denmark
Period: 26 Oct 2016
Asger Bech Abrahamsen (Organizer)
Department of Wind Energy

Description
Battle of teh wind generators Workshop at Wind Energy Denmark 2016, Odense 26-27 October (2016) Conference day: Day 1 - Wednesday Date: 26 October, 2016 Time: 14.00 - 15.15 CET Keywords: Superconductor wind turbine generators, direct drive generators, medium speed drive trains Description: What are the options for the future generators of the wind industry? Will copper and silicon steel do? Should we use more advanced materials like permanent magnets or even superconductors? In this session, the findings of the INNWIND.EU project on superconducting direct drive and pseudo magnetic direct drive will be presented together with state-of-the-art drivetrain technologies. A workshop debate will

Battle of the wind generators
Workshop as part of Wind Energy Denmark 2016, Odense 26-27 October (2016)
Documents:
Battle of the drive trains @ WindEnergyDenmark2016
Links:

Related event

Wind Energy Denmark
26/10/2016 → 27/10/2016
Odense, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Norwegian University of Science and Technology
Kasper Sandal (Visiting researcher)
Department of Wind Energy

Description
Research stay at NTNU, Norway
Collaboration on optimal design of jackets within the research project ABYSS
Activity: Visiting an external institution › Visiting another research institution

Blade Inspection Damage and Repair Forum
Period: 10 Oct 2016
Christian Bak (Invited speaker)
Department of Wind Energy
Aerodynamic design

Related event

Blade Inspection Damage and Repair Forum
10/10/2016 → 11/10/2016
Amsterdam, Netherlands
Activity: Talks and presentations › Conference presentations

International Technical Meeting on Air Pollution Modelling and Its Application
Sven-Erik Gryning (Participant)
Department of Wind Energy
Resource Assessment Modelling

Related event

35th International Technical Meeting on Air Pollution Modelling and Its Application
03/10/2016 → 07/10/2016
Chania, Greece
Activity: Attending an event › Participating in or organising a conference

**Wind Europe Summit 2016**
Period: 29 Sep 2016
Alexander Meyer Forsting (Participant)
Department of Wind Energy
Aerodynamic design

**Related event**

**Wind Europe Summit 2016**
26/09/2016 → 29/09/2016
Hamburg, Germany
Activity: Attending an event › Participating in or organising a conference

**Framework of Multi-Objective Wind Farm Controller Applicable to Real Wind Farms**
Period: 28 Sep 2016
Jonas Kazda (Guest lecturer)
Tuhfe Göçmen (Guest lecturer)
Gregor Giebel (Guest lecturer)
Michael Courtney (Guest lecturer)
Nicolaos Antonio Cutululis (Guest lecturer)
Department of Wind Energy
Integration & Planning
Test and Measurements
Degree of recognition: International

**Related event**

**Wind Europe Summit 2016**
26/09/2016 → 29/09/2016
Hamburg, Germany
Activity: Talks and presentations › Conference presentations

**Wind Europe Summit 2016**
Period: 27 Sep 2016
Merete Badger (Participant)
Department of Wind Energy
Meteorology & Remote Sensing

**Description**
Wind Europe Exhibition

**Related event**

**Wind Europe Summit 2016**
26/09/2016 → 29/09/2016
Hamburg, Germany
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

**Wind Europe Summit 2016**
Period: 26 Sep 2016 → 29 Sep 2016
Antoine Borracino (Participant)
Department of Wind Energy
Meteorology & Remote Sensing
Description
V infinity is found! (Near flow measurements with nacelle lidars: the future of power performance verification?)

Wind Europe Summit 2016
Documents:
20160909_NearFlow_PCV_naclidars_ABorraccino_UniTTe_website
Links:
http://www.unitte.dk/nyheder/nyhed?id=2E6ED207-A0F7-4240-8945-AFE7E0670542 (UniTTe at the WindEurope Summit 2016)

Related event
Wind Europe Summit 2016
26/09/2016 → 29/09/2016
Hamburg, Germany
Activity: Attending an event › Participating in or organising a conference

ScanFlow: High-resolution full-scale wind field measurements of the ECN’s 2.5 MW aerodynamic research wind turbine using DTU’s 3D WindScanner and SpinnerLidar for iRPWind’s and EERA’s benchmark
Period: 19 Sep 2016
Charlotte Bay Hasager (Lecturer)
Department of Wind Energy
Meteorology & Remote Sensing

Description
Authors Charlotte Hasager, Torben Mikkelsen, Nikolas Angelou, Alfredo Peña, Gregor Giebel (DTU), Jan Willem Wagenaar, Gerard Schepers, Erwin Werkhoven (ECN)
Documents:
ScanFlow-iRPWIND-Hasager-et-al2016

Related event
iRPWIND Conference 2016
19/09/2016 → 20/09/2016
Amsterdam, Netherlands
Activity: Talks and presentations › Conference presentations

Journal of Geophysical Research - Part C - Ocean (Journal)
Period: 16 Sep 2016
Ioanna Karagali (Reviewer)
Department of Wind Energy
Meteorology & Remote Sensing

Related journal
Journal of Geophysical Research - Part C - Ocean
Local database
Activity: Research › Peer review of manuscripts

The single tree experiment: 16th EMS Annual Meeting & 11th European Conference on Applied Climatology (ECAC)
Period: 16 Sep 2016
Ebba Dellwik (Lecturer)
Department of Wind Energy
Meteorology & Remote Sensing

Description
Conference presentation
Documents:
16th EMS Annual Meeting & 11th European Conference on Applied Climatology
Period: 15 Sep 2016
Elliot Simon (Speaker)
Department of Wind Energy
Meteorology & Remote Sensing

Description
Oral Presentation in Energy Meteorology Session at EMS

Related event
16th EMS Annual Meeting & 11th European Conference on Applied Climatology
12/09/2016 → 16/09/2016
Trieste, Italy
Activity: Talks and presentations › Conference presentations

16th EMS Annual Meeting & 11th European Conference on Applied Climatology
Period: 15 Sep 2016
Sven-Erik Gryning (Speaker)
Department of Wind Energy
Resource Assessment Modelling

Description
A hybrid model for the wind profile (direction and speed) for the whole boundary layer (Sven-Erik Gryning and Ekaterina Batchvarova)

Related event
16th EMS Annual Meeting & 11th European Conference on Applied Climatology
12/09/2016 → 16/09/2016
Trieste, Italy
Activity: Talks and presentations › Conference presentations

16th EMS Annual Meeting & 11th European Conference on Applied Climatology
Period: 15 Sep 2016
Sven-Erik Gryning (Chairman)
Department of Wind Energy
Resource Assessment Modelling

Description
Convener at several sessions

Related event
16th EMS Annual Meeting & 11th European Conference on Applied Climatology
12/09/2016 → 16/09/2016
Trieste, Italy
Activity: Attending an event › Participating in or organising a conference
Assessing the quality of Synthetic Aperture Radar (SAR) wind retrieval in coastal zones using multiple Lidars
Period: 12 Sep 2016 → 16 Sep 2016
Tobias Torben Ahsbahs (Speaker)
Merete Badger (Speaker)
Ioanna Karagali (Speaker)
Xiaoli Guo Larsén (Speaker)
Department of Wind Energy
Meteorology & Remote Sensing
Resource Assessment Modelling
Documents:
presentationEMS2016Tobias

Related event

16th EMS Annual Meeting & 11th European Conference on Applied Climatology
12/09/2016 → 16/09/2016
Trieste, Italy
Activity: Talks and presentations › Conference presentations

WRF idealized-roughness response: PBL scheme and resolution dependence
Period: 12 Sep 2016 → 16 Sep 2016
Mark C. Kelly (Speaker)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International

Related event

16th EMS Annual Meeting & 11th European Conference on Applied Climatology
12/09/2016 → 16/09/2016
Trieste, Italy
Activity: Talks and presentations › Conference presentations

A review of state-of-the-art in torque generation and control of floating vertical-axis wind turbines
Period: 7 Sep 2016 → 9 Sep 2016
Uwe Schmidt Paulsen (Keynote speaker)
Department of Wind Energy
Wind turbine loads & control

Description
Large-scale floating vertical axis wind turbines have great potential for offshore applications. This presentation will review recent developments for generating torque and controlling vertical-axis wind turbines (VAWTs) specifically for floating applications. The phenomena presented include dynamic stall and pitching of the blades, as well as design of airfoils for VAWT applications.
Held at the Euromech 2016 colloquium hosted by TUDelft 7-9 September in Delft, The Nederlands
Degree of recognition: International
Documents:
A review of state-of-the-art in torque generation and control

Related external organisation

Euromech
Laboratoire de Mécanique et d’Acoustique Impasse Nikola Tesla CS 40006, 13453, Marseille, France
Activity: Talks and presentations › Conference presentations

Digital Master Programme in Wind Energy: A new initiative for continuing education
Period: 29 Aug 2016
Merete Badger (Speaker)
Department of Wind Energy
Meteorology & Remote Sensing

Related event

Følgegruppen for kandidatuddannelsen i Vindenergi
29/08/2016 → 29/08/2016
Roskilde, Denmark
Activity: Talks and presentations › Conference presentations

DHL Global Forwarding seminar
Period: 26 Aug 2016
Charlotte Bay Hasager (Organizer)
Department of Wind Energy
Meteorology & Remote Sensing

Description
DHL Global Forwarding. Seminar program. Lecturers Flemming Rasmussen, Christian Bak, Hilmar Kjartansson Danielsen, Poul Hummelshøj, Søren O. Lind

DHL Global Forwarding seminar

Related event

DHL Global Forwarding seminar
26/08/2016 → 26/08/2016
Roskilde, Denmark
Activity: Attending an event › Participating in or organising a conference

Assessment of the Wind Power Production Potential in the North Sea
Period: 24 Aug 2016
Jens Nørkær Sørensen (Invited speaker)
Department of Wind Energy
Fluid Mechanics

Related event

2nd INTERNATIONAL CONFERENCE ON NEXT GENERATION WIND ENERGY, Lund University, Sweden. August 24-26.
24/08/2016 → 26/08/2016
Lund, Sweden
Activity: Talks and presentations › Conference presentations

24th International Congress of Theoretical and Applied Mechanics
Susana Rojas Labanda (Participant)
Department of Wind Energy

Description
On slowly moving boundaries in density based structural topology optimization

24th International Congress of Theoretical and Applied Mechanics (ICTAM 2016)
Oral presentation
Documents:
On slowly moving boundaries in density based structural topology optimization

Related event
DESCOTLO
Period: 1 Aug 2016 → 22 Dec 2016
Ioanna Karagali (Consultant)
Rogier Ralph Floors (Consultant)
Andrea Vignaroli (Consultant)
Jakob Mann (Consultant)
Department of Wind Energy
Meteorology & Remote Sensing
Resource Assessment Modelling
Test and Measurements

Description
Design Conditions for Tower Loads

Related external organisation
Vestas Wind Systems (DK)
Activity: Public and private sector consultancy › Consultancy

Remote Sensing (Journal)
Period: 27 Jul 2016
Ioanna Karagali (Reviewer)
Department of Wind Energy
Meteorology & Remote Sensing

Related journal
Remote Sensing
2072-4292
Indexed yes
Indexed in DOAJ
Central database
Activity: Research › Peer review of manuscripts

Education and E-learning
Period: 7 Jul 2016
Merete Badger (Speaker)
Department of Wind Energy
Meteorology & Remote Sensing

Related event
Visit from Vestas
07/07/2016 → 07/07/2016
Roskilde, Denmark
Activity: Talks and presentations › Conference presentations

IEC 61400-15 meeting/workshop 8 (Event)
Mark C. Kelly (Member)
Department of Wind Energy

Resource Assessment Modelling

**Description**
IEC 61400-15 workshop and creation of standard for uncertainty in resource assessment. I am an active author of drafts. In this meeting I explained vertical-extrapolation uncertainty model and modified it and the draft per industry requests.

Degree of recognition: International

**Related event**

**IEC 61400-15 meeting/workshop 8**
07/06/2016 → 07/10/2016
Skærbæk, Denmark
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

**WEMC / UK Met Office / Europias Workshop on Climate and Energy**
Period: 4 Jul 2016 → 7 Jul 2016
Elliot Simon (Participant)
Department of Wind Energy
Meteorology & Remote Sensing

**Description**
WEMC / UK Met Office / Europias Workshop on Climate and Energy

**Related event**

**WEMC / UK Met Office / Europias Workshop on Climate and Energy**
04/07/2016 → 07/07/2016
Norwich, United Kingdom
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

**SCIENCE OF MAKING TORQUE FROM WIND (Journal)**
Period: 30 Jun 2016
Ioanna Karagali (Reviewer)
Department of Wind Energy
Meteorology & Remote Sensing

**Related journal**

**SCIENCE OF MAKING TORQUE FROM WIND**
1742-6596
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447, ISI indexed (2013): ISI indexed no, Web of Science (2017): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

**DanmarksNationaleVindtunnel: Præsentation ved "Første spadestik" 22. juni 2016**
Period: 22 Jun 2016
Christian Bak (Invited speaker)
Department of Wind Energy
Aerodynamic design

**Related event**

**Første spadestik til den Nationale Vindtunnel**
22/06/2016 → 22/06/2016
Roskilde, Denmark
Activity: Talks and presentations › Conference presentations
Sizing optimization of frame structures subjected to dynamic stress constraints
Period: 21 Jun 2016
Alexander Verbart (Speaker)
Kasper Sandal (Other)
Mathias Stolpe (Other)
Department of Wind Energy
Wind Turbine Structures and Component Design
Degree of recognition: International

Related event
5th International Conference of Engineering Optimization
19/06/2016 → 23/06/2016
Foz de Iguassu, Brazil
Activity: Talks and presentations › Conference presentations

Stress Constraint Aggregation without Constraint Relaxation in Topology Optimization
Period: 21 Jun 2016
Alexander Verbart (Speaker)
Mathijs Langelaar (Other)
Fred van Keulen (Other)
Department of Wind Energy
Wind Turbine Structures and Component Design
Degree of recognition: International

Related event
5th International Conference of Engineering Optimization
19/06/2016 → 23/06/2016
Foz de Iguassu, Brazil
Activity: Talks and presentations › Conference presentations

5th International Conference of Engineering Optimization
Period: 20 Jun 2016
Susana Rojas Labanda (Participant)
Department of Wind Energy

Description
Solving large-scale structural topology optimization problems using second-order methods

Oral presentation
Documents:
Solving large-scale structural topology optimization problems using a second-order interior point method

Related event
5th International Conference of Engineering Optimization
19/06/2016 → 23/06/2016
Foz de Iguassu, Brazil
Activity: Attending an event › Participating in or organising a conference

5th International Conference of Engineering Optimization
Alemseged Gebrehiwot Weldeyesus (Speaker)
Department of Wind Energy
Related event

5th International Conference of Engineering Optimization
Period: 19/06/2016 → 23/06/2016
Foz de Iguassu, Brazil
Activity: Talks and presentations › Conference presentations

16th EMS Annual Meeting & 11th European Conference on Applied Climatology
Period: 14 Jun 2016
Sven-Erik Gryning (Organizer)
Department of Wind Energy
Resource Assessment Modelling

Description
Convener for session on Energy Meteorology

Related event

16th EMS Annual Meeting & 11th European Conference on Applied Climatology
Period: 12/09/2016 → 16/09/2016
Trieste, Italy
Activity: Attending an event › Participating in or organising a conference

Rapid upgrading through experimental (self-)disruptive impasse: The case of China's wind turbine industry
Period: 12 Jun 2016
Julia Kirch Kirkegaard (Invited speaker)
Department of Wind Energy
Integration & Planning

Related event

International Conference - Innovation and Social Development in China
Period: 12/06/2016 → 15/06/2016
Guangzhou, China
Activity: Talks and presentations › Conference presentations

Using SST for improved mesoscale modelling of the coastal zone
Period: 10 Jun 2016
Ioanna Karagali (Speaker)
Department of Wind Energy
Meteorology & Remote Sensing
Documents:
Karagali_RUNE

Related event

GHRSSST Science Team Meeting XVII
Period: 05/06/2016 → 10/06/2016
Washington, United States
Activity: Talks and presentations › Conference presentations

ISARS2016
Period: 8 Jun 2016
Sven-Erik Gryning (Chairman)
Department of Wind Energy
Resource Assessment Modelling

Description
Ground-Based Remote Sensing Technology Applications

Related event
ISARS2016: 18th International Symposium for the Advancement of boundary-layer Remote Sensing
06/06/2016 → 09/06/2016
Varna, Bulgaria
Activity: Attending an event › Participating in or organising a conference

Winning the Wind Back during a Market—Quake: The Politics of Wind Power Marketization in China
Period: 8 Jun 2016 → 10 Jun 2016
Julia Kirch Kirkegaard (Lecturer)
Department of Wind Energy
Integration & Planning

Description
Presentation of joint paper abstract with Professor Koray Caliskan, Bogazici University, Istanbul

Related event
4th Interdisciplinary Market Studies Workshop
08/06/2016 → 10/06/2016
St Andrews, United Kingdom
Activity: Talks and presentations › Conference presentations

ECCOMAS Congress 2016
Period: 7 Jun 2016
Alexander Meyer Forsting (Speaker)
Department of Wind Energy
Aerodynamic design

Description
Validation of a CFD model with a triple-lidarsystem upstream of a wind turbine in complex terrain

Related event
ECCOMAS Congress 2016: VII European Congress on Computational Methods in Applied Sciences and Engineering
05/06/2016 → 10/06/2016
Hersonissos, Greece
Activity: Talks and presentations › Conference presentations

ISARS2016
Period: 7 Jun 2016
Antoine Borraccino (Speaker)
Department of Wind Energy
Meteorology & Remote Sensing

Description
Wind field reconstruction from nacelle-mounted profiling lidars for power performance

Documents:
Effect of Carrier to Noise Ratio threshold filtering on the long-term wind speed and Weibull distribution parameters for a pulsed heterodyne wind-lidar

**Effect of Carrier to Noise Ratio threshold filtering on the long-term wind speed and Weibull distribution parameters for a pulsed heterodyne wind-lidar**

Period: 6 Jun 2016

Sven-Erik Gryning (Speaker)

Department of Wind Energy

**Description**

Effect of Carrier to Noise Ratio threshold filtering on the long-term wind speed and Weibull distribution parameters for a pulsed heterodyne wind lidar (Sven-Erik Gryning; Ekaterina Batchvarova, Rogier Floors and Alfredo Peña)

**Related event**

**ISARS2016: 18th International Symposium for the Advancement of boundary-layer Remote Sensing**

06/06/2016 → 09/06/2016

Varna, Bulgaria

**Activity:** Talks and presentations › Conference presentations

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GHRSST Science Team Meeting XVII

**GHRSST Science Team Meeting XVII**

Period: 5 Jun 2016 → 10 Jun 2016

Ioanna Karagali (Participant)

Department of Wind Energy

**Meteorology & Remote Sensing**

**Description**

GHRSST Science Team Meeting XVII

**Related event**

**GHRSST Science Team Meeting XVII**

05/06/2016 → 10/06/2016

Washington, United States

**Activity:** Attending an event › Participating in or organising a conference

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EuroTech Summer School 2016 @ EPFL: Energy Systems

**EuroTech Summer School 2016 @ EPFL: Energy Systems**

Elliot Simon (Participant)
Department of Wind Energy
Meteorology & Remote Sensing

Description
EuroTech Summer School 2016 @ EPFL: Energy Systems

Related event
EuroTech Summer School 2016 @ EPFL: Energy Systems
06/06/2016 → 17/06/2016
Lausanne, Switzerland
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

IEA Task 36 - Wind Forecasting (External organisation)
Period: 1 Jun 2016 → …
Elliot Simon (Participant)
Department of Wind Energy
Meteorology & Remote Sensing
Degree of recognition: International

Related external organisation
IEA Task 36 - Wind Forecasting
31-35 rue de la Fédération, 75739 , Paris Cedex 15, France
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

VindkraftNet 2016 Skærbæk, Denmark
Period: 23 May 2016
Charlotte Bay Hasager (Participant)
Department of Wind Energy
Meteorology & Remote Sensing

Description
Hasager, C.B., Badger, M., Peña, A., Hahmann, A., Volker, P.: Lifting satellite winds from 10 m to hub-height (oral presentation)

VindkraftNet meeting, Skærbæk, Denmark
Documents:
VindkraftNet-23May2016-Hasager-et-al

Related event
VindkraftNet 2016 Skærbæk, Denmark
23/05/2016 → 23/05/2016
Skærbæk, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Online teaching at DTU Wind Energy
Period: 19 May 2016
Merete Badger (Speaker)
Department of Wind Energy
Meteorology & Remote Sensing

Related event
Visit from University of Massachusets
19/05/2016 → 19/05/2016
Acoustic Day 2016
Period: 18 May 2016
Christian Bak (Organizer)
Department of Wind Energy
Aerodynamic design

Description
Christian Bak was chairman for the workshop and partly organizer

Related event
Acoustic Day 2016
18/05/2016 → 18/05/2016
Roskilde, Denmark
Activity: Attending an event › Participating in or organising a conference

Optimal Design Software for Bucket Foundations
Period: 18 May 2016
Mathias Stolpe (Invited speaker)
Department of Wind Energy
Wind Turbine Structures and Component Design

Related event
Universal Foundation Workshop 2016
18/05/2016 → 19/05/2016
Hamburg, Germany
Activity: Talks and presentations › Conference presentations

E-læring om vindenergi til fysikundervisningen i gymnasierne
Period: 17 May 2016
Merete Badger (Speaker)
Department of Wind Energy
Meteorology & Remote Sensing

Related event
Overgange i Naturfag
17/05/2016 → 17/05/2016
Roskilde, Denmark
Activity: Talks and presentations › Conference presentations

Perdigão NEWA meeting
Period: 13 May 2016
Alexander Meyer Forsting (Speaker)
Department of Wind Energy
Aerodynamic design

Description
Induction zone measurements and simulations at Perdigão

Induction zone measurements and simulations at Perdigão
Documents:
InductionZone_Web
Related event

Perdigao NEWA meeting: General meeting
10/05/2016 → 13/05/2016
Perdigão, Portugal
Activity: Talks and presentations › Conference presentations

ESA Living Planet Symposium 2016
Period: 9 May 2016 → 13 May 2016
Ioanna Karagali (Participant)
Department of Wind Energy
Meteorology & Remote Sensing

Description
ESA Living Planet Symposium

Related event

ESA Living Planet Symposium 2016
09/05/2016 → 13/05/2016
Prague, Czech Republic
Activity: Attending an event › Participating in or organising a conference

Forskningens Døgn i Roskilde
Period: 30 Apr 2016
Christian Bak (Participant)
Department of Wind Energy
Aerodynamic design

Related event

Forskningens Døgn i Roskilde 2016
30/04/2016 → 30/04/2016
Roskilde, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Period: 27 Apr 2016 → 28 Apr 2016
Torben J. Larsen (Speaker)
Department of Wind Energy
Wind turbine loads & control

Description
Documents:
HAWC2 Offshore Wind Turbine Simulations

Related event

27/04/2016 → 28/04/2016
Washington, DC 20024, United States
Activity: Talks and presentations › Conference presentations

Period: 27 Apr 2016 → 28 Apr 2016
Torben J. Larsen (Invited speaker)
Department of Wind Energy

Wind turbine loads & control

**Description**
Goals and Objectives: This workshop will provide an overview of:
- Recent efforts to develop and validate numerical modelling codes for dynamic analysis of OWT,
- Recent research efforts on geotechnical aspects of soil-structure interactions of OWT, and
- The latest wind farm/wind plant design tools.

This workshop will seek to identify ways to ensure that the current state of practice and capabilities of industry’s structural and geotechnical modelling tools and techniques are appropriately considered in the future development of U.S. offshore wind standards and regulations.

