Department of Wind Energy - DTU Orbit (28/01/2018)

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Organisation profile

Research
The Danish wind energy research environment is internationally recognized as being in the forefront of wind energy technology, and The Technical University of Denmark (DTU) has provided a major part of the wind energy research in Denmark.

Education
Based on intensive efforts in research, development, innovation and transfer of knowledge, the Technical University of Denmark (DTU) has for many years contributed to Denmark's leading position in wind energy.

Innovation
An important part of the work at DTU Wind Energy is that research results are disseminated and used by Danish industry in order to support and develop the entire sector. DTU Wind Energy contributes to industry and society's knowledge about wind energy and related areas through innovation, technology transfer and research based services.

Organisational unit: Department

Publications:

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)
Publication date: 2018
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—notably 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.

General information

State: Published
Organisations: Department of Wind Energy, Integration & Planning, Universidad de Castilla-La Mancha, HTW Berlin - University of Applied Sciences
Authors: Honrubia-Escribano, A. (Ekstern), Gómez-Lázaro, E. (Ekstern), Fortmann, J. (Ekstern), Sørensen, P. (Intern), Martin-Martinez, S. (Ekstern)
Pages: 1939-1952
Publication date: 2018
Main Research Area: Technical/natural sciences
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.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics, National University of Science and Technology MISIS
Authors: Loginov, P. (Ekstern), Sidorenko, D. (Ekstern), Levashov, E. (Ekstern), Petzhik, M. (Ekstern), Bychkova, M. (Ekstern), Mishnaevsky, L. (Intern)
Pages: 36-44
Publication date: 2018
Main Research Area: Technical/natural sciences

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BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.221 SNIP 2.157
BFI (2013): BFI-level 1
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ISI indexed (2013): ISI indexed no
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.341 SNIP 2.284
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.157 SNIP 2.133
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.198 SNIP 1.524
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.202 SNIP 1.734
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.04 SNIP 1.703
Scopus rating (2007): SJR 0.882 SNIP 1.191
Scopus rating (2006): SJR 0.609 SNIP 0.947
Scopus rating (2005): SJR 0.741 SNIP 1.237
Scopus rating (2004): SJR 0.693 SNIP 1.2
Scopus rating (2003): SJR 0.566 SNIP 0.908
Scopus rating (2002): SJR 0.658 SNIP 0.844
Scopus rating (2001): SJR 0.864 SNIP 1.162
Scopus rating (2000): SJR 0.748 SNIP 1.049
Scopus rating (1999): SJR 0.607 SNIP 1.031
Original language: English
DOIs: 10.1016/j.ijrmhm.2017.10.017
Publication: Research - peer-review › Journal article – Annual report year: 2018
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.
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.

General information

State: Published
Organisations: Department of Wind Energy, Integration & Planning, Resource Assessment Modelling, Meteorology & Remote Sensing
Authors: Nuño Martinez, E. (Intern), Maule, P. (Intern), Hahmann, A. N. (Intern), Cutululis, N. A. (Intern), Sørensen, P. E. (Intern), Karagali, I. (Intern)
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.
The Offshore Wind Service sector is about to establish 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 provide 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.
Uncertainty propagation through an aeroelastic wind turbine model using polynomial surrogates

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 workflows 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.
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.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Uppsala University
Authors: Breton, S. P. (Ekstern), Shen, W. Z. (Intern), Ivanell, S. (Ekstern)
Number of pages: 11
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Main Research Area: Technical/natural sciences

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Condition monitoring of a rotor arrangement in particular a wind turbine

The present invention relates to a method of determining the condition of a device comprising a rotor arrangement. The rotor arrangement comprises 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 (Φ) (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 (qf). 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
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.
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.
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.

General information
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
Main Research Area: Technical/natural sciences

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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.288 SNIP 1.362 CiteScore 3.39
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.324 SNIP 1.349 CiteScore 3.27
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.357 SNIP 1.44 CiteScore 3.38
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.365 SNIP 1.35 CiteScore 2.93
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.239 SNIP 1.301 CiteScore 3.03
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.449 SNIP 1.324
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.347 SNIP 1.359
Web of Science (2009): Indexed yes
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)
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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 \cite{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.
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 wind 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.

**General information**

State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing
Authors: Mikkelsen, T. K. (Intern), Sjöholm, M. (Intern), Angelou, N. (Intern), Mann, J. (Intern)
Number of pages: 14
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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.172 SNIP 0.281 CiteScore 0.22
Scopus rating (2014): SJR 0.186 SNIP 0.306 CiteScore 0.18
Scopus rating (2013): SJR 0.183 SNIP 0.256 CiteScore 0.16
ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 0.161 SNIP 0.203 CiteScore 0.14
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.155 SNIP 0.149 CiteScore 0.1
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.151 SNIP 0.112
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**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)
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
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.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design
Authors: van der Laan, P. (Intern), Sørensen, N. N. (Intern)
Number of pages: 24
Publication date: 2017

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.

**General information**
- **State:** Published
- **Organisations:** Department of Wind Energy, Meteorology & Remote Sensing, Technical University of Denmark, Uppsala University
- **Authors:** Svensson, N. (Ekstern), Sahlée, E. (Ekstern), Bergström, H. (Ekstern), Nilsson, E. (Ekstern), Badger, M. (Intern), Rutgersson, A. (Ekstern)
- **Number of pages:** 15
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- **Main Research Area:** Technical/natural sciences

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  - Scopus rating (2015): CiteScore 1.05 SNIP 0.555 SJR 0.515
  - Scopus rating (2014): CiteScore 0.92 SNIP 0.55 SJR 0.51
  - Scopus rating (2013): CiteScore 0.92 SNIP 0.533 SJR 0.551
- **Original language:** English
- **DOIs:** 10.1155/2017/9015891
- **Source:** FindIt
- **Source-ID:** 2392074300
- **Publication:** Research - peer-review › Journal article – Annual report year: 2017

**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.

**General information**
- **State:** Published
- **Organisations:** Department of Wind Energy, Meteorology & Remote Sensing
- **Authors:** Vasiljevic, N. (Intern), Courtney, M. (Intern)
- **Number of pages:** 32
- **Publication date:** 2017

**Publication information**
- **Media of output:** PowerPoint
- **Original language:** English
- **Place of publication:** Kgs. Lyngby
- **Publisher:** Danmarks Tekniske Universitet (DTU)
- **Main Research Area:** Technical/natural sciences
- **Electronic versions:** Submitted_Vasiljevic.pptx
- **Publication:** Research › Sound/Visual production (digital) – Annual report year: 2017

**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
State: Published
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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Main Research Area: Technical/natural sciences
Conference: Wind Energy Science Conference 2017, Lyngby, Denmark, 26/06/2017 - 26/06/2017
Electronic versions:
207
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2017

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
State: Published
Organisations: Department of Wind Energy, Aerodynamic design
Authors: Bertagnolio, F. (Intern), Aagaard Madsen, H. (Intern), Fischer, A. (Intern)
Pages: 1331-1348
Publication date: 2017
Main Research Area: Technical/natural sciences

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Journal: Wind Energy
Volume: 20
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BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.37 SJR 1.104 SNIP 2.306
Web of Science (2016): Indexed yes
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
State: Published
Organisations: Department of Wind Energy, Aerodynamic design, Norwegian University of Science and Technology
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

General information
State: Submitted
Organisations: Department of Wind Energy
Authors: Jørgensen, J. B. (Intern)
Publication date: 2017

Publication information
Publisher: DTU Wind Energy
Original language: English
Main Research Area: Technical/natural sciences
DOIs: 10.11581/DTU:00000027

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Projects:
Adhesive Joints in Wind Turbine Blades
Publication: Research › Ph.D. thesis – Annual report year: 2017

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).

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control
Authors: Galinos, C. (Intern)
Number of pages: 37
Publication date: 2017

Publication information
Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy E
Volume: 635
Main Research Area: Technical/natural sciences
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%.
A framework for medium-fidelity wake dynamics in moderately complex terrain

General information
State: Published
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)
Number of pages: 23
Publication date: 2017

Publication information
Media of output: Power Point Presentation
Original language: English
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.

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)
Pages: 604-619
Publication date: 2017
Main Research Area: Technical/natural sciences

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Journal: Renewable Energy
Volume: 107
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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.83 SJR 1.697 SNIP 2.044
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.845 SNIP 2.118 CiteScore 4.51
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.983 SNIP 2.687 CiteScore 4.51
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 2.066 SNIP 2.767 CiteScore 4.63
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.852 SNIP 2.745 CiteScore 3.97
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.688 SNIP 2.404 CiteScore 3.9
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.494 SNIP 2.215
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.305 SNIP 1.945
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.449 SNIP 1.867
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.

General information
State: Published
Organisations: Department of Wind Energy, Materials science and characterization, Advanced Technology Research Laboratories
Authors: Yu, T. (Intern), Hong, C. (Intern), Kitamura, K. (Ekstern), Tomatsu, K. (Ekstern), Taniyama, A. (Ekstern), Huang, X. (Intern), Hansen, N. (Intern)
Number of pages: 6
Publication date: 2017
Conference: 38th Risø International Symposium on Materials Science, Roskilde, Denmark, 04/09/2017 - 04/09/2017
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BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.39 SJR 0.187 SNIP 0.499
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.172 SNIP 0.281 CiteScore 0.22
Scopus rating (2014): SJR 0.186 SNIP 0.306 CiteScore 0.18
Scopus rating (2013): SJR 0.183 SNIP 0.256 CiteScore 0.16
ISI indexed (2013): ISI indexed no
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.

General information
State: Published
Organisations: Department of Wind Energy, Materials science and characterization, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Pages: 313–321
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Microscopy
Volume: 265
Issue number: 3
ISSN (Print): 0022-2720
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.9 SJR 0.734 SNIP 0.852
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.964 SNIP 1.106 CiteScore 2.37
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.059 SNIP 1.357 CiteScore 2.41
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.736 SNIP 1.048 CiteScore 1.96
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.757 SNIP 1.286 CiteScore 1.84
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.865 SNIP 0.928 CiteScore 1.67
ISI indexed (2011): ISI indexed yes
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.

General information
State: Published
Organisations: Department of Electrical Engineering, Biomedical Engineering, Department of Wind Energy, Composites and Materials Mechanics, Hvidovre University Hospital
Authors: Salmingo, R. A. (Intern), Skytte, T. L. (Ekstern), Traberg, M. S. (Intern), Mikkelsen, L. P. (Intern), Henneberg, K. (Intern), Wong, C. (Ekstern)
Pages: 443–456
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Bio-Medical Materials and Engineering
Volume: 28
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.

General information

State: Published
Authors: Eder, M. A. (Intern), Belloni, F. (Intern), Tesauro, A. (Ekstern), Hanis, T. (Intern)
Number of pages: 18
Pages: 123-140
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Main Research Area: Technical/natural sciences
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 overcomes 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.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Haselbach, P. U. (Intern)
Pages: 521-530
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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
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4.45 SJR 2.13 SNIP 2.033
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.247 SNIP 2.236 CiteScore 4.25
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.331 SNIP 2.524 CiteScore 4.03
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.017 SNIP 2.937 CiteScore 3.7
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.867 SNIP 2.838 CiteScore 2.85
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.683 SNIP 2.581 CiteScore 2.68
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
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.
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.

General information
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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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Main Research Area: Technical/natural sciences

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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.172 SNIP 0.281 CiteScore 0.22
Scopus rating (2014): SJR 0.186 SNIP 0.306 CiteScore 0.18
Scopus rating (2013): SJR 0.183 SNIP 0.256 CiteScore 0.16
ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 0.161 SNIP 0.203 CiteScore 0.14
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.155 SNIP 0.149 CiteScore 0.1
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.151 SNIP 0.112
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Publication: Research - peer-review › Journal article – Annual report year: 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 $h/(gT^2p)$ 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.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics
Authors: Schløer, S. (Intern), Bredmose, H. (Intern), Ghadirian, A. (Intern)
Pages: 223-237
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
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.16 SJR 0.467 SNIP 0.586
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.365 SNIP 0.561 CiteScore 0.92
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.433 SNIP 0.81 CiteScore 1.09
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.425 SNIP 0.785 CiteScore 1.02
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
Scopus rating (2012): SJR 0.425 SNIP 0.563 CiteScore 1.08
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
Scopus rating (2011): SJR 0.918 SNIP 1.505 CiteScore 2.42
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.433 SNIP 0.957
Web of Science (2009): Indexed yes
Original language: English
NewForce, Experimental data, Average force shape, Extreme forces
Electronic versions:
filestore_48_.pdf
DOIs:
10.1016/j.egypro.2017.10.376
Source: FindIt
Source-ID: 2394200540
Publication: Research - peer-review › Conference article – Annual report year: 2017

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 aerelastic 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.

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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Source-ID: 128507617
Publication: Research - peer-review › Report – Annual report year: 2017

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)
Number of pages: 3
Pages: 102-104
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 Politècnica de Catalunya, Reykjavik University, Leosphere, Halo Photonics
Authors: O'Connor, E. (Ekstern), Hirsikko, 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)
Publication date: 2017

Host publication information
Title of host publication: EMS Annual Meeting Abstracts
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Main Research Area: Technical/natural sciences
Electronic versions: EMS2017_745.pdf

Relations
Activities:
An emerging European Doppler lidar network for meteorological applications
Publication: Research - peer-review » Conference abstract in proceedings – Annual report year: 2017

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)
Number of pages: 11
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Main Research Area: Technical/natural sciences

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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.37 SJR 1.104 SNIP 2.306
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
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.

**General information**

State: Published

Organisations: Department of Mechanical Engineering, Fluid Mechanics, Coastal and Maritime Engineering, Department of Wind Energy, Fluid Mechanics, University of Zagreb

Authors: Pedersen, J. R. (Intern), Eltard-Larsen, B. (Intern), Bredmose, H. (Intern), Jasak, H. (Ekstern)

Number of pages: 12

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Main Research Area: Technical/natural sciences

CFD, Marine Engineering, Interfacial Flows, IsoAdvector, VOF Methods, Surface Gravity Waves

Electronic versions: Roenbyetal2017.pdf

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**Anholt offshore wind farm wake investigated from satellite data and wake models**

**General information**

State: Published

Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Fluid Mechanics, Resource Assessment Modelling, Aerodynamic design


Number of pages: 21

Publication date: 2017

**Publication information**

Media of output: Power Point Presentation

Original language: English

Main Research Area: Technical/natural sciences

Electronic versions: OWE17_Hasager_et_al_Anholt.pdf

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.
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 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 was 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 the 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 different wake generators on the rotor vibrations.