Documents:
HAWC2_pdf

**Related event**

**2016 Workshop on State of Practice for Design of Offshore Wind Energy Generation Systems In the United States**
27/04/2016 → 28/04/2016
Washington, DC 20024, United States
Activity: Talks and presentations › Guest lectures, external teaching and course activities at other universities

**DTU Wind Energy Department: Danish/Turkish Collaboration and Funds**
Period: 27 Apr 2016
Andreas Bechmann (Invited speaker)
Department of Wind Energy

Resource Assessment Modelling
Documents:
20160427 ICCI2016 A_Bechmann_DTU Wind Energy Department

**Related event**

**ICCI 2016: 22nd International Energy & Environment Fair & Conference**
27/04/2016 → 29/05/2016
Istanbul, Turkey
Activity: Talks and presentations › Conference presentations

**Aalborg University**
Period: 25 Apr 2016 → 29 Apr 2016
Kasper Sandal (Visiting researcher)
Department of Wind Energy

**Description**
Research stay at AAU: Collaboration on modelling of offshore wind turbine support structures
Activity: Visiting an external institution › Visiting another research institution

**I O P Conference Series: Earth and Environmental Science (Journal)**
Period: 25 Apr 2016
Ioanna Karagali (Reviewer)
Department of Wind Energy

Meteorology & Remote Sensing

**Related journal**

**I O P Conference Series: Earth and Environmental Science**
1755-1307
Scopus rating (2017): CiteScore 0.3 SJR 0.149 SNIP 0.327, ISI indexed (2013): ISI indexed no, Web of Science (2018): Indexed yes
Central database
E-læring om vindenergi til fysikundervisningen i gymnasierne
Period: 21 Apr 2016
Merete Badger (Speaker)
Department of Wind Energy
Meteorology & Remote Sensing

Related event
Campus Roskilde meeting
21/04/2016 → 21/04/2016
Roskilde, Denmark

I O P Conference Series: Earth and Environmental Science (Journal)
Period: 20 Apr 2016
Ioanna Karagali (Reviewer)
Department of Wind Energy
Meteorology & Remote Sensing

Related journal
I O P Conference Series: Earth and Environmental Science
1755-1307
Scopus rating (2017): CiteScore 0.3 SJR 0.149 SNIP 0.327, ISI indexed (2013): ISI indexed no, Web of Science (2018): Indexed yes
Central database

Development towards rotor blades with combined passive and distributed active load control
Period: 19 Apr 2016
Flemming Rasmussen (Invited speaker)
Department of Wind Energy
Aerodynamic design
Degree of recognition: International

Related event
IQPC Conference 2016 - Advances in Rotor Blades for Wind Turbines
19/04/2016 → 21/04/2016
Bremen, Germany
**Forskningens Døgn**
Period: 16 Apr 2016
Christian Bak (Participant)
Department of Wind Energy
Aerodynamic design

**Description**
Presentation with the title "The National Wind Tunnel" (in Danish)

**Related event**

**Forskningens Døgn**
26/04/2016 → 26/04/2016
Kgs. Lyngby, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

**Industry meets science, Stavanger, Norway**
Period: 6 Apr 2016
Torben J. Larsen (Speaker)
Department of Wind Energy
Wind turbine loads & control

**Description**
Industry meets science, Stavanger, Norway
Documents:
windturbine_loads
Links:
http://www.norcowe.no/index.cfm?id=428950

**Related event**

**Industry meets science, Stavanger, Norway**
06/04/2016 → 06/04/2016
Stavanger, Norway
Activity: Talks and presentations › Conference presentations

**Wind Turbine Loading**
Period: 6 Apr 2016
Torben J. Larsen (Invited speaker)
Department of Wind Energy
Wind turbine loads & control
Documents:
windturbine_loads

**Related event**

**Industry meets science, Stavanger, Norway**
06/04/2016 → 06/04/2016
Stavanger, Norway
Activity: Talks and presentations › Conference presentations

**Computers & Fluids (Journal)**
Period: Mar 2016 → May 2016
Mark C. Kelly (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International

Related journal

Computers & Fluids
0045-7930
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 2.76 SJR 1.077 SNIP 1.667, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

Coursera Partnership Conference
Merete Badger (Participant)
Department of Wind Energy
Meteorology & Remote Sensing
Description
Coursera partnership conference 2016

Related event

Coursera Partnership Conference
20/03/2016 → 22/03/2016
de Haag, Netherlands
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

E-learning master at DTU
Period: 18 Mar 2016
Merete Badger (Speaker)
Department of Wind Energy
Meteorology & Remote Sensing

Related event

Visit from CFWind, China
18/03/2016 → 18/03/2016
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

Challenges and perspectives in passive and active blade load control
Period: 4 Feb 2016
Flemming Rasmussen (Invited speaker)
Department of Wind Energy
Aerodynamic design
Degree of recognition: National

Related event

SmartBlades Conference
03/02/2016 → 04/02/2016
Stade, Germany
Activity: Talks and presentations › Conference presentations

IEC 61400-15 meeting/workshop 7 (Event)
Period: 2 Feb 2016 → 5 Feb 2016
Mark C. Kelly (Member)
Department of Wind Energy

Resource Assessment Modelling

Description
IEC 61400-15 workshop and creation of standard for uncertainty in resource assessment. I am an active author of drafts. In this meeting I contributed to, edited, and wrote parts of the uncertainty sections on vertical extrapolation, virtual met-mast (mesoscale), and uncertainty combination, while interacting in plenum and advising on horizontal extrapolation and site-suitability for extremes.
Degree of recognition: International

Related event
IEC 61400-15 meeting/workshop 7
02/02/2016 → 05/02/2016
San Diego, United States
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

Satellite winds for NEWA offshore: Envisat, Sentinel-1, ASCAT, and lifting method
Period: 2 Feb 2016
Merete Badger (Speaker)
Department of Wind Energy

Related event
NEWA workshop - Nordic experiment
02/02/2016 → 03/02/2016
Copenhagen, Denmark
Activity: Talks and presentations › Conference presentations

Remote sensing for offshore wind energy
Period: 29 Jan 2016
Merete Badger (Speaker)
Department of Wind Energy

Related event
Seminar at HZG
29/01/2016 → 29/01/2016
Geestacht, Germany
Activity: Talks and presentations › Conference presentations

E-læringsplaner i Vindenergi
Period: 13 Jan 2016
Merete Badger (Speaker)
Department of Wind Energy
Meteorology & Remote Sensing

Related event
Fallegrupper for uddannelse i Vindenergi
13/01/2016 → 13/01/2016
Glostrup, Denmark
Activity: Talks and presentations › Conference presentations

Near-real-time wind retrievals from S-1 SAR
Period: 7 Jan 2016
Merete Badger (Other)
Department of Wind Energy
**Coastal Boundary Layer Development, Impacted by terrain inhomogeneity and non-ideal conditions**

**Period:** 4 Jan 2016 → 4 Jul 2016

**Mark C. Kelly (Main supervisor)**

**Dalibor Cavar (Supervisor)**

**Lars Landberg (External examiner)**

**Department of Wind Energy**

**Resource Assessment Modelling**

**Meteorology**

**Description**

The wind is continually affected by the surfaces over which it flows, including the surface roughness. When airflow encounters a roughness change, a turbulent internal boundary layer (IBL) develops, where the flow adjusts to be in equilibrium with the ‘new’ surface. The development and characteristics of the IBL are affected by the terrain morphology and thermodynamic structure of the atmosphere; the IBL’s that tend to most affect the wind are those due to large changes in roughness, such as across coastlines. The scope of this project is to investigate the development of the internal boundary layer downwind of the coastline near Høvsøre, at the Danish National Test Station for wind turbines. The Høvsøre case is of interest due to the presence of a sand dune along the coast. The dune affects the growth of IBL, leading to results that cannot be described by classical IBL models and theory. A three-dimensional representation of the dune will be used as a boundary condition in CFD simulations using the DTU Reynolds-Averaged Navier Stokes (RANS) solver Ellipsys, which is part of the semi-automated wind software WAsP-CFD. Standard wind models (e.g. WAsP) will also be considered. The numerical simulation results and corresponding measurements from Høvsøre will be compared and analyzed. The Høvsøre data include wind and heat flux (stability) measurements at different heights and multiple meteorological masts, and also wind data from the IBL-WiSH project, where multiple ‘WindScanner’ lidars measured the flow downwind of the dunes. The wind modelling is expected to deviate from measurements in some conditions, and limitations of the models will be subsequently investigated. A further understanding of the characteristics and parameters that affect the IBL can benefit Wind Energy in a number of ways. Better estimation of annual energy production can be made in wind climates affected by heterogeneous roughness, e.g. in coastal zones. A better estimation of wind conditions can also lead to more realistic loads estimation for wind turbines. In this project, taking terrain inhomogeneity as a starting point (most real-world sites are affected by such irregularities), the models used will be evaluated and further improvements-corrections will be investigated. This work will hopefully contribute to further understanding of IBLs and their effects on wind energy.

**Degree of recognition:** National

**Activity:** Examinations and supervision › Supervisor activities

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**12th EAWE PhD seminar on Wind Energy in Europe**

**Period:** 1 Jan 2016 → 31 May 2016

**Elliot Simon (Organizer)**

**Department of Wind Energy**

**Description**

Seminar organisation and chair of the session: Structures and materials. Oral presentation within session: Wind resource assessment, atmospheric effects and inflow modelling

**Links:**

http://eawephd2016.org/en/ (Seminar website)

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**Related event**

**12th EAWE PhD seminar on Wind Energy in Europe**

**Period:** 25/05/2016 → 27/05/2016

**Lyngby, Denmark**

**Activity:** Attending an event › Participating in or organising a conference
Period: 2015
William Tucker Courtney (Participant)
Department of Wind Energy
Wind Turbines

Description
Optimal Design of Stiffeners for Bucket Foundations

Related event
04/02/2015 → 06/02/2015
Trondheim, Norway
Activity: Attending an event › Participating in or organising a conference

Period: 2015
Kasper Sandal (Speaker)
Wind Turbines
Department of Wind Energy

Description
Poster presentation
Documents:
Sandal_Kasper_deepwindposter

Related event
04/02/2015 → 06/02/2015
Trondheim, Norway
Activity: Talks and presentations › Conference presentations

Approaches to validate wind resource grid data
Period: 2015
Xiaoli Guo Larsén (Supervisor)
Department of Wind Energy
Resource Assessment Modelling

Description
Master Project: Tobias Torben Ahsbahs from DTU
Activity: Examinations and supervision › Supervisor activities

Coastal offshore winds, ocean waves and currents using remote sensing
Period: 2015 → 2018
Xiaoli Guo Larsén (Supervisor)
Department of Wind Energy
Resource Assessment Modelling

Description
PhD project Tobias Torben Ahsbahs from DTU
Activity: Examinations and supervision › Supervisor activities
Design of large composite structures
Period: 2015
Philipp Ulrich Haselbach (Lecturer)
Department of Wind Energy

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

Journal of Renewable and Sustainable Energy (Journal)
Period: 2015 → …
Patrick Volker (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International
Links:
http://aip.scitation.org/doi/full/10.1063/1.4907600 (Link to published article)

Related journal
Journal of Renewable and Sustainable Energy
1941-7012
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 1.41 SJR 0.44 SNIP 0.588, ISI indexed (2013): ISI indexed yes, Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

NAFEMS Nordic Steering Committee (NNSC) (External organisation)
Period: 2015 → …
Lars Pilgaard Mikkelsen (Participant)
Department of Wind Energy
Composites and Materials Mechanics
Degree of recognition: International
Links:
https://www.nafems.org/about/regional/nordic/committee/

Related external organisation
NAFEMS Nordic Steering Committee (NNSC)
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

Resources (Journal)
Period: 2015 → …
Patrick Volker (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International
Links:
http://www.mdpi.com/2079-9276/4/1/155 (link to article)

Related journal
Resources
2079-9276
Scopus rating (2017): CiteScore 2.69 SJR 0.688 SNIP 1.387, Web of Science (2018): Indexed yes
Indexed in DOAJ
Central database
Activity: Research › Peer review of manuscripts

**Wind Energy (Journal)**
Period: 2015 → …
Mark C. Kelly (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International

**Related journal**

**Wind Energy**
1095-4244
BFI (2018): BFI-level 2, Scopus rating (2017): CiteScore 3.18 SJR 1.051 SNIP 1.834, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Central database

Activity: Research › Peer review of manuscripts

**Continuing education in Wind Energy through E-learning**
Period: 17 Dec 2015
Merete Badger (Speaker)
Department of Wind Energy
Meteorology & Remote Sensing

**Related event**

**DTU Sustain Conference 2015**
17/12/2015 → 17/12/2015
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

**Chairing committee at Dr. Techn. Defence of Jens Nørkær Sørensen, December 11, 2015 (External organisation)**
Period: 11 Dec 2015
Helge Aagaard Madsen (Chairman)
Department of Wind Energy
Aeroelastic Design

**Related external organisation**

**Chairing committee at Dr. Techn. Defence of Jens Nørkær Sørensen, December 11, 2015**
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

**Impact of leading edge roughness and erosion on the annual energy production and how to improve it with aerodynamic devices**
Period: 10 Dec 2015
Christian Bak (Speaker)
Department of Wind Energy
Aerodynamic design

**Related event**

**The Wind Operator Congress Europe**
09/12/2015 → 10/12/2015
London, United Kingdom
Activity: Talks and presentations › Conference presentations
**European Academy of Wind Energy (External organisation)**
Period: 1 Dec 2015 → 15 Nov 2018
Elliot Simon (Chairman)
Department of Wind Energy
Meteorology & Remote Sensing

**Description**
Committee chair for DTU
Degree of recognition: International

**Related external organisation**
European Academy of Wind Energy
Küpkersweg 70, 26129, Oldenburg, Germany
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

**EWEA Annual Conference and Exhibition 2015**
Antoine Borraccino (Participant)
Department of Wind Energy
Meteorology & Remote Sensing

**Description**
Poser presenter
Radial wind speed calibration uncertainty of nacelle-based profiling lidars
Documents:
EWEA2015_Poster_Lidar_RWS_calib_uncertainties_ABorraccino

**Related event**
EWEA Annual Conference and Exhibition 2015
17/11/2015 → 20/11/2015
Paris, France
Activity: Attending an event › Participating in or organising a conference

**EWEA Annual Conference and Exhibition 2015**
Elliot Simon (Participant)
Department of Wind Energy
Meteorology & Remote Sensing

**Description**
EWEA Annual Event 2015: Paris

**Related event**
EWEA Annual Conference and Exhibition 2015
17/11/2015 → 20/11/2015
Paris, France
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

**Innovation from JSME 2015**
Period: 14 Nov 2015 → 15 Nov 2015
Kristine Munk Jespersen (Participant)
Department of Wind Energy
Composites and Materials Mechanics
Description
Poster presentation

Japanese conference
Documents:
iJSMEposter_formatresearch (1)
2015-11-12 iJSME Hiroshima speed presentation (1)

Related event

Innovation from JSME 2015
14/11/2015 → 15/11/2015
Hiroshima, Japan
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Offshore winds from satellites: Examples from Chinese and European seas
Period: 12 Nov 2015
Merete Badger (Other)
Department of Wind Energy

Related external organisation

Unknown external organisation
Activity: Talks and presentations › Conference presentations

Science Honours Academy from University of Utrecht, the Netherlands visits DTU Wind Energy
Period: 10 Nov 2015
Charlotte Bay Hasager (Organizer)
Department of Wind Energy
Meteorology

Description

Science Honours Academy from University of Utrecht, the Netherlands visits DTU Wind Energy

Related event

Science Honours Academy from University of Utrecht, the Netherlands visits DTU Wind Energy
10/11/2015 → 10/11/2015
Roskilde, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Wind Turbines
Period: 10 Nov 2015
Christian Bak (Lecturer)
Department of Wind Energy
Aerodynamic design

Description
Presentation for Science Honours Academy students from Uni Utrecht at DTU Risoe Campus

Related external organisation

Unknown external organisation
Activity: Talks and presentations › Conference presentations
Challenges of using composite materials for large wind turbine blades
Period: 2 Nov 2015
Lars Pilgaard Mikkelsen (Lecturer)
Department of Wind Energy
Composites and Materials Mechanics

Description
Seminar at: Yamagata University, Yonezawa City, Japan
Organized by Japan Society of Mechanical Engineers
Documents:
Abstract-LPMikkelsen
Links:
http://www.jsme.or.jp/th/presen/H27/H27.html

Related event
Seminar organized by Japan Society of Mechanical Engineering
02/11/2015 → …
yonezawa city, Japan
Activity: Talks and presentations › Conference presentations

Remote Sensing of Environment (Journal)
Period: 31 Oct 2015
Ioanna Karagali (Reviewer)
Department of Wind Energy
Meteorology & Remote Sensing

Related journal
Remote Sensing of Environment
0034-4257
BFI (2018): BFI-level 2, Scopus rating (2017): CiteScore 7.16 SJR 3.121 SNIP 2.5, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

Experimental investigations of flow over terrain for wind energy
Period: 21 Oct 2015
Jakob Mann (Invited speaker)
Department of Wind Energy
Meteorology

Related event
2nd International Conference on Future Technologies In Wind Energy
19/10/2015 → 21/10/2015
London, ON, Canada
Activity: Talks and presentations › Conference presentations

3D Wind Field Measurements obtained with DTU Wind Energy's Space and Time Synchronized WindScanners
Period: 19 Oct 2015
Torben Krogh Mikkelsen (Invited speaker)
Department of Wind Energy
Test and Measurements

Related event
Recent developments in Free Material Optimization for design of composite structures
Period: 13 Oct 2015
Mathias Stolpe (Invited speaker)
Department of Wind Energy
Wind Turbines

Related event
3rd International Workshops on Advances in Computational Mechanics
12/10/2015 → 14/10/2015
Tokyo, Japan
Activity: Talks and presentations › Conference presentations

Determination of an Optimum Sector Size for Plan Position Indicator Measurements using a Long Range Coherent Scanning Atmospheric Doppler LiDAR: Presentation for Public Defence at Uppsala University, Sweden
Period: 2 Oct 2015
Elliot Simon (Lecturer)
Department of Wind Energy
Meteorology & Remote Sensing
Documents:
Determination of an Optimum Sector Size for Plan Position Indicator Measurements using a Long Range Coherent Scanning Atmospheric Doppler LiDAR

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

Boundary-Layer Meteorology (Journal)
Period: Sep 2015 → Dec 2015
Mark C. Kelly (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International

Related journal
Boundary-Layer Meteorology
0006-8314
Central database
Activity: Research › Peer review of manuscripts

WAsP Online course
Period: Sep 2015
Mark C. Kelly (Lecturer)
Department of Wind Energy
Meteorology

Description
Online course on wind resource assessment using WAsP.
Related organisation

WAsP Online course
Kelly, M. C. (Lecturer)
Sep 2015
Activity: Talks and presentations › Guest lectures, external teaching and course activities at other universities

IEC 61400-15 meeting/workshop 6 (Event)
Period: 29 Sep 2015 → 2 Oct 2015
Mark C. Kelly (Member)
Department of Wind Energy
Resource Assessment Modelling

Description
IEC 61400-15 workshop and creation of standard for uncertainty in resource assessment. I am an active author of drafts. In this meeting I contributed to, edited, and wrote parts of the uncertainty sections on vertical extrapolation, and co-founded the uncertainty combination subgroup, while interacting in plenum and advising on horizontal extrapolation and uncertainty quantification.
Degree of recognition: International

Related event

IEC 61400-15 meeting/workshop 6
29/09/2015 → 02/10/2015
Paris, France
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

Reducing the Sensitivity to Leading Edge Roughness and Enhancing AEP and Long-Term Performance by Applying Aerodynamic Devices
Period: 29 Sep 2015
Christian Bak (Speaker)
Department of Wind Energy
Aerodynamic design

Related event

Blade Inspection Damage and Repair Forum
29/09/2015 → 30/09/2015
Copenhagen
Activity: Talks and presentations › Conference presentations

Probabilistic Gust Characterization
Period: 24 Sep 2015
Ásta Hannesdóttir (Speaker)
Department of Wind Energy
Resource Assessment Modelling

Description
Background:
The IEC international standards for wind turbines prescribe a set of design requirements to ensure that wind turbines are properly engineered. These standards take into consideration extreme wind conditions and various operational turbine load regimes, and specify the damage a wind turbine may withstand over its lifetime. The characterization of loads in the IEC standards is limited, and does not adequately represent the variability in the atmospheric flow parameters used as input in load simulations. Deterministic ‘gust shapes’ are used for several types of load cases, which do not take into account a large number of expected gust scenarios.
Aim:
In this project, a more realistic representation of gusts, based on statistical analysis, will account for the variability observed in real-world gusts. The gust representation will focus on temporal, spatial, and velocity scales that are relevant for modern wind turbines and which possibly affect the loads. Emphasis will be put on gust rise time and velocity jump (amplitude), within the context of extreme as well as normal turbulence.
Related event

11th EAWE PhD seminar on Wind Energy in Europe
Stuttgart, Germany
Activity: Talks and presentations › Conference presentations

Implications of upscaling - challenges and perspectives
Period: 22 Sep 2015
Flemming Rasmussen (Lecturer)
Department of Wind Energy
Aerodynamic design

Related event

Wind Energy Denmark 2015
22/09/2015 → 23/09/2015
Herning, Denmark
Activity: Talks and presentations › Conference presentations

Wind resources
Period: 21 Sep 2015
Merete Badger (Lecturer)
Department of Wind Energy

Related event

MAREWINT Workshop
21/09/2015 → …
Malmö, Denmark
Activity: Talks and presentations › Conference presentations

Seminar on small turbines
Period: 18 Sep 2015
Andreas Bechmann (Invited speaker)
Department of Wind Energy
Meteorology

Description
New tools for design, production calculation
dtu-emd

Related external organisation

Unknown external organisation
Activity: Talks and presentations › Conference presentations

Danish Centre for Composite Structures and Materials for Wind Turbines (DCCSM)
Period: 16 Sep 2015 → 17 Sep 2015
Philipp Ulrich Haselbach (Speaker)
Department of Wind Energy
Wind Turbines

Description
P.U. Haselbach, Ultimate strength of wind turbine blade structures under multiaxial loading; oral presentation

Related event

Danish Centre for Composite Structures and Materials for Wind Turbines (DCCSM)
16/09/2015 → 17/09/2015
Middelfart, Denmark
Activity: Talks and presentations › Talks and presentations in private or public companies and organisations

The DTU 10MW Reference Wind Turbine
Period: 15 Sep 2015
Christian Bak (Lecturer)
Department of Wind Energy
Aerodynamic design

Related event

The DTU 10MW Reference Wind Turbine
15/09/2015 → 15/09/2015
Bergen, Norway
Activity: Talks and presentations › Conference presentations

ESA Advanced Training in Land Remote Sensing
Period: 14 Sep 2015 → 18 Sep 2015
Ioanna Karagali (Participant)
Department of Wind Energy
Meteorology

Description
ESA Advanced Training in Land Remote Sensing

Related event

ESA Advanced Training in Land Remote Sensing
14/09/2015 → 18/09/2015
Bucharest, Romania
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

15th European Meteorological Society Annual meeting
Period: 10 Sep 2015
Sven-Erik Gryning (Chairman)
Department of Wind Energy
Meteorology

Description
chair - poster session

Related event

15th European Meteorological Society Annual meeting
07/09/2015 → 11/09/2015
Sofia, Bulgaria
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

15th European Meteorological Society Annual meeting
Period: 10 Sep 2015
Sven-Erik Gryning (Chairman)
Department of Wind Energy
Meteorology

Description
15th European Meteorological Society Annual meeting
Chair at several sessions, oral sessions

Related event

15th European Meteorological Society Annual meeting
07/09/2015 → 11/09/2015
Sofia, Bulgaria
Activity: Attending an event › Participating in or organising a conference

Wind profile modelling using WAsP and 'tall' wind measurements
Period: 10 Sep 2015
Rogier Ralph Floors (Speaker)
Department of Wind Energy
Meteorology

Description
Horizontal and vertical extrapolations of wind speed and power density are needed in the wind energy industry to perform wind resource assessments. The Wind Atlas Analysis and Application Program (WAsP) is a tool that combines several physical models to perform such extrapolations. For vertical extrapolations (the wind profile) this is done using the Weibull distribution and the geostrophic drag law. Wind lidar measurements obtained during the ‘Tall wind’ campaign at three different sites are used to evaluate the assumptions and equations that are used in the WAsP vertical extrapolation strategy. The surface fluxes were estimated from the wind, temperature and humidity profiles using an iterative method for consistency with WAsP, while the geostrophic wind and boundary-layer wind veering angle were estimated using the combined mast and lidar measurements. The effect of baroclinicity on the constants A and B in the geostrophic drag law was taken into account by specifying a mean offset between the thermal and surface geostrophic wind vector and a mean magnitude of the thermal wind vector.

Wind lidar and mast measurements from 11 different sites (that were not used in determining the empirical constants) in the North Sea area were used to evaluate different versions of the WAsP for vertical extrapolation of wind. The effect of baroclinicity and the implementation of newly chosen constants on the reversal height, the profiles of the Weibull A and k parameters and the overall model performance is discussed

Documents:
presentation_fino3

Related event

15th European Meteorological Society Annual meeting
07/09/2015 → 11/09/2015
Sofia, Bulgaria
Activity: Talks and presentations › Conference presentations
Reducing the uncertainty of near-shore wind estimations using wind lidars and mesoscale models

Period: 8 Sep 2015

Rogier Ralph Floors (Speaker)

Department of Wind Energy

Meteorology

Description

Many countries plan to meet renewable energy targets by installing near-shore wind farms, because of the high offshore wind speeds and good grid connectivity. Because of the strong relation between mean wind speed and the annual energy production, there is an interest in reducing uncertainty of the estimation of the wind speed in these coastal areas.

Mesoscale models can provide a detailed spatial and temporal picture of the wind speed, but are known to have difficulties predicting the complex microscale processes. The RUNE project aims to provide recommendations on the use of lidar systems and mesoscale models results to find the most effective (cost vs. accuracy) solution of estimating near-shore wind resources. Here we show first results of an intercomparison between the long-range WindScanner system, a multi-lidar instrumentation, that will be deployed during the experimental campaign in autumn 2015: wind speeds obtained from the simultaneous operation of three scanning lidars in a sector-scanning and dual-Doppler modes will be compared with measurements from a meteorological mast. We use the Weather Research and Forecasting (WRF) model to model wind speeds near the coast. Problems of a mesoscale model to model the wind speed for a smooth-to-rough and rough-to-smooth transition in a coastal area will be discussed.

Documents:

EMS2015_RUNE (1)
EMS2015_RUNE_1_.pdf

Related event

15th European Meteorological Society Annual meeting
07/09/2015 → 11/09/2015
Sofia, Bulgaria

Activity: Talks and presentations › Conference presentations

15th EMS Annual Meeting & 12th European Conference on Applications of Meteorology (ECAM)
Period: 7 Sep 2015 → 11 Sep 2015
Sven-Erik Gryning (Organizer)

Department of Wind Energy

Meteorology

Description

Convener of session on Energy Meteorologi (ASI 16)

Links:

Related event

15th EMS Annual Meeting & 12th European Conference on Applications of Meteorology (ECAM)
07/09/2015 → 11/09/2015
Sofia, Bulgaria

Activity: Attending an event › Participating in or organising a conference

Computers & Fluids (Journal)

Period: Jul 2015 → Sep 2015

Mark C. Kelly (Reviewer)

Department of Wind Energy

Resource Assessment Modelling

Degree of recognition: International

Related journal

Computers & Fluids
Effect of trailing edge damage on fullscale wind turbine blade failure

GHRSST XVI Science Team Meeting
Noordwijck, Netherlands
Activity: Attending an event › Participating in or organising a conference

3rd International Conference Energy and Meteorology
Period: 26 Jun 2015
Sven-Erik Gryning (Speaker)
Degree of recognition: International
Related event
3rd International Conference Energy and Meteorology: Weather & Climate for the Energy Industry
22/06/2015 → 26/06/2015
Boulder, United States
Activity: Talks and presentations › Conference presentations
**WEng [WAsP-Engineering] course**  
*Period: 15 Jun 2015 → 17 Jun 2015*

*Mark C. Kelly (Lecturer)*  
Department of Wind Energy  
Resource Assessment Modelling  
Risø National Laboratory for Sustainable Energy  
Meteorology  

**Description**  
Course on site-assessment and site-suitability (turbulence, extremes, terrain) using WAsP-Engineering [WEng'], for both DTU graduate students and commercial industrial participants.

**Related organisation**  
**WEng [WAsP-Engineering] course**  
Kelly, M. C. (Lecturer)  
15 Jun 2015 → 17 Jun 2015  
Activity: Talks and presentations › Guest lectures, external teaching and course activities at other universities

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**Ocean winds from satellites – applications for offshore wind energy**  
*Period: 11 Jun 2015*

*Merete Badger (Speaker)*  
Department of Wind Energy  
Meteorology  

**Description**  
Seminar at Johns Hopkins University Applied Physics Laboratory

**Related external organisation**  
Unknown external organisation  
Activity: Talks and presentations › Conference presentations

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**11th World Congress of Structural and Multidisciplinary Optimization**  
*Period: 9 Jun 2015*

*Susana Rojas Labanda (Participant)*  
Department of Wind Energy  
Wind Turbines  

**Description**  
An efficient second-order SQP method for structural topology optimization  

Oral presentation  
Documents:  
An efficient second-order SQP method for structural topology optimization

**Related event**  
**11th World Congress of Structural and Multidisciplinary Optimization**  
07/06/2015 → 12/06/2015  
Sydney, Australia  
Activity: Attending an event › Participating in or organising a conference

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**11th World Congress of Structural and Multidisciplinary Optimisation**  
*Period: 7 Jun 2015 → 12 Jun 2015*

*Alemseged Gebrehiwot Weldeyesus (Speaker)*  
Department of Wind Energy
Wind Turbines

Related event

11th World Congress of Structural and Multidisciplinary Optimization
07/06/2015 → 12/06/2015
Sydney, Australia
Activity: Talks and presentations › Conference presentations

Offshore CREYAP Part 2 - final results
Period: 3 Jun 2015
Niels Gylling Mortensen (Invited speaker)
Department of Wind Energy
Meteorology

Related event

EWEA Technology Workshop: Resource Assessment 2015
02/06/2015 → 03/06/2015
Helsinki, Finland
Activity: Talks and presentations › Conference presentations

Challenges in developing +10 MW Wind Turbines
Period: 2 Jun 2015
Christian Bak (Lecturer)
Department of Wind Energy
Aerodynamic design

Description
Invited speaker at Flensburg University of Applied Sciences
Links:
http://weti.fh-flensburg.de/303.html

Related external organisation

Unknown external organisation
Activity: Talks and presentations › Conference presentations

EWEA Technology Workshop
Period: 2 Jun 2015 → 3 Jun 2015
Antoine Borraccino (Participant)
Department of Wind Energy
Test and Measurements
Documents:
Tech15a-PO-026

Related event

EWEA Technology Workshop: Resource Assessment 2015
02/06/2015 → 03/06/2015
Helsinki, Finland
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Scientific Computing Using Python - 1
Period: 2 Jun 2015 → 4 Jun 2015
Kristine Munk Jespersen (Participant)
Department of Wind Energy
Composites and Materials Mechanics

Related event

Scientific Computing Using Python - 1: Python + Scientific Computing
02/06/2015 → 04/06/2015
Aalborg, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

NORCOWE SAC (External organisation)
Period: 1 Jun 2015 → …
Thomas Buhl (Participant)
Department of Wind Energy
Wind Turbines

Description
Scientific Advisory Committee
Degree of recognition: International

Related external organisation

NORCOWE SAC
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

IEC 61400-15 and TC-88 (External organisation)
Period: May 2015 → …
Mark C. Kelly (Member)
Department of Wind Energy
Resource Assessment Modelling

Description
International electrotechnical commission, standard on uncertainty and site-assessment/suitability plus reporting for wind energy

lead contributor for vertical extrapolation uncertainty subgroup, co-founder of subgroups on uncertainty combination and virtual met-mast

Body type: International
Degree of recognition: International

Related external organisation

IEC 61400-15 and TC-88
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

12th German Wind Energy Conference DEWEK 2015
Antoine Borraccino (Speaker)
Department of Wind Energy
Test and Measurements

Description
Participation in the DEWEK 2015 conference in Bremen, 19-20 May. Oral presentation on "Generic calibration procedures of nacelle-based profiling lidars"
Documents:
2015_05_20_DEWEK_ABorraccino_slides_Orbit
Related event

**12th German Wind Energy Conference**
19/05/2015 → 20/05/2015
Bremen, Germany
Activity: Talks and presentations › Conference presentations

**Fracture Mechanics for Laminated Composite Structures**
Kristine Munk Jespersen (Participant)
Department of Wind Energy
Composites and Materials Mechanics
Documents:
FractureMechCourse_poster_kmunn

Related event

**Ph.D. Course 2015: Fracture Mechanics for Laminated Composite Structures**
18/05/2015 → 22/05/2015
Aalborg, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

**IOVWST Meeting 2015**
Ioanna Karagali (Participant)
Department of Wind Energy
Meteorology
Links:
http://coaps.fsu.edu/scatterometry/meeting/index.php

Related event

**IOVWST Meeting 2015: International Ocean Vector Winds Science Team Meeting**
18/05/2015 → 21/05/2015
Portland, OR, United States
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

**Project review for RCUK Energy Programme – March 2015 (External organisation)**
Period: 10 May 2015
Helge Aagaard Madsen (Participant)
Department of Wind Energy
Aeroelastic Design
Degree of recognition: International

Related external organisation

**Project review for RCUK Energy Programme – March 2015**
Activity: Membership › Membership in review committee

**Microscale Meteorology: turbulence, measurement, and boundary-layer parameterization (Københavns Universitet)**
Period: Apr 2015 → Aug 2015
Mark C. Kelly (Lecturer)
Department of Wind Energy
Resource Assessment Modelling

Meteorology

**Description**
Course for PhD/M.Sci students at Copenhagen University, within Niels Bohr Institute/geophysics. Created course content, orginization, and did all teaching.
Degree of recognition: International

**Related external organisation**
University of Copenhagen
Thorvaldsensvej 40, DK-1871 Frederiksberg C, Copenhagen, Denmark
Activity: Talks and presentations › Guest lectures, external teaching and course activities at other universities

**PLENARY - An overview of recent research on AM and OAM of wind turbine noise**
Period: 23 Apr 2015
Helge Aagaard Madsen (Speaker)

Aeroelastic Design

Department of Wind Energy
Degree of recognition: International
Documents:
AM_WTN_2015_hama_final

**Related event**
6th International Conference on Wind Turbine Noise
20/04/2015 → 23/04/2015
Glasgow, United Kingdom
Activity: Talks and presentations › Conference presentations

6th International Meeting on Wind Turbine Noise
Period: 20 Apr 2015 → 23 Apr 2015
Wei Jun Zhu (Speaker)

Fluid Mechanics

Documents:
full_paper_WeijunZhu

**Related event**
6th International Meeting on Wind Turbine Noise
20/04/2015 → 23/04/2015
Glasgow, United Kingdom
Activity: Talks and presentations › Conference presentations

European Geosciences Union General Assembly 2015
Period: 17 Apr 2015
Anna Maria Sempreviva (Organizer)

Meteorology
Department of Wind Energy

**Description**
Wind and solar power are the predominant new sources of electrical power in recent years. Solar power reached a milestone of providing 50% of demand in Germany during one hour in 2012, and wind power occasionally exceeds 100% of demand in Denmark. By their very nature, wind and solar power, as well as hydro, tidal, wave and other weather dependent renewable forms of generation are dependent on weather and climate. Modelling and measurement for resource assessment, site selection and operational forecasting for horizons ranging from decades to minutes are of paramount importance. The success of wind power means that wind turbines are increasingly put in sites with complex terrain or forests, with towers extending beyond the strict logarithmic profile, and in offshore regions that are difficult to
model and measure. Major challenges for solar power are accurate measurements and the short-term prediction of the spatiotemporal evolution of the cloud field. For both solar and wind power, the integration of large amounts of renewable energy into the grid is another critical research problem due to the uncertainties linked to their forecast. Of particular interest these days is the field of urban meteorology applied to the renewable energy sector. The urban energy field is quite new, but there are several “Smart Cities” and “Smart Grids” projects in Europe focusing on urban measurement development for forecasts or resource mapping. We invite contributions on all aspects of weather dependent renewable power generation, especially:

- Wind conditions (both resources and loads) on short and long time scales for wind power development, especially in complex environments (e.g. mountains, forests, coastal or urban).
- Wind and solar resource and atlases.
- Wake effect models and measurements, especially for large wind farms and offshore.
- Performance and uncertainties of forecasts of renewable power at different time horizons and in different external conditions.
- Forecast of extreme wind events and wind ramps.
- Local, regional and global impacts of renewable energy power plants or of large-scale integration.
- Dedicated wind measurement techniques (SODARS, LIDARS, UAVs etc.).
- Dedicated solar measurement techniques (radiation, aerosol, cloud cover etc.) from ground-based and space-borne remote sensing.
- Tools for urban area renewable energy supply strategic planning and control.

ERE1.4 Energy Meteorology
Links:

Related event

European Geosciences Union General Assembly 2015
12/04/2015 → 17/04/2015
Vienna, Austria
Activity: Attending an event › Participating in or organising a conference

Fremtidens vindenergi – en magisters historie på Risø og DTU
Period: 15 Apr 2015
Niels Gylling Mortensen (Speaker)
Department of Wind Energy Meteorology

Description
Foredrag ved DM fyraftensmøde om vindenergi
Documents:
En magister paa Risoe og DTU

Related external organisation

Unknown external organisation
Activity: Talks and presentations › Conference presentations

Wake Conference 2015 (Event)
Period: Mar 2015 → Apr 2015
Mark C. Kelly (Reviewer)
Department of Wind Energy Resource Assessment Modelling

Description
Reviewed 2 papers
Degree of recognition: International

Related event

Wake Conference 2015
09/06/2015 → 11/06/2015
Visby, Sweden
Activity: Research › Peer review of manuscripts

WAsP Online course
Period: Mar 2015
Mark C. Kelly (Lecturer)
Department of Wind Energy
Meteorology

Description
Online course on wind resource assessment using WAsP.

Related organisation
WAsP Online course
Kelly, M. C. (Lecturer)
Mar 2015
Activity: Talks and presentations › Guest lectures, external teaching and course activities at other universities

Assessment of Doppler lidar as tool for wind environment mapping around a windbreak
Period: 16 Mar 2015 → 22 May 2015
Nikolas Angelou (Participant)
Test and Measurements
Department of Wind Energy

Description
The measurement process of mapping of wind environment around a windbreak using Doppler lidar will be investigated and the results will be compared to CFD analyses of the site. The assessment emerges through a holistic discussion of the process of wind environment determined with Doppler lidar.

Related event
Assessment of Doppler lidar as tool for wind environment mapping around a windbreak
16/03/2015 → 22/05/2015
Denmark
Activity: Other

DCAMM 15th Internal Symposium
Susana Rojas Labanda (Participant)
Department of Wind Energy
Wind Turbines

Description
The use of second-order information in topology optimization

Oral presentation
Documents:
The use of second-order information in topology optimization

Related event
DCAMM 15th Internal Symposium
16/03/2015 → 18/03/2015
Horsens, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Modelling of Wind Turbine Blades with ABAQUS
Period: 12 Mar 2015
Robert Bitsche (Speaker)
Department of Wind Energy
Wind Turbines

Description
Composites Seminar at DTU Risø Campus
Documents:
Modelling of Wind Turbine Blades with ABAQUS

Related event

Composites Seminar
12/03/2015 → …
Roskilde, Denmark
Activity: Talks and presentations › Conference presentations

EWEA Offshore 2015 Conference
Period: 10 Mar 2015 → 12 Mar 2015
Thomas Buhl (Organizer)
Department of Wind Energy

Description
Lead session chair and program committee member

Related event

EWEA Offshore 2015 Conference
10/03/2015 → 12/03/2015
Copenhagen, Denmark
Activity: Attending an event › Participating in or organising a conference

EWEA Offshore 2015 Conference
Period: 10 Mar 2015 → 12 Mar 2015
Elliot Simon (Participant)
Department of Wind Energy
Meteorology & Remote Sensing

Description
EWEA Offshore 2015: Copenhagen

Related event

EWEA Offshore 2015 Conference
10/03/2015 → 12/03/2015
Copenhagen, Denmark
Activity: Attending an event › Participating in or organising a conference

Offshore CREYAP Part 2 – preliminary results
Period: 10 Mar 2015
Niels Gylling Mortensen (Invited speaker)
Department of Wind Energy
Meteorology

Description
Presentation of results from the 2nd Offshore Comparison of Resource and Energy Yield Assessment Procedures (CREYAP) exercise.

Related event

EWEA Offshore 2015 Conference
10/03/2015 → 12/03/2015
Copenhagen, Denmark
Activity: Talks and presentations › Conference presentations

IEC 61400-15 and TC-88 (External organisation)
Period: Feb 2015 → Apr 2015
Mark C. Kelly (Participant)
Department of Wind Energy
Meteorology

Description
International electrotechnical commission, standard on uncertainty and site-assessment/suitability plus reporting for wind energy
lead contributor for vertical extrapolation uncertainty subgroup, co-founder of subgroups on uncertainty combination and virtual met-mast

Body type: International
Degree of recognition: International

Related external organisation
IEC 61400-15 and TC-88
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

IQPC Conference - Advances in Rotor Blades for Wind Turbines
Period: 26 Feb 2015
Christian Bak (Speaker)
Department of Wind Energy
Aerodynamic design

Description
Organizer of the workshop "Challenges in integrated design" in connection to the conference

Related event
IQPC Conference - Advances in Rotor Blades for Wind Turbines
24/02/2015 → 26/02/2015
Bremen, Germany
Activity: Talks and presentations › Conference presentations

Review of project proposal at Stanford University - February 2015 (External organisation)
Period: 25 Feb 2015
Helge Aagaard Madsen (Member)
Aeroelastic Design
Department of Wind Energy

Description
Review a proposal entitled "Integrative Modeling and Optimization of Mega Wind Farms" submitted by Professors Lele, Kochenderfer and Rajagopal to the Global Climate and Energy Project (GCEP) at Stanford University.
Degree of recognition: International

Related external organisation
Review of project proposal at Stanford University - February 2015
Activity: Membership › Membership in review committee

Uncertainty in wind resources: probabilistic methods and quantification
Period: 25 Feb 2015
Mark C. Kelly (Guest lecturer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International

Related event
IEC 61400-15 meeting/workshop 4
24/02/2015 → 27/02/2015
San Diego, United States
Activity: Talks and presentations › Guest lectures, external teaching and course activities at other universities

From Trades to Turbines: State-of-the-art in Wind Power Resource Assessment
Period: 24 Feb 2015
Andrea N. Hahmann (Invited speaker)
Department of Wind Energy
Meteorology

Related event
Mexico WindPower
25/02/2015 → 26/02/2015
Mexico City, Mexico
Activity: Talks and presentations › Conference presentations

IEC 61400-15 meeting/workshop 4 (Event)
Period: 24 Feb 2015 → 27 Feb 2015
Mark C. Kelly (Participant)
Department of Wind Energy

Description
IEC 61400-15 workshop and creation of standard for uncertainty in resource assessment. I became an active author of draft material after coming to this meeting, giving a presentation, and discussing.
Degree of recognition: International

Related event
IEC 61400-15 meeting/workshop 4
24/02/2015 → 27/02/2015
San Diego, United States
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

IQPC Conference - Advances in Rotor Blades for Wind Turbines
Period: 24 Feb 2015
Frederik Zahle (Invited speaker)
Department of Wind Energy
Aeroelastic Design

Description
Talk on "Rotor Design Optimization Tools and Cost Models"
Workshop on aeroelastic design of wind turbines
Documents:
iqpc_hawtopt2
iqpc_casesudy

Related event
IQPC Conference - Advances in Rotor Blades for Wind Turbines  
24/02/2015 → 26/02/2015  
Bremen, Germany  
Activity: Talks and presentations › Conference presentations

Period: 4 Feb 2015 → 6 Feb 2015  
Thomas Buhl (Organizer)  
Department of Wind Energy  
Wind Turbines  
Description  
Chairman and member of scientific committee  
Related event  
04/02/2015 → 06/02/2015  
Trondheim, Norway  
Activity: Attending an event › Participating in or organising a conference

Period: 4 Feb 2015 → 6 Feb 2015  
Dariusz Dabrowski (Speaker)  
Department of Wind Energy  
Wind Turbines  
Description  
Assessment of Gearbox Operational Loads and Reliability under High Mean Wind Speeds  
Related event  
04/02/2015 → 06/02/2015  
Trondheim, Norway  
Activity: Talks and presentations › Conference presentations

Period: 4 Feb 2015 → 6 Feb 2015  
Juan Felipe Gallego Calderon (Speaker)  
Wind Turbines  
Department of Wind Energy  
Description  
Effects of Bearing Configuration in Wind Turbine Gearbox Reliability  
Poster presentation  
Related event  
04/02/2015 → 06/02/2015  
Trondheim, Norway  
Activity: Talks and presentations › Conference presentations

E-learning activities at DTU Wind Energy  
Period: 3 Feb 2015  
Merete Badger (Invited speaker)
Description
TEMPUS Lifelong Learning workshop at DTU

Related external organisation

Unknown external organisation
Activity: Talks and presentations › Conference presentations

Virtual Campus Hub
Period: 3 Feb 2015
Merete Badger (Other)
Department of Wind Energy
Meteorology

Description
Project overview
Links:
https://indico.cern.ch/event/358127/contribution/9

Related event

Federated Identity management for Research Collaborations
03/02/2015 → 04/02/2015
Switzerland
Activity: Talks and presentations › Conference presentations

Winterwind 2015: International Wind Energy Conference
Period: 2 Feb 2015 → 6 Feb 2015
Elliot Simon (Participant)
Department of Wind Energy
Meteorology & Remote Sensing

Related event

Winterwind 2015: International Wind Energy Conference
02/02/2015 → 06/02/2015
Piteå, Sweden
Activity: Attending an event › Participating in or organising a conference

Implementation of a hysteretic 3D soil model in an aeroelastic code. Dynamic analysis of an offshore wind turbine in misaligned wind and waves
Period: 28 Jan 2015
Signe Schløer (Speaker)
Department of Wind Energy
Fluid Mechanics

Description
Signe Schløer, Alan Castellano and Henrik Bredmose
Documents:
Implementation of a hysteretic 3D soil model in an aeroelastic code. Dynamic analysis of an offshore wind turbine in misaligned wind and waves

Related event

Boundary-Layer Meteorology (Journal)
Period: 2014 → 2017
Xiaoli Guo Larsén (Reviewer)
Department of Wind Energy
Resource Assessment Modelling

Related journal

Boundary-Layer Meteorology
0006-8314
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 2.47 SJR 1.262 SNIP 1.193, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

COST Action TU1304 (External organisation)
Period: 2014
Anna Maria Sempreviva (Chairman)
Department of Wind Energy
Resource Assessment Modelling

Description

Wind energy technology reconsideration to enhance the concept of smart cities (WINERCOST)

The Action aims to merge the efforts of the European research groups working on the Wind Energy Technology and the pathways to introduce it by means of robust applications to the urban and suburban built environment, thus enhancing the concept of Smart Future Cities. This Action revisits safe, cost-effective and societally accepted wind energy technology for consideration in the design and development of the future urban/suburban habitat.

The principal objective of WINERCOST is to collect the existing expertise on the Built environment Wind energy Technology (BWT) recently developed as a follow-up of the Onshore/Offshore Wind Energy Technology (ON/OFF-WET) and to investigate effective adoption methods for enabling the concept of Smart Future Cities. In addition, the utmost important issue of the social acceptance strategy will be scrutinized in close collaboration with municipality authorities, industry, manufacturers as well as the international wind energy organisations and platforms.