General information
State: Published
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
Main Research Area: Technical/natural sciences
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Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2017

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)
Number of pages: 9
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Volume: 854
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Series: Journal of Physics: Conference Series
ISSN: 1742-6596
Main Research Area: Technical/natural sciences
Conference: Wake Conference 2017, Visby, Sweden, 30/05/2017 - 30/05/2017
Electronic versions:
DOIs: 10.1088/1742-6596/854/1/012034
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Publication: Research - peer-review › Article in proceedings – Annual report year: 2017

An interaction of impacting droplets with superhydrophobic coatings

General information
State: Published
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)
Publication date: 2017
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Main Research Area: Technical/natural sciences
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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.
Turbulence, Uncertainty, Constrained, Lidar, Load simulations, Wind measurements, Load verification, Random field

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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Main Research Area: Technical/natural sciences

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Journal: Journal of Sound and Vibration
Volume: 387
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BFI (2016): BFI-level 2
Web of Science (2016): Indexed yes
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Scopus rating (2016): CiteScore 3.09 SJR 1.462 SNIP 2.162
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.391 SNIP 2.142 CiteScore 2.71
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.447 SNIP 2.38 CiteScore 2.54
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.391 SNIP 2.64 CiteScore 2.61
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.495 SNIP 2.992 CiteScore 2.3
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.441 SNIP 2.698 CiteScore 2.05
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
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):1031–1055 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.
Organisations: Department of Wind Energy, Aerodynamic design
Authors: Troldborg, N. (Intern), Meyer Forsting, A. R. (Intern)
Pages: 2011-2020
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Main Research Area: Technical/natural sciences

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Web of Science (2018): Indexed yes
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Web of Science (2017): Indexed yes
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Scopus rating (2016): CiteScore 3.37 SJR 1.104 SNIP 2.306
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.196 SNIP 2.086 CiteScore 3.06
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.272 SNIP 3.75 CiteScore 3.42
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.275 SNIP 2.464 CiteScore 2.75
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.126 SNIP 2.39 CiteScore 2.36
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.024 SNIP 2.718 CiteScore 2.49
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.487 SNIP 2.013
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.124 SNIP 1.448
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.826 SNIP 1.559
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.053 SNIP 1.453
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.637 SNIP 1.689
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.287 SNIP 0.9
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.528 SNIP 0.846
Web of Science (2004): Indexed yes
Web of Science (2003): Indexed yes
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.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning, Aalto University
Authors: Ekstrom, J. (Ekstern), Koivisto, M. J. (Intern), Mellin, I. (Ekstern), Millar, J. (Ekstern), Lehtonen, M. (Ekstern)
Number of pages: 10
Publication date: 2017
Main Research Area: Technical/natural sciences

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Journal: IEEE Transactions on Sustainable Energy
Volume: 8
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Scopus rating (2016): CiteScore 7.8 SJR 2.636 SNIP 2.883
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 3.031 SNIP 3.235 CiteScore 7.09
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 2.972 SNIP 3.954 CiteScore 7.03
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 2.384 SNIP 3.777 CiteScore 7.03
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
Scopus rating (2012): SJR 1.355 SNIP 3.731 CiteScore 6.58
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.818 SNIP 3.133 CiteScore 5.13
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)
Number of pages: 127
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Main Research Area: Technical/natural sciences

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Journal: Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences
Volume: 375
Issue number: 2091
Article number: 20160097
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Web of Science (2018): Indexed yes
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.26 SJR 0.874 SNIP 1.024
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.78 SNIP 0.985 CiteScore 2.08
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.847 SNIP 1.256 CiteScore 2.39
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.12 SNIP 1.534 CiteScore 3.12
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.068 SNIP 1.387 CiteScore 2.89
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)
Number of pages: 5
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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.

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Organisations: Department of Wind Energy, Wind turbine loads & control
Authors: Galinos, C. (Intern), Schmidt Paulsen, U. (Intern)
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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 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
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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)
Number of pages: 14
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Main Research Area: Technical/natural sciences

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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...
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 Havsøre, 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
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
Authors: Gómez Arranz, P. (Intern), Georgieva Yankova, G. (Intern)
Number of pages: 33
Publication date: 2017

Publication information
Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy LC I
Number: 110
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
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 date: 2017

Publication information
Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy LC I
Number: 112
Main Research Area: Technical/natural sciences

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 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: Gómez Arranz, P. (Intern), Georgieva Yankova, G. (Intern)
Number of pages: 30
Publication date: 2017

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Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy LC I
Number: 113
Main Research Area: Technical/natural sciences

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 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
Authors: Villanueva, H. (Intern), Georgieva Yankova, G. (Intern)
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Publication date: 2017

Publication information
Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy LC I
Number: 112
Main Research Area: Technical/natural sciences

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 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: Gómez Arranz, P. (Intern), Georgieva Yankova, G. (Intern)
Number of pages: 30
Publication date: 2017

Publication information
Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy LC I
Number: 113
Main Research Area: Technical/natural sciences

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 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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Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy LC I
Number: 112
Main Research Area: Technical/natural sciences

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 me
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.

**General information**

State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Georgieva Yankova, G. (Intern), Villanueva, H. (Intern)
Number of pages: 29
Publication date: 2017

**Publication information**

Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy LC I
Number: 115
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
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: Georgieva Yankova, G. (Intern), Villanueva, H. (Intern)
Number of pages: 29
Publication date: 2017

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)
Number of pages: 31
Publication date: 2017
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.
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. The comparison of the lidar measurements of the wind direction with that from wind vanes measurements are given for information only. The purpose of this report is the comparison of calibration results of the same lidar unit in two calibration campaigns, at 2 separate test sites. For this purpose, only the results at 2 heights are presented.
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.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Gómez Arranz, P. (Intern), Courtney, M. (Intern)
Number of pages: 42
Publication date: 2017

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)
Number of pages: 57
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 an 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 Brøndsted (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 many 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.
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.

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control, Universitat Rovira i Virgili
Authors: Tourn, S. (Ekstern), Pallarès, J. (Ekstern), Cuesta, I. (Ekstern), Schmidt Paulsen, U. (Intern)
Number of pages: 14
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Main Research Area: Technical/natural sciences

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Volume: 9
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Article number: 033302
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BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.2 SJR 0.418 SNIP 0.523
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.372 SNIP 0.52 CiteScore 1.02
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Characterization of Cu Distribution in an Al-0.3%Cu Alloy Cold Rolled to 98%

In this study, the distribution of Cu element in an 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
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Main Research Area: Technical/natural sciences

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BFI (2017): BFI-level 1
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.39 SJR 0.187 SNIP 0.499
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.172 SNIP 0.281 CiteScore 0.22
Scopus rating (2014): SJR 0.186 SNIP 0.306 CiteScore 0.18
Scopus rating (2013): SJR 0.183 SNIP 0.256 CiteScore 0.16
ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 0.161 SNIP 0.203 CiteScore 0.14
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.155 SNIP 0.149 CiteScore 0.1
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.151 SNIP 0.112
Original language: English
Electronic versions:
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.

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.
Comparison of fatigue constraints in optimal design of jacket structures for offshore wind turbines

General information
State: Published
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
Pages: 88-89
Publication date: 2017

Host publication information
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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
Electronic versions:
BoA_web.pdf
Source: FindIt
Source-ID: 2390404430
Publication: Research › Conference abstract in proceedings – Annual report year: 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), Peijs, T. (Ekstern)
Number of pages: 12
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Main Research Area: Technical/natural sciences

Publication information
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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Volume: 854
Article number: 012033

Series: Journal of Physics: Conference Series
ISSN: 1742-6596
Main Research Area: Technical/natural sciences
Conference: Wake Conference 2017, Visby, Sweden, 30/05/2017 - 30/05/2017
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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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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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.26 SJR 0.874 SNIP 1.024
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.78 SNIP 0.985 CiteScore 2.08
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.847 SNIP 1.256 CiteScore 2.39
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.12 SNIP 1.534 CiteScore 3.12
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.068 SNIP 1.387 CiteScore 2.89
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.964 SNIP 1.297 CiteScore 2.65
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.095 SNIP 1.365
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.068 SNIP 1.309
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.867 SNIP 1.016
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.683 SNIP 0.685
Scopus rating (2006): SJR 0.856 SNIP 0.888
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.843 SNIP 0.824
Scopus rating (2004): SJR 0.651 SNIP 0.834
Scopus rating (2003): SJR 0.527 SNIP 0.765
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.368 SNIP 0.631
Scopus rating (2001): SJR 0.296 SNIP 0.4
Scopus rating (2000): SJR 0.315 SNIP 0.393
Scopus rating (1999): SJR 0.436 SNIP 0.297
Original language: English
Doppler lidar, Complex terrain, Meteorological experiment
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.

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Authors: Fraisse, A. (Intern), Brøndsted, P. (Intern)
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Publication date: 2017
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.

General information
State: Published
Organisations: Test and Measurements, Department of Wind Energy, Aerodynamic design, University of Padua
Authors: Bedon, G. (Ekstern), Schmidt Paulsen, U. (Intern), Aagaard Madsen , H. (Intern), Belloni, F. (Ekstern), Raciti Castelli, M. (Ekstern), Benini, E. (Ekstern)
Number of pages: 9
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Issue number: 2
ISSN (Print): 0306-2619
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
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Scopus rating (2016): CiteScore 7.78 SJR 3.058 SNIP 2.573
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.912 SNIP 2.61 CiteScore 6.4
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 3.254 SNIP 3.28 CiteScore 6.93
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 3.164 SNIP 3.377 CiteScore 6.59
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 2.854 SNIP 3.108 CiteScore 5.69
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 2.473 SNIP 2.84 CiteScore 5.5
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.516 SNIP 2.25
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.003 SNIP 1.781
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.974 SNIP 1.215
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.179 SNIP 1.709
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.979 SNIP 1.293
Scopus rating (2005): SJR 1.043 SNIP 0.996
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.643 SNIP 0.839
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.778 SNIP 0.797
Scopus rating (2002): SJR 0.577 SNIP 0.775
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.376 SNIP 0.578
Scopus rating (2000): SJR 0.352 SNIP 0.515
Scopus rating (1999): SJR 0.182 SNIP 0.45
Original language: English
Aerodynamic optimization, BEM algorithm, DeepWind project, Vertical axis wind turbine
DOI:
10.1016/j.apenergy.2015.10.038
Source: FindIt
Source-ID: 2287636796
Publication: Research - peer-review › Journal article – Annual report year: 2017
Computational Modelling of Materials for Wind Turbine Blades: Selected DTU Wind 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
Publication date: 2017
Main Research Area: Technical/natural sciences

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Journal: Materials
Volume: 10
Issue number: 11
Article number: 1278
ISSN (Print): 1996-1944
Ratings:
Web of Science (2018): Indexed yes
Web of Science (2017): Indexed Yes
Scopus rating (2016): CiteScore 3.26 SJR 0.834 SNIP 1.497
Web of Science (2016): Indexed yes
Scopus rating (2015): SJR 0.852 SNIP 1.495 CiteScore 3.11
Scopus rating (2014): SJR 0.777 SNIP 1.256 CiteScore 2.69
Web of Science (2014): Indexed yes
Scopus rating (2013): SJR 0.998 SNIP 1.673 CiteScore 3.12
ISI indexed (2013): ISI indexed yes
Scopus rating (2012): SJR 0.838 SNIP 1.471
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.65 SNIP 1.239
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
Scopus rating (2010): SJR 0.394 SNIP 0.99
Original language: English
Electronic versions:
materials_10_01278_v2.pdf
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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, SDU Mads Clausen Institute
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

Publication information
Media of output: Power Point Presentation
Original language: English
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 5MW 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.
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 work 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)
Coordinated 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 DlgSILIENT 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.
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 is 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
Main Research Area: Technical/natural sciences

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Journal: Journal of Physics Communications
Volume: 1
Issue number: 5
Article number: 055001
ISSN (Print): 2399-6528
Original language: English
in situ TEM, Liquid Pb inclusions, Fixed dislocation, Thermal motion, Elastic interaction, Al-Pb alloy
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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 \( z_0 \) with wave parameters such as wave age, steepness, significant wave height, etc. However, it is found in storm and coastal conditions, \( z_0 \) parameterization method often fails in reproducing \( z_0 \) 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 \( z_0 \) 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.
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.

Data Requirements for WAsP, CFD & WRF
Flow model uncertainty is often caused by the models inability to correctly describe the wind flow. However, another important and often overlooked source of error is the topographical input data used for the flow modelling; these must be sufficiently detailed and accurate to obtain accurate results. This report reviews the requirements of WAsP, WAsP CFD and WRF on the topographical input data to obtain accurate results.

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.

**General information**
- State: Published
- Organisations: Department of Wind Energy, Composites and Materials Mechanics, China University of Mining And Technology
- Authors: Zhou, H. W. (Ekstern), Yi, H. Y. (Ekstern), Mishnaevsky, L. (Intern), Wang, R. (Ekstern), Duan, Z. Q. (Ekstern), Chen, Q. (Ekstern)
- Pages: 151-161
- Publication date: 2017
- Main Research Area: Technical/natural sciences

**Publication information**
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- Volume: 21
- Issue number: 2
- ISSN (Print): 1385-2000
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  - BFI (2018): BFI-level 1
  - Web of Science (2018): Indexed yes
  - BFI (2017): BFI-level 1
  - Web of Science (2017): Indexed Yes
  - BFI (2016): BFI-level 1
  - Scopus rating (2016): SJR 0.44 SNIP 0.915 CiteScore 1.17
  - Web of Science (2016): Indexed yes
  - BFI (2015): BFI-level 1
  - Scopus rating (2015): SJR 0.457 SNIP 0.793 CiteScore 1.27
  - BFI (2014): BFI-level 1
  - Scopus rating (2014): SJR 0.628 SNIP 1.35 CiteScore 1.62
  - BFI (2013): BFI-level 1
  - Scopus rating (2013): SJR 0.448 SNIP 1.304 CiteScore 1.67
  - ISI indexed (2013): ISI indexed yes
  - Web of Science (2013): Indexed yes
  - BFI (2012): BFI-level 1
  - Scopus rating (2012): SJR 0.53 SNIP 0.916 CiteScore 0.86
  - ISI indexed (2012): ISI indexed yes
  - Web of Science (2012): Indexed yes
  - BFI (2011): BFI-level 1
  - Scopus rating (2011): SJR 0.913 SNIP 1.479 CiteScore 1.59
  - ISI indexed (2011): ISI indexed yes
  - BFI (2010): BFI-level 1
  - Scopus rating (2010): SJR 0.831 SNIP 1.631
  - BFI (2009): BFI-level 1
  - Scopus rating (2009): SJR 0.583 SNIP 1.11
  - BFI (2008): BFI-level 1
  - Scopus rating (2008): SJR 0.34 SNIP 0.874
  - Scopus rating (2007): SJR 0.412 SNIP 0.857
  - Scopus rating (2006): SJR 0.45 SNIP 1.134
  - Scopus rating (2005): SJR 0.816 SNIP 1.073
  - Scopus rating (2004): SJR 0.761 SNIP 1.206
  - Web of Science (2004): Indexed yes
  - Scopus rating (2003): SJR 0.577 SNIP 0.906
  - Scopus rating (2002): SJR 0.975 SNIP 0.867
  - Scopus rating (2001): SJR 0.342 SNIP 0.659
  - Scopus rating (2000): SJR 0.271 SNIP 0.657
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
Publication date: 2017
Main Research Area: Technical/natural sciences

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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.24 SJR 0.665 SNIP 1.013
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.479 SNIP 0.713 CiteScore 0.74
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.65 SNIP 1.003 CiteScore 0.71
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.516 SNIP 0.75 CiteScore 0.61
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.624 SNIP 1.369 CiteScore 0.87
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.474 SNIP 0.899 CiteScore 0.71
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.636 SNIP 0.89
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)
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Publication date: 2017
Main Research Area: Technical/natural sciences

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Journal: Acta Materialia
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Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.67 SJR 3.283 SNIP 2.674
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 3.542 SNIP 2.927 CiteScore 5.22
Web of Science (2015): 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 resource.