A meticulously developed dissemination plan centrally based on the Action's website, scientific publications in international journals, conferences and training schools, as well as the motivation of senior prominent experts, early stage researchers and opinion makers and involvement of industry and city authorities leaders to enhance the relevant social acceptance strategy

Related external organisation

COST Action TU1304
University of Birmingham, B15 2TT, Birmingham, United Kingdom
**Activity: Membership › Membership of research networks or expert groups**

**Coupling Atmospheric and Ocean Wave Models for Storm Simulation**
*Period: 2014 → 2017*

Xiaoli Guo Larsén (Main supervisor)

Department of Wind Energy

Resource Assessment Modelling

**Description**
PhD thesis
Degree of recognition: International

**Activity: Examinations and supervision › Supervisor activities**

**Development of e-learning materials**
*Period: 2014*

Robert Bitsche (Participant)

Department of Wind Energy

**Description**
Development of e-learning materials for the course "Aeroelastic Simulation of Wind Turbines using HAWC2"

**Activity: Other**

**Fiber Reinforced Lightweight Structures**
*Period: 2014*

Philipp Ulrich Haselbach (Lecturer)

Department of Wind Energy

**Description**
Teaching at the Master course "Fiber Reinforced Lightweight Structures" at the Technical University of Denmark, DTU Wind Energy.
(Course lecturer)

**Related organisation**

**Fiber Reinforced Lightweight Structures**
Haselbach, P. U. (Lecturer)
2014

**Activity: Other**

**Journal of Coastal Research (Journal)**
*Period: 2014 → 2017*

Xiaoli Guo Larsén (Reviewer)

Department of Wind Energy

Resource Assessment Modelling

**Related journal**

**Journal of Coastal Research**
0749-0208

BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 0.87 SJR 0.383 SNIP 0.552, ISI indexed (2013): ISI indexed yes, Web of Science (2018): Indexed yes

Central database

**Activity: Research › Peer review of manuscripts**
Journal of Fluid Mechanics (Journal)
Period: 2014 → 2017
Xiaoli Guo Larsén (Reviewer)
Department of Wind Energy
Resource Assessment Modelling

Related journal
Journal of Fluid Mechanics
0022-1120
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

Journal of Wind Engineering & Industrial Aerodynamics (Journal)
Period: 2014 → 2017
Xiaoli Guo Larsén (Reviewer)
Department of Wind Energy
Resource Assessment Modelling

Related journal
Journal of Wind Engineering & Industrial Aerodynamics
0167-6105
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 3.42 SJR 1.264 SNIP 2.071, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

Linear Algebra and Optimization Seminar 2014
Period: 2014
Susana Rojas Labanda (Participant)
Department of Wind Energy
Wind Turbines

Description
Mathematical Programming Methods for Large-scale Structural Topology Optimization

Oral Presentation
Documents:
Abstract

Related event
Linear Algebra and Optimization Seminar 2014
20/02/2014 → …
Palo Alto, United States
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Danish Wind Power: Presentation at NREL Dec 2014A
Period: Dec 2014
Bonnie Ram (Lecturer)
Department of Wind Energy
Wind Energy Systems
Documents:
Ram Danish Wind Power presentation at NREL Dec 2014A
Related external organisation

Unknown external organisation
Activity: Talks and presentations › Conference presentations

DTU Sustain Conference 2014
Period: 17 Dec 2014
Ioanna Karagali (Speaker)
Department of Wind Energy
Meteorology

Description
Oral presentation

Related event

DTU Sustain Conference 2014
17/12/2014 → 17/12/2014
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

Wind in the sea around Iceland
Period: 3 Dec 2014
Charlotte Bay Hasager (Invited speaker)
Department of Wind Energy
Meteorology

Description
ICEWIND project final seminar at Vestas, Århus, Denmark

Related external organisation

Unknown external organisation
Activity: Talks and presentations › Conference presentations

Release of BECAS v3.0
Period: Nov 2014
Robert Bitsche (Participant)
Department of Wind Energy
Wind Turbines

Description
Release of the newest version of DTU Wind Energy's cross section analysis software BECAS.
Documents:
BECAS - Newsletter November 2014
Links:
http://www.becas.dtu.dk
Activity: Other

The Offshore Wind Energy Potential of Iceland
Period: 25 Nov 2014
Charlotte Bay Hasager (Invited speaker)
Department of Wind Energy
Meteorology

Related event
ICEWIND – Opnun Íslenska vindatlasins: Opening of Icelandic wind atlas
25/11/2014 → …
Reykjavik, Iceland
Activity: Talks and presentations › Conference presentations

ABYSS: Optimal design of offshore wind turbine support structures
Period: 24 Nov 2014
Thomas Buhl (Lecturer)
Department of Wind Energy
Wind Turbines

Related event
Conference on Energy and Environment for the Future: Sustainable energy for a fossil free society and environmentally friendly technologies
Copenhagen, Denmark
Activity: Talks and presentations › Conference presentations

International Conference on Giant Offshore Wind Turbines
Period: 24 Nov 2014
Christian Bak (Participant)
Department of Wind Energy
Aeroelastic Design

Description
Aeroelastic optimization of offshore 10MW wind turbines
Links:
http://www.giant-offshore-turbines.com/

Related event
International Conference on Giant Offshore Wind Turbines
24/11/2014 → 26/11/2014
Bremen, Germany
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

WEng [WAsP-Engineering] course
Period: 24 Nov 2014 → 26 Nov 2014
Mark C. Kelly (Lecturer)
Department of Wind Energy
Meteorology

Description
Course on site-assessment and site-suitability (turbulence, extremes, terrain) using WAsP-Engineering [WEng], for both DTU graduate students and commercial industrial participants.

Related organisation
WEng [WAsP-Engineering] course
Kelly, M. C. (Lecturer)
24 Nov 2014 → 26 Nov 2014
Activity: Talks and presentations › Guest lectures, external teaching and course activities at other universities

UDTU: Education in University Teaching at DTU - Module 3
Period: 5 Nov 2014 → 7 Nov 2014
Robert Bitsche (Participant)
Department of Wind Energy

Wind Turbines

Related event

**UDTU: Education in University Teaching at DTU - Module 3**
05/11/2014 → 07/11/2014
Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

**IEA task 32 (Lidar)**
Period: 4 Nov 2014 → 6 Nov 2014
Antoine Borraccino (Speaker)
Department of Wind Energy
Test and Measurements
Documents:
Lidars calibration and metrology - Black & White methodologies (presentation slides)
Links:
http://www.ieawind.org/summary_page_32.html (IEA task 32; Wind Lidar Systems for Wind Energy Deployment (webpage))

Related event

**IEA task 32 (Lidar): meeting**
04/11/2014 → 06/11/2014
Glasgow, United Kingdom
Activity: Talks and presentations › Conference presentations

**Public Engagement Strategies for Wind Energy: Are We on the Right Track?**
Period: Oct 2014
Bonnie Ram (Lecturer)
Department of Wind Energy
Wind Energy Systems
Documents:
Bonnie Ram EERA Amsterdam RT6

Related external organisation

**Unknown external organisation**
Activity: Talks and presentations › Conference presentations

**WEng Online course**
Period: Oct 2014
Mark C. Kelly (Lecturer)
Department of Wind Energy
Meteorology
Description
Online course on site-assessment and site-suitability (turbulence, extremes, terrain) using WASP-Engineering ['WEng'].

Related organisation

**WEng Online course**
Kelly, M. C. (Lecturer)
Oct 2014
Activity: Talks and presentations › Guest lectures, external teaching and course activities at other universities
ESA SOLAS EO for Ocean-Atmosphere Interactions Science
Period: 28 Oct 2014
Charlotte Bay Hasager (Participant)
Department of Wind Energy
Meteorology

Description
Poster presentation

Offshore Wind farm wake study using Envisat ASAR and Radarsat in the Northern European Seas

Related event

ESA SOLAS EO for Ocean-Atmosphere Interactions Science
28/10/2014 → 31/10/2014
Frascati, Italy
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Teaching and Learning
Niels Gylling Mortensen (Participant)
Department of Wind Energy
Meteorology

Description
This is a basic course in teaching and learning at university level. The course aims to make you able to plan and carry out teaching lessons focusing on students learning. Through presentations, discussions and practical exercises you will become familiar with different teaching methods.

Links:

Related event

Teaching and Learning: Education in University Teaching at DTU
28/10/2014 → 31/10/2014
Lyngby, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Using a 1-d model to reproduce diurnal SST signals
Ioanna Karagali (Speaker)
Department of Wind Energy
Meteorology

Related event

ESA SOLAS EO for Ocean-Atmosphere Interactions Science
28/10/2014 → 31/10/2014
Frascati, Italy
Activity: Talks and presentations › Conference presentations

Wind Operator Congress Europe
Period: 28 Oct 2014
Torben Krogh Mikkelsen (Participant)
Department of Wind Energy
Panel Discussion: Overview of the latest developments in lidar technology and their implications for O&M

Documents:
Programme

Related event

Wind Operator Congress Europe
27/10/2014 → 28/10/2014
London, United Kingdom
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Observations and modeling of the wind profile and wind turning in the atmospheric boundary layer
Period: 7 Oct 2014
Rogier Ralph Floors (Speaker)
Department of Wind Energy
Meteorology

Description
We illustrate observations of the variation of both horizontal wind components with height from combined sonic and wind lidar measurements from 10 m up to 1200 m. The observations were carried out within a one-year campaign at Høvsøre, a flat coastal farmland area in western Denmark. The observations are analyzed over a wind sector, in which the upstream topographical conditions are nearly homogeneous, and a number of cases representing a variety of forcing, stability, turbulence and wind conditions are presented. For the turbulence and stability conditions we use the sonics located on booms along a 116 m meteorological mast. A pulsed wind lidar, located besides the mast, complements the sonic measurements of both horizontal wind components from 100 m up to 1200 m. For the forcing conditions, we perform numerical simulations as we do not have observations of the horizontal pressure and temperature gradients. The simulations are done using the WRF mesoscale model and the outputs of variables such as pressure and geopotential are used to derive the surface geostrophic wind, gradient wind (the surface geostrophic wind accounting for centrifugal forces) and the thermal wind, and therefore the total geostrophic wind (adding the thermal to the gradient wind). Such geostrophic winds are helpful for understanding the behavior of the wind profile and wind turning particularly close to the boundary-layer height as the observed wind approaches them far from the surface and thus can be used to analyze the wind shear and wind turning. The observed wind profiles nicely approach the simulated geostrophic wind close to the boundary-layer height under both barotropic and baroclinic conditions. The largest deviations (the wind is highly ageostrophic) are found under a period where a low-level jet is observed. The simulated wind from WRF is generally underpredicted, particularly higher up, as well as the wind turning.

Links:

Related event

14th EMS Annual Meeting and 10th European Conference on Applied Climatology (ECAC)
06/10/2014 → 10/10/2014
Prague, Czech Republic
Activity: Talks and presentations › Conference presentations

Observations of the boundary-layer height and the wind profile in the marine boundary layer
Period: 7 Oct 2014
Rogier Ralph Floors (Speaker)
Department of Wind Energy
Meteorology

Description
Because of the large number of wind turbines that is planned to be installed offshore in the North Sea, there is an increasing interest in the representation of the wind profile in the marine boundary layer. We present an evaluation of the WRF model using a combination of mast measurements and remote sensing techniques. The wind, temperature and humidity and wave parameters are measured at the FINO 3 platform in the North Sea. The boundary layer height is estimated using a CL51 ceilometer from Väisälä and the wind profile up to the PBL height is measured using a wind lidar...
from Leosphere from August 2013 onwards. The backscatter coefficient was generally high and therefore the ceilometer was able to estimate the PBL height well. The PBL height showed a pronounced seasonal cycle: unstable conditions availed during autumn, while stable conditions were more common during spring. This caused a distinct behaviour of the wind profile, with relatively large wind shears during spring. The differences between the WRF model and the observations at FINO 3 will be discussed.

Links:

Related event

14th EMS Annual Meeting and 10th European Conference on Applied Climatology (ECAC)
06/10/2014 → 10/10/2014
Prague, Czech Republic
Activity: Talks and presentations › Conference presentations

Selected research results from Danish offshore wind farms
Period: 25 Sep 2014
Thomas Buhl (Lecturer)
Department of Wind Energy
Wind Turbines

Related event

EERA IRPWind & Joint Programme Wind R&D Conference 2014
25/09/2014 → 26/09/2014
Amsterdam, Netherlands
Activity: Talks and presentations › Conference presentations

UDTU: Education In University Teaching at DTU - Module 2
Period: 24 Sep 2014 → 26 Sep 2014
Robert Bitsche (Participant)
Department of Wind Energy
Wind Turbines

Related event

UDTU: Education in University Teaching at DTU - Module 2
24/09/2014 → 26/09/2014
Gentofte, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Seminar on small turbines
Period: 19 Sep 2014
Andreas Bechmann (Invited speaker)
Department of Wind Energy
Meteorology

Documents:
andreas_bechmann

Related external organisation

Unknown external organisation
Activity: Talks and presentations › Conference presentations

UDTU: Education in University Teaching at DTU - Module 1
Period: 16 Sep 2014 → 19 Sep 2014
Robert Bitsche (Participant)
Department of Wind Energy

Wind Turbines

Related event

UDTU: Education in University Teaching at DTU - Module 1
16/09/2014 → 19/09/2014
Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Danish Smart Grid Research Network Event, Wind and the Smart Grid
Period: 15 Sep 2014
Abdul Basit (Participant)
Department of Wind Energy
Wind Energy Systems

Description
Integrating Wind Power Plants control in Automatic Generation Control

Poster presentation
Documents:
Poster-Vestas

Related event

Danish Smart Grid Research Network Event, Wind and the Smart Grid
05/09/2014 → …
Aarhus, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Aerodynamics on Eroded Blades and How to Improve AEP
Period: 11 Sep 2014
Christian Bak (Lecturer)
Department of Wind Energy
Aeroelastic Design

Related event

Blade Inspection Damage And Repair Forum
10/09/2014 → 11/09/2014
Hamburg, Germany
Activity: Talks and presentations › Conference presentations

OBIDAM 14
Period: 8 Sep 2014 → 9 Sep 2014
Ioanna Karagali (Participant)
Department of Wind Energy
Meteorology

Related event

OBIDAM 14: Ocean Big Data Mining
08/09/2014 → 09/09/2014
Brest, France
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.
Estuarine, Coastal and Shelf Science (Journal)
Period: 26 Aug 2014
Ioanna Karagali (Reviewer)
Department of Wind Energy
Meteorology & Remote Sensing

Related journal

Estuarine, Coastal and Shelf Science
0272-7714
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 2.61 SJR 1.059 SNIP 1.149, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

The 2014 Sandia Wind Turbine Blade Workshop
Helge Aagaard Madsen (Participant)
Department of Wind Energy
Aeroelastic Design
Documents:
Smart_rotor_research_DTU

Related event

The 2014 Sandia Wind Turbine Blade Workshop
26/08/2014 → 28/08/2014
Albuquerque, United States
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

DTU Energy Conversion 2nd International PhD Summer School
Kristine Munk Jespersen (Participant)
Department of Wind Energy
Composites and Materials Mechanics
Department of Energy Conversion and Storage

Description
Participation in DTU Energy Conversion 2nd International PhD Summer School along with poster presentation. The poster
has been attached to this description.
Documents:
IMAGINE Poster by kmun

Related event

Microstructure
25/08/2014 → 29/08/2014
Hundested, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Wind Energy (Journal)
Period: 1 Aug 2014 → 1 Jun 2015
Patrick Volker (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
**Description**
review of the article "A numerical model of wind-farm flows" that was rejected and resubmitted at the end of December 2015. That article has been published without me being a reviewer.

Degree of recognition: International

**Related journal**

*Wind Energy*
1095-4244


Central database
Activity: Research › Peer review of manuscripts

**Group for High Resolution Sea Surface Temperature (External organisation)**

Period: 30 Jul 2014

Ioanna Karagali (Member)

Department of Wind Energy
Meteorology & Remote Sensing

**Description**
GHRSST Science Team
Degree of recognition: International

Links:
https://www.ghrsst.org/about-ghrsst/

**Related external organisation**

**Group for High Resolution Sea Surface Temperature**

Activity: Membership › Membership of research networks or expert groups

11th World Congress on Computational Mechanics, 5th European Conference on Computational Mechanics, 6th European Conference on Computational Fluid Dynamics

Period: 24 Jul 2014

Susana Rojas Labanda (Participant)

Department of Wind Energy
Wind Turbines

**Description**
Benchmarking of optimization methods for topology optimization problems.

Oral presentation

Documents:
Benchmarking of optimization methods for topology optimization problems.

**Related event**

11th World Congress on Computational Mechanics, 5th European Conference on Computational Mechanics, 6th European Conference on Computational Fluid Dynamics

20/07/2014 → 25/07/2014
Barcelona, Spain

Activity: Attending an event › Participating in or organising a conference

**Large-scale Free Material Optimization on 3D design domains by an interior point method**

Period: 22 Jul 2014

Mathias Stolpe (Speaker)

Department of Wind Energy

Wind Turbines
Related event

11th World Congress on Computational Mechanics, 5th European Conference on Computational Mechanics, 6th European Conference on Computational Fluid Dynamics
20/07/2014 → 25/07/2014
Barcelona, Spain
Activity: Talks and presentations › Conference presentations

11th World Congress on Computational Mechanics, 5th European Conference on Computational Mechanics, 6th European Conference on Computational Fluid Dynamics
Alemseged Gebrehiwot Weldeyesus (Speaker)
Department of Wind Energy
Wind Turbines
Documents:
MULTIDISCIPLINARY FREE MATERIAL OPTIMIZATION FOR LAMINATED PLATE AND SHELL STRUCTURES

Related event

American Meteorological Society. Bulletin (Journal)
Period: Jun 2014 → Nov 2014
Mark C. Kelly (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International

Related journal

Bulletin of the American Meteorological Society
0003-0007
Central database
Activity: Research › Peer review of manuscripts

Hard Bop and Cool Jazz
Period: Jun 2014
Bonnie Ram (Lecturer)
Department of Wind Energy
Wind Energy Systems
Documents:
hard bop and cool jazz June 2014

Related external organisation

Unknown external organisation
Activity: Talks and presentations › Conference presentations

Dislocation boundary formation and effect of high angle boundaries in nano copper crystals during in-situ TEM deformation
Period: 18 Jun 2014
Xiaodan Zhang (Invited speaker)
Department of Wind Energy
Materials science and characterization

**Description**
Zhang, Xiaodan ; Huang, Xiaoxu ; Hansen, Niels

**Documents:**
Dislocation boundary formation and effect of high angle boundaries in nano copper crystals during in-situ TEM deformation

**Related event**
17th U.S. National Congress on Theoretical and Applied Mechanics
15/06/2014 → 20/06/2014
East Lansing, Michigan, United States
Activity: Talks and presentations › Conference presentations

**Probabilistic Meteorological Characterization for Turbine Loads**
**Period:** 18 Jun 2014
Mark C. Kelly (Speaker)

Department of Wind Energy
Risø National Laboratory for Sustainable Energy
Meteorology

**Description**
Relating shear, turbulence, and stability: from theory to practice, towards probabilistic loads input.
Degree of recognition: International

**Related event**
5th International Conference on The Science of Making Torque from Wind 2014
10/06/2014 → 20/06/2014
Copenhagen, Denmark
Activity: Talks and presentations › Conference presentations

**SAR for wind energy**
**Period:** 13 Jun 2014
Merete Badger (Lecturer)

Department of Wind Energy
Meteorology

**Description**
PhD Summer School presentation

**Related external organisation**
Unknown external organisation
Activity: Talks and presentations › Conference presentations

**The 15th GHRSST Science Team Meeting**
**Period:** 2 Jun 2014 → 6 Jun 2014
Ioanna Karagiali (Participant)

Department of Wind Energy
Meteorology

**Description**
15th GHRSST Science Team Meeting.
Related event

The 15th GHRSST Science Team Meeting
02/06/2014 → 06/06/2014
Cape Town, South Africa
Activity: Attending an event › Participating in or organising a conference

Weather Intelligence for Renewable Urban Areas
Period: 2 Jun 2014 → 3 Jun 2014
Anna Maria Sempreviva (Organizer)
Meteorology
Department of Wind Energy
Department of Informatics and Mathematical Modeling

Description
COST WIRE and CITIES WORKSHOP,

Documents:
Participants & Programme 29052014
Links:
http://www.wire1002.ch/ (COST ACTION E1002 Weather Intelligence for Renewable Energy)

Related event

Weather Intelligence for Renewable Urban Areas
02/06/2014 → 03/06/2014
Roskilde, Denmark
Activity: Attending an event › Participating in or organising a conference

Site Suitability/Assessment, and WEng
Period: 27 May 2014 → 30 May 2014
Mark C. Kelly (Lecturer)
Department of Wind Energy
Resource Assessment Modelling
Meteorology

Description
Customized course on site-assessment and site-suitability (turbulence, extremes, terrain) using WAsP-Engineering ['WEng'], for both NREL scientists and for graduate students from Texas Tech.University & Univ. Colorado.

Related external organisation
National Renewable Energy Laboratory
United States
Activity: Talks and presentations › Guest lectures, external teaching and course activities at other universities

ESA SciNet 2014
Period: 14 May 2014
Ioanna Karagali (Participant)
Department of Wind Energy
Meteorology

Related event

ESA SciNet 2014
14/05/2014 → 14/05/2014
Noordwijk, Netherlands
Sea-surface roughness and wave characteristics-The variety of expressions
Period: 14 May 2014 → 17 May 2014
Søren Ejling Larsen (Lecturer)
Department of Wind Energy
Meteorology

Description
Review of expression for the sea surface roughness

Related event
Mini Workshop
14/05/2014 → 17/05/2014
Uppsala, Sweden
Activity: Talks and presentations › Conference presentations

Wind Resource Assessment and WAsP
Period: 13 May 2014 → 16 May 2014
Mark C. Kelly (Lecturer)
Department of Wind Energy
Resource Assessment Modelling
Meteorology

Description
Customized Wind Resource course using WAsP, for both NREL scientists and for graduate students from Texas Tech.University & Univ. Colorado.

Related external organisation
National Renewable Energy Laboratory
United States
Activity: Talks and presentations › Guest lectures, external teaching and course activities at other universities

European Geosciences Union General Assembly 2014
Period: 27 Apr 2014 → 2 May 2014
Anna Maria Sempreviva (Organizer)
Meteorology
Department of Wind Energy

Description
Wind and solar power are the predominant new sources of electrical power in recent years. Solar power reached a milestone of providing 50 % of demand in Germany during one hour in 2012, and wind power occasionally exceeds 100 % of demand in Denmark. This kind of explosive growth is likely to continue in the near future. By their very nature, wind and solar power are dependent on weather and climate. Modelling and measurement of both for resource assessment, site selection and operational forecasting for minutes-days time horizon are of paramount importance for the success of wind and solar power integration. The success of wind power means that wind turbines are increasingly put in sites with complex terrain or forests, with towers extending beyond the strict logarithmic profile and offshore regions that are difficult to model and where data are scarcer. Major challenges for solar power are accurate measurements and the short-term prediction of the spatiotemporal evolution of the cloud field. For both solar and wind power, the integration of large amounts of renewable energy into the grid is another critical research problem due to the uncertainties linked to their forecast. We therefore invite contributions in the following areas: • Wind conditions (both resources and loads) on short and long time scales for wind power development. • Solar resource and solar atlas. • Wind conditions in complex terrain (mountains, forests and coastal). • Wake effects, especially for large wind farms and offshore. • Performance and uncertainties of forecasts of wind or solar power at different time horizons and in different external conditions. • Forecast of extreme wind events and wind ramps. • Effects of large-scale integration of wind and solar power. • Local, regional and global impacts of renewable energy power plants. • Dedicated wind measurement techniques (SODARS, LIDARS, UAVs etc.). • Dedicated solar measurement techniques (radiation, aerosol, cloud cover etc.). Any abstract related to other weather dependent renewable energy generation (e.g. wave power, tidal or hydro) will also be considered.
Co-convener at the European Geophysical Union, EGU, General Assembly in the ERE1 Session "Energy Meteorology Links:

Related event

European Geosciences Union General Assembly 2014
27/04/2014 → 02/05/2014
Vienna, Austria
Activity: Attending an event › Participating in or organising a conference

Wind energy - issues you did not know
Period: 24 Apr 2014
Niels-Erik Clausen (Lecturer)
Office for Study Programmes and Student Affairs
Department of Wind Energy
Wind Energy Systems

Description
Two invited lectures. Ørsted (Sjælland) and Roskilde Katedralskole

Related event

Bestil en Forsker - Forskningens Døgn
24/04/2014 → 26/04/2014
Denmark
Activity: Talks and presentations › Conference presentations

Participation in A2e planning meeting to be held 16-18 April 2014 at the National Renewable Energy Laboratory, in Golden, Colorado. (External organisation)
Period: 16 Apr 2014 → 18 Apr 2014
Helge Aagaard Madsen (Participant)
Department of Wind Energy
Aeroelastic Design
Degree of recognition: International

Related external organisation

Participation in A2e planning meeting to be held 16-18 April 2014 at the National Renewable Energy Laboratory, in Golden, Colorado.
Activity: Membership › Membership in review committee

How to use CFD for long-term energy assessments
Period: 8 Apr 2014
Andreas Bechmann (Invited speaker)
Department of Wind Energy
Meteorology
Documents:
ABechmann How to use CFD

Related event

Wind Resource Assessment 2014
08/04/2014 → 10/04/2014
London, United Kingdom
Activity: Talks and presentations › Conference presentations
5th International Conference on The Science of Making Torque from Wind 2014 (Event)
Period: Mar 2014 → Jun 2014
Mark C. Kelly (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International

Related event

5th International Conference on The Science of Making Torque from Wind 2014
10/06/2014 → 20/06/2014
Copenhagen, Denmark
Activity: Research › Peer review of manuscripts

A I P Conference Proceedings Series (Journal)
Period: Mar 2014 → May 2014
Mark C. Kelly (Reviewer)
Department of Wind Energy
Resource Assessment Modelling

Description
Reviewed 4 different Torque 2014 papers.
Degree of recognition: International

Related journal

A I P Conference Proceedings Series
0094-243X
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 0.26 SJR 0.165 SNIP 0.3, ISI indexed (2013): ISI indexed no,
Web of Science (2011): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

Is the Power Density of Large Offshore Wind Farms Limited?
Period: 27 Mar 2014
Patrick Volker (Speaker)
Department of Wind Energy
Meteorology

Description
Presentation
Documents:
pvol_dtuwindenergy

Related event

The Danish Wind Industry Annual Event 2014
26/03/2014 → 27/03/2014
Herning, Denmark
Activity: Talks and presentations › Conference presentations

Advancing beyond shallow waters: Structural optimization of wind turbine substructures
Period: 26 Mar 2014
Mathias Stolpe (Speaker)
Department of Wind Energy
Wind Turbines

Related event

Danish Wind Industry Annual Event 2014
26/03/2014 → 27/03/2014
Herning, Denmark
Activity: Talks and presentations › Conference presentations

EERA DTOC wake results offshore
Period: 12 Mar 2014
Charlotte Bay Hasager (Speaker)
Department of Wind Energy
Meteorology

Related event

European Wind Energy Conference & Exhibition 2014
10/03/2014 → 13/03/2014
Barcelona, Spain
Activity: Talks and presentations › Conference presentations

Geophysical and Astrophysical Fluid Dynamics (Journal)
Period: Feb 2014 → Jul 2014
Mark C. Kelly (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International

Related journal

Geophysical and Astrophysical Fluid Dynamics
0309-1929
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 1 SJR 0.744 SNIP 0.707, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

Advances in Science and Research (Journal)
Period: 17 Feb 2014
Ioanna Karagali (Reviewer)
Department of Wind Energy
Meteorology & Remote Sensing

Related journal

Advances in Science and Research
1992-0628
Indexed in DOAJ
Central database
Activity: Research › Peer review of manuscripts

Period: 22 Jan 2014 → 25 Jan 2014
Thomas Buhl (Organizer)
Department of Wind Energy
Wind Turbines

**Description**
Chairman and member of scientific committee

**Related event**

**EERA DeepWind 2014 - 11th Deep Sea Offshore Wind R&D Conference**
22/01/2014 → 24/01/2014
Trondheim, Norway
Activity: Attending an event › Participating in or organising a conference

**EERA Design Tool for Offshore wind farm Cluster (DTOC)**
Period: 22 Jan 2014
Charlotte Bay Hasager (Invited speaker)
Department of Wind Energy
Meteorology

**Related event**

**EERA DeepWind 2014 - 11th Deep Sea Offshore Wind R&D Conference**
22/01/2014 → 24/01/2014
Trondheim, Norway
Activity: Talks and presentations › Conference presentations

**INNWIND.EU. Overview of project and recent results**
Period: 22 Jan 2014
Peter Hjuler Jensen (Invited speaker)
Department of Wind Energy

**Related event**

**EERA DeepWind 2014 - 11th Deep Sea Offshore Wind R&D Conference**
22/01/2014 → 24/01/2014
Trondheim, Norway
Activity: Talks and presentations › Conference presentations

**Journal of Geophysical Research - Part C - Ocean (Journal)**
Period: 10 Jan 2014
Ioanna Karagali (Reviewer)
Department of Wind Energy
Meteorology & Remote Sensing

**Related journal**

**Journal of Geophysical Research - Part C - Ocean**
Local database
Activity: Research › Peer review of manuscripts

**DCAMM 14th Internal Symposium**
Period: 2013
Susana Rojas Labanda (Participant)
Department of Wind Energy
Wind Turbines

**Description**
Mathematical programming methods for large-scale topology optimization problems
Poster Presentation

Documents:
abstract_DCAMM_2013

**Related event**

**DCAMM 14th Internal Symposium**
13/03/2013 → 15/03/2013
Nyborg, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

**DCAMM's Videnskabelige Råd (External organisation)**
Period: 2013 → …
Lars Pilgaard Mikkelsen (Participant)
Department of Wind Energy
Composites and Materials Mechanics
Links:
http://www.dcamm.dk/

**Related external organisation**

**DCAMM's Videnskabelige Råd**
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

**Design of Lightweight Composite Structures**
Period: 2013
Philipp Ulrich Haselbach (Lecturer)
Department of Wind Energy
Wind Turbines

**Description**
Teaching at the Master course "Design of Lightweight Composite Structures" at the Technical University of Denmark, DTU Wind Energy.
(Course lecturer)

**Related organisation**

**Design of Lightweight Composite Structures**
Haselbach, P. U. (Lecturer)
2013
Activity: Other

**IEA Task 31 2nd Annual Meeting**
Period: 2013
Andrey Sogachev (Speaker)
Risø National Laboratory for Sustainable Energy
Department of Wind Energy
Meteorology

**Description**
Improving a two-equation closure models for atmospheric stratified flow.

**Related event**

**IEA Task 31 2nd Annual Meeting**
14/11/2013 → 15/11/2013
Stuttgart, Germany
Activity: Talks and presentations › Conference presentations
Journal of Geophysics Research (Journal)
Period: 2013 → 2017
Xiaoli Guo Larsén (Reviewer)
Department of Wind Energy
Resource Assessment Modelling

Related journal
Journal of Geophysics Research

Local database
Activity: Research › Peer review of manuscripts

The behaviour of wind wind power during Nordic storms
Period: 2013
Xiaoli Guo Larsén (Main supervisor)
Department of Wind Energy
Resource Assessment Modelling

Description
Master Project: Dimitrios Alexandropoulos from DTU
Activity: Examinations and supervision › Supervisor activities

EarthTemp Arctic SST Meeting
Period: 18 Dec 2013 → 19 Dec 2013
Ioanna Karagali (Speaker)
Department of Wind Energy
Meteorology

Description
EarthTemp Arctic SST Meeting.

Related event
EarthTemp Arctic SST Meeting
18/12/2013 → 19/12/2013
Exeter, United Kingdom
Activity: Talks and presentations › Conference presentations

Megavind strategy – Increasing the owners’ value of wind in energy systems with large shares of wind (External organisation)
Period: Nov 2013 → Sep 2014
Poul Ejnar Sørensen (Secretary)
Department of Wind Energy
Integration & Planning
Degree of recognition: National

Related external organisation
Megavind strategy – Increasing the owners’ value of wind in energy systems with large shares of wind
Denmark
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

Graded structures in materials: Microstructure, strength and application
Period: 29 Nov 2013
Xiaodan Zhang (Speaker)
Department of Wind Energy
Materials science and characterization

**Description**
MAC section meeting, Nov 2013.
Documents:
Graded structures in materials, Microstructure, Strength and Application

**Related external organisation**

**Unknown external organisation**
Activity: Talks and presentations › Conference presentations

**First Offshore Comparative Resource and Energy Yield Assessment Procedures (CREYAP)**
**Period:** 21 Nov 2013
Niels Gylling Mortensen (Invited speaker)
Department of Wind Energy
Meteorology

**Description**
Presentation of results from the 1st Offshore Comparison of Resource and Energy Yield Assessment Procedures (CREYAP) exercise.

**Related external organisation**

**Unknown external organisation**
Activity: Talks and presentations › Conference presentations

**EWEA Offshore 2013**
**Period:** 19 Nov 2013 → 21 Nov 2013
Thomas Buhl (Organizer)
Department of Wind Energy
Wind Turbines

**Description**
Lead session chair and program committee.

**Related event**

**EWEA Offshore 2013**
19/11/2013 → 21/11/2013
Frankfurt, Germany
Activity: Attending an event › Participating in or organising a conference

**Topical Expert Meeting on "Challenges of wind energy in complex terrain"**
**Period:** 12 Nov 2013
Andrey Sogachev (Speaker)
Department of Wind Energy
Meteorology

**Description**
Towards the consistent two-equation closure modeling of atmospheric flows.

**Related event**

**Topical Expert Meeting on "Challenges of wind energy in complex terrain": IEA R&D Wind Task 11**
Flow stabilization in submicron-sized copper crystals by introducing high angle boundaries
Period: 28 Oct 2013
Xiaodan Zhang (Invited speaker)
Department of Wind Energy
Materials science and characterization
Documents:
Flow stabilization in submicron-sized copper crystals by introducing high angle boundaries

Related event
Materials Science and Technology Conference and Exhibition 2013
27/10/2013 → 31/10/2013
Montreal, Canada
Activity: Talks and presentations › Conference presentations

Interior point methods for the variable thickness sheet problem
Period: 27 Sep 2013
Mathias Stolpe (Invited speaker)
Department of Wind Energy
Wind Turbines
Description
Seminar at optimization and Systems theory, Department of Mathematics, KTH.

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

9th European Academy of Wind Energy PhD seminar in Wind Energy in Europe
Period: 18 Sep 2013 → 20 Sep 2013
Philipp Ulrich Haselbach (Participant)
Department of Wind Energy
Wind Turbines
Description
Ultimate strength of wind turbine blade structures under multiaxial loading

Related event
9th European Academy of Wind Energy PhD seminar in Wind Energy in Europe
18/09/2013 → 20/09/2013
Visby, Gotland, Sweden
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

2013 EUMETSAT Meterological Satellite Conference and 19th American Meteorological Society AMS Satellite Meteorology, Oceanography, and Climatology Conference
Period: 16 Sep 2013 → 20 Sep 2013
Ioanna Karagali (Speaker)
Department of Wind Energy
Meteorology
Related event
The European Energy Research Alliance (EERA) – Aligning National and European Wind Energy Research
Period: 10 Sep 2013 → 12 Sep 2013
Peter Hauge Madsen (Speaker)
Department of Wind Energy

Related event

DTU International Energy Conference 2013: Sustainable energy for green economic growth
10/09/2013 → 12/09/2013
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

Methods for large-scale variable thickness sheet problems
Period: 8 Sep 2013 → 13 Sep 2013
Mathias Stolpe (Invited speaker)
Department of Wind Energy
Wind Turbines

Related event

IFIP TC 7 / 2013 System Modelling and Optimization
08/09/2013 → 13/09/2013
Klagenfurt, Austria
Activity: Talks and presentations › Conference presentations

Sea Surface Temperature Diurnal Variability Regional Extend – Implications in Atmospheric Modelling
Period: 8 Sep 2013 → 13 Sep 2013
Ioanna Karagali (Speaker)
Department of Wind Energy
Meteorology

Related event

ESA Living Planet Symposium
09/09/2013 → 13/09/2013
Edinburgh, United Kingdom
Activity: Talks and presentations › Conference presentations

Microstructure and strength: graded nanostructures in materials
Period: 23 Aug 2013
Xiaodan Zhang (Speaker)
Department of Wind Energy
Materials science and characterization
Documents: Microstructure and strength_graded structures in materials

Related event

Summer school and symposium on nanometals 2013
19/08/2013 → 23/08/2013
Weihai, China
Activity: Talks and presentations › Conference presentations
Vortex wake models with application to yawed rotor
Period: 6 Aug 2013
Emmanuel Simon Pierre Branlard (Speaker)
Department of Wind Energy
Aeroelastic Design
Documents:
NAWEA-2A-VortexWakeModelsYawedRotor-Branlard-2013

Related event
North American Wind Energy Academy Symposium
06/08/2013 → 08/08/2013
Boulder, United States
Activity: Talks and presentations › Conference presentations

19th International Conference on Composite Materials
Period: 29 Jul 2013
Sanita Zike (Participant)
Department of Wind Energy
Composites and Materials Mechanics
Description
Participation in the conference included poster presentation and published paper in the conference proceedings
Documents:
DCB TEST SAMPLE DESIGN FOR MICRO-MECHANICAL TESTING
Poster
Links:
http://www.iccm19.org/

Related event
19th International Conference on Composite Materials
28/07/2013 → 02/08/2013
Montréal, Canada
Activity: Attending an event › Participating in or organising a conference

ECCOMAS Multibody Dynamics 2013
Period: 1 Jul 2013 → 4 Jul 2013
Juan Felipe Gallego Calderon (Participant)
Department of Wind Energy
Wind Turbines
Description
Towards a Detailed Drive-train Model with MATLAB and Aeroelastic Wind Turbine Code

Related event
ECCOMAS Multibody Dynamics 2013
01/07/2013 → 04/07/2013
Zagreb, Croatia
Activity: Attending an event › Participating in or organising a conference

Geophysical and Astrophysical Fluid Dynamics (Journal)
Period: Jun 2013 → Aug 2013
Mark C. Kelly (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International

Related journal

Geophysical and Astrophysical Fluid Dynamics
0309-1929
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 1 SJR 0.744 SNIP 0.707, ISI indexed (2013): ISI indexed yes, Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

Journal of the Atmospheric Sciences (Journal)
Period: Jun 2013 → Nov 2013
Mark C. Kelly (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International

Related journal

Journal of the Atmospheric Sciences
0022-4928
Central database
Activity: Research › Peer review of manuscripts

Comparative Resource and Energy Yield Assessment Procedures (CREYAP) Pt. II
Period: 26 Jun 2013
Niels Gylling Mortensen (Invited speaker)
Department of Wind Energy
Meteorology
Description
Presentation of results from the 2nd Comparison of Resource and Energy Yield Assessment Procedures (CREYAP) exercise.

Related external organisation

Unknown external organisation
Activity: Talks and presentations › Conference presentations

14th GHRSST Science Team Meeting
Period: 17 Jun 2013 → 21 Jun 2013
Ioanna Karagali (Speaker)
Department of Wind Energy
Meteorology
Related event

14th GHRSST Science Team Meeting: Group for High Resolution Sea Surface Temperature
17/06/2013 → 21/07/2013
WoodsHole, MA, United States
Activity: Talks and presentations › Conference presentations

Design tool for offshore clusters: objectives of the project
Period: 6 Jun 2013
Peter Hauge Madsen (Speaker)
Department of Wind Energy

Related event

Offshore Wind Farm Clusters: Design tools for enhanced performance and value of North Sea Offshore Wind Power
06/06/2013 → …
London, United Kingdom
Activity: Talks and presentations › Conference presentations

Journal of Geophysical Research: Atmospheres (Journal)
Period: May 2013 → Jul 2013
Mark C. Kelly (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International

Related journal

Journal of Geophysical Research: Atmospheres
0148-0227
Central database
Activity: Research › Peer review of manuscripts

Optimal design of laminated composite beams with mass, stiffness, and frequency constraints
Period: 23 May 2013
José Pedro Albergaria Amaral Blasques (Speaker)
Department of Wind Energy
Wind Turbines

Description

Related event

10th World Congress on Structural and Multidisciplinary Optimization
19/05/2013 → 24/05/2013
Orlando, FL, United States
Activity: Talks and presentations › Conference presentations

10th World Congress on Structural and Multidisciplinary Optimization
Period: 19 May 2013 → 23 May 2013
Alemseged Gebrehiwot Weldeyesus (Speaker)
Department of Wind Energy
Wind Turbines
Documents:
Multidisciplinary Free Material Optimization of 2D and Laminate Structures
Links:
http://www2.mae.ufl.edu/mdo/Abstracts/5087.pdf

Related event

10th World Congress on Structural and Multidisciplinary Optimization
19/05/2013 → 24/05/2013
Orlando, FL, United States
Activity: Talks and presentations › Conference presentations
The variable thickness sheet problem revisited
Period: 19 May 2013 → 24 May 2013
Mathias Stolpe (Lecturer)
Department of Wind Energy
Wind Turbines

Related event
10th World Congress on Structural and Multidisciplinary Optimization
19/05/2013 → 24/05/2013
Orlando, FL, United States
Activity: Talks and presentations › Conference presentations

6th International Conference on Composites Testing and Model Identification
Period: 22 Apr 2013 → 24 Apr 2013
Sanita Zike (Participant)
Department of Wind Energy
Composites and Materials Mechanics
Description
Participating with poster presentation
Documents:
Related event
6th International Conference on Composites Testing and Model Identification
22/04/2013 → 24/04/2013
Aalborg, Denmark
Activity: Attending an event › Participating in or organising a conference

DCAMM 14th Internal Symposium
Period: Mar 2013
Philipp Ulrich Haselbach (Participant)
Department of Wind Energy
Wind Turbines
Description
Ultimate strength of wind turbine blade structures under multiaxial loading
Related event
DCAMM 14th Internal Symposium
13/03/2013 → 15/03/2013
Nyborg, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Uncertainties in wind resource assessment
Period: 19 Mar 2013
Niels Gylling Mortensen (Lecturer)
Department of Wind Energy
Meteorology
Related event
**MARINET training courses: Offshore wind measurement techniques**
18/03/2013 → 22/03/2013
Roskilde, Denmark
Activity: Talks and presentations › Conference presentations

**Offshore wind resource assessment**
Period: 18 Mar 2013
Niels Gylling Mortensen (Lecturer)
Department of Wind Energy
Meteorology

**Related event**

**MARINET training courses: Offshore wind measurement techniques**
18/03/2013 → 22/03/2013
Roskilde, Denmark
Activity: Talks and presentations › Conference presentations

**DCAMM 14th Internal Symposium**
Period: 13 Mar 2013 → 15 Mar 2013
Sanita Zike (Participant)
Department of Wind Energy
Composites and Materials Mechanics

**Description**
Participation with oral presentation: Micro-Scale Experiments and Models for Composite Materials
Documents:
Abstract
Presentation

**Related event**

**DCAMM 14th Internal Symposium**
13/03/2013 → 15/03/2013
Nyborg, Denmark
Activity: Attending an event › Participating in or organising a conference

**DCAMM 14th Internal Symposium**
Period: 13 Mar 2013 → 15 Mar 2013
Alemseged Gebrehiwot Weldeyesus (Speaker)
Department of Wind Energy
Wind Turbines
Documents:
Free Material Optimization of Composite Structures

**Related event**

**DCAMM 14th Internal Symposium**
13/03/2013 → 15/03/2013
Nyborg, Denmark
Activity: Talks and presentations › Conference presentations

**DCAMM 14th Internal Symposium**
Period: 13 Mar 2013 → 15 Mar 2013
Juan Felipe Gallego Calderon (Participant)
Department of Wind Energy
Wind Turbines

Description
Electromechanical Drive-train Simulation

Related event

DCAMM 14th Internal Symposium
13/03/2013 → 15/03/2013
Nyborg, Denmark
Activity: Attending an event › Participating in or organising a conference

Wind Energy: Strengthening the collaboration between Denmark and Japan
Period: 9 Mar 2013
Peter Hauge Madsen (Speaker)
Department of Wind Energy
Documents:
Program

Related event

Pugwash: Remembering Fukushima
09/03/2013 → …
København, Denmark
Activity: Talks and presentations › Conference presentations

10th Deep Sea Offshore Wind R & D Conference
Period: Feb 2013
Philipp Ulrich Haselbach (Participant)
Department of Wind Energy

Wind Turbines

Description
Presentation of "Comparison of coupled and uncoupled load simulations on a jacket support structure"

Comparison of coupled and uncoupled load simulations on a jacket support structure

Related event

10th Deep Sea Offshore Wind R & D Conference
24/01/2013 → 25/01/2013
Trondheim, Norway
Activity: Attending an event › Participating in or organising a conference

DTU-KAIST Workshop
Period: 21 Feb 2013 → 22 Feb 2013
Ioanna Karagali (Speaker)
Department of Wind Energy

Meteorology

Description
DTU-KAIST Workshop in Division of Ocean Systems Engineering

Related external organisation

Korea Advanced Institute of Science and Technology
Korea, Republic of
Activity: Talks and presentations › Guest lectures, external teaching and course activities at other universities
European Wind Energy Conference & Exhibition 2013
Period: 6 Feb 2013
Marisciel Litong-Palima (Speaker)
Department of Wind Energy
Wind Energy Systems

**Description**
Impact of Offshore Wind Turbine Controls on Danish Power System 2020 in Critical Weather Situations
Oral Presentation

**Related event**
European Wind Energy Conference & Exhibition 2013
04/02/2013 → 07/02/2013
Vienna, Austria
Activity: Talks and presentations › Conference presentations

**Journal of Renewable and Sustainable Energy (Journal)**
Period: Jan 2013 → Feb 2013
Mark C. Kelly (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International

**Related journal**
Journal of Renewable and Sustainable Energy
1941-7012
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 1.41 SJR 0.44 SNIP 0.588, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

**Meteorological Applications (Journal)**
Period: Jan 2013 → Mar 2013
Mark C. Kelly (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International

**Related journal**
Meteorological Applications
1350-4827
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 1.96 SJR 0.654 SNIP 1.025, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

**Weather Research & Forecasting User Tutorial**
Period: 28 Jan 2013 → 5 Feb 2013
Ioanna Karagali (Participant)
Department of Wind Energy
Meteorology
Description
Training course for the Weather Research & Forecasting (WRF) model, at the National Center for Atmospheric Research (NCAR), Boulder, Colorado

Related event
Weather Research & Forecasting User Tutorial
28/01/2013 → 05/02/2013
Boulder, CO, United States
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

10th Deep Sea Offshore Wind R & D Conference
Period: 24 Jan 2013 → 25 Jan 2013
Thomas Buhl (Organizer)
Department of Wind Energy
Wind Turbines

Description
Chairman and member of scientific committee

Related event
10th Deep Sea Offshore Wind R & D Conference
24/01/2013 → 25/01/2013
Trondheim, Norway
Activity: Attending an event › Participating in or organising a conference

8th WES workshop
Period: 23 Jan 2013
Marisciel Litong-Palima (Speaker)
Department of Wind Energy
Wind Energy Systems

Description
Impact of Offshore Wind Turbine Controls on Danish Power System 2020 in Critical Weather Situations

Related event
8th WES workshop: TWENTIES project - Economic assessment and EU wide replication potential
23/01/2013 → …
Roskilde, Denmark
Activity: Talks and presentations › Conference presentations

Participation in A2e planning meeting January 20-21, 2013 at the Virginia Tech Executive Briefing Center in Arlington, Virginia. (External organisation)
Period: 20 Jan 2013 → 21 Jan 2013
Helge Aagaard Madsen (Participant)
Department of Wind Energy
Aeroelastic Design
Degree of recognition: International

Related external organisation
Participation in A2e planning meeting January 20-21, 2013 at the Virginia Tech Executive Briefing Center in Arlington, Virginia.
Activity: Membership › Membership in review committee

Composite Structures (Journal)
Period: 2012 → …
Robert Bitsche (Reviewer)
Department of Wind Energy

Description
Composite Structures

Related journal
Composite Structures
0263-8223
Central database
Activity: Research › Peer review of manuscripts

Consiglio Nazionale delle Ricerche (External organisation)
Period: 2012 → 30 Apr 2014
Anna Maria Sempreviva (Member)

Meteorology
Description
CNR representative in the Board of Directors for the CRATI s.c.r.l, "Consorzio per la Ricerca e Applicazioni di Tecnologie Innovative. Cosenza, Italy
Degree of recognition: National
Documents:
TELEGRAMMA NOMINA_CRATI_SEMPREVIVA

Related external organisation
Consiglio Nazionale delle Ricerche
Italy
Activity: Membership › Board duties in companies, associations, or public organisations

DTU Wind Energy's Board of Studies (Studienævn) (External organisation)
Period: 2012 → …
Lars Pilgaard Mikkelsen (Participant)
Department of Wind Energy
Composites and Materials Mechanics

Related external organisation
DTU Wind Energy's Board of Studies (Studienævn)
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

On the predictability of Hub Height Winds
Period: 2012
Xiaoli Guo Larsén (External examiner)
Department of Wind Energy
Resource Assessment Modelling

Description
PhD defense by Caroline Draxl from DTU
Activity: Examinations and supervision › External examination

Flow distortion at a dense forest edge
Period: 3 Dec 2012
Ebba Dellwik (Speaker)
Department of Wind Energy
Meteorology

Related event

2012 AGU Fall Meeting
03/12/2012 → 07/12/2012
San Francisco, United States
Activity: Talks and presentations › Conference presentations

Præsentation om planerne om en vindtunnel på DTU
Period: 7 Nov 2012
Christian Bak (Lecturer)
Department of Wind Energy
Aeroelastic Design

Related event

Gå-hjem-møde for Roskilde Håndværkerforening
07/11/2012 → …
Roskilde, Denmark
Activity: Talks and presentations › Conference presentations

I E T Renewable Power Generation (Journal)
Poul Ejnar Sørensen (Editor)
Department of Wind Energy
Integration & Planning
Degree of recognition: International

Related journal

I E T Renewable Power Generation
1752-1416
Central database
Activity: Research › Journal editor

TKI WoZ Advisory Board Meeting (External organisation)
Period: 1 Oct 2012 → …
Thomas Buhl (Participant)
Department of Wind Energy
Wind Turbines

Description
Dutch innovation fund for offshore wind enerngy. Agentschap NL en Dienst Regelingen. RVO.nl
Degree of recognition: International