**General information**

**State:** Published  
**Organisations:** Department of Wind Energy, Resource Assessment Modelling, ForWind, DNV GL, University of Latvia, Fraunhofer Institute for Wind Energy and Energy System Technology (IWES), Istanbul Technical University, CIEMAT, Technical University of Madrid, WeatherTech Scandinavia AB  
**Authors:** Hahmann, A. N. (Intern), Witha, B. (Ekstern), Rife, D. L. (Ekstern), Frouzakis, N. (Ekstern), Junk, C. (Ekstern), Sile, T. (Ekstern), Baltscheffsky, M. (Ekstern), Dörenkämper, M. (Ekstern), Ezber, Y. (Ekstern), Bustamante, E. G. (Ekstern), Gonzalez-Rouco, F. (Ekstern), Mentes, S. (Ekstern), Navarro, J. (Ekstern), Söderberg, S. (Ekstern), Unal, Y. (Ekstern)  
**Number of pages:** 30  
**Publication date:** 2017

**Publication information**  
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**Main Research Area:** Technical/natural sciences  
**Electronic versions:**  
NEWA_D3.1_ProbWA_final.pdf  
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**Source-ID:** 139259911  
**Publication:** Research - peer-review › Report – Annual report year: 2017

**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.

**General information**

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**Organisations:** Department of Wind Energy, Wind turbine loads & control, Resource Assessment Modelling  
**Authors:** Pavese, C. (Intern), Kim, T. (Intern), Murcia, J. P. (Intern)  
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**Journal:** Renewable Energy  
**Volume:** 102  
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Web of Science (2017): Indexed yes  
BFI (2016): BFI-level 1  
Scopus rating (2016): CiteScore 4.83 SJR 1.697 SNIP 2.044  
Web of Science (2016): Indexed yes
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 output while maintaining the structural feasibility with respect to international standards.

**General information**

State: Published  
Organisations: Department of Wind Energy, Fluid Mechanics, Chongqing University  
Authors: Sun, Z. (Ekstern), Sessarego, M. (Intern), Chen, J. (Ekstern), Shen, W. Z. (Intern)  
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Scopus rating (2016): CiteScore 2.5 SJR 0.691 SNIP 1.053  
Web of Science (2016): Indexed yes  
BFI (2015): BFI-level 2  
Scopus rating (2015): SJR 0.804 SNIP 1.416 CiteScore 2.87  
Web of Science (2015): Indexed yes  
BFI (2014): BFI-level 2  
Scopus rating (2014): SJR 0.87 SNIP 1.601 CiteScore 2.66  
Web of Science (2014): Indexed yes  
BFI (2013): BFI-level 1  
Scopus rating (2013): SJR 0.632 SNIP 1.345 CiteScore 2.29  
ISI indexed (2013): ISI indexed yes  
Web of Science (2013): Indexed yes  
BFI (2012): BFI-level 1  
Scopus rating (2012): SJR 0.874 SNIP 1.54 CiteScore 2.46  
ISI indexed (2012): ISI indexed yes  
Web of Science (2012): Indexed yes  
BFI (2011): BFI-level 1  
Scopus rating (2011): SJR 0.659 SNIP 1.439 CiteScore 2.24  
ISI indexed (2011): ISI indexed no  
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Wind energy, Wind turbine blade design, Aeroelastic blade design, Finite-element analysis, Site-specific design  
DOI: 10.3390/en10060777  
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Source-ID: 2371223645  
Publication: Research - peer-review › Journal article – Annual report year: 2017

**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
A 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)
Number of pages: 168
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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**
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Volume: 854
Article number: 012020
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
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Series: 35th Wind Energy Symposium
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Source: FindIt
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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
Pages: 1145-1170
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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.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics, Lulea University of Technology
Authors: Kusano, Y. (Intern), Madsen, B. (Intern), Berglund, L. (Ekstern), Aitomäki, Y. (Ekstern), Oksman, K. (Ekstern)
Number of pages: 7
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Web of Science (2017): Indexed Yes
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Scopus rating (2016): CiteScore 1.29 SJR 0.406 SNIP 0.716
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
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BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.453 SNIP 0.862 CiteScore 1.34
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.594 SNIP 0.843 CiteScore 1.54
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.619 SNIP 0.919 CiteScore 1.5
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.375 SNIP 0.752 CiteScore 0.88
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.353 SNIP 0.564
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.257 SNIP 0.383
Web of Science (2009): Indexed yes
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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Publication information

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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.63 SJR 1.625 SNIP 1.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
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
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Publisher: IEEE
Main Research Area: Technical/natural sciences
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Doppler lidar horizontal wind retrievals from a meteorological perspective

General information
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Organisations: Department of Wind Energy, Météo-France, Finnish Meteorological Institute, University of Reading, Deutscher Wetterdienst, University of Helsinki, University of Köln, Icelandic Meteorological Office, NUI Galway,
Do regional weather models contribute to better wind power forecasts? A few Norwegian case studies.

In most operational wind 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 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.

General information
State: Accepted/In press
Organisations: Department of Wind Energy, Composites and Materials Mechanics, Queen Mary University of London
Authors: Goutianos, S. (Intern), Mao, R. (Ekstern), Peijs, T. (Ekstern)
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.8 SJR 1.501 SNIP 1.713
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.502 SNIP 1.917 CiteScore 2.66
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.643 SNIP 2.048 CiteScore 2.72
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.587 SNIP 2.148 CiteScore 2.6
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.584 SNIP 2.262 CiteScore 2.33
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.668 SNIP 1.911 CiteScore 2.11
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.599 SNIP 1.845
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.86 SNIP 1.774
Web of Science (2009): Indexed yes
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)
Number of pages: 13
Publication date: 2017

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Title of host publication: ASME 2017 36th International Conference on Ocean, Offshore and Arctic Engineering
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Main Research Area: Technical/natural sciences
Conference: 36th International Conference on Ocean, Offshore and Arctic Engineering, Trondheim, Norway, 25/06/2017 - 25/06/2017
DOIs:
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
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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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BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.39 SJR 0.187 SNIP 0.499
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.172 SNIP 0.281 CiteScore 0.22
Scopus rating (2014): SJR 0.186 SNIP 0.306 CiteScore 0.18
Scopus rating (2013): SJR 0.183 SNIP 0.256 CiteScore 0.16
ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 0.161 SNIP 0.203 CiteScore 0.14
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.155 SNIP 0.149 CiteScore 0.1
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.151 SNIP 0.112
Original language: English
MATERIALS, GRAIN-SIZE
Electronic versions:
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Source: Findit
Source-ID: 2392652623
Publication: Research - peer-review › Article in proceedings – Annual report year: 2017
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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Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.83 SJR 1.697 SNIP 2.044
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.845 SNIP 2.118 CiteScore 4.51
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.983 SNIP 2.687 CiteScore 4.51
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 2.066 SNIP 2.767 CiteScore 4.63
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.852 SNIP 2.745 CiteScore 3.97
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.688 SNIP 2.404 CiteScore 3.9
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.494 SNIP 2.215
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.305 SNIP 1.945
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 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.
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
State: Published
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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  BFI (2012): BFI-level 2
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Efficiency of large wind farms: investigation of dependency on turbine technology and cluster layout

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

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

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Organisations: Department of Wind Energy, Fluid Mechanics, Wind turbine loads & control
Authors: Borg, M. (Intern), Bredmose, H. (Intern), Hansen, A. M. (Intern)
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DOIs: 10.1115/OMAE2017-61446
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.

Enhancement of Fracture Resistance by Multiple Cracks in Layered Structures under Mode I and Mix Mode Loading

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.

General information
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Organisations: Department of Wind Energy, Materials science and characterization, Southwest Technology and Engineering Research Institute, Chongqing University
Authors: Chen, Q. (Ekstern), Shu, D. Y. (Ekstern), Lin, J. (Ekstern), Wu, Y. (Ekstern), Xia, X. S. (Ekstern), Huang, S. H. (Ekstern), Zhao, Z. D. (Ekstern), Mishin, O. V. (Intern), Wu, G. L. (Ekstern)
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Scopus rating (2013): SJR 0.857 SNIP 1.465 CiteScore 1.89
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Scopus rating (2011): SJR 0.456 SNIP 0.899 CiteScore 0.94
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Scopus rating (2002): SJR 0.219 SNIP 0.395
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Scopus rating (1999): SJR 0.211 SNIP 0.312
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.

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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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Extreme variance vs. turbulence: What can the IEC cover?

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Authors: Hannesdóttir, Á. (Intern), Kelly, M. C. (Intern), Dimitrov, N. K. (Intern)
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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.

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 oshore 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 aect 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 Hørsholm, Danish Hydraulic Institute
Authors: Larsen, X. G. (Intern), Bolanos, R. (Ekstern), Du, J. (Intern), Kelly, M. C. (Intern), Kofoed-Hansen, H. (Ekstern), Larsen, S. E. (Intern), Karagali, I. (Intern), Badger, M. (Intern), Hahmann, A. N. (Intern), Imberger, M. (Intern), Tornfeldt Sørensen, J. (Ekstern), Jackson, S. (Ekstern), Volker, P. (Intern), Svenstrup Petersen, O. (Ekstern), Jenkins, A. (Ekstern), Graham, A. (Forskerdatabase)
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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**
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Organisations: Department of Chemistry, NanoChemistry, Department of Wind Energy, Materials science and characterization, Chongqing University, Yanshan University
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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**

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**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)  
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**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.

**General information**

**State:** Published  
**Organisations:** Department of Wind Energy, Materials science and characterization, Yanshan University, University of Kentucky  
**Authors:** Lv, Z. (Ekstern), Cai, P. (Ekstern), Yu, T. (Intern), Jin, Y. (Ekstern), Zhang, H. (Ekstern), Fu, W. (Ekstern), Zhai, T. (Ekstern)  
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Scopus rating (2015): SJR 0.987 SNIP 1.43 CiteScore 3.03  
Web of Science (2015): Indexed yes  
BFI (2014): BFI-level 1  
Scopus rating (2014): SJR 1.135 SNIP 1.66 CiteScore 3.13  
Web of Science (2014): Indexed yes  
BFI (2013): BFI-level 1  
Scopus rating (2013): SJR 1.064 SNIP 1.597 CiteScore 2.73
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

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Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Biel, A. (Intern), Toftegaard, H. L. (Intern)
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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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Organisations: Department of Wind Energy, Composites and Materials Mechanics, Department of Applied Mathematics and Computer Science, LM Wind Power
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KMUNThesis_Fatigue_damage_evolution_in_fibre_composites_for_wind_turbine_blades_FinalAfterModifications_withFrontPage.pdf

Relations
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.
Those 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 tensiobxygen 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.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Mikkelsen, L. P. (Intern)
Number of pages: 1
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Event: Abstract from International Symposium on Multiscale Computational Analysis of Complex Materials, Lyngby,
Denmark.
Main Research Area: Technical/natural sciences
Electronic versions:
MikkelsenLP_MultisScaleRisoe.pdf
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Source-ID: 134177183
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2017

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
Authors: Rafsanjani, H. M. (Ekstern), Serensen, J. D. (Intern), Fæster, S. (Intern), Sturlason, A. (Ekstern)
Number of pages: 14
Publication date: 2017
Main Research Area: Technical/natural sciences

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Journal: Energies
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Article number: 466
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BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.5 SJR 0.691 SNIP 1.053
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.804 SNIP 1.416 CiteScore 2.87
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, i.e., 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: Accepted/In press
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
Authors: Niemann, H. H. (Intern), Poulsen, N. K. (Intern), Mirzaei, M. (Intern), Henriksen, L. C. (Ekstern)
Number of pages: 28
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Main Research Area: Technical/natural sciences

Publication information

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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
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 the last few 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 operation and management , Department of Wind Energy, Resource Assessment Modelling , Agence d’Energie Renouvelable, 3E
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.

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
Authors: Xu, H. (Ekstern), Yang, H. (Ekstern), Liu, C. (Ekstern), Shen, W. (Intern), Hong, Z. (Ekstern)
Number of pages: 9
Pages: 56-64
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Journal: Yingyong Jichu yu Gongcheng Kexue Xuebao/Journal of Basic Science and Engineering
Volume: 25
Issue number: 1
ISSN (Print): 1005-0930
Ratings:
Scopus rating (2016): CiteScore 0.39
Scopus rating (2015): CiteScore 0.48
Scopus rating (2014): CiteScore 0.41
Scopus rating (2013): CiteScore 0.38
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Flow field, Load, Numerical simulation, Wind turbines
DOIs:
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Source-ID: 85015330596
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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).

Flow induced by a skewed vortex cylinder
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General information
State: Published
Organisations: Department of Wind Energy
Authors: Branlard, E. S. P. (Intern)
Number of pages: 11
Pages: 461-471
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Title of host publication: Wind Turbine Aerodynamics and Vorticity-Based Methods
Volume: 7
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: Accepted/In press
Organisations: Department of Wind Energy, Composites and Materials Mechanics, Danish Technological Institute, University of Southern Denmark
Authors: Kusano, Y. (Intern), Bardenshtein, A. (Ekstern), Morgen, P. (Ekstern)
Number of pages: 10
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information

Journal: Plasma Processes and Polymers
Article number: e1700131
ISSN (Print): 1612-8850
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.69 SJR 0.869 SNIP 1.044
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.912 SNIP 1.315 CiteScore 3.05
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.894 SNIP 1.16 CiteScore 2.67
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.113 SNIP 1.404 CiteScore 3.39
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.222 SNIP 1.205 CiteScore 2.59
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.342 SNIP 1.295 CiteScore 2.71
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.87 SNIP 0.776
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.798 SNIP 0.993
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.

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling, Meteorology & Remote Sensing
Authors: Sogachev, A. (Intern), Dellwik, E. (Intern)
Pages: 326-339
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Agricultural and Forest Meteorology
Volume: 237-238
ISSN (Print): 0168-1923
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4.62 SJR 1.976 SNIP 1.889
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.169 SNIP 1.987 CiteScore 4.63
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.048 SNIP 1.907 CiteScore 4.31
Web of Science (2014): Indexed yes
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.
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.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning
Authors: Saborío-Romano, O. (Intern), Bidadfar, A. (Intern), Göksu, Ö. (Intern), Cutululis, N. A. (Intern)
Number of pages: 6
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

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.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, University of Stavanger, Christian Michelsen Research AS
Authors: Cheynet, E. (Ekstern), Jakobsen, J. B. (Ekstern), Snæbjörnsson, J. (Ekstern), Angelou, N. (Intern), Mikkelsen, T. K. (Intern), Sjöholm, M. (Intern), Svardal, B. (Ekstern)
Pages: 261-272
Publication date: 2017
Main Research Area: Technical/natural sciences

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Journal: Journal of Wind Engineering and Industrial Aerodynamics
Volume: 171
ISSN (Print): 0167-6105
Ratings:
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.61 SJR 1.002 SNIP 1.92
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.011 SNIP 1.966 CiteScore 2.51
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)
Number of pages: 18
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Main Research Area: Technical/natural sciences

**Publication information**
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Volume: 68
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- Web of Science (2018): Indexed yes
- BFI (2017): BFI-level 1
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 1
  - Scopus rating (2016): SJR 1.316 SNIP 2.051 CiteScore 2.62
  - Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 1
  - Scopus rating (2015): SJR 1.277 SNIP 1.895 CiteScore 2.33
- BFI (2014): BFI-level 1
- Scopus rating (2014): SJR 1.428 SNIP 2.738 CiteScore 2.69
- BFI (2013): BFI-level 1
- Scopus rating (2013): SJR 1.582 SNIP 2.841 CiteScore 2.96
  - ISI indexed (2013): ISI indexed yes
- BFI (2012): BFI-level 1
- Scopus rating (2012): SJR 1.154 SNIP 2.356 CiteScore 2.14
  - ISI indexed (2012): ISI indexed yes
- BFI (2011): BFI-level 1
- Scopus rating (2011): SJR 1.386 SNIP 2.369 CiteScore 2.16
  - ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 1
  - Scopus rating (2010): SJR 1.534 SNIP 2.711
- BFI (2009): BFI-level 1
- Scopus rating (2009): SJR 1.515 SNIP 2.366
- BFI (2008): BFI-level 1
- Scopus rating (2008): SJR 1.398 SNIP 2.688
  - Web of Science (2008): Indexed yes
- Scopus rating (2007): SJR 1.385 SNIP 2.142
  - Web of Science (2007): Indexed yes
- Scopus rating (2006): SJR 1.285 SNIP 2.934
- Scopus rating (2005): SJR 1.205 SNIP 1.962
- Scopus rating (2004): SJR 1.68 SNIP 1.703
- Scopus rating (2003): SJR 0.766 SNIP 1.521
- Scopus rating (2002): SJR 0.998 SNIP 1.792
- Scopus rating (2001): SJR 1.206 SNIP 1.357
  - Web of Science (2001): Indexed yes
- Scopus rating (2000): SJR 0.668 SNIP 1.377
- Scopus rating (1999): SJR 1.332 SNIP 1.307
  - Original language: English

**Aeroelastic response, Aeroelastic stability, Aerofoil section, Bend-twist coupling**

**Electronic versions**
Fundamental aeroelastic properties
Future defence plan requirements with high penetration of renewable generation

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning
Authors: Das, K. (Intern), Altin, M. (Intern), Hansen, A. D. (Intern), Sørensen, P. E. (Intern)
Number of pages: 7
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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
Electronic versions:
Future_Defence_Plan_requirements_5C_4_GIZ17_087_paper_Kaushik_Das.pdf
Source: PublicationPreSubmission
Source-ID: 140139745
Publication: Research - peer-review › Paper – Annual report year: 2017

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)
Number of pages: 15
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Publication information
Media of output: Power Point Presentation
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
Global_Wind_Atlas_validation_DTU_Wind_Energy.pdf
Source: PublicationPreSubmission
Source-ID: 131010964
Publication: Research › Sound/Visual production (digital) – Annual report year: 2017

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
State: Published
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)
Publication date: 2017
Conference: 38th Risø International Symposium on Materials Science, Roskilde, Denmark, 04/09/2017 - 04/09/2017
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.

**General information**
State: Published
Organisations: Department of Wind Energy, University of Copenhagen
Authors: Krizek, F. (Ekstern), Kanne, T. (Ekstern), Razmadze, D. (Ekstern), Johnson, E. (Intern), Nygaard, J. (Ekstern), Marcus, C. M. (Ekstern), Krogstrup, P. (Ekstern)
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ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
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Scopus rating (2012): CiteScore 13.78
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Web of Science (2011): Indexed yes
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BFI (2008): BFI-level 2
Web of Science (2008): Indexed yes
Web of Science (2007): Indexed yes
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Kinked nanowires, branched nanowires, nanowire junctions, nanowire shadow mask, nanowire networks
Guest Editorial

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.

General information

State: Published
Organisations: Department of Wind Energy, Integration & Planning, Huazhong University of Science and Technology, Zhejiang University, University College Dublin, China Electric Power Research Institute
Authors: Hu, J. (Ekstern), Xu, L. (Ekstern), Flynn, D. (Ekstern), Cutululis, N. A. (Intern), Chi, Y. (Ekstern)
Pages: 1079-1081
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Scopus rating (2016): CiteScore 3.55 SJR 0.988 SNIP 1.379
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.054 SNIP 1.64 CiteScore 3.13
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.375 SNIP 2.338 CiteScore 3.56
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.814 SNIP 2.78 CiteScore 4.96
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.5 SNIP 2.854 CiteScore 4.64
Hierarchical Structure and Strengthening Mechanisms in Pearlitic Steel Wire

Microstructural 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 in 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.

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.
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
Publication date: 2017

Host publication information
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
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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
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Article number: 012021

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.

**General information**
State: Published
Authors: Hasager, C. B. (Intern), Nygaard, N. G. (Ekstern), Volker, P. (Intern), Karagali, I. (Intern), Andersen, S. J. (Intern), Badger, J. (Intern)
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Main Research Area: Technical/natural sciences
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2017

**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.

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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 turbinerators 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 trailingedge of the blades. The interaction of the vortex filaments in the near vicinity of the wind turbine is evaluated using
adirect 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 forevolving 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**

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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)
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- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 2
- Scopus rating (2015): SJR 1.196 SNIP 2.086 CiteScore 3.06
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 2
- Scopus rating (2014): SJR 1.272 SNIP 3.75 CiteScore 3.42
- Web of Science (2014): Indexed yes
- BFI (2013): BFI-level 2
- Scopus rating (2013): SJR 1.275 SNIP 2.464 CiteScore 2.75
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- Web of Science (2013): Indexed yes
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- Scopus rating (2012): SJR 1.126 SNIP 2.39 CiteScore 2.36
- ISI indexed (2012): ISI indexed yes
- Web of Science (2012): Indexed yes
- BFI (2011): BFI-level 2
- Scopus rating (2011): SJR 1.024 SNIP 2.718 CiteScore 2.49
- ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 2
- Scopus rating (2010): SJR 1.487 SNIP 2.013
- Web of Science (2010): Indexed yes
- BFI (2009): BFI-level 2
- Scopus rating (2009): SJR 1.124 SNIP 1.448
- Web of Science (2009): Indexed yes
- BFI (2008): BFI-level 2
- Scopus rating (2008): SJR 0.826 SNIP 1.559
- Web of Science (2008): Indexed yes
- Scopus rating (2007): SJR 1.053 SNIP 1.453
- Web of Science (2007): 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 μm. Adding a ball milling step resulted in full density isotropic magnets for d > 100 μm. The coercivity reached Hci = 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)
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Scopus rating (2016): CiteScore 2.41 SJR 0.71 SNIP 1.22
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.756 SNIP 1.391 CiteScore 2.33
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.821 SNIP 1.435 CiteScore 2.07
Web of Science (2014): Indexed yes
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Scopus rating (2013): SJR 0.807 SNIP 1.4 CiteScore 2.03
ISI indexed (2013): ISI 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
Authors: Yuan, B. (Ekstern), Jin, Y. (Ekstern), Hong, C. (Intern), Zhang, X. (Ekstern), Huang, X. (Intern)
Number of pages: 6
Publication date: 2017
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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.

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

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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.

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State: Published
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Scopus rating (2015): SNIP 0.525 SJR 0.319 CiteScore 0.19
BFI (2014): BFI-level 1
Scopus rating (2014): SNIP 0.622 SJR 0.407 CiteScore 0.23
BFI (2013): BFI-level 1
Scopus rating (2013): SNIP 0.557 SJR 0.338 CiteScore 0.23
ISI indexed (2013): ISI indexed no
BFI (2012): BFI-level 1
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.

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Organisations: Wind Turbines, Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Dabrowski, D. (Intern), Natarajan, A. (Intern)
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Loss of Contact, Multi-body model, Planet bearing failure, Transient Conditions, Wind turbine drivetrain

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

General information
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Organisations: Department of Wind Energy, Composites and Materials Mechanics, FEI Czech Republic s.r.o., University of Manchester
Authors: Wang, Y. (Ekstern), Pyka, G. (Ekstern), Jespersen, K. M. (Intern), Mikkelsen, L. P. (Intern), Withers, P. J. (Ekstern)
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Helical imaging, Staining, Fatigue, Fibre break, Matrix crack
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Impact of renewable energy uncertainty on electric power system reliability

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Organisations: Department of Wind Energy, Integration & Planning, University of Copenhagen
Authors: Gunnarsson, J. S. G. (Forskerdatabase), Cikusa, N. S. (Forskerdatabase), Hansen, A. D. (Intern)
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Impact of renewable energy uncertainty on electric power system reliability

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Organisations: Department of Wind Energy, Integration & Planning
Authors: Nuño Martinez, E. (Intern)
Publication date: 2017

Publication Information
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Original language: English
Main Research Area: Technical/natural sciences
DOIs:
10.11581/DTU:00000024

Relations
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.

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling , Meteorology & Remote Sensing, DHI Hørsholm
Authors: Larsén, X. G. (Intern), Du, J. (Intern), Bolanos, R. (Ekstern), Badger, M. (Intern), Larsen, S. E. (Intern), Kelly, M. C. (Intern)
Number of pages: 20
Publication date: 2017

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
EGU_Impact_of_interfaces_for_wind_and_wave_modeling_20170425.pdf
Source: PublicationPreSubmission
Source-ID: 132922198
Publication: Research › Sound/Visual production (digital) – Annual report year: 2017

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.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning
Authors: Sarkar, M. (Intern), Altin, M. (Intern), Hansen, A. D. (Intern), Sørensen, P. E. (Intern)
Number of pages: 7
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
Electronic versions:
10C_3_GIZ17_088_paper_Moumita_Sarkar.pdf
Publication: Research - peer-review › Paper – Annual report year: 2017

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

Host publication information
Title of host publication: 14th International Conference on the European Energy Market (EEM), 2017
Publisher: IEEE Xplore
Main Research Area: Technical/natural sciences
Conference: 14th International Conference on the European Energy Market, Dresden, Germany, 06/06/2017 - 06/06/2017
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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
Organisations: Department of Wind Energy, Fluid Mechanics, Chongqing University, Technical University of Denmark
Authors: Sun, Z. (Ekstern), Shen, W. Z. (Intern), Chen, J. (Ekstern), Zhu, W. J. (Intern)
Pages: 1585-1600
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Wind Energy
Volume: 20
ISSN (Print): 1095-4244
Ratings:
BFI (2018): BFI-level 2
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

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Journal: IEEE Transactions on Power Delivery
Volume: 32
Issue number: 1
ISSN (Print): 0885-8977
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.46 SJR 1.791 SNIP 2.408
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.967 SNIP 2.66 CiteScore 3.96
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.726 SNIP 2.693 CiteScore 3.4
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.64 SNIP 2.845 CiteScore 3.51
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.386 SNIP 2.688 CiteScore 3.28
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.117 SNIP 2.257 CiteScore 2.89
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.172 SNIP 2.068
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.985 SNIP 2.053
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.12 SNIP 2.157
Scopus rating (2007): SJR 0.926 SNIP 1.978
Scopus rating (2006): SJR 0.944 SNIP 1.821
Scopus rating (2005): SJR 0.973 SNIP 1.925
Scopus rating (2004): SJR 0.807 SNIP 1.946
Scopus rating (2003): SJR 1.727 SNIP 1.876
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)
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

Publication information
Journal: Composites Part A: Applied Science and Manufacturing
Volume: 97
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Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4.82 SJR 1.402 SNIP 2.053
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.53 SNIP 2.18 CiteScore 4.09
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.67 SNIP 2.538 CiteScore 4.08
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.59 SNIP 2.828 CiteScore 3.92
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.559 SNIP 2.706 CiteScore 3.36
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.443 SNIP 2.499 CiteScore 3.23
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.553 SNIP 2.241
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.536 SNIP 1.976
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.388 SNIP 1.853
Scopus rating (2007): SJR 1.222 SNIP 2.188
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.208 SNIP 2.268
Scopus rating (2005): SJR 1.109 SNIP 2.103
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.159 SNIP 1.671
Scopus rating (2003): SJR 1.132 SNIP 1.411
Scopus rating (2002): SJR 1.308 SNIP 1.512
Scopus rating (2001): SJR 1.426 SNIP 1.33
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 1.273 SNIP 1.298
Scopus rating (1999): SJR 0.824 SNIP 1.104
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:
abstract_WESC2017_final.pdf

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

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Wind turbine loads & control, Technical University of Denmark
Authors: Dellwik, E. (Intern), Papetta, A. (Ekstern), Arnqvist, J. (Ekstern), Nielsen, M. (Ekstern), Larsen, T. J. (Intern)
Number of pages: 27
Publication date: 2017

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Media of output: Power Point Presentation
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
Inflow_conditions_and_wake_effects_for_wind_turbines.pptx
Source: PublicationPreSubmission
Source-ID: 141913845
Publication: Research - peer-review › Sound/Visual production (digital) – Annual report year: 2017
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 grating 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.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Mikkelsen, L. P. (Intern)
Number of pages: 1
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Main Research Area: Technical/natural sciences
Electronic versions:
MikkelsenLP_WESC2017b.pdf
Source: PublicationPreSubmission
Source-ID: 134177097
Publication: Research - peer-review » Conference abstract for conference – Annual report year: 2017

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 (Risø 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. Lett. 8(1), 011005 (2013)] to be finalized in 2020.

General information
State: Published
Organisations: Department of Wind Energy
Authors: Lundtang Petersen, E. (Intern)
Number of pages: 11
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Renewable and Sustainable Energy
Volume: 9
Issue number: 5
Article number: 052301
ISSN (Print): 1941-7912
Ratings:
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.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Georgieva Yankova, G. (Intern), Villanueva, H. (Intern)
Number of pages: 29
Publication date: 2017

Publication information
Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy LC I
Number: 123
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
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.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Georgieva Yankova, G. (Intern), Villanueva, H. (Intern)
Number of pages: 10
Publication date: 2017

Publication information
Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy WTT I
Number: 1194
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

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.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Lilholt, H. (Intern), Sørensen, B. F. (Intern)
Number of pages: 20
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

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Journal: I O P Conference Series: Materials Science and Engineering
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BFI (2017): BFI-level 1
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.39 SJR 0.187 SNIP 0.499
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.172 SNIP 0.281 CiteScore 0.22
Scopus rating (2014): SJR 0.186 SNIP 0.306 CiteScore 0.18
Scopus rating (2013): SJR 0.183 SNIP 0.256 CiteScore 0.16
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 partly 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 fossil fuel 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.

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 compactant 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.
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.
measurement activities constitute the Joint Experiment Project 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.

**General information**

State: Published
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)
Pages: 339-345
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Main Research Area: Technical/natural sciences

**Publication information**

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Volume: 137
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BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.16 SJR 0.467 SNIP 0.586
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.365 SNIP 0.561 CiteScore 0.92
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.433 SNIP 0.81 CiteScore 1.09
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.425 SNIP 0.785 CiteScore 1.02
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
Scopus rating (2012): SJR 0.425 SNIP 0.563 CiteScore 1.08
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
Scopus rating (2011): SJR 0.918 SNIP 1.505 CiteScore 2.42
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.433 SNIP 0.957
Web of Science (2009): Indexed yes
Original language: English
Lidar, Lidic, WindScanner, Wind Tunnel, Icing Conditions, Wind Turbine Wake, Blind test

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10.1016/j.egypro.2017.10.358
Source: Findit
Source-ID: 2394200561
Publication: Research - peer-review › Conference article – Annual report year: 2017

**Lidars Lifted: The Østerild Balconies Experiment**

**General information**

State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing
Authors: Simon, E. (Intern), Courtney, M. (Intern), Vasiljevic, N. (Intern), Lea, G. (Intern), Deliwik, E. (Intern), Karagali, I. (Intern), Mann, J. (Intern)
Number of pages: 13
Publication date: 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].