Related external organisation

TKI WoZ Advisory Board Meeting
Activity: Membership › Membership of commitees, commissions, boards, councils, associations, organisations, or similar

Polymers - Experimental characterization and numerical predictions
Period: 19 Sep 2012 → 20 Sep 2012
Sanita Zike (Participant)
Department of Wind Energy
Composites and Materials Mechanics

Related event
\textbf{Polymers - Experimental characterization and numerical predictions}
19/09/2012 → 20/09/2012
Roskilde, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

\textbf{Præsentation om planerne om en vindtunnel på DTU}
Period: 18 Sep 2012
Christian Bak (Lecturer)
Department of Wind Energy
Aeroelastic Design

Related event
\textbf{Gå-hjem-møde for IDA, Region Sjælland}
18/09/2012 → …
Roskilde, Denmark
Activity: Talks and presentations › Conference presentations

\textbf{Cold-drawn pearlitic steel wire and its applications}
Period: 30 Aug 2012
Xiaodan Zhang (Invited speaker)
Department of Wind Energy
Materials science and characterization

Related event
\textbf{11th International Conference on Nanostructured Materials}
26/08/2012 → 31/08/2012
Rhodes, Greece
Activity: Talks and presentations › Conference presentations

\textbf{Local and mesoscale atmospheric impacts of wind farms}
Period: 26 Aug 2012
Xiaoli Guo Larsén (External examiner)
Department of Wind Energy
Resource Assessment Modelling

Description
PhD defense by Anna Fitch from Bergen University
Degree of recognition: International
Activity: Examinations and supervision › External examination

\textbf{Censor at University of Copenhagen, Institute of Geography and Geology}
Period: 24 Aug 2012
Charlotte Bay Hasager (External examiner)
Meteorology
Department of Wind Energy

Description
Censor at M.Sc. examination
Activity: Examinations and supervision › External examination

**Composites Design Workshop VII**
Sanita Zike (Participant)
Department of Wind Energy
Composites and Materials Mechanics
Links:
http://www.stanford.edu/group/composites/Workshop/previous.html (Workshop homepage)

**Related event**

**Composites Design Workshop VII**
14/08/2012 → 23/08/2012
United States
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

**Fundamental properties of discrete topology optimization problems**
Mathias Stolpe (Lecturer)
Wind Turbines
Department of Wind Energy

**Related event**

**Topology Optimization in Structural and Continuum Mechanics**
18/06/2012 → 22/07/2012
Udine, Italy
Activity: Talks and presentations › Conference presentations

**Global optimization by branch-and-bound methods – Part I**
Mathias Stolpe (Lecturer)
Wind Turbines
Department of Wind Energy

**Related event**

**Topology Optimization in Structural and Continuum Mechanics**
18/06/2012 → 22/07/2012
Udine, Italy
Activity: Talks and presentations › Conference presentations

**Global topology optimization by branch-and-bound methods – Part II**
Mathias Stolpe (Lecturer)
Wind Turbines
Department of Wind Energy

**Related event**

**Topology Optimization in Structural and Continuum Mechanics**
18/06/2012 → 22/07/2012
Udine, Italy
Activity: Talks and presentations › Conference presentations
Global topology optimization by local branching
Mathias Stolpe (Lecturer)
Wind Turbines
Department of Wind Energy

Related event
Topology Optimization in Structural and Continuum Mechanics
18/06/2012 → 22/07/2012
Udine, Italy
Activity: Talks and presentations › Conference presentations

Trajectories of material interpolation schemes
Mathias Stolpe (Speaker)
Wind Turbines
Department of Wind Energy

Related event
Topology Optimization in Structural and Continuum Mechanics
18/06/2012 → 22/07/2012
Udine, Italy
Activity: Talks and presentations › Conference presentations

An alternative material interpolation scheme (RAMP) for minimum compliance topology optimization
Period: 19 Jun 2012 → 20 Jun 2012
Mathias Stolpe (Lecturer)
Wind Turbines
Department of Wind Energy

Related event
Topology Optimization in Structural and Continuum Mechanics
18/06/2012 → 22/07/2012
Udine, Italy
Activity: Talks and presentations › Guest lectures, external teaching and course activities at other universities

Djøf - Representative of scientific and administrative staff (VIP/TAP) (External organisation)
Period: 12 Jun 2012 → 31 Dec 2016
Karen Holm Olsen (Participant)
Wind Energy Systems
Department of Management Engineering
UNEP DTU Partnership

Description
Union representative

Related external organisation
Djøf - Representative of scientific and administrative staff (VIP/TAP)
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

Optimizing Reliability using BECAS - an Open-Source Cross Section Analysis Tool
Period: 11 Jun 2012
Robert Bitsche (Speaker)
Department of Wind Energy
Wind Turbines
Documents:
vinddag2012_bitsche_public_version

Related event
DTU Wind Power Day 2012: Optimising reliability
11/06/2012 → …
Activity: Talks and presentations › Conference presentations

Sanita Zike (Participant)
Department of Wind Energy
Composites and Materials Mechanics
Links:
http://media.cism.it/courses%2FC1201%2F1--Sadowski-Trovalusci7____.pdf (Course description)

Related event
Multiscale Modelling of Complex Materials
21/05/2012 → 25/05/2012
Udine, Italy
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Marisciel Litong-Palima (Participant)
Department of Wind Energy
Wind Energy Systems
Description
Poster Presentation - Wind-induced day-ahead and hour-ahead imbalances in a power system with a significant wind mix: Simulations in the Danish experience

Related event
EWEA 2012 - European Wind Energy Conference & Exhibition
16/04/2012 → 19/04/2012
Copenhagen, Denmark
Activity: Attending an event › Participating in or organising a conference

Thomas Buhl (Organizer)
Department of Wind Energy
Wind Turbines
Description
Chairman and member of scientific committee

Related event
9th Deep Sea Offshore Wind R&D Seminar
19/01/2012 → 20/01/2012
Trondheim, Norway
Activity: Attending an event › Participating in or organising a conference

**Advances in Meteorology (Journal)**
Period: 2011 → 2017
Xiaoli Guo Larsén (Reviewer)
Department of Wind Energy
Resource Assessment Modelling

**Related journal**
**Advances in Meteorology**
1687-9317
Scopus rating (2017): CiteScore 1.15 SJR 0.48 SNIP 0.565, Web of Science (2018): Indexed yes
Indexed in DOAJ
Local database

Activity: Research › Peer review of manuscripts

**QuikSCAT for wind energy resource assessment**
Period: 5 Dec 2011 → 9 Dec 2011
Ioanna Karagali (Speaker)
Department of Wind Energy
Meteorology

**Related event**
**2011 AGU Fall Meeting**
05/12/2011 → 09/12/2011
San Francisco, CA, United States
Activity: Talks and presentations › Conference presentations

**EWEA offshore 2011**
Period: 29 Nov 2011 → 1 Dec 2011
Thomas Buhl (Participant)
Department of Wind Energy
Wind Turbines

**Description**
Lead session chair and program committee

**Related event**
**EWEA offshore 2011**
29/11/2011 → 01/12/2011
Amsterdam, Netherlands
Activity: Attending an event › Participating in or organising a conference

**6th Wind Energy Systems Workshop (WES Workshop); 8: SimBa Intra-hour Simulation of the Power Balances**
Period: 8 Nov 2011
Marisciel Litong-Palima (Speaker)
Risø National Laboratory for Sustainable Energy
Wind Energy Division
Wind Energy Systems

**Description**
Energinet.dk is working to find out how future development of the energy system, which implies a new combination of production sources, will affect the system balance and what the future costs of balancing this system will be. In order to be able to give a qualified answer to these questions, a new model called SimBa has been developed. SimBa models the
intra-hour balancing of the power system and is based on the Danish principles of balancing. Traditionally, modelling issues have put the main focus on calculating hourly energy values, while intra-hourly modelling attracted little attention. SimBa has closed this gap.

Place: H.H. Koch Auditorium, DTU - Risø Campus Roskilde

Documents:
SimBa – the (Wind) Forecasts.pdf

Links:
http://www.risoe.dtu.dk/Conferences/VES_Workshop/workshop_six.aspx (REL-OA)
http://www.risoe.dtu.dk/Conferences/VES_Workshop/~media/Risoe_dk/Conferences/VES_workshop/Documents/workshop_6/3SimBathe_Wind_Forecasts.ashx (DOC-OA)

Related external organisation

Unknown external organisation
Activity: Talks and presentations › Conference presentations

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**Current status and challenges in wind energy assessment**

**Period:** 7 Nov 2011

Sven-Erik Gryning (Speaker)

Risø National Laboratory for Sustainable Energy

Wind Energy Division

Meteorology

**Description**

Place: 1st International conference on Energy and Meteorology : Weather and climate for the energy industry, Australia 8-11 Nov

Related external organisation

Unknown external organisation
Activity: Talks and presentations › Conference presentations

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**COST ACTION ES1002 Weather Intelligence for Renewable Energy (External organisation)**

**Period:** 1 Nov 2011 → 31 Oct 2014

Anna Maria Sempreviva (Chairman)

Meteorology

Department of Wind Energy

**Description**

Vice-Chairman

Degree of recognition: International

Links:
http://www.wire1002.ch/ (COST Action ES1002 WIRE: Weather Intelligence for Renewable Energies Due to climate change and shrinking fossil resources, the transition to more and more renewable energy shares is unavoidable. But, as wind and solar energy is strongly dependent on highly variable weather processes, increased penetration rates will also lead to strong fluctuations in the electricity grid which need to be balanced. Proper and specific forecasting of 'energy weather' is a key component for this. Therefore, it is timely to scientifically address the requirements to provide the best possible specific weather information for forecasting the energy production of wind and solar power plants for the next minutes up to several days ahead. Towards such aims, this Action will have two main lines of activity: first develop dedicated post-processing algorithms coupled with weather prediction models and measurement data especially remote sensing observations; second investigate the difficult relationship between the highly intermittent weather dependent power production and the energy distribution towards end users. The second goal will raise new challenges as this will require from the energy producers and distributors definitions of the requested forecast data and new technologies dedicated to the management of power plants and electricity grids.)

Related external organisation
Overview of the development of wind turbine technology
Flemming Rasmussen (Speaker)
Risø National Laboratory for Sustainable Energy
Wind Energy Division
Aeroelastic Design

Description
Place: China Wind Energy 2011, Beijing, 19-21 Oct

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

Long Term Research Needs - status and perspectives
Period: 5 Oct 2011
Flemming Rasmussen (Speaker)
Risø National Laboratory for Sustainable Energy
Wind Energy Division
Aeroelastic Design

Description
Place: IEA R&D Wind Task XI - Topical Expert Meeting On Long Term R&D Needs on Wind Power, Brussels (BE)

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

Introduction to offshore wind resources: WAsP for offshore wind farms
Period: 21 Sep 2011
Niels Gylling Mortensen (Lecturer)
Department of Wind Energy
Meteorology

Related event
South Baltic OFF.E.R: Offshore Summer School and Workshop
19/09/2011 → 22/09/2011
Roskilde, Denmark
Activity: Talks and presentations › Conference presentations

Airfoil design
Period: 1 Aug 2011 → 5 Aug 2011
Christian Bak (Lecturer)
Wind Energy Division
Aeroelastic Design
Risø National Laboratory for Sustainable Energy

Description
Place: SYSWIND Summer School 2011 on Structural and Aerodynamics of Wind Turbines, aalborg (DK)
Related event

SYSWIND Summer School 2011 on Structural and Aerodynamics of Wind Turbines
01/08/2011 → 05/08/2011
Aalborg, Denmark
Activity: Talks and presentations › Guest lectures, external teaching and course activities at other universities

Related event

GHRSSST XII Science Team Meeting
Period: 27 Jun 2011 → 01 Jul 2011
Ioanna Karagali (Participant)
Department of Wind Energy
Meteorology

GHRSSST XII Science Team Meeting
27/06/2011 → 01/07/2011
Edinburgh, United Kingdom
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

European Wind Energy Technology Platform - TPWind (External organisation)
Period: 1 Jun 2011 → …
Thomas Buhl (Participant)
Department of Wind Energy
Wind Turbines
Description
TPWind is composed of an Executive Committee, a Steering Committee, Working Groups, an Advisory Board and a Secretariat. Working Groups are the following: WG1 : Wind Conditions WG2 : Wind Power Systems WG3 : Grid Integration WG4 : Offshore WG5 : Environment & Deployment
Degree of recognition: International

Related external organisation

European Wind Energy Technology Platform - TPWind
Activity: Membership › Membership of research networks or expert groups

Member of Industrial Advisory Board, University of Strathclyde - Doctoral Training Centre (External organisation)
Period: 1 Jun 2011 → 31 Dec 2015
Helge Aagaard Madsen (Participant)
Department of Wind Energy
Aeroelastic Design
Description
Invited as one of two non-UK members of the advisory board for PhD education at the University of Stratchclyde
Degree of recognition: International

Related external organisation

Member of Industrial Advisory Board, University of Strathclyde - Doctoral Training Centre
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

Comparison of Resource and Energy Yield Assessment Procedures
Period: 11 May 2011
Niels Gylling Mortensen (Invited speaker)
Department of Wind Energy
Meteorology
Presentation of results from the 1st Comparison of Resource and Energy Yield Assessment Procedures (CREYAP) exercise.

**Trends in Wind Energy Technology Development**
Period: 10 May 2011 → 12 May 2011
Flemming Rasmussen (Speaker)
Risø National Laboratory for Sustainable Energy
Wind Energy Division
Aeroelastic Design

**Ocean winds for wind power using stellite winds**
Period: 27 Apr 2011
Charlotte Bay Hasager (Speaker)
Risø National Laboratory for Sustainable Energy
Wind Energy Division
Meteorology

**Fra atomkraft til vindenergi**
Period: 13 Apr 2011
Torben Krogh Mikkelsen (Speaker)
Risø National Laboratory for Sustainable Energy
Wind Energy Division
Meteorology

**Aerodynamics and aero-elastics**
Period: 16 Mar 2011
Flemming Rasmussen (Speaker)
Risø National Laboratory for Sustainable Energy
Wind Energy Division
Aeroelastic Design

**Description**
Place: UpWind workshop, Brussels (BE), 16 Mar

**Related external organisation**
Unknown external organisation
Activity: Talks and presentations › Conference presentations

**DCAMM 13th internal Symposium**
Alemseged Gebrehiwot Weldeyesus (Speaker)
Department of Wind Energy
Wind Turbines
Documents:
Alemseged_EWEA2013-poster

**Related event**
DCAMM 13th internal Symposium
01/01/2011 → …
Vejle
Activity: Talks and presentations › Conference presentations

**EWEA Annual Event 2011**
Ioanna Karagali (Participant)
Department of Wind Energy
Meteorology

**Related event**
EWEA Annual Event 2011
14/03/2011 → 17/03/2011
Brussels, Belgium
Activity: Attending an event › Participating in or organising a conference

**Power performance measured using a nacelle-based lidar**
Period: 14 Mar 2011
Rozenn Wagner (Speaker)
Risø National Laboratory for Sustainable Energy
Wind Energy Division
Test and Measurements

**Description**
Place: EWEA Annual Event 2011, Brussels (BE)

**Related external organisation**
Unknown external organisation
Activity: Talks and presentations › Conference presentations
**WindScanner projektet**
Period: 3 Mar 2011
Torben Krogh Mikkelsen (Speaker)
Risø National Laboratory for Sustainable Energy
Wind Energy Division
Meteorology
*Description*
Place: Møde i Gladsaxe Syd Rotary, 3. marts 2011

**Related external organisation**
Unknown external organisation
Activity: Talks and presentations › Conference presentations

**GIS Techniques in Environmental Sciences**
Period: 14 Feb 2011 → 19 Feb 2011
Niels Gylling Mortensen (Participant)
Department of Wind Energy
Meteorology
*Description*
GIS Techniques in Environmental Sciences. PhD course at Graduate School of Environmental Stress Studies.

**Related event**
GIS Techniques in Environmental Sciences
14/02/2011 → 19/02/2011
Roskilde, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

**Land og kystvindmøller**
Period: 26 Jan 2011
Jørgen Kjærgaard Lemming (Organizer)
Risø National Laboratory for Sustainable Energy
Wind Energy Division
Wind Turbines

**Related event**
Land og kystvindmøller
26/01/2011 → 26/01/2011
Klimaomstilling på Sjælland. Konference med workshops på RUC
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

**Planning and Development of Wind Farms**
Period: 3 Jan 2011 → 21 Jan 2011
Marisciel Litong-Palima (Participant)
Department of Wind Energy
Wind Energy Systems
*Description*
Participation in a course

**Related event**
Planning and Development of Wind Farms: DTU Course # 46200
03/01/2011 → 21/01/2011
Roskilde, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

**Energinet.dk working group on Technical regulation 3.2.5 for wind power plants (External organisation)**

Period: 2010 → …
Poul Ejnar Sørensen (Participant)

Department of Wind Energy

Integration & Planning

Degree of recognition: National

Related external organisation

**Energinet.dk working group on Technical regulation 3.2.5 for wind power plants**

Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

**Advanced WASP Course**

Period: 22 Nov 2010 → 26 Nov 2010
Niels Gylling Mortensen (Guest lecturer)

Meteorology

Department of Wind Energy

Related event

**Advanced WASP Course**
22/11/2010 → 26/11/2010
Pune, India
Activity: Talks and presentations › Guest lectures, external teaching and course activities at other universities

**The new State-of-the-Art report and the European Experience in SafeWind and other projects**

Period: 16 Oct 2010
Gregor Giebel (Speaker)

Risø National Laboratory for Sustainable Energy

Wind Energy Division

Meteorology

Related event

**4th Workshop on Best Practice in the Use of Short-term Forecasting of Wind Power**
16/10/2010 → 16/10/2010
Quebec City, Canada
Activity: Talks and presentations › Conference presentations

**Industri i verdensklasse**

Period: 6 Oct 2010
Peter Hjuler Jensen (Participant)

Risø National Laboratory for Sustainable Energy

Wind Energy Division

Wind Energy Division. Management

Description
Hvordan industriens udfordringer kan vendes til nye udviklingsmuligheder
Erhvervskonference om lokal industri, Herning (DK)

Related event
Industri i verdensklassen
06/10/2010 → 06/10/2010
Herning, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Scientific Committee for NOWITECH (External organisation)
Period: 1 Oct 2010 → …
Thomas Buhl (Participant)
Department of Wind Energy
Wind Turbines
Degree of recognition: International
Related external organisation
Scientific Committee for NOWITECH
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

2010 EUMETSAT Meteorological Satellite Conference
Period: 20 Sep 2010 → 24 Sep 2010
Ioanna Karagali (Speaker)
Department of Wind Energy
Meteorology
Related event
2010 EUMETSAT Meteorological Satellite Conference
20/09/2010 → 24/09/2010
Cordoba, Spain
Activity: Talks and presentations › Conference presentations

ESA EO Summer School
Ioanna Karagali (Participant)
Department of Wind Energy
Meteorology
Description
ESA 3rd Earth Observation Summer School.
Related event
ESA EO Summer School
02/08/2010 → 13/08/2010
Frascati, Italy
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Poster presentation: Diurnal Variability of Sea Surface Temperature and Wind
Ioanna Karagali (Speaker)
Risø National Laboratory for Sustainable Energy
Wind Energy Division
Meteorology
Description
Place: ESA Earth Observation Summer School, Frascati (IT)
Documents:
Related external organisation

**Unknown external organisation**
Activity: Talks and presentations › Conference presentations

**GAP funding (DTU internal GAP funding committee) (External organisation)**
Period: 1 Aug 2010 → 1 Aug 2014
Thomas Buhl (Participant)
Department of Wind Energy
Wind Turbines

Related external organisation

**GAP funding (DTU internal GAP funding committee)**
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

**11th GHRSST Science Team Meeting**
Ioanna Karagali (Participant)
Department of Wind Energy
Meteorology

Related event

**11th GHRSST Science Team Meeting**
21/06/2010 → 25/06/2010
Lima, Peru
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

**International Ocean Vector Winds Science Team Meeting 2010**
Period: 18 May 2010 → 20 May 2010
Ioanna Karagali (Participant)
Department of Wind Energy
Meteorology

Related event

**International Ocean Vector Winds Science Team Meeting 2010**
18/05/2010 → 20/05/2010
Barcelona, Spain
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

**Supervision of larger projects at DTU**
Period: 2 Mar 2010
Niels Gylling Mortensen (Participant)
LearningLab DTU
Department of Wind Energy
Meteorology

**Description**
Workshop for MSc and BSc supervisors at Risø DTU.

Related event
Supervision of larger projects at DTU
02/03/2010 → …
Lyngby, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Journal of Renewable and Sustainable Energy (Journal)
Period: 1 Jan 2010 → …
Torben Krogh Mikkelsen (Reviewer)
Department of Wind Energy
Meteorology & Remote Sensing
Description
Associate Editor re Wind Energy
Degree of recognition: International

Related journal
Journal of Renewable and Sustainable Energy
1941-7012
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 1.41 SJR 0.44 SNIP 0.588, ISI indexed (2013): ISI indexed yes, Web of Science (2018): Indexed yes
Central database
Activity: Research › Journal editor

Journal of Renewable and Sustainable Energy (Journal)
Period: 1 Jan 2010 → …
Torben Krogh Mikkelsen (Reviewer)
Department of Wind Energy
Meteorology & Remote Sensing
Description
Associate Editor
Degree of recognition: International
Links:
https://aip.scitation.org/journal/rse (The Journal of Renewable and Sustainable Energy (JRSE) is an interdisciplinary, peer-reviewed journal covering all areas of renewable and sustainable energy relevant to the physical science and engineering communities. The interdisciplinary approach of the publication ensures that the editors draw from researchers worldwide in a diverse range of fields. Topics covered include: •Renewable energy economics and policy •Renewable energy resource assessment •Solar energy: photovoltaics, solar thermal energy, solar energy for fuels •Wind energy: wind farms, rotors and blades, on- and offshore wind conditions, aerodynamics, fluid dynamics •Bioenergy: biofuels, biomass conversion, artificial photosynthesis •Distributed energy generation: rooftop PV, distributed fuel cells, distributed wind, micro-hydrogen power generation •Power distribution & systems modeling: power electronics and controls, smart grid •Energy efficient buildings: smart windows, PV, wind, power management )

Related journal
Journal of Renewable and Sustainable Energy
1941-7012
BFI (2018): BFI-level 1, Scopus rating (2017): CiteScore 1.41 SJR 0.44 SNIP 0.588, ISI indexed (2013): ISI indexed yes, Web of Science (2018): Indexed yes
Central database
Activity: Research › Journal editor

Measnet Site Assessment Working Group (External organisation)
Period: 2009 → 2016
Niels Gylling Mortensen (Participant)
Department of Wind Energy
Meteorology

**Description**
Working group has produced the following publications in 2009:
Degree of recognition: International

**Links:**

**Related external organisation**
Measnet Site Assessment Working Group
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

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**Wind Energy (Journal)**
**Period:** 2009 → …
**Robert Bitsche (Reviewer)**
Department of Wind Energy

**Description**
Wind Energy

**Related journal**
Wind Energy

**Central database**
Activity: Research › Peer review of manuscripts

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**Wind Energy (Journal)**
**Period:** 2009 → 2017
**Xiaoli Guo Larsén (Reviewer)**
Department of Wind Energy

**Description**
Resource Assessment Modelling

**Related journal**
Resource Assessment Modelling

**Central database**
Activity: Research › Peer review of manuscripts
Wind Energy
1095-4244
BFI (2018): BFI-level 2, Scopus rating (2017): CiteScore 3.18 SJR 1.051 SNIP 1.834, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

The Bolund Experiment: Blind Comparison of Models for Wind in Complex Terrain
Period: 14 Dec 2009 → 18 Dec 2009
Andreas Bechmann (Speaker)
Risø National Laboratory for Sustainable Energy
Wind Energy Division
Aeroelastic Design

Description
Place: AGU Fall Meeting 2009, San Francisco, CA (US)

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

Guidelines on the Technical Certification Scheme for the Design, Manufacture, Installation, Maintenance and Service of Wind Turbines
Period: 4 Dec 2009
Peter Hauge Madsen (Speaker)
Risø National Laboratory for Sustainable Energy
Wind Energy Division
Wind Energy Division. Management

Description
Arranged by the South African Wind Energy

Related event
Wind Energy Turbine technology and components Standards, Testing and Certification workshop
04/12/2009 → 04/12/2009
Activity: Talks and presentations › Conference presentations

The role of standards in the development of the wind industry
Period: 4 Dec 2009
Peter Hauge Madsen (Speaker)
Risø National Laboratory for Sustainable Energy
Wind Energy Division
Wind Energy Division. Management

Description
Arranged by the South African Wind Energy Association

Related event
Wind Energy Turbine technology and components Standards, Testing and Certification workshop
04/12/2009 → 04/12/2009
Activity: Talks and presentations › Conference presentations

Upwind spinner-based lidar measurements from the NM80 wind turbine at Tjæreborg
Period: 25 Nov 2009
Kasper Hjorth Hansen (Participant)  
Risø National Laboratory for Sustainable Energy  
Wind Energy Division  
Test and Measurements  

Related event  
Upwind spinner-based lidar measurements from the NM80 wind turbine at Tjæreborg  
Internal seminar series in the Wind Energy Division, Risø (DK)  
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Mikael Sjöholm (Participant)  
Risø National Laboratory for Sustainable Energy  
Wind Energy Division  
Test and Measurements  

Related event  
Upwind spinner-based lidar measurements from the NM80 wind turbine at Tjæreborg  
Period: 25 Nov 2009  
Internal seminar series in the Wind Energy Division, Risø (DK)  
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Torben Krogh Mikkelsen (Speaker)  
Risø National Laboratory for Sustainable Energy  
Wind Energy Division  
Meteorology  

Related event  
Upwind spinner-based lidar measurements from the NM80 wind turbine at Tjæreborg  
Period: 25 Nov 2009  
Internal seminar series in the Wind Energy Division, Risø (DK)  
Activity: Other

Ioanna Karagali (Participant)  
Department of Wind Energy  
Meteorology  

Description  
ESA Advanced Training on Ocean Remote Sensing

Related event  
2nd Advanced Training on Ocean Remote Sensing - ESA  
Period: 28 Sep 2009 → 2 Oct 2009  
Bergen, Norway  
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.
From the air - wind energy
Period: 17 Sep 2009
Peter Hauge Madsen (Speaker)
Risø National Laboratory for Sustainable Energy
Wind Energy Division
Wind Energy Division. Management

Description
Place: ISO General Assembly 2009. Open Session: Why international standards are vital

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

Presentation of the project
Period: 10 Jun 2009
Torben Krogh Mikkelsen (Speaker)
Risø National Laboratory for Sustainable Energy
Wind Energy Division
Meteorology

Description
Place: 1. Meeting of the Tall Wind project, Risø (DK)

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

Presentation of the project
Period: 10 Jun 2009
Ekaterina Batchvarova (Speaker)
Risø National Laboratory for Sustainable Energy
Wind Energy Division
Meteorology

Description
Place: 1. Meeting of the Tall Wind project, Risø (DK)

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

Full scale measurements with Pontos
Uwe Schmidt Paulsen (Speaker)
Risø National Laboratory for Sustainable Energy
Wind Energy Division
Test and Measurements

Related event
Full scale measurements with Pontos
25/05/2009 → 26/05/2009
Braunschweig (DE)
Activity: Talks and presentations › Conference presentations

IEC TC88 WG27: Wind Turbines - Electrical Simulation Models (External organisation)
Period: Apr 2009 → …
Poul Ejnar Sørensen (Chairman)

Department of Wind Energy
Wind Energy Systems

Description
The purpose of the IEC working group TC88 WC27 is to define standard dynamic simulation models for wind turbines and wind power plants (i.e. wind farms), which are intended for use in power system and grid stability analyses, and should be applicable for dynamic simulations of power system events such as short circuits (low voltage ride through), loss of generation or loads, and system separation. The proposed work shall develop a standard consisting of two parts with the following scope.