General information

State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Federici, P. (Intern), Kock, C. W. (Intern)
Number of pages: 348
Publication date: 2017

Publication information

Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy WTT I
Number: 1198
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
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].

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

Publication information
Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy WTT I
Number: 1217
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

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
WindTech 2017
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
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
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.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Kutateladze Institute of Thermophysics SB RAS
Authors: Okulov, V. L. (Intern), Naumov, I. V. (Ekstern), Tsoy, M. A. (Ekstern), Mikkelsen, R. F. (Intern)
Pages: 545-551
Publication date: 2017
Main Research Area: Technical/natural sciences

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Journal: Thermophysics and Aeromechanics
Volume: 24
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ISSN (Print): 0869-8643
Ratings:
Web of Science (2018): Indexed yes
Web of Science (2017): Indexed Yes
Scopus rating (2016): CiteScore 0.81 SJR 0.384 SNIP 1.422
Web of Science (2016): Indexed yes
Scopus rating (2015): SJR 0.325 SNIP 0.787 CiteScore 0.4
Scopus rating (2014): SJR 0.253 SNIP 0.856 CiteScore 0.39
Web of Science (2014): Indexed yes
Scopus rating (2013): SJR 0.392 SNIP 0.712 CiteScore 0.37
ISI indexed (2013): ISI indexed yes
Scopus rating (2012): SJR 0.288 SNIP 0.528 CiteScore 0.28
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Scopus rating (2011): SJR 0.265 SNIP 0.652 CiteScore 0.27
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.208 SNIP 0.507
Scopus rating (2009): SJR 0.247 SNIP 0.766
Scopus rating (2008): SJR 0.211 SNIP 0.217
Scopus rating (2007): SJR 0.186 SNIP 0.047
Original language: English
DOIs:
10.1134/S0869864317040059
Source: FindIt
Source-ID: 2392109493
Publication: Research - peer-review › Journal article – Annual report year: 2017

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
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.
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)
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Remote Sensing
Volume: 9
Issue number: 10
Article number: 977
ISSN (Print): 2072-4292
Ratings:
Web of Science (2018): Indexed yes
Web of Science (2017): Indexed Yes
Scopus rating (2016): CiteScore 3.56 SJR 1.31 SNIP 1.661
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)
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Publication date: 2017

Publication information
Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy WTT I
Number: 1165
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: Vesth, A. (Intern), Georgieva Yankova, G. (Intern)
Number of pages: 136
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Publication information
Publisher: DTU Wind Energy
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), Villanueva, H. (Intern)
Number of pages: 88
Publication date: 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: Georgieva Yankova, G. (Intern), Federici, P. (Intern)
Number of pages: 196
Publication date: 2017

Publication information
Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy WTT I
Number: 1197
Main Research Area: Technical/natural sciences

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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)
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Number: 1186
Main Research Area: Technical/natural sciences

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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

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

Bibliographical note
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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.
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
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Article number: 012026

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Conference: Wake Conference 2017, Visby, Sweden, 30/05/2017 - 30/05/2017
Applied fluid mechanics, Boundary layer and shear turbulence, Wakes, Power and plant engineering (mechanical engineering), Other structures, Fluid mechanics and aerodynamics (mechanical engineering), Elasticity (mechanical engineering), Buckling and instability (mechanical engineering), Fracture mechanics and hardness (mechanical engineering), boundary layer turbulence, elasticity, fatigue, mechanical stability, offshore installations, wakes, wind turbines, medium fidelity loads modelling, nonneutral ABL stability conditions, wind turbine component fatigue loading, wake affected nonstationary flow fields, nonneutral atmospheric stability conditions, dynamic wake meandering model, atmospheric boundary layer stability, primary wake meandering dynamics, large turbulent scales, wake expansion, atmospheric boundary layer turbulence, classical Mann spectral tensor, buoyancy effects, nonstationary wind turbine inflow fields, fatigue loads, aeroelastic model HAWC2, Lillgrund offshore wind farm, WF, wind farm model validation, wake effects, tower load recordings, atmospheric boundary layer stability effects, rotating wind turbine components, unstable atmospheric boundary layer stratification
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
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ISSN (Print): 0035-9009
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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.33 SJR 2.449 SNIP 1.429
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.538 SNIP 1.402 CiteScore 3.1
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 5.04 SNIP 2.339 CiteScore 5
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 4.35 SNIP 2.035 CiteScore 4.17
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 3.564 SNIP 1.566 CiteScore 2.99
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
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.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Sørensen, B. F. (Intern)
Number of pages: 11
Pages: 38-48
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Mechanics of Materials
Volume: 104
ISSN (Print): 0167-6636
Ratings:
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
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 transmission electron microscopy, 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.
Copper, Mechanical properties, Spark plasma sintering, Ultra-fine grain size, Grain size and shape, Recrystallization (metallurgy), Tensile testing, Transmission electron microscopy, Average grain size, Electron back scatter diffraction, Grain size control, Hardness measurement, High angle boundaries, Microstructural examination, Particle diameters, Sintering

DOIs:
10.1016/j.matdes.2016.12.042

Source: FindIt
Source-ID: 2349816363
Publication: Research - peer-review › Journal article – Annual report year: 2017
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
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Main Research Area: Technical/natural sciences

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Journal: Wind Energy Science Discussions
Volume: 2
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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)
Publication date: 2017
Main Research Area: Technical/natural sciences
Electronic versions:
AbstractTemplate_Boulder2017_final.pdf
Source: PublicationPreSubmission
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 $\eta(\theta)$. 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
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Main Research Area: Technical/natural sciences

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Volume: 74
Issue number: 4
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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.23 SJR 2.803 SNIP 1.307
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 3.312 SNIP 1.399 CiteScore 3.36
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 3.163 SNIP 1.427 CiteScore 3.04
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 3.395 SNIP 1.479 CiteScore 3.04
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 3.26 SNIP 1.263 CiteScore 2.58
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 2.621 SNIP 1.174 CiteScore 2.55
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 2.946 SNIP 1.394
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 3.755 SNIP 1.422
Web of Science (2009): Indexed yes
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.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Hohai University, Nanjing University of Aeronautics and Astronautics
Authors: Zhao, Z. (Ekstern), Shen, W. (Intern), Wang, R. (Ekstern), Wang, T. (Ekstern), Xu, B. (Ekstern), Zheng, Y. (Ekstern), Qian, S. (Ekstern)
Number of pages: 18
Publication date: 2017
Main Research Area: Technical/natural sciences

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Journal: Journal of Renewable and Sustainable Energy
Volume: 9
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Article number: 053301
ISSN (Print): 1941-7012
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
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
Organizations: 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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Title of host publication: Wake Conference 2017
Volume: 854
Article number: 012014

Series: Journal of Physics: Conference Series
ISSN: 1742-6596
Main Research Area: Technical/natural sciences
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

Electronic versions:
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 modulus 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
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Publication information

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BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.9 SJR 1.751 SNIP 2.481
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.885 SNIP 2.654 CiteScore 4.51
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 2.418 SNIP 3.474 CiteScore 4.36
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 2.045 SNIP 3.269 CiteScore 3.8
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.988 SNIP 3.212 CiteScore 3.31
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.406 SNIP 2.521 CiteScore 2.63
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
Publication date: 2017

Publication information
Media of output: Power Point Presentation
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
OWE17_Hasager_et_al_Wake_photo.pdf
Publication: Research › Sound/Visual production (digital) – Annual report year: 2017

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, undisrupted 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
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.
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
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Series: DTU Wind Energy WTT I
Number: 1170
Main Research Area: Technical/natural sciences
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
Publication date: 2017

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.
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

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Journal: Materials
Volume: 10
Issue number: 10
ISSN (Print): 1996-1944

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Web of Science (2018): Indexed yes
Web of Science (2017): Indexed Yes
Scopus rating (2016): CiteScore 3.26 SJR 0.834 SNIP 1.497
Web of Science (2016): Indexed yes
Scopus rating (2015): SJR 0.852 SNIP 1.495 CiteScore 3.11
Scopus rating (2014): SJR 0.777 SNIP 1.256 CiteScore 2.69
Web of Science (2014): Indexed yes
Scopus rating (2013): SJR 0.998 SNIP 1.673 CiteScore 3.12
ISI indexed (2013): ISI indexed yes
Scopus rating (2012): SJR 0.838 SNIP 1.471
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.65 SNIP 1.239
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
Scopus rating (2010): SJR 0.394 SNIP 0.99
Original language: English
Electronic versions:
materials_10_01171.pdf
DOIs:
10.3390/ma10101171
Source: FindIt
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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 assuming normality.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning
Authors: Koivisto, M. J. (Intern), Sørensen, P. E. (Intern), Maule, P. (Intern), Nuño Martinez, E. (Intern)
Number of pages: 22
Publication date: 2017

Publication information
Publisher: DTU Wind Energy
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
WP1.3_FlexibilityReport_REVISION_ver01.pdf
Source: PublicationPreSubmission
Source-ID: 136859432
Publication: Research - peer-review › Report – Annual report year: 2017

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 in. 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. Variable renewable energy generation is analysed using 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 VRE 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)
Publication date: 2017
Main Research Area: Technical/natural sciences
Electronic versions:
Pages_from_WESC_Conference_06_2017_Lyngby_Denmark_toOrbit.pdf

Relations
Projects:

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

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Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
Pages_from_WESC_Conference_06_2017_Lyngby_Denmark_toOrbit2.pdf

Relations
Projects:
Publication: Research - peer-review › Sound/Visual production (digital) – Annual report year: 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

Host publication information
Title of host publication: Proceedings of 3rd International Conference on Tomography of Materials and Structures
Main Research Area: Technical/natural sciences
Conference: 3rd International Conference on Tomography of 3D Materials and Structures, Lund, Sweden, 26/06/2017 - 28/06/2017
Segmentation, Composite characterisation, Validation, Fibre analysis

Relations
Activities:
New approach for validating the segmentation of 3D data applied to individual fibre extraction
Source: PublicationPreSubmission
Source-ID: 134493070
Publication: Research - peer-review › Article in proceedings – Annual report year: 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)
New methodologies to observe wind gusts: research aircraft and Doppler lidar measurements

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

Nonlinear blade element-momentum analysis of Betz-Goldstein rotors
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.
NSON-DK energy system scenario

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
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Scopus rating (2016): CiteScore 3.16 SJR 1.382 SNIP 2.094
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BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.545 SNIP 2.5 CiteScore 2.44
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.473 SNIP 2.793 CiteScore 2.51
ISI indexed (2013): ISI indexed yes
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BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.406 SNIP 2.331 CiteScore 1.96
ISI indexed (2012): ISI indexed yes
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BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.247 SNIP 2.209 CiteScore 1.89
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.394 SNIP 2.159
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.294 SNIP 2.09
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
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.64 SJR 1.743 SNIP 1.566
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
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Number of pages: 6
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Scopus rating (2015): SJR 0.149 SNIP 0.327
Scopus rating (2014): SJR 0.214 SNIP 0.418
Scopus rating (2013): SJR 0.213 SNIP 0.447
Scopus rating (2012): SJR 0.202 SNIP 0.465
Scopus rating (2011): SJR 0.206 SNIP 0.425
Scopus rating (2010): SJR 0.23 SNIP 0.445
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Scopus rating (2008): SJR 0.25 SNIP 0.282
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Scopus rating (2005): SJR 0.14 SNIP 0.659
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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
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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
OC5 Project Phase II: Validation of Global Loads of the DeepCwind Floating Semisubmersible Wind Turbine

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, Tecnalia, DNV GL, IFP Energies nouvelles, PRINCIPIA, Politecnico di Milano, Siemens PLM, Universidad de Cantabria, University of Ulsan, University of Tokyo, Universitat Politecnica de Catalunya, WavEC – Offshore Renewables
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Journal: Energy Procedia
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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
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Number of pages: 5
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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

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing
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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)
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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
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Organisations: Department of Wind Energy, Resource Assessment Modelling, Risø National Laboratory for Sustainable Energy, DHI
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BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.88 SNIP 0.974 CiteScore 1.74
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.05 SNIP 1.226 CiteScore 1.99
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.345 SNIP 1.272 CiteScore 1.94
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.203 SNIP 1.058 CiteScore 1.69
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.14 SNIP 0.981 CiteScore 1.72
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.962 SNIP 0.928
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.692 SNIP 1.821
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.526 SNIP 1.315
Scopus rating (2007): SJR 1.28 SNIP 1.427
Scopus rating (2006): SJR 0.917 SNIP 1.26
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.589 SNIP 1.144
Scopus rating (2004): SJR 0.718 SNIP 1.115
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.

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 $2 \times 10^5$. 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.
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.
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 SMARTEOLE 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 SMARTEOLE planned for the second semester of 2017.

General information
State: Published
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Number of pages: 92
Publication date: 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.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics, Aalborg University
Authors: Sokoli, H. U. (Ekstern), Beauson, J. (Intern), Simonsen, M. E. (Ekstern), Fraisse, A. (Intern), Brøndsted, P. (Intern), Sogaard, E. G. (Ekstern)
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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.

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State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics, Aalborg University
Authors: Sokoli, H. U. (Ekstern), Beauson, J. (Intern), Simonsen, M. E. (Ekstern), Fraisse, A. (Intern), Brøndsted, P. (Intern), Sogaard, E. G. (Ekstern)
Pages: 80-89
Publication date: 2017
Main Research Area: Technical/natural sciences

Electronic versions:
DUC_Thomas_Master_thesis_final.pdf
Publication: Research › Report – Annual report year: 2017
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.

General information
State: Published
Organisations: Department of Wind Energy, Materials science and characterization, Chinese Academy of Sciences
Authors: Lu, Q. (Ekstern), Huang, X. (Intern), Hansen, N. (Intern), Lu, L. (Ekstern)
Number of pages: 6
Publication date: 2017
Conference: 38th Risø International Symposium on Materials Science, Roskilde, Denmark, 04/09/2017 - 04/09/2017
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
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.
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
Volume: 14
Article number: 778
Main Research Area: Technical/natural sciences
Electronic versions:
EMS2017_778_2.pdf

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

Publication information
Media of output: Power Point Presentation
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
2017_08_30_Antoine_Borraccino_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/mm(2). 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
### 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: 1_Charlotte_Hasager_YES.pdf  
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.
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.
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 analysis 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: 73
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
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

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 analysis 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: 92
Publication date: 2017

Publication information
Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy WTT I
Number: 1196
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

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 analysis 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

Publication information
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
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
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: Villanueva, H. (Intern), Gómez Arranz, P. (Intern)
Number of pages: 78
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), Kock, C. W. (Intern)
Number of pages: 73
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: 75
Publication date: 2017

Publication information

Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy WTT I
Number: 1221
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
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), Federici, P. (Intern)
Number of pages: 69
Publication date: 2017

Publication information
Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy WTT I
Number: 1184
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
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)
Number of pages: 99
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
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

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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)
Number of pages: 96
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

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

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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

Publication information
Publisher: DTU Wind Energy
Original language: English
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, \( \lambda \), of 5 with a constant design lift coefficient along the span, \( C_l = 0.8 \). 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.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, RAS
Authors: Okulov, V. (Intern), Mikkelsen, R. F. (Intern), Sørensen, J. N. (Intern), Naumov, I. (Intern), Tsoy, M. A. (Ekstern)
Number of pages: 6
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Energy Resources Technology
Volume: 139
Issue number: 5
Article number: 051210-1
ISSN (Print): 0195-0738
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.511 SNIP 1.067 CiteScore 1.6
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.661 SNIP 1.363 CiteScore 1.16
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.735 SNIP 1.768 CiteScore 1.66
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.672 SNIP 0.923 CiteScore 1.32
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.392 SNIP 0.737 CiteScore 0.83
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.264 SNIP 0.382 CiteScore 0.47
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.241 SNIP 0.493
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.328 SNIP 0.853
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.39 SNIP 0.811
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.363 SNIP 0.833
Scopus rating (2006): SJR 0.528 SNIP 0.897
Scopus rating (2005): SJR 0.501 SNIP 0.642
Scopus rating (2004): SJR 0.356 SNIP 0.785
Scopus rating (2003): SJR 0.438 SNIP 0.617
Scopus rating (2002): SJR 0.269 SNIP 0.809
Scopus rating (2001): SJR 0.717 SNIP 0.826
Scopus rating (2000): SJR 0.701 SNIP 0.861
Scopus rating (1999): SJR 0.813 SNIP 1.511
Original language: English
DOI: 10.1115/1.4036250
**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
Publication date: 2017
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Energies
Volume: 10
Issue number: 4
Article number: 555
ISSN (Print): 1996-1073
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.5 SJR 0.691 SNIP 1.053
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.804 SNIP 1.416 CiteScore 2.87
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.87 SNIP 1.601 CiteScore 2.66
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.632 SNIP 1.345 CiteScore 2.29
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.874 SNIP 1.54 CiteScore 2.46
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.659 SNIP 1.439 CiteScore 2.24
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.303 SNIP 0.76
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 suffer 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), Schlæer, S. (Intern)
Extreme wave, FORM, First Order Reliability Method, NewWave, NewForce

Probabilistic Design of Wind Turbine Structures

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
State: Published
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
Publication date: 2017
Main Research Area: Technical/natural sciences
Publication information
Journal: Environmental Research Letters
Volume: 12
Issue number: 3
Article number: 034022
ISSN (Print): 1748-9326
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.74 SJR 2.628 SNIP 1.575
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.726 SNIP 1.557 CiteScore 4.51
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 2.153 SNIP 1.435 CiteScore 3.91
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 2.284 SNIP 1.676 CiteScore 4.06
Quantification of deformation microstructure at ultra-low tensile strain in pure Al prepared by spark plasma sintering

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 large deformation. Other possible reasons for the different deformation behaviour between individual grains are briefly discussed.

General information
State: Published
Organisations: Department of Wind Energy, Materials science and characterization, Department of Mechanical Engineering, Manufacturing Engineering, Tsinghua University, Chongqing University, Argonne National Laboratory
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

Publication information
Journal: I O P Conference Series: Materials Science and Engineering
Volume: 219
ISSN (Print): 1757-8981
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
BFI (2016): BFI-level 1
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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Ramp events in the marine boundary-layer investigated by a wind lidar
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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.

General information
State: Accepted/In press
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: NJOMO WANDJI, W. (Intern)
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
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.
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 lidars 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 trough 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.

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Authors: Borraccino, A. (Intern), Courtney, M. (Intern), Wagner, R. (Intern)
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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 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 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)
Number of pages: 1
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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 elongated 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.

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.
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.71 SJR 1.901 SNIP 1.696
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Scopus rating (2015): SJR 2.3 SNIP 1.876 CiteScore 3.54
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.744 SNIP 2.124 CiteScore 3.55
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Scopus rating (2012): SJR 2.309 SNIP 2.022 CiteScore 3.01
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.333 SNIP 2.108 CiteScore 3.21
ISI indexed (2011): ISI indexed yes
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BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.445 SNIP 2.125
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.574 SNIP 2.02
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.634 SNIP 2.128
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 2.229 SNIP 2.174
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 2.1 SNIP 1.915
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Scopus rating (2005): SJR 1.831 SNIP 1.915
Web of Science (2005): Indexed yes
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Web of Science (2004): Indexed yes
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Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.509 SNIP 1.345
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.301 SNIP 1.361
Web of Science (2001): Indexed yes
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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.

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Authors: Peña, A. (Intern)
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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 Høvsøre, 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—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 Høvsøre, 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—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 Høvsøre, 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. 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 Høvsøre, 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.

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BFI (2013): BFI-level 1
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BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 0.67
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
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Scopus rating (2011): CiteScore 0.85
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BFI (2009): BFI-level 1
BFI (2008): BFI-level 1
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Web of Science (2000): Indexed yes
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**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.

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.
Self-Reinforced PLA Composites: Bio-based and Biodegradable Polymer Materials for Industrial Applications

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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 = 2·10^5) 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.

General information
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Organisations: Department of Wind Energy, Fluid Mechanics, Russian Academy of Sciences
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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.

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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.
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
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Authors: van der Laan, P. (Intern), Pena Diaz, A. (Intern), Volker, P. (Intern), Hansen, K. S. (Intern), Sørensen, N. N. (Intern), Ott, S. (Intern), Hasager, C. B. (Intern), Hasager, C. B. (Intern)
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Simulating coastal effects on an offshore wind farm
Wind turbine wakes can cause energy losses in wind farms1 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 build 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.2 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.

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Authors: Angelou, N. (Intern), Zhang, X. (Intern), Sjöholm, M. (Intern), Lorentzen, L. (Intern), Huang, X. (Intern)
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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.

**General information**

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Organisations: Department of Wind Energy, Resource Assessment Modelling, Energy Transport & Climate Directorate, Energy Transport & Climate Directorate
Authors: Gonzalez-Aparicio, I. (Ekstern), Monforti, F. (Ekstern), Volker, P. (Intern), Zucker, A. (Ekstern), Careri, F. (Ekstern), Huld, T. (Ekstern), Badger, J. (Intern)
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- Web of Science (2014): Indexed yes
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- Scopus rating (2011): SJR 2.473 SNIP 2.84 CiteScore 5.5
- ISI indexed (2011): ISI indexed yes
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- Web of Science (2010): Indexed yes
- BFI (2009): BFI-level 1
- Scopus rating (2009): SJR 1.003 SNIP 1.781
- Web of Science (2009): Indexed yes
- BFI (2008): BFI-level 2
- Scopus rating (2008): SJR 0.974 SNIP 1.215
- Web of Science (2008): Indexed yes
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 forms 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 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
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Scopus rating (2014): SJR 1.179 SNIP 1.923 CiteScore 2.72
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.096 SNIP 1.985 CiteScore 2.73
Site assessment
This report describes the site assessment of 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.

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Organisations: Department of Wind Energy, Test and Measurements
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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
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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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Scopus rating (2015): SJR 3.388 SNIP 2.373 CiteScore 3.32
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.851 SNIP 2.513 CiteScore 2.98
Web of Science (2014): Indexed yes
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ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.529 SNIP 2.773 CiteScore 3.05
ISI indexed (2012): ISI indexed yes
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Scopus rating (2011): SJR 2.339 SNIP 2.217 CiteScore 2.4
ISI indexed (2011): ISI indexed yes
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Scopus rating (2010): SJR 2.361 SNIP 2.324
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Scopus rating (2008): SJR 2.316 SNIP 2.178
Scopus rating (2007): SJR 2.759 SNIP 2.183
Scopus rating (2006): SJR 2.118 SNIP 2.312
Scopus rating (2005): SJR 3.127 SNIP 2.721
Scopus rating (2004): SJR 4.01 SNIP 3.038
Scopus rating (2003): SJR 3.371 SNIP 2.613
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.
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 35 kHz 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.

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Organisations: Department of Wind Energy, Composites and Materials Mechanics, Lund University, Swedish Defence Research Agency
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BFI (2014): BFI-level 1
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Web of Science (2014): Indexed yes
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Scopus rating (2012): SJR 1.463 SNIP 1.267 CiteScore 1.83
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ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
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Scopus rating (2010): SJR 1.471 SNIP 1.309
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Scopus rating (2008): SJR 1.562 SNIP 1.37
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Web of Science (2006): Indexed yes
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Web of Science (2003): Indexed yes
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Specimen design and instrumentation for monitoring fatigue crack growth initiating at ply drops

Unpredictable and excessive loads, for example caused by aerodynamic interaction between different turbines, can accelerate fatigue damage in wind turbine blades (Ghosal et al. (2000)). Fatigue damage can also initiate in the early service life of a wind turbine blade in regions of stress concentration, such as those caused by ply drops (Cairns et al. (1999)). Due to these issues, the design philosophy is based on conservative analysis methods and inspections at certain time intervals are required to assess the damage in the wind blades.

An alternative approach is to use damage tolerant materials and a structural health monitoring system (McGugan et al. (2015)). In this approach, a distribution of damage types within the blades is accepted as long as they can be detected by structural health monitoring techniques and their severity evaluated by material damage models.

The present work aims to demonstrate this design philosophy at the laboratory level. A test specimen, which includes ply drops at different distances from each other, is tested under static and fatigue loads. The aim is to investigate if cracks starting from these locations are stable (damage tolerant) and if the cracks and their location can be detected by non-destructive methods (detection of damage initiation and evolution).

The focus of the paper is on the experimental details and set-up: a) Design of the specimen based on a finite element model. b) Manufacturing of the ply drop specimens including manufacturing issues when embedding fibre Bragg grating sensors. c) Instrumentation of the test specimen e.g. strain gauges, acoustic emission sensors, fibre Bragg grating sensors.

Selected static and cyclic results will be presented showing that certain damage types (cracks at ply drops) are stable and thus not critical for the integrity of a structure (wind turbine blade) and that structural health monitoring techniques (acoustic emission and fibre Bragg grating sensors) can detect damage initiation and monitor the damage evolution.

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Authors: Goutianos, S. (Intern), Di Crescenzo, L. (Intern), McGugan, M. (Intern), Sørensen, B. F. (Intern)
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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 adding 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 $\beta$, 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 ($z_0$) 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 $z_0$ 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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Organisations: Department of Wind Energy, Resource Assessment Modelling, Meteorology & Remote Sensing
Authors: Kelly, M. C. (Intern), Ejsing Jørgensen, H. (Intern)
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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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Organisations: Department of Wind Energy, Materials science and characterization
Authors: Zhang, Y. (Intern), Mishin, O. (Intern)
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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 full scale 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.
operation of the turbine, the optimum design fulfils 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 limitations are also fulfilled.

**General information**

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Organisations: Department of Wind Energy, Aerodynamic design, Technical University of Denmark
Authors: Barlas, A. (Intern), Lin, Y. (Ekstern), Aagaard Madsen , H. (Intern)
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Main Research Area: Technical/natural sciences

**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.

**General information**

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Organisations: Department of Chemical and Biochemical Engineering, Department of Wind Energy, Materials science and characterization, Chongqing University, Kyoto University
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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.

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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.

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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Main Research Area: Technical/natural sciences
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 DlgSILENT 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.
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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Organisations: Department of Wind Energy, Aerodynamic design, Energy Research Centre of the Netherlands, Centro Nacional de Energias Renovables, Kiel University of Applied Sciences, National Technical University of Athens, Fraunhofer Institute for Wind Energy and Energy System Technology (IWES), ForWind, University of Stuttgart, Offshore Renewable Energy Catapult
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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.

General information
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Organisations: Department of Wind Energy, Materials science and characterization, Banedanmark, Technical University of Denmark
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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Organisations: Department of Wind Energy, Materials science and characterization, Department of Mechanical Engineering, Manufacturing Engineering, Composites and Materials Mechanics, Argonne National Laboratory, VESTAS Wind Systems A/S, Oak Ridge National Laboratory
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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 subsurface 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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Web of Science (2015): Indexed yes
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Web of Science (2014): Indexed yes
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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, concentricating 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 offshore 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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Organisations: Department of Wind Energy, Resource Assessment Modelling, Meteorology & Remote Sensing, Test and Measurements
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.

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Organisations: Department of Wind Energy, Aerodynamic design
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.

General information
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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.821 SNIP 1.435 CiteScore 2.07
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.807 SNIP 1.4 CiteScore 2.03
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.929 SNIP 1.302 CiteScore 1.95
ISI indexed (2012): ISI indexed yes
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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.

General information
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Organisations: Department of Wind Energy, Materials science and characterization, Tsinghua University
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The Martian Planetary Boundary Layer

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Authors: Read, P. (Ekstern), Galperin, B. (Ekstern), Larsen, S. E. (Intern), Lewis, S. (Ekstern), Määttänen, A. (Ekstern), Petrosyan, A. (Ekstern), Renno, N. (Ekstern), Savijärvi, H. (Ekstern), Silli, T. (Ekstern), Spiga, A. (Ekstern), Toigo, A. (Ekstern), Vazquez, L. (Ekstern)
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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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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Aalborg Universitet København
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BFI (2018): BFI-level 2
The Role of Logistics in Practical Levelized Cost of Energy Reduction Implementation and Government Sponsored Cost Reduction Studies: Day and Night in Offshore Wind Operations and Maintenance Logistics

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 initiatives. 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.

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Aalborg University, Offshoreenergy.dk
Authors: Poulsen, T. (Ekstern), Hasager, C. B. (Intern), Jensen, C. M. (Ekstern)
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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.

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Organisations: Department of Wind Energy, Fluid Mechanics, University of Stuttgart, Technical University of Denmark, Centro Nacional de Energías Renovables
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Main Research Area: Technical/natural sciences
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.
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.
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Scopus rating (2016): CiteScore 3.36 SJR 1.996 SNIP 1.313
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Scopus rating (2014): SJR 2.324 SNIP 1.349 CiteScore 3.27
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Scopus rating (2010): SJR 2.449 SNIP 1.324
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Scopus rating (2006): SJR 2.166 SNIP 1.351
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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.
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 Risø 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.
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 ($T_t$) 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 ($T_r$) of the gliding arc discharge whereas the NO $A-X$ (1, 0) and (0, 1) bands were used to determine its vibrational temperature ($T_v$). 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 ($T_e$) 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 ($T_e>T_v>T_r>T_t$) suggest a high-degree non-equilibrium state of the gliding arc discharge.

General information

State: Published
Organisations: Department of Physics, Plasma Physics and Fusion Energy, Department of Wind Energy, Composites and Materials Mechanics, Lund University
Authors: Zhu, J. (Ekstern), Ehn, A. (Ekstern), Gao, J. (Ekstern), Kong, C. (Ekstern), Aldén, M. (Ekstern), Salewski, M. (Intern), Leipold, F. (Intern), Kusano, Y. (Intern), Li, Z. (Ekstern)
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Publication date: 2017
Main Research Area: Technical/natural sciences
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.

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Organisations: Department of Wind Energy, Composites and Materials Mechanics, LM Wind Power
Authors: Jørgensen, J. B. (Intern), Sørensen, B. F. (Intern), Kildegaard, C. (Ekstern)
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Scopus rating (2011): SJR 1.793 SNIP 2.237 CiteScore 1.92
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
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Scopus rating (2010): SJR 1.482 SNIP 1.946
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'.