Part 1 shall specify dynamic simulation models for the generic wind turbine topologies/ concepts / configurations on the market. The standard shall define the generic terms and parameters with the purpose of specifying the electrical characteristics of a wind turbine at the connection terminals. In addition the standard shall specify a metrology to create models for future wind turbine concepts.

The standard shall include procedures for validation of the models specified. The simulation models shall refer to the wind turbine connection terminals. The validation procedures shall include tests as specified in IEC 61400-21, Ed. 2, focusing response to voltage dips and set-point requests.

Part 2 shall specify dynamic simulation models for the generic wind farm topologies / configurations on the market including wind farm control and auxiliary equipment. In addition the standard shall specify a metrology to create models for future wind farm configurations.

The standard shall include procedures for validation of the specified models. The simulation models shall refer to the wind farm point of common coupling.

The electrical simulation models shall be developed to the outmost degree of independency from the applied simulation tools. If specific simulation tool considerations are required they shall be separated in the models by a clear tool interface definition.

The working group consists of more than 40 members from more than 15 countries.

Body type: IEC Standard Working Group
Links:

Related external organisation
IEC TC88 WG27: Wind Turbines - Electrical Simulation Models
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

Havmølleforskning på de danske universiteter - udfordringer og muligheder
Period: 28 Apr 2009
Peter Hauge Madsen (Speaker)

Risø National Laboratory for Sustainable Energy
Wind Energy Division
Wind Energy Division. Management

Description
Place: Vindmølleindustriens offshorekonference, København (DK)

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations
Novel aerodynamic control approaches for very large wind turbine rotors
Period: 18 Mar 2009
Flemming Rasmussen (Lecturer)
Wind Energy Division
Aeroelastic Design

Description
Place: 2009 European Wind Energy Conference and Exhibition. Side Event: Remarkable Results of the UpWind Project, Marseille (FR)

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

IEA Wind Task 25 - Design and operation of power systems with large amounts of wind power (External organisation)
Period: Jan 2009 → …
Poul Ejnar Sørensen (Participant)
Department of Wind Energy
Integration & Planning

Description
The ultimate objective is to provide information to facilitate the highest economically feasible wind energy penetration within electricity power systems worldwide. This task supports this goal by analysing and further developing the methodology to assess the impact of wind power on power systems. The Task has established an international forum for exchange of knowledge and experiences related to power system operation with large amounts of wind power. The challenge is to create coherence between parallel activities with Transmission System Operators and other research and development work worldwide.

The participants collect and share information on the experience gained and the studies conducted up to and during the task. The case studies address different aspects of power system operation and design: reserve requirements, balancing and generation efficiency, capacity credit of wind power, efficient use of existing transmission capacity and requirements for new network investments, bottlenecks, cross-border trade and system stability issues. The main emphasis is on the technical operation. Costs are assessed when necessary as a basis for comparison. Also technology that supports enhanced penetration are being addressed: wind farm controls and operating procedures; dynamic line ratings; storage; demand side management (DSM), etc.

The task work began with a state-of-the-art report that collected the knowledge and results through 2008. This report was updated in 2013 as a final report of the second phase, and will see an update in 2015 for the third phase. The task developed guidelines on the recommended methodologies when estimating the system impacts and the costs of wind power integration: Recommended Practices 16 of IEA Wind.

Degree of recognition: International
Links:
https://www.ieawind.org/task_25.html (Task 25 Homepage)

Related external organisation
IEA Wind Task 25 - Design and operation of power systems with large amounts of wind power
Finland
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

DTU 46200 Planning and Development of Wind Farms
Period: 2008 → 2017
Niels Gylling Mortensen (Lecturer)
Department of Wind Energy
Meteorology

Description
Lecturer in wind resource and energy yield assessment and siting of wind farms
Links:
Wind Integration Workshop - International Advisory Committee (External organisation)
Period: 2008 → …
Poul Ejnar Sørensen (Participant)
Department of Wind Energy
Integration & Planning

Description
The general purpose of this workshop is to get researchers, economists and practicing engineers from different fields relating to wind power and transmission systems to exchange their knowledge and discuss their experience in the area of large-scale integration of wind power into power systems and transmission networks for offshore wind farms. The emphasis of this workshop is on both theoretical discussion and practical applications.
Degree of recognition: International
Links:
http://windintegrationworkshop.org/ (Homepage)

Related external organisation
Wind Integration Workshop - International Advisory Committee
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

European Wind Energy Technology Platform – TPWind. WG3 – Wind energy integration (External organisation)
Period: Oct 2008 → Nov 2014
Poul Ejnar Sørensen (Participant)
Department of Wind Energy
Integration & Planning

Description
In 2006, the European wind energy sector launched the European Wind Energy Technology Platform (TPWind). TPWind’s tasks are to identify and prioritise areas for increased innovation, and new and existing research and development (R&D) tasks. Its primary objective is to reduce the social, environmental and technological costs of wind energy.
Degree of recognition: International

Related external organisation
European Wind Energy Technology Platform – TPWind. WG3 – Wind energy integration
Brussels, Belgium
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

Cutting-edge clean-tech and energy technologies in Denmark: A happy marriage with the wind turbine industry
Period: 1 Sep 2008 → …
Peter Hjuler Jensen (Speaker)
Risø National Laboratory for Sustainable Energy
Wind Energy Division
Wind Turbines

Description
Place: Copenmind, Copenhagen (DK)

Related external organisation
**Cutting-edge clean-tech and energy technologies in Denmark: A happy marriage with the wind turbine industry**

Period: 1 Sep 2008 → …

Flemming Rasmussen (Speaker)

Risø National Laboratory for Sustainable Energy

Wind Energy Division

Aeroelastic Design

**Description**

Place: Copenmind, Copenhagen (DK)

**Related external organisation**

**The role of wind energy in the future energy supply**

Period: 19 Jun 2008 → …

Gregor Giebel (Speaker)

Risø National Laboratory for Sustainable Energy

Wind Energy Division

Meteorology

**Description**

Place: Visit of German politicians from Deutscher Bundestag, Risø (DK)

**Related external organisation**

**Wind energy research at Risø DTU**

Period: 7 May 2008 → …

Peter Hjuler Jensen (Speaker)

Risø National Laboratory for Sustainable Energy

Wind Energy Division

Wind Turbines

**Description**

Place: Visit of wind delegation from Canada, Copenhagen (DK)

**Related external organisation**

**Megavind strategy - Wind Power Plants in the Energy System (External organisation)**

Period: Mar 2008 → Dec 2011

Poul Ejnar Sørensen (Participant)

Department of Wind Energy

Integration & Planning

**Related external organisation**
Megavind strategy - Wind Power Plants in the Energy System
Denmark
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

Danish Standard - S588 Wind Turbines - A11 Power Quality (External organisation)
Period: 2007 → …
Poul Ejnar Sørensen (Participant)
Department of Wind Energy
Integration & Planning

Related external organisation

Danish Standard - S588 Wind Turbines - A11 Power Quality
Denmark
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

DTU 46300 Wind Turbine Technology and Aerodynamics
Period: 2007 → 2016
Niels Gylling Mortensen (Lecturer)
Department of Wind Energy
Meteorology

Description
Lecturer in wind resource and energy yield assessment and siting of wind farms
Links:
http://www.kurser.dtu.dk/46300.aspx?menulanguage=en-gb (DTU course 46300)

Related external organisation

Unknown external organisation
Activity: Talks and presentations › Conference presentations

Risø DTU Board of Studies (External organisation)
Period: 2007 → 2012
Lars Pilgaard Mikkelsen (Participant)
Department of Wind Energy
Composites and Materials Mechanics

Related external organisation

Risø DTU Board of Studies
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

Wind Energy (Journal)
Period: 1 Mar 2007 → 31 Dec 2013
Poul Ejnar Sørensen (Editor)
Department of Wind Energy

Description
Wind Energy
Links:
http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1099-1824/homepage/ProductInformation.html (Journal website)

Related journal

Wind Energy
1095-4244
The world expedition Galathea 3 seen from Satellite Eye; EGU2007-ES3-1TH4O-001
Period: 1 Jan 2007 → …
Charlotte Bay Hasager (Speaker)
Risø National Laboratory for Sustainable Energy
Wind Energy Division
Meteorology

Description
Place: Vienna, Austria

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

WAsP days '06
Period: 26 Jan 2006
Niels Gylling Mortensen (Invited speaker)
Department of Wind Energy
Meteorology
Links:
http://www.wasp.dk/

Related event
WAsP days '06
26/01/2006 → …
Risø, Denmark
Activity: Talks and presentations › Conference presentations

WAsP days '05
Period: 24 Jan 2005 → 25 Jan 2005
Niels Gylling Mortensen (Invited speaker)
Department of Wind Energy
Meteorology
Related event

WAsP days '05
24/01/2005 → 25/01/2005
Risø, Denmark
Activity: Talks and presentations › Conference presentations

Board of Governors, Risø National Laboratory (External organisation)
Period: 2004 → 2007
Niels Gylling Mortensen (Participant)
Department of Wind Energy
Meteorology
Risø National Laboratory
Description
Elected by Risø's personnel.

Related external organisation

Board of Governors, Risø National Laboratory
Activity: Membership › Board duties in companies, associations, or public organisations

IEEE (External organisation)
Period: 2004 → …
Poul Ejnar Sørensen (Participant)
Department of Wind Energy
Integration & Planning

Related external organisation

IEEE
United States
Activity: Membership › Membership of research networks or expert groups

IASTED Technical Committee (External organisation)
Period: Jan 2002 → Dec 2005
Poul Ejnar Sørensen (Participant)
Department of Wind Energy
Integration & Planning
Degree of recognition: International
Links:
http://www.iasted.org/

Related external organisation

IASTED Technical Committee
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

IEA Wind Task 21 - Dynamic models of wind farms for power system studies (External organisation)
Period: Jan 2002 → Dec 2005
Poul Ejnar Sørensen (Participant)
Department of Wind Energy
Integration & Planning
Degree of recognition: International

Related external organisation
IEA Wind Task 21 - Dynamic models of wind farms for power system studies
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

WAsP certification examination
Period: 2001 → 2016
Niels Gylling Mortensen (Organizer)
Department of Wind Energy
Meteorology

Description
Organiser and examiner on 1-day WAsP certification examinations from 2001 and onwards.

WAsP certification examinations 1991-present
Links:
http://www.wasp.dk/Courses-and-Certification/WAsP-Certification (WAsP Certification)

Related event
WAsP certification examination
01/11/2001 → …
Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

WAsP Certification Exams
Period: 2001 → 2016
Ole Steen Rathmann (Internal examiner)
Department of Wind Energy
Resource Assessment Modelling

Description
Exams certifying the holder's ability to perform professional wind resource assessments using the WAsP software.

Preparation of exams and acting as examiner

At Risoe campus and abroad
Activity: Examinations and supervision › Internal examination

Wind farm wake modelling
Period: 2001 → …
Ole Steen Rathmann (Other)
Department of Wind Energy
Resource Assessment Modelling

Description
Development of models for the mutual wake effects between wind farm turbines, incl. development of software implementing the models.
Activity: Other

WAsP certification examination
Period: 1 Nov 2001
Niels Gylling Mortensen (Participant)
Department of Wind Energy
Meteorology

Description
WAsP certified user #3

WAsP certification examination

Related event

WAsP certification examination
01/11/2001 → …
Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Wind Data Analysis
Period: 2000 → …
Ole Steen Rathmann (Participant)
Department of Wind Energy
Resource Assessment Modelling

Description
Analysis with respect to mean and extreme wind climate

Analysis of time series of wind data to provide mean wind climate statistics and extreme wind statistics.
Activity: Other

Eurosun 2000 - Technical scientific committee (External organisation)
Period: Jan 2000 → Jun 2000
Poul Ejnar Sørensen (Participant)
Department of Wind Energy
Integration & Planning

Related external organisation

Eurosun 2000 - Technical scientific committee
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

Danish Standard - S588 Wind Turbines - A11 Power Quality (External organisation)
Period: 1999 → 2007
Poul Ejnar Sørensen (Chairman)
Department of Wind Energy
Integration & Planning

Related external organisation

Danish Standard - S588 Wind Turbines - A11 Power Quality
Denmark
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

Danish Energy Agency - Committee for requirements to wind turbines with other grid connections than directly connected induction generators (External organisation)
Period: 1998 → 1999
Poul Ejnar Sørensen (Participant)
Department of Wind Energy
Integration & Planning
Degree of recognition: National

Related external organisation

Danish Energy Agency - Committee for requirements to wind turbines with other grid connections than directly connected induction generators
Denmark
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

Terrain description software: Map Editor
Period: 1998 → …
Ole Steen Rathmann (Participant)
Department of Wind Energy
Resource Assessment Modelling

Description
Development for software - Map Editor -for compiling terrain description (digital maps) from various sources for wind resource software (WAsP) .
Head: Ole Steen Rathmann
Activity: Other

Danish Utilities Research Institute (DEFU) - Working group for recommendations for lightning protection of wind turbines (External organisation)
Period: 1997 → 1999
Poul Ejnar Sørensen (Participant)
Department of Wind Energy
Integration & Planning
Degree of recognition: National

Related external organisation

Danish Utilities Research Institute (DEFU) - Working group for recommendations for lightning protection of wind turbines
Denmark
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

Solar Energy Centre Denmark - Coordination committee (External organisation)
Period: 1997 → 2000
Poul Ejnar Sørensen (Participant)
Department of Wind Energy
Integration & Planning
Degree of recognition: National

Related external organisation

Solar Energy Centre Denmark - Coordination committee
Denmark
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

WAsP Courses: Continued Education
Period: 1997 → 2016
Ole Steen Rathmann (Lecturer)
Department of Wind Energy
Resource Assessment Modelling

Description
Hands-on Wind Resource Software (WAsP) courses for participants from the international wind energy community

Have prepared and given lectures at numerous WAsP courses
Related external organisation

**Unknown external organisation**

Activity: Talks and presentations › Conference presentations

**IEC TC88 MT21: Wind Turbines - Measurement and assessment of power quality characteristics of grid connected wind turbines (External organisation)**

Period: 1996 → …

Poul Ejnar Sørensen (Participant)

Risø National Laboratory for Sustainable Energy

Department of Wind Energy

Wind Energy Systems

**Description**

IEC 61400-21 includes: - Definition and specification of the quantities to be determined for characterizing the electrical characteristics of a grid connected wind turbine; - Measurement procedures for quantifying the electrical characteristics; - Procedures for assessing compliance with electrical connection requirements, including estimation of the power quality expected from the wind turbine type when deployed at a specific site Presently, IEC 61400-21 is presently available in a second edition issued in 2008. MT21 works on a new edition separated in two parts: - IEC 61400-21-1 for testing of wind turbines - IEC 61400-21-2 for testing of wind power plants The international maintenance team MT21 consists of approximately 40 members from more than 10 countries.

Degree of recognition: International

**Links:**


**Related external organisation**

**IEC TC88 MT21: Wind Turbines - Measurement and assessment of power quality characteristics of grid connected wind turbines**

Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

**Wind Resource assessments: Various wind farm projects**

Period: 1996 → …

Ole Steen Rathmann (Participant)

Department of Wind Energy

Resource Assessment Modelling

**Description**

wind resource assessments based on available wind- and terrain data.

1st and 2nd opinion wind resource assessments for existing and candidate wind farm projects.

Activity: Other

**University of Copenhagen (External organisation)**

Period: 1994 → 2006

Niels Gylling Mortensen (Participant)

Department of Wind Energy

Meteorology

**Description**

Member of the Corps of External Examiners at the University of Copenhagen.

**Related external organisation**

**University of Copenhagen**

Thorvaldsensvej 40, DK-1871 Frederiksberg C, Copenhagen, Denmark

Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar
National Center for Atmospheric Research
Period: 10 Jan 1992 → 5 Jul 1992
Niels Gylling Mortensen (Visiting researcher)
Meteorology
Department of Wind Energy
Degree of recognition: International
Activity: Visiting an external institution › Visiting another research institution

WAsP course
Period: 1991 → 2017
Niels Gylling Mortensen (Participant)
Meteorology
Department of Wind Energy
Description
Lecturer on 2- and 3-day WAsP courses from 1991 and onwards.

WAsP standard courses 1991-present
Course lecturer
Links:
http://www.wasp.dk/Courses-and-Certification/WAsP-course

Related event
WAsP course
26/02/1991 → …
Activity: Other

The Øresund Experiment Data Bank: Version 2.0
Period: 1 Apr 1987
Niels Gylling Mortensen (Other)
Risø National Laboratory
Meteorology
Department of Wind Energy
Description
The documented data set of the Øresund Experiment (1984) compiled according to GF3.2.

Data bank established and managed by Niels G. Mortensen. Project manager for the Øresund Experiment was Sven-Erik Gryning.

Coordinated by Niels Gylling Mortensen
Documents:

Related external organisation
Risø National Laboratory
Roskilde, Denmark
Activity: Other

Prizes:

AMS 8ENERGY Student Presentation Award
Elliot Simon (Recipient)
Department of Wind Energy, Meteorology & Remote Sensing

**Details**
Awarded date: 5 Feb 2017  
Degree of recognition: International  
Granting Organisations: American Meteorological Society  
event: AMS 97th Annual Meeting  
Prize: Prizes, scholarships, distinctions

**IEC 1996 Award**
Poul Ejnar Sørensen (Recipient)  
Department of Wind Energy, Integration & Planning

**Description**
The price was given in recognition of devotion and excellent leadership of electrical system modelling and power quality standards

**Details**
Awarded date: 31 Jul 2012  
Degree of recognition: International  
Granting Organisations: International Electrotechnical Committee  
Prize: Prizes, scholarships, distinctions

**IEEE Senior Member**
Poul Ejnar Sørensen (Recipient)  
Department of Wind Energy, Integration & Planning

**Details**
Awarded date: 2007  
Degree of recognition: International  
Granting Organisations: IEEE  
Prize: Prizes, scholarships, distinctions

**MSc: Graduation with distinction**
Robert Bitsche (Recipient)  
Department of Wind Energy, Wind Turbines

**Details**
Awarded date: 2005  
Granting Organisations: Vienna University of Technology, Austria  
Prize: Prizes, scholarships, distinctions

**PhD Award Wind Energy Denmark 2016: Design optimization of jackets**
Kasper Sandal (Recipient)  
Department of Wind Energy

**Description**
Poster presentation and 5 minute oral presentation in the PhD session at Wind Energy Denmark Annual Event 2016.

**Details**
Awarded date: 27 Oct 2016  
Prize: Prizes, scholarships, distinctions

**PhD: Graduation with distinction**
Robert Bitsche (Recipient)  
Department of Wind Energy, Wind Turbines

**Details**
Awarded date: 2009  
Granting Organisations: Vienna University of Technology, Austria  
Prize: Prizes, scholarships, distinctions
Poster: A quasi 3D computation of merging wakes using a boundary layer equation model approach
Heige Aagaard Madsen (Recipient)
Rise National Laboratory for Sustainable Energy, Wind Energy Division, Aeroelastic Design

Details
Awarded date: 14 Mar 2011
event: EWEA Annual Event 2011
Prize: Prizes, scholarships, distinctions

Poster: Gearbox loads caused by double contact simulated with HAWC2
Torben J. Larsen (Recipient)
Rise National Laboratory for Sustainable Energy, Wind Energy Division, Aeroelastic Design

Details
Awarded date: 14 Mar 2011
event: EWEA Annual Event 2011
Prize: Prizes, scholarships, distinctions

Press clippings:

The Troubled Quest for the Superconducting Wind Turbine
Asger Bech Abrahamsen
26/07/2018

Description
Article in IEEE Spectrum on Superconducting wind turbine generator and their performance compared to Magnetic Pseudo Direct Drive generator for offshore wind turbine up to 20 MW


Subject
Superconducting wind turbine generators
Department of Wind Energy, Wind Turbine Structures and Component Design

Media coverage (1)

The Troubled Quest for the Superconducting Wind Turbine
26/07/2018
IEEE Spectrum (International), New York, United States, Print
Samuel K. Moore
8 sider
Asger Bech Abrahamsen
Press / Media

An Overview of 3D X-ray Microscopy
Lars Pilgaard Mikkelsen
19/02/2018

Description
Customer profiles: Dr. Lars Pilgaard Mikkelsen with online interview
Department of Wind Energy, Composites and Materials Mechanics, Department of Applied Mathematics and Computer Science

Media contribution (1)

An Overview of 3D X-ray Microscopy
19/02/2018
Microscopy And Analysis, Denmark
Wiley
4:13
https://microscopy-analysis.com/zeiss-xrm-overview
**Global Wind Atlas 2.0**

Jake Badger
04/12/2017

**Description**
Radio interview on DR P1 Morgen

**Subject**
The launch of the new global wind atlas (Global Wind Atlas 2.0) was discussed during a 5 minute long live telephone on the P1 national morning new radio program.
Department of Wind Energy, Resource Assessment Modelling

**Media contribution (1)**

**Global Wind Atlas 2.0 radio interview**
04/12/2017
DR P1 (National), Denmark, Radio
5 minutes
A live telephone interview was conducted on DR P1 Morgen, national news program, to talk about the new Global Wind Atlas 2.0.
Jake Badger
Press / Media

**Drømmen får vinger**

Asger Bech Abrahamsen
14/11/2017

**Description**
Artikel i Paperboy d. 14 November 2017 om mulighed for placering af 100 m vindmølle ved Kara og motorvejen i Roskilde Kommune.