General information
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Organisations: Department of Wind Energy, Fluid Mechanics
Authors: Andersen, S. J. (Intern), Sørensen, J. N. (Intern), Mikkelsen, R. F. (Intern)
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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 ensemble averaged 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 forward-looking nacelle lidars are investigated: a pulsed system that uses a five-beam configuration and a continuous-wave 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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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Technical University of Denmark
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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.

**General information**
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Organisations: Department of Wind Energy, Resource Assessment Modelling, National Research Council of Italy
Authors: Gulli, 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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Scopus rating (2013): SJR 0.425 SNIP 0.785 CiteScore 1.02
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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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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.744 SNIP 2.124 CiteScore 3.55
Web of Science (2014): Indexed yes
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Scopus rating (2013): SJR 2.347 SNIP 1.975 CiteScore 3.19
ISI indexed (2013): ISI indexed yes
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BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.309 SNIP 2.022 CiteScore 3.01
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.

**General information**
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- **Organisations**: Department of Wind Energy, Meteorology & Remote Sensing, Danish Meteorological Institute, ESTEC
- **Authors**: Karagali, I. (Intern), Høyer, J. L. (Ekstern), Donlon, C. J. (Ekstern)
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  - Scopus rating (2014): SJR 2.324 SNIP 1.349 CiteScore 3.27
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  - Scopus rating (2012): SJR 2.365 SNIP 1.35 CiteScore 2.93
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  - Web of Science (2012): Indexed yes
  - BFI (2011): BFI-level 2
  - Scopus rating (2011): SJR 2.239 SNIP 1.301 CiteScore 3.03
  - ISI indexed (2011): ISI indexed yes
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  - BFI (2010): BFI-level 2
  - Scopus rating (2010): SJR 2.449 SNIP 1.324
  - Web of Science (2010): Indexed yes
  - BFI (2009): BFI-level 2
  - Scopus rating (2009): SJR 2.347 SNIP 1.359
  - Web of Science (2009): Indexed yes
  - BFI (2008): BFI-level 2
  - Scopus rating (2008): SJR 2.101 SNIP 1.296
  - Web of Science (2008): Indexed yes
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  - Web of Science (2007): Indexed yes
  - Scopus rating (2006): SJR 2.166 SNIP 1.351
Using a finite element pediatric hip model in clinical evaluation - a feasibility study

The paper describes 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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Bibliographical note
Copyright: © 2017 Skytte TL, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.
Publication: Research - peer-review › Journal article – Annual report year: 2018
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 fullscale 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.

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.
Validation of sentinel-1A SAR coastal wind speeds against scanning LiDAR

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: 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 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.

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control, Test and Measurements, Department of Applied Mathematics and Computer Science, Dynamical Systems
Authors: Larsen, T. J. (Intern), Larsen, G. C. (Intern), Pedersen, M. M. (Intern), Enevoldsen, K. (Intern), Madsen, H. A. (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 wakeexpansion coefficients of the Park2 model.

General information
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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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Main Research Area: Technical/natural sciences
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Publication: Research - peer-review › Poster – Annual report year: 2017

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 wakeexpansion coefficients of the Park2 model.

General information
State: Published
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)
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.

Verification of a novel innovative blade root design for wind turbines using a hybrid numerical method

To enhance the performance of horizontal axis wind turbines, it is proposed to place a cylindrical disc in front of the rotor in order to lead the incoming flow from the inner part to the outer part of the rotor blades. This is expected to increase the power output, as the kinetic energy is mainly captured at the outer part of the blades, where the relative wind speed is high. To assess the impact of this novel design idea, a hybrid numerical technique, based on solving the Reynolds-averaged Navier-Stokes equations, is utilized to determine the aerodynamic performance. The in-house developed EllipSys3D code, which is employed as basic numerical solver, is combined with an actuator disc representation of the wind turbine rotor and an immersed boundary technique for representing the upstream cylindrical disc. The impact of the disc on the rotor performance is assessed by systematically changing the size of the circular disc and its axial distance to the rotor. Based on a numerical study of a Megawatt size commercial wind turbine, it is found that up to 1.5% additional energy can be captured by placing a circular disc with a suitable diameter upstream of the rotor plane.
Vindmøller. Opskalering, Koncepter

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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.

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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
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
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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State: Published
Organisations: Department of Wind Energy, Aerodynamic design
Authors: van der Laan, P. (Intern), Sørensen, N. N. (Intern)
Pages: 285-294
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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.

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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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BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.668 SNIP 1.041 CiteScore 2.46
Web of Science (2015): Indexed yes
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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Organisations: Department of Wind Energy, Test and Measurements
Authors: Georgieva Yankova, G. (Intern), Federici, P. (Intern)
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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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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
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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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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.

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Organisations: Department of Wind Energy, Fluid Mechanics
Authors: Feng, J. (Intern), Shen, W. Z. (Intern)
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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.

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Authors: Hasager, C. B. (Intern), Karagali, I. (Intern), Volker, P. (Intern), Andersen, S. J. (Intern), Nygaard, N. G. (Ekstern)
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Links:
https://www.windtech-international.com/editorial-features/wind-farm-wake
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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 2008. 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.

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Wind field determination from multiple Spinner-Lidar line-of-sight measurements using linearized CFD

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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.

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Power curve measurement using \( \bar{Q} \) estimates from nacelle lidars and its uncertainty
Source: FindIt
Source-ID: 2357339786
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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
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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)
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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.
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 “Hamburg”. 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 windturbines 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.

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Authors: Larsen, T. J. (Intern), Andersen, S. J. (Intern)
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Number: 0143
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Electronic versions:
DTU_Vindenergi_E_0143_EN_.pdf
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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] and to implement modern control system strategies.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning
Authors: Hansen, A. D. (Intern)
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ISBN (Print): 978-0-12-809451-8
Chapter: 8
Main Research Area: Technical/natural sciences
Publication: Research - peer-review › Book chapter – Annual report year: 2017
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 component to the induced velocity at the rotor disk is investigated. The content of this chapter is based on the publication of the author titled 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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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.

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Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Mikkelsen, L. P. (Intern), Zike, S. (Intern)
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Publication information
IPC: G01L 1/26 A I
Patent number: WO2016020152
Date: 11/02/2016
Priority date: 06/08/2014
Priority number: EP20140180022
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 10x10x30mm3 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.
3D X-ray CT of fatigue damage in fibre composites

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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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.

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Organisations: Department of Wind Energy, Wind Turbines, Department of Mechanical Engineering, Solid Mechanics
Authors: Blasques, J. P. A. A. (Intern), Bitsche, R. D. (Intern), Fedorov, V. (Intern), Lazarov, B. S. (Intern)
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Web of Science (2015): Indexed yes
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Scopus rating (2014): SJR 1.272 SNIP 3.75 CiteScore 3.42
Web of Science (2014): Indexed yes
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ISI indexed (2013): ISI indexed yes
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Scopus rating (2012): SJR 1.126 SNIP 2.39 CiteScore 2.36
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Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.024 SNIP 2.718 CiteScore 2.49
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
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Scopus rating (2010): SJR 1.487 SNIP 2.013
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.124 SNIP 1.448
Web of Science (2009): Indexed yes
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Scopus rating (2008): SJR 0.826 SNIP 1.559
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Scopus rating (2007): SJR 1.053 SNIP 1.453
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.637 SNIP 1.689
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.287 SNIP 0.9
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.528 SNIP 0.846
Web of Science (2004): Indexed yes
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Wind turbine blade, Structural analysis, Beam model, Cross-section analysis

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10.1002/we.1939
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 \times 10^5) 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

State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Technical University of Denmark
Authors: Lin, M. (Ekstern), Sarlak Chivaee, H. (Intern)
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BFI (2015): BFI-level 1
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BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.165 SNIP 0.191 CiteScore 0.17
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.16 SNIP 0.173 CiteScore 0.16
ISI indexed (2013): ISI indexed no
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.17 SNIP 0.176 CiteScore 0.14
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.153 SNIP 0.141 CiteScore 0.12
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.16 SNIP 0.144
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.157 SNIP 0.137
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.162 SNIP 0.112
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.157 SNIP 0.125
Scopus rating (2006): SJR 0.157 SNIP 0.121
Scopus rating (2005): SJR 0.157 SNIP 0.187
Scopus rating (2004): SJR 0.122 SNIP 0
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.416 SNIP 0.765
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.

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This report encompasses deliverable D1.2 of the ForskEL project RUNE (Reducing uncertainty of nearshore wind resource estimates using onshore lidars). It is an abridged version of the master thesis work completed at DTU by Elliot I. Simon while enrolled at Uppsala University in Sweden. The full text is available at the following link: http://orbit.dtu.dk/files/125274101/Thesis_Elliot_DTU_final.pdf
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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 fulfill 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.

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BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.272 SNIP 3.75 CiteScore 3.42
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Scopus rating (2010): SJR 1.487 SNIP 2.013
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
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
Organisations: Department of Wind Energy, Fluid Mechanics, DHI Denmark, University of Zagreb
Authors: Roenby, J. (Ekstern), Bredmose, H. (Intern), Jasak, H. (Ekstern)
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Interfacial flows, Volume of fluid method, Unstructured meshes, IsoAdvector, OpenFOAM®
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 account 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 $C_4\epsilon$ 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.

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Organisations: Department of Wind Energy, Fluid Mechanics, Hohai University, Chinese Academy of Sciences
Authors: Han, X. X. (Ekstern), Xu, C. (Ekstern), Liu, D. Y. (Ekstern), Shen, W. Z. (Intern), Zhen, Y. (Ekstern), Zhang, M. M. (Ekstern)
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Aerial LIDAR scans for validation of CFD models in complex forested terrain

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Authors: Dellwik, E. (Intern), Arnqvist, J. (Ekstern), Cavar, D. (Intern), Enevoldsen, P. (Ekstern), van der Laan, P. (Intern)
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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 system has gone through multiple stages of development, and will be greatly enhanced by the synchronization technology from this project.

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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.

General information
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Organisations: Department of Wind Energy, Fluid Mechanics
Authors: Debertshäuser, H. (Intern), Shen, W. Z. (Intern), Zhu, W. J. (Intern)
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Scopus rating (2011): SJR 0.292 SNIP 0.352 CiteScore 0.43
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Scopus rating (2008): SJR 0.265 SNIP 0.294
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Scopus rating (2007): SJR 0.257 SNIP 0.39
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.

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.

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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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Scopus rating (2015): SJR 0.365 SNIP 0.561 CiteScore 0.92
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Scopus rating (2013): SJR 0.425 SNIP 0.785 CiteScore 1.02
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Web of Science (2013): Indexed yes
Scopus rating (2012): SJR 0.425 SNIP 0.563 CiteScore 1.08
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Web of Science (2012): Indexed yes
Scopus rating (2011): SJR 0.918 SNIP 1.505 CiteScore 2.42
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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 an 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 an 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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Organisations: Department of Wind Energy, Aerodynamic design, Delft University of Technology
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Main Research Area: Technical/natural sciences
Conference: 34th Wind Energy Symposium, San Diego, CA, United States, 04/01/2016 - 04/01/2016
DOI: 10.2514/6.2016-1735

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
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Delft University of Technology
Authors: Sørensen, J. N. (Intern), Ferreira, C. (Ekstern)
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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.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Yangzhou University
Authors: Sessarego, M. (Intern), Ramos García, N. (Intern), Yang, H. (Ekstern), Shen, W. Z. (Intern)
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Web of Science (2016): Indexed yes
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Web of Science (2015): Indexed yes
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Scopus rating (2013): SJR 2.066 SNIP 2.767 CiteScore 4.63
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Web of Science (2013): Indexed yes
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ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
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Scopus rating (2011): SJR 1.688 SNIP 2.404 CiteScore 3.9
ISI indexed (2011): ISI indexed yes
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Scopus rating (2010): SJR 1.494 SNIP 2.215
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Aeroelastic Optimization of a 10 MW Wind Turbine Blade with Active Trailing Edge Flaps

This article presents the aeroelastic optimization of a 10MW 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.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design, Wind turbine loads & control
Authors: Barlas, A. (Intern), Tibaldi, C. (Intern), Zahle, F. (Intern), Aagaard Madsen, H. (Intern)
Publication date: 2016

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.

General information
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Organisations: Department of Wind Energy, Wind turbine loads & control
Authors: Tibaldi, C. (Intern), Hansen, M. H. (Intern)
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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.

General information
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Organisations: Department of Wind Energy, Resource Assessment Modelling, University of Helsinki
Authors: Rannik, Ü. (Ekstern), Zhou, L. (Ekstern), Zhou, P. (Ekstern), Gierens, R. (Ekstern), Mammarella, I. (Ekstern), Sogachev, A. (Intern), Boy, M. (Ekstern)
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A finite difference approach to despiking in-stationary velocity data - tested on a triple-lidar

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
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Organisations: Department of Wind Energy, Materials science and characterization, University of Copenhagen, Chalmers University of Technology
Authors: Meyer-Holdt, J. (Ekstern), Kanne, T. (Ekstern), Sestoft, J. E. (Ekstern), Gejl, A. N. (Intern), Zeng, L. (Ekstern), Johnson, E. (Intern), Ölsson, E. (Ekstern), Nygaard, J. (Ekstern), Krogstrup, P. (Ekstern)
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BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.87 SJR 1.096 SNIP 0.814
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.18 SNIP 0.966 CiteScore 3.07
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.465 SNIP 1.258 CiteScore 3.09
Web of Science (2014): Indexed yes
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Scopus rating (2013): SJR 1.585 SNIP 1.244 CiteScore 2.74
ISI indexed (2013): ISI indexed yes
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BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.846 SNIP 1.306 CiteScore 3.34
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Web of Science (2012): Indexed yes
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Scopus rating (2011): SJR 1.892 SNIP 1.461 CiteScore 3.86
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.844 SNIP 1.259
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 nanostructure 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.

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Organisations: Department of Wind Energy, Integration & Planning
Authors: Nuño Martinez, E. (Intern), Cutululis, N. A. (Intern)
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A hybrid model for the wind profile (direction and speed) for the whole

General information
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Organisations: Department of Wind Energy, Resource Assessment Modelling
Authors: Gryning, S. (Intern), Batchvarova, E. (Intern)
Publication date: 2016

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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
Authors: Mirzaei, M. (Intern), Hansen, M. H. (Intern)
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Publication date: 2016

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 -12-2standard 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.

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Organisations: Department of Wind Energy, Fluid Mechanics, Technical University of Denmark, VESTAS Wind Systems 
A/S
Authors: Krishna, V. B. (Ekstern), Ormel, F. (Ekstern), Hansen, K. S. (Intern)
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BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.267 SNIP 0.515 CiteScore 0.58
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

General information
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Organisations: Department of Wind Energy, Fluid Mechanics
Authors: Okulov, V. (Intern)
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Helical vortex, Vortex pair, Self-induced motion, Analytical solution
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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.