**Subject**
Windturbine Roskilde Municipality
Department of Wind Energy, Wind Turbine Structures and Component Design

**Media coverage (1)**

**Drømmen får vinger**
14/11/2017
Paperboy (Local), Denmark, Print
Tomas Skov
http://viborher.dk/paperboy/nyheder-paperboy/nyt/droemmen-faar-vinger
Asger Bech Abrahamsen
Press / Media

**Vi skal stadig blive klogere på vindmøller (We still need to learn more about wind turbines)**

Niels-Erik Clausen & Tom Nervil
17/10/2017

**Description**

**Subject**
Noise from wind turbines
Støj fra vindmøller
Department of Micro- and Nanotechnology, Office for Research and Relations, Department of Wind Energy, Integration & Planning

**Media contribution (1)**
Vi skal stadig blive klogere på vindmøller
17/10/2017
Bornholms Tidende (Regional), Denmark, Print
Niels-Erik Clausen and Tom Nervil
1 page
Niels-Erik Clausen & Tom Nervil
Department of Wind Energy, Integration & Planning, Office for Research and Relations, Department of Micro- and Nanotechnology
Press / Media

Forskere foreslår plads til vindmøler i Roskilde
Asger Bech Abrahamsen
27/05/2017
Description
Artikel i Roskilde Dagblad d. 27/5-2017 om undersøgelse af placering af 100 m høje vindmæller i Roskilde Kommune.
Asger Bech Abrahamsen udtaler sig på vegne af Vind i Roskilde (VIROS) projektet, som ledes af DTU Vind Energi.

Subject
Windturbines in Roskilde Municipality
Department of Wind Energy, Wind Turbine Structures and Component Design

Media contribution (1)

Forskere foreslår plads til vindmøller i Roskilde
27/05/2017
Roskilde Dagblad (Local), Denmark, Print
Lars Kimer
https://sn.dk/Roskilde/Forskere-foreslar-plads-til-vindmoeller-i-Roskilde/artikel/658262
Asger Bech Abrahamsen
Press / Media

Sjældent fænomen: Vindmøller kløver skyer over Nordsøen
Charlotte Bay Hasager
15/05/2017
Description
Forklaringen på fænomenet skal findes i den perfekte kombination af varm og fugtig luft, et koldt hav og hård vind fra sydvest.
Department of Wind Energy, Meteorology & Remote Sensing

Media contribution (1)

dr.dk
15/05/2017
Denmark
http://www.dr.dk/nyheder/viden/naturvidenskab/sjaeldent-faenomen-vindmoeller-kloever-skyer-over-nordsoen
Charlotte Bay Hasager
Press / Media

Vindmøller kløver skyerne over Nordsøen
Charlotte Bay Hasager
01/05/2017
Department of Wind Energy, Meteorology & Remote Sensing

Media contribution (1)

DTU Avisen
01/05/2017
Denmark
http://emagstudio.win.dtu.dk/DTU-avisen/DTUavisen1705/#/10/24
Charlotte Bay Hasager
Press / Media
Forskningens døgn - forskning for fremtiden
Lars Pilgaard Mikkelsen
29/04/2017

Description
Forskningens døgn er en årlig tilbagevendende begivenhed, der afholdes over hele landet. I Roskilde har forskellige uddannelsesinstitutioner og foreninger opstået en række teltet, og viser eksempler på, hvad de arbejder med.

Department of Wind Energy, Composites and Materials Mechanics, Department of Applied Mathematics and Computer Science

Forskningens døgn i Roskilde 2017
Event: Exhibition

Media coverage (1)

Forskningens døgn i Roskilde
29/04/2017
Kanal Roskilde (Local), Denmark, Television
29 min.
https://www.youtube.com/watch?v=hVh8FuWcy-k&t=880s
Lars Pilgaard Mikkelsen
Press / Media

Should we power ahead with very large wind farms?
Patrick Volker, Andrea N. Hahmann, Jake Badger & Hans Ejsing Jørgensen
17/03/2017
Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling

Media contribution (1)

Should we power ahead with very large wind farms?
17/03/2017
Environmental Research Web (International), United Kingdom, Web
Liz Kalaugher
http://environmentalresearchweb.org/cws/article/news/68185
Patrick Volker, Andrea N. Hahmann, Jake Badger & Hans Ejsing Jørgensen
Department of Wind Energy, Resource Assessment Modelling, Meteorology & Remote Sensing
Press / Media

Big can be best when it comes to wind farms
Patrick Volker, Andrea N. Hahmann, Jake Badger & Hans Ejsing Jørgensen
17/03/2017
Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling

Media contribution (1)

Big can be best when it comes to wind farms
17/03/2017
IOP Publishing (International), United Kingdom, Web
Patrick Volker, Andrea N. Hahmann, Jake Badger & Hans Ejsing Jørgensen
Department of Wind Energy, Resource Assessment Modelling, Meteorology & Remote Sensing
Press / Media

Vindmølleparkers logistik er for omkostningstung
Charlotte Bay Hasager
30/11/2016

Subject
Logistik udgør næsten en femtedel af de samlede udgifter for en vindmøllepark i hele dens levetid. Det er en overraskende stor andel og derfor en væsentlig post at se nærmere på, hvis man vil bringe mølleparkernes udgifter ned.

Vindmølleparkers logistik er for omkostningstung
30/11/2016
EnergySupply, Web
http://www.energy-supply.dk/article/view/303626/vindmoller-parkers_logistik_er_for_omkostningstung
Vindmølleparkers logistik er for omkostningstung
Charlotte Bay Hasager
Department of Wind Energy, Meteorology & Remote Sensing
Press / Media

Skype dialog på web-tv – Grøn omstilling: Panel diskussion af den grønne omstilling med spørgsmål fra gymnasie elever
Asger Bech Abrahamsen
07/11/2016

Subject
Grøn omstilling vind møller
Department of Wind Energy, Wind Turbine Structures and Component Design

Media contribution (1)

Skype dialog på web-tv – Grøn omstilling: Panel diskussion af den grønne omstilling med spørgsmål fra gymnasie elever
07/11/2016
Mediehuset København, Web
Sune Gudmundsson
1,5 time
https://mediehuset-kbh.dk/groen-omstilling-svart-kan-vaere/
Skype dialog on web-tv – Green Energy Transition
Asger Bech Abrahamsen
Department of Wind Energy, Wind Turbine Structures and Component Design
Press / Media

Spørg Scientariet: Hvorfor er vindmøller ikke udstyret med winglets som fly?
Christian Bak
12/07/2016

Description
"Spørg Scientariet" (eng: "Ask the scientists" - approximately) is a part of the weekly magazine "Ingeniøren" (eng: "The Engineer"), where people can ask all sorts of technical questions and scientists will answer.
Department of Wind Energy, Aerodynamic design

Media contribution (1)

Spørg Scientariet: Hvorfor er vindmøller ikke udstyret med winglets som fly?
12/07/2016
Ingeniøren, Print
Christian Bak
Department of Wind Energy, Aerodynamic design
Press / Media

Risø i gang med at bygge ‘verdens bedste’ vindtunnel
Christian Bak
27/06/2016
Department of Wind Energy, Aerodynamic design

Media contribution (1)

Risø i gang med at bygge ‘verdens bedste’ vindtunnel
27/06/2016
Ingeniøren, Print
Sanne Wittrup
https://ing.dk/artikel/risoe-i-gang-med-bygge-verdens-bedste-vindtunnel-185163
Christian Bak
Department of Wind Energy, Aerodynamic design
Press / Media

42% wind power in Danish power system 2015: Go'morgen P3 2016-01-15
Poul Ejnar Sørensen
15/01/2016
Department of Wind Energy, Wind Energy Systems

Media contribution (1)

42% wind power in Danish power system 2015: Go'morgen P3 2016-01-15
15/01/2016
DR P3, Radio
Mads Møller Lauritsen
4 minutes
http://www.dr.dk/radio/ondemand/p3/go-morgen-p3-2016-01-15#!/
begin 1:04:10 end 1:08:40
Poul Ejnar Sørensen
Department of Wind Energy, Wind Energy Systems
Press / Media

DTU Wind Energy plans 2nd stage of offshore wind farms project planning tool
Charlotte Bay Hasager
01/01/2016

Description
DTU Wind Energy's streamlined project planning tool for offshore wind farms is now being commercialised. An upgrade of the tool, involving strategic planners, is already in the pipeline.

https://issuu.com/energyinsight/docs/energy_insight_yearbook_2016/1
Department of Wind Energy, Meteorology & Remote Sensing

Media contribution (1)

DTU Wind Energy plans 2nd stage of offshore wind farms project planning tool
01/01/2016
Energy Insight Yearbook 2016, pp 48-49, Print
NEM Media
Charlotte Bay Hasager
Department of Wind Energy, Meteorology & Remote Sensing
Press / Media

Dansk teknologi revolutionerer vindmåling
Torben Krogh Mikkelsen
01/01/2016
Department of Wind Energy, Meteorology & Remote Sensing

Media contribution (1)

Dansk teknologi revolutionerer vindmåling
01/01/2016
Dynamo, 2016, no. 47, Print
Danmarks Tekniske Universitet
Torben Krogh Mikkelsen
Department of Wind Energy, Meteorology & Remote Sensing
Press / Media

Biofibre på spring til industrien
Bo Madsen
Biofibre på spring til industrien
29/05/2015
Ingeniøren, Print
Bo Madsen
Department of Wind Energy, Composites and Materials Mechanics
Press / Media

DTU vil bruge Vestas' pensionist-mølle til forskning
Thomas Buhl
31/03/2015
Department of Wind Energy, Wind Turbines

Vestas-mølle til Riso: DTU Vindenergi har investeret i en Vestas V52-mølle fra et strandet projekt i Italien, der har proportionerne til at kunne stå i DTU Riso Campus møllerrække
Thomas Buhl
30/03/2015
Department of Wind Energy, Wind Turbines

Ny og større forskningsvindmølle til Riso Campus: Den karakteristiske vindmøllerrække på DTU Riso Campus får til april et nyt medlem – "et ungt frisk pust til plejehjemmet,"
Thomas Buhl
27/03/2015
Department of Wind Energy, Wind Turbines

Vestas-mølle til Riso: DTU Vindenergi har investeret i en Vestas V52-mølle fra et strandet projekt i Italien, der har proportionerne til at kunne stå i DTU Riso Campus møllerrække
30/03/2015
www.teknovation.dk, Web
Thore Dam Mortensen
http://www.teknovation.dk/?type=page&id=750&itemid=7010
Thomas Buhl
Department of Wind Energy, Wind Turbines
Press / Media

Ny og større forskningsvindmølle til Riso Campus: Den karakteristiske vindmøllerrække på DTU Riso Campus får til april et nyt medlem – "et ungt frisk pust til plejehjemmet,"
27/03/2015
jemindustri, Web
http://www.jemindustri.dk/article/view/199994/ny_og_storre_forskningsvindmoller_til_riso_campus#.VcHE0_ntlBc
Thomas Buhl
Department of Wind Energy, Wind Turbines
Press / Media
Risø-forsker: 50 m/s havde skubbet kronprinsens bil af Storebæltsbroen
Christian Bak
15/01/2015
Department of Wind Energy, Aerodynamic design

Media contribution (1)

Risø-forsker: 50 m/s havde skubbet kronprinsens bil af Storebæltsbroen
15/01/2015
Ingeniøren, Print
Bjørn Godske
https://ing.dk/artikel/risoe-forsker-50-ms-havde-skubbet-kronprinsens-bil-af-storebæltsbroen-173483
Christian Bak
Department of Wind Energy, Aerodynamic design

Harnessing the power of wind with a learning platform
Merete Badger
19/09/2014

Description
See more at the attached link.
Department of Wind Energy, Meteorology

Media contribution (1)

Harnessing the power of wind with a learning platform
19/09/2014
itslearning Newsletter, Web
itslearning
http://www.itslearning.co.uk/harnessing-the-power-of-wind-with-a-learning-platform#sthash.iWUVArim.dpuf
Merete Badger
Department of Wind Energy, Meteorology

Relations
Projects:
Virtual Campus Hub

Press / Media

The Danish National Wind Tunnel moving into detailed design phase
Christian Bak
01/04/2014
Department of Wind Energy, Aeroelastic Design

Media contribution (1)

The Danish National Wind Tunnel moving into detailed design phase
01/04/2014
ON/OFF. The magazine on offshore business in Denmark, Print
Karin Jensen
Christian Bak
Department of Wind Energy, Aeroelastic Design

Press / Media

Ny supercomputer optimerer vindmøllevejinger
Thomas Buhl
31/03/2014

Subject
Super computer, vindenergi
Department of Wind Energy, Wind Turbines

Media contribution (1)
**Ny supercomputer optimerer vindmøllevej**
31/03/2014
NetAvisen, Web
William Høst-Madsen
http://navisen.dk/blog/ny-supercomputer-optimerer-vindmøllevej/
Thomas Buhl
Department of Wind Energy, Wind Turbines
Press / Media

**Universiteterne mødes på nettet: E-system. Fire tekniske universiteter er forbundet via den europæiske e-infrastruktur eduGAIN.**
01/02/2014
Universitetsavisen, Print
DTU
Merete Badger
Department of Wind Energy, Meteorology

**Media contribution (1)**

**Universiteterne mødes på nettet: E-system. Fire tekniske universiteter er forbundet via den europæiske e-infrastruktur eduGAIN.**
01/02/2014
Universitetsavisen, Print
DTU
Merete Badger
Department of Wind Energy, Meteorology

**Relations**
Projects:
Virtual Campus Hub
Press / Media

**Vingeforkanter er som dækkene på en bil**
Christian Bak
08/12/2013
Department of Wind Energy, Aeroelastic Design

**Media contribution (1)**

**Vingeforkanter er som dækkene på en bil**
08/12/2013
Ingeniøren, Print
Sanne Wittrup*
http://ing.dk/artikel/vingeforkanter-er-som-daekkene-paa-en-bil-164767
Christian Bak
Department of Wind Energy, Aeroelastic Design
Press / Media

**Virtual Campus Hub**
Merete Badger
04/12/2013
Department of Wind Energy, Meteorology

**Media contribution (1)**

**Virtual Campus Hub**
04/12/2013
DTU Wind Energy web site, Web
DTU Wind Energy
http://www.vindenergi.dtu.dk/Nyheder/Nyhed?id=0c10daf9-888c-4d62-8e3c-8ef6fc68cc6e
Merete Badger
Department of Wind Energy, Meteorology

**Relations**
Projects:
Virtual Campus Hub
Her er havmøllernes udfordringer
Thomas Buhl
27/09/2013
Department of Wind Energy, Wind Turbines

Media contribution (1)

Her er havmøllernes udfordringer
27/09/2013
Børsen.dk, Web
Manja Spork
Thomas Buhl
Department of Wind Energy, Wind Turbines
Press / Media

Metropol om grøn energi
Christian Bak
27/08/2013
Department of Wind Energy, Aeroelastic Design

Media contribution (1)

Metropol om grøn energi
27/08/2013
TV2 Lorry, Television
Regitze Bryld
30 min
http://www.lorry.dk/arkiv/2013/8/27?video_id=82450
Christian Bak
Department of Wind Energy, Aeroelastic Design
Press / Media

Forsker: Lygtepæl skal producere egen strøm
Christian Bak
19/04/2013
Department of Wind Energy, Aeroelastic Design

Media contribution (1)

Forsker: Lygtepæl skal producere egen strøm
19/04/2013
Sjællandske Medier, Print
Lars Kimer
http://www.sn.dk/Roskilde/Forsker-Lyttepael-skal-producere-egen-strom/artikel/268269#.Uq1k8sTuJu0
Christian Bak
Department of Wind Energy, Aeroelastic Design
Press / Media

Metropol Grøn Teknologi
Christian Bak
16/04/2013
Department of Wind Energy, Aeroelastic Design

Media contribution (1)

Metropol Grøn Teknologi
16/04/2013
TV2 Lorry, Television
Regitze Bryld
30 min
http://www.lorry.dk/arkiv/2013/4/16?video_id=78458
International students get single sign-on for wind energy training: A Danish university avoids unnecessary hassles with user management by exchanging student data in an international identity federation.

Merete Badger
01/01/2013
Department of Wind Energy, Meteorology

Media contribution (1)

International students get single sign-on for wind energy training: A Danish university avoids unnecessary hassles with user management by exchanging student data in an international identity federation.
01/01/2013
WAYF Newsletter 2013 no.4, Print
WAYF
Merete Badger
Department of Wind Energy, Meteorology

Relations
Projects:
Virtual Campus Hub

DTU's ønskeseddel: Hvor meget supercomputer kan vi få for 9 millioner?
Thomas Buhl
19/12/2012
Department of Wind Energy, Wind Turbines

Media contribution (1)

DTU's ønskeseddel: Hvor meget supercomputer kan vi få for 9 millioner?
19/12/2012
http://www.version2.dk/, Web
Mikkel Meister
Thomas Buhl
Department of Wind Energy, Wind Turbines

Ny software ruster vindmøllevinger mod vindstød
Thomas Buhl
09/08/2012
Department of Wind Energy, Wind Turbines

Media contribution (1)

Ny software ruster vindmøllevinger mod vindstød
09/08/2012
ing.dk, Web
Theis Holtz Hansen
http://ing.dk/artikel/ny-software-ruster-vindmollevinger-mod-vindstod-131112
Thomas Buhl
Department of Wind Energy, Wind Turbines

Dong fastholder troen på havmøller
Thomas Buhl
05/06/2012
Department of Wind Energy, Wind Turbines
Dong fastholder troen på havmøller
05/06/2012
Børsen, Print
Jakob Skouboe
Thomas Buhl
Department of Wind Energy, Wind Turbines
Press / Media

DTU's nye vindtunnel kan blæse tre orkaner
Christian Bak
25/05/2012
Department of Wind Energy, Aeroelastic Design

Hvordan kan vindmøller nedbringe en færges luftmodstand?
Mac Gaunaa
27/08/2011
Aeroelastic Design, Risø National Laboratory for Sustainable Energy, Wind Energy Division

Nye mega-møller
Torben J. Larsen
30/03/2011
Aeroelastic Design, Risø National Laboratory for Sustainable Energy, Wind Energy Division

Hvorfor drejer vingerne samme vej på alle vindmøller, og hvorfor ligger vindmøller altid på en række?
Mac Gaunaa
20/12/2010
Aeroelastic Design, Risø National Laboratory for Sustainable Energy, Wind Energy Division

Interview med Mac Gaunaa på videnskab.dk, Print
Hvorfor har vindmøller tre vinger?
Mac Gaunaa
13/12/2010
Aeroelastic Design, Risø National Laboratory for Sustainable Energy, Wind Energy Division

Media contribution (1)

Vindmøller skal flyde på vandet
Troels Friis Pedersen
09/11/2010
Aeroelastic Design, Risø National Laboratory for Sustainable Energy, Wind Energy Division

Media contribution (1)

Vindenergi - nu og i fremtiden
Hans Ejsging Jørgensen
17/10/2010
Meteorology, Risø National Laboratory for Sustainable Energy, Wind Energy Division

Media contribution (1)

Kan vindmøller ændre Jordens rotation?
Mac Gaunaa
18/08/2010
Aeroelastic Design, Risø National Laboratory for Sustainable Energy, Wind Energy Division

Media contribution (1)
Danske vindmølleekspert gør Kina miljøvenlig
Niels Gylling Mortensen
18/08/2010
Meteorology, Risø National Laboratory for Sustainable Energy, Wind Energy Division

**Media contribution (1)**

Danske vindmølleekspert gør Kina miljøvenlig
18/08/2010
Interview med Niels Gylling Mortensen på videnskab.dk, Print
http://www.videnskab.dk/content/dk/miljo_natur/danske_vindmølleekspert_gør_kina_miljøvenlig
DOC-OA
Niels Gylling Mortensen
Risø National Laboratory for Sustainable Energy, Wind Energy Division, Meteorology
Press / Media

Strømninger i vandet er den største hav vindmølle-udfordring
Troels Friis Pedersen
05/08/2010
Aeroelastic Design, Risø National Laboratory for Sustainable Energy, Wind Energy Division

**Media contribution (1)**

Strømninger i vandet er den største hav vindmølle-udfordring
05/08/2010
Ingeniøren (ing.dk), Q&A, torsdag d. 5. august 2010, Web
Troels Friis Pedersen
Risø National Laboratory for Sustainable Energy, Wind Energy Division, Aeroelastic Design
Press / Media

Urealistisk at teste på havet. Om det planlagte vindmølleanlæg ved Østerild Klitplantage
Peter Hjuler Jensen
12/05/2010
Wind Energy Division. Management, Risø National Laboratory for Sustainable Energy, Wind Energy Division

**Media contribution (1)**

Urealistisk at teste på havet. Om det planlagte vindmølleanlæg ved Østerild Klitplantage
12/05/2010
Ingeniøren (ing.dk), Q&A, onsdag d. 12. maj 2010, Web
Peter Hjuler Jensen
Risø National Laboratory for Sustainable Energy, Wind Energy Division, Wind Energy Division. Management
Press / Media

Meisterforscher
Peter Hauge Madsen
01/03/2010
Wind Energy Division. Management, Risø National Laboratory for Sustainable Energy, Wind Energy Division

**Media contribution (1)**

Meisterforscher
01/03/2010
Interview med Peter Hauge Madsen m.fl. i Neue Energie 03/2010, s. 38-41, Print
Peter Hauge Madsen
Supernøjagtig måling kan øge vindproduktion markant
Troels Friis Pedersen
15/02/2010
Aeroelastic Design, Risø National Laboratory for Sustainable Energy, Wind Energy Division

Media contribution (1)

Risø-forsøg med lynhurtige flaps på møllevinger er en succes
Helge Aagaard Madsen
11/02/2010
Aeroelastic Design, Risø National Laboratory for Sustainable Energy, Wind Energy Division

Media contribution (1)

Nye vindmøllevinger efterligner høgen
Thomas Buhl
18/01/2010
Risø National Laboratory for Sustainable Energy, Wind Turbines, Wind Energy Division

Media contribution (1)

Nye vindmøllevinger efterligner høgen: Høgens evne til at finjustere sine vinger har givet forskere fra Risø DTU inspiration til en ny type vindmøller. De første prototyper testes nu.
Thomas Buhl
18/01/2010
http://videnskab.dk/teknologi/nye-vindmollevinger-efterligner-hogen

Subject
Vindenergi
Department of Wind Energy, Wind Turbines

Media contribution (1)
Jorden set fra oven
Charlotte Bay Hasager
12/12/2009
Meteorology, Risø National Laboratory for Sustainable Energy, Wind Energy Division

Media contribution (1)

Jorden set fra oven
12/12/2009
Videnskabens verden, Danmarks Radio P1, 12. december 2009 kl. 16:03, Radio
http://www.dr.dk/p1/videnskabensverden
PUB-OA
Charlotte Bay Hasager
Risø National Laboratory for Sustainable Energy, Wind Energy Division, Meteorology

Wind energy still going at full speed: Stadig fuld kraft på vindenergi
Peter Hauge Madsen
07/12/2009
Wind Energy Division. Management, Risø National Laboratory for Sustainable Energy, Wind Energy Division

Media contribution (1)

Wind energy still going at full speed: Stadig fuld kraft på vindenergi
07/12/2009
Interview with Peter Hauge Madsen in Børsen, Climate and Energy, theme: New Technology, 7 Dec 2009, p. 44-45 (also available in Danish), Print
Peter Hauge Madsen
Risø National Laboratory for Sustainable Energy, Wind Energy Division, Wind Energy Division. Management

Spild af vindenergi giver ingen miljøkatastrofer
Sten Tronæs Frandsen
03/09/2009
Risø National Laboratory for Sustainable Energy, Wind Turbines, Wind Energy Division

Media contribution (1)

Spild af vindenergi giver ingen miljøkatastrofer
03/09/2009
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Dansk projekt knækker vindmøliers turbulensproblemer
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17/08/2009
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Media contribution (1)

Dansk projekt knækker vindmøliers turbulensproblemer
17/08/2009
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Press / Media
Flaps på møllevinger reducerer turbulensproblemer
Thomas Buhl
17/08/2009
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Media contribution (1)

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Press / Media

Modvindsbil
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06/01/2009
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Media contribution (1)

Modvindsbil
06/01/2009
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Risø National Laboratory for Sustainable Energy, Wind Energy Division, Aeroelastic Design
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