**General information**

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Authors: Okulov, V. (Intern)
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- Scopus rating (2010): SJR 0.396 SNIP 0.627
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- Scopus rating (2008): SJR 0.602 SNIP 0.989
- Scopus rating (2007): SJR 0.391 SNIP 0.913
- Scopus rating (2006): SJR 0.519 SNIP 0.905
- Scopus rating (2005): SJR 0.485 SNIP 0.688
- Scopus rating (2004): SJR 0.381 SNIP 0.833
- Scopus rating (2003): SJR 0.44 SNIP 0.897
- Web of Science (2003): Indexed yes
- Scopus rating (2002): SJR 0.597 SNIP 1.093
- Scopus rating (2001): SJR 0.5 SNIP 0.797
- Scopus rating (2000): SJR 0.527 SNIP 1.384
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.

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.
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.

**General information**

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Authors: Chivaee, H. S. (Intern), Sørensen, J. N. (Intern)  
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Scopus rating (2016): CiteScore 3.37 SJR 1.104 SNIP 2.306  
Web of Science (2016): Indexed yes  
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Scopus rating (2015): SJR 1.196 SNIP 2.086 CiteScore 3.06  
Web of Science (2015): Indexed yes  
BFI (2014): BFI-level 2  
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Web of Science (2012): Indexed yes  
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Scopus rating (2011): SJR 1.024 SNIP 2.718 CiteScore 2.49  
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Web of Science (2011): Indexed yes  
BFI (2010): BFI-level 2  
Scopus rating (2010): SJR 1.487 SNIP 2.013  
Web of Science (2010): Indexed yes  
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Scopus rating (2009): SJR 1.124 SNIP 1.448  
Web of Science (2009): Indexed yes  
BFI (2008): BFI-level 2  
Scopus rating (2008): SJR 0.826 SNIP 1.559  
Web of Science (2008): Indexed yes  
Scopus rating (2007): SJR 1.053 SNIP 1.453  
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Analytical techniques and tools for power balancing assessments

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Organisations: Department of Wind Energy, Integration & Planning, Norwegian University of Science and Technology, Aalborg University, SINTEF, National Institute of Animal Health
Authors: Uhlen, K. (Ekstern), Jaehnert, S. (Ekstern), Hamon, C. (Ekstern), Bruno, C. (Forskerdatabase), Farahmand, H. (Ekstern), Inoue, T. (Ekstern), Matevosjana, J. (Ekstern), Nobel, F. (Ekstern), Sørensen, P. E. (Intern)
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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.

General information
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Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Rojas Labanda, S. (Intern), Stolpe, M. (Intern)
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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, Risø 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.

General information
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Organisations: Department of Wind Energy, Composites and Materials Mechanics, Complutense University
Authors: Dominguez, J. (Ekstern), Oliet, M. (Ekstern), Alonso, M. V. (Ekstern), Rodriguez, L. F. (Ekstern), Madsen, B. (Intern)
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Scopus rating (2015): SJR 0.172 SNIP 0.281 CiteScore 0.22
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 positions 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 $\alpha$ 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 $\alpha$ values within $\pm2.7\%$ of the mean value for four successive tests at the same rotor position.

General information

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Authors: Demurtas, G. (Intern), Janssen, N. G. C. (Ekstern)
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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.

**General information**

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Authors: Pauscher, L. (Ekstern), Vasiljevic, N. (Intern), Callies, D. (Ekstern), Lea, G. (Intern), Mann, J. (Intern), Klaas, T. (Ekstern), Hieronimus, J. (Ekstern), Gottschall, J. (Ekstern), Schwesig, A. (Ekstern), Kühn, M. (Ekstern), Courtney, M. (Intern)
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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.
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.

General information
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Organisations: Department of Wind Energy, Composites and Materials Mechanics, University of Latvia, Lulea University of Technology, Bemis Valkeakoski Oy
Authors: Andersons, J. (Ekstern), Modniks, J. (Ekstern), Joffe, R. (Ekstern), Madsen, B. (Intern), Nättinen, K. (Ekstern)
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Web of Science (2016): Indexed yes
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BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.048 SNIP 1.889 CiteScore 2.27
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.22 SNIP 2.212 CiteScore 2.46
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.062 SNIP 2.348 CiteScore 2.15
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
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Scopus rating (2011): SJR 1.313 SNIP 2.344 CiteScore 2.5
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Scopus rating (2010): SJR 1.452 SNIP 2.432
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.888 SNIP 1.955
Web of Science (2009): Indexed yes
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Application of helical vortex solutions to determine wind turbine tip loss

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Authors: Wood, D. H. (Ekstern), Okulov, V. (Intern), Bhattacharjee, D. (Ekstern)
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Wind turbine, Tip loss, Vortex models, Blade element analysis
Source: PublicationPreSubmission
Source-ID: 125109871
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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.

General information
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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Test and Measurements, University of Stavanger, Reykjavik University, Christian Michelsen Research AS
Authors: Cheynet, E. (Ekstern), Jakobsen, J. B. (Ekstern), Snæbjörnsson, J. (Ekstern), Mikkelsen, T. K. (Intern), Sjöholm, M. (Intern), Mann, J. (Intern), Hansen, P. (Intern), Angelou, N. (Intern), Svardal, B. (Ekstern)
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.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Mikkelsen, L. P. (Intern), Jespersen, K. M. (Intern)
Number of pages: 2
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Main Research Area: Technical/natural sciences
Electronic versions:
MikkelsenLP_CASMaT_3_.pdf

Bibliographical note
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http://www.conferencemanager.dk/ISMEM1/home.html
Source: PublicationPreSubmission
Source-ID: 126140929
Publication: Research - peer-review › Paper – Annual report year: 2016

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 is 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.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics
Authors: Sørensen, J. N. (Intern), Dag, K. O. (Intern), Ramos García, N. (Intern)
Number of pages: 16
Pages: 787–802
Publication date: 2016
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.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Friberg, H. A. (Intern)
Pages: 718-722
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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
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BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.959 SNIP 0.988 CiteScore 0.99
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.823 SNIP 1.167 CiteScore 1
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 0.856 SNIP 0.954 CiteScore 0.85
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.932 SNIP 1.073 CiteScore 0.96
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.183 SNIP 1.041
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 0.963 SNIP 1.231
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.286 SNIP 1.398
Scopus rating (2007): SJR 1.101 SNIP 1.191
Scopus rating (2006): SJR 1.037 SNIP 1.407
Scopus rating (2005): SJR 0.755 SNIP 1.184
Scopus rating (2004): SJR 0.753 SNIP 1.178
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 Gd$_2$Zr$_2$O$_7$ 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 Gd$_2$Zr$_2$O$_7$ buffer layers after dip coating and sintering.

**General information**

**State:** Published

**Organisations:** Department of Energy Conversion and Storage, Electrofunctional materials, Department of Wind Energy, Materials science and characterization, SUBRA IVS, Sharif University of Technology

**Authors:** Wulff, A. C. (Intern), Lundeman, J. H. (Ekstern), Hansen, J. B. (Ekstern), Mishin, O. (Intern), Yue, Z. (Intern), Mohajeri, R. (Ekstern), Grivel, J. (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
- **Web of Science (2017):** Indexed yes
- **BFI (2016):** BFI-level 1
- **Scopus rating (2016):** CiteScore 1.42 SJR 0.395 SNIP 1.031
- **Web of Science (2016):** Indexed yes
- **BFI (2015):** BFI-level 1
- **Scopus rating (2015):** SJR 0.35 SNIP 0.935 CiteScore 1.27
- **Web of Science (2015):** Indexed yes
- **BFI (2014):** BFI-level 1
- **Scopus rating (2014):** SJR 0.47 SNIP 1.113 CiteScore 0.83
- **Web of Science (2014):** Indexed yes
- **BFI (2013):** BFI-level 1
- **Scopus rating (2013):** SJR 0.431 SNIP 1.171 CiteScore 1.32
- **ISI indexed (2013):** ISI indexed yes
- **Web of Science (2013):** Indexed yes
- **BFI (2012):** BFI-level 1
- **Scopus rating (2012):** SJR 0.575 SNIP 1.27 CiteScore 1.11
- **ISI indexed (2012):** ISI indexed yes
- **BFI (2011):** BFI-level 1
- **Scopus rating (2011):** SJR 0.364 SNIP 1.063 CiteScore 1.16
- **ISI indexed (2011):** ISI indexed yes
- **Web of Science (2011):** Indexed yes
- **BFI (2010):** BFI-level 1
- **Scopus rating (2010):** SJR 0.468 SNIP 1.073
- **BFI (2009):** BFI-level 1
- **Scopus rating (2009):** SJR 0.452 SNIP 1.033
- **Web of Science (2009):** Indexed yes
- **BFI (2008):** BFI-level 1
- **Scopus rating (2008):** SJR 0.878 SNIP 0.987
- **Scopus rating (2007):** SJR 0.611 SNIP 1.104
- **Web of Science (2007):** Indexed yes
- **Scopus rating (2006):** SJR 0.731 SNIP 0.935
- **Scopus rating (2005):** SJR 0.645 SNIP 0.996
- **Web of Science (2005):** Indexed yes
- **Scopus rating (2004):** SJR 0.867 SNIP 0.9
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.

General information

State: Published
Organisations: Department of Wind Energy, Wind Turbines, Department of Mechanical Engineering, Solid Mechanics, University of California at Berkeley
Authors: Dimitrov, N. K. (Intern), Kiureghian, A. D. (Ekstern), Berggreen, C. (Intern)
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Web of Science (2017): Indexed Yes
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Scopus rating (2016): CiteScore 1.42 SJR 0.517 SNIP 0.781
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.586 SNIP 0.88 CiteScore 1.4
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.606 SNIP 1.183 CiteScore 1.44
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
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.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design, Wind turbine loads & control, University of Stuttgart, National Technical University of Athens, Delft University of Technology
Authors: Barlas, A. (Intern), Jost, E. (Ekstern), Pirrung, G. (Intern), Tsiantas, T. (Ekstern), Riziotis, V. (Ekstern), Navalkar, S. T. (Ekstern), Lutz, T. (Ekstern), van Wingerden, J. (Ekstern)
Number of pages: 8
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
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.

General information
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
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Organisations: Department of Wind Energy, Wind turbine loads & control
Authors: Rinker, J. M. (Intern)
Number of pages: 11
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Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Physics: Conference Series (Online)
Volume: 753
Issue number: 3
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.
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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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
State: Published
Organisations: Department of Wind Energy, Test and Measurements
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Calibration of Ground-based Lidar instrument
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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.

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DTU Wind Energy LC I-093(EN), LC-I-093, LC-I-093EN)
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
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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
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Series: DTU Wind Energy LC I
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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.
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.

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.

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.
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 Havvøre, 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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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

Publication information
Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy LC I
Number: 089(EN)
Main Research Area: Technical/natural sciences
DTU Wind Energy LC I-089(EN), LC-I-089, LC-I-089(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.

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 Havvøre, 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

Publication information
Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy LC I
Number: 094(EN)
Main Research Area: Technical/natural sciences
DTU Wind Energy LC I-094(EN), LC-I-094, LC-I-094(EN)

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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.
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: Gómez Arranz, P. (Intern), Courtney, M. (Intern)
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Series: DTU Wind Energy LC I
Number: 101(EN)
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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 Lidar 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.

**General information**

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Authors: Borraccino, A. (Intern), Courtney, M. (Intern)
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**Relations**

Projects:
Calibration report for Avent 5-beam Demonstrator lidar
Publication: Research › Report – Annual report year: 2016

Calibration report for ZephIR Dual Mode lidar (unit 351)
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 ZephIR Dual Mode lidar manufactured by ZephIR LiDAR. 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 the ZephIR Dual Mode lidar unit 351. The calibration was performed at DTU's test site for large wind turbines, Høvsøre, Denmark. The methods to assess line-of-sight velocity uncertainties are detailed together with an example of how to derive reconstructed wind parameters' uncertainties.

**General information**

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Series: DTU Wind Energy E
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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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.

General information
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Authors: Friberg, H. A. (Intern)
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Web of Science (2018): Indexed yes
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BFI (2016): BFI-level 1
Scopus rating (2016): SJR 2.451 SNIP 2.995 CiteScore 3.86
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.777 SNIP 3.084 CiteScore 4.68
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 2.255 SNIP 2.923 CiteScore 3.87
CFD code comparison for 2D airfoil flows

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), Colonía, 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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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.24 SNIP 0.373 CiteScore 0.35
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.

General information

State: Published
Organisations: Department of Wind Energy, Aerodynamic design, Energy Research Centre of the Netherlands
Authors: Sørensen, N. N. (Intern), Zahle, F. (Intern), Boorsma, K. (Ekstern), Schepers, G. (Ekstern)
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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)
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.

General information
State: Published
Organisations: Composites and Materials Mechanics, Department of Wind Energy, Rockwool International, Ecole Polytechnique de Montreal
Authors: Chapelle, L. (Intern), Brøndsted, P. (Intern), Kusano, Y. (Intern), Foldschack, M. R. (Ekstern), Lybye, D. (Ekstern), Lévesque, M. (Ekstern)
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Main Research Area: Technical/natural sciences
Publication: Research › Ph.D. thesis – Annual report year: 2016

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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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
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 Rise 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 18% 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 46% were observed for the longitudinal and radial components, respectively, near the center of the rotor.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, University of Colorado at Boulder
Authors: Simley, E. (Ekstern), Angelou, N. (Intern), Mikkelsen, T. K. (Intern), Sjöholm, M. (Intern), Mann, J. (Intern), Pao, L. Y. (Ekstern)
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Scopus rating (2016): CiteScore 1.2 SJR 0.418 SNIP 0.523
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.372 SNIP 0.52 CiteScore 1.02
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.406 SNIP 0.697 CiteScore 1.05
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.441 SNIP 0.856 CiteScore 1.26
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.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Technical University of Denmark, University of Stuttgart
Authors: Yazicioglu, H. (Ekstern), Angelou, N. (Intern), Mikkelsen, T. K. (Intern), Trujillo, J. (Ekstern)
Number of pages: 10
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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.24 SNIP 0.373 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.253 SNIP 0.344 CiteScore 0.32
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.

General information
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Organisations: Department of Wind Energy, Integration & Planning
Authors: Kirkegaard, J. (Intern)
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Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
Journal: Copenhagen Journal of Asian Studies
Volume: 34
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 DigSILENT 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.
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.
Main Research Area: Technical/natural sciences

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Web of Science (2017): Indexed yes
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Scopus rating (2016): CiteScore 5.67 SJR 3.283 SNIP 2.674
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 3.542 SNIP 2.927 CiteScore 5.22
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 4.045 SNIP 3.348 CiteScore 5.16
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 3.29 SNIP 2.709 CiteScore 4.37
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 3.409 SNIP 2.917 CiteScore 4.28
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 3.247 SNIP 2.81 CiteScore 4.27
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 3.745 SNIP 2.724
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 3.677 SNIP 2.648
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 3.863 SNIP 2.787
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 3.298 SNIP 3.068
Web of Science (2007): Indexed yes
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 3.172 SNIP 3.082
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 3.066 SNIP 3.154
Web of Science (2004): Indexed yes
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 4.016 SNIP 3.081
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 3.225 SNIP 2.732
Web of Science (2001): Indexed yes
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.

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.

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Authors: Dimitrov, N. K. (Intern)
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Scopus rating (2016): CiteScore 3.37 SJR 1.104 SNIP 2.306
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.196 SNIP 2.086 CiteScore 3.06
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.272 SNIP 3.75 CiteScore 3.42
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.275 SNIP 2.464 CiteScore 2.75
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.126 SNIP 2.39 CiteScore 2.36
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 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 Glaubert 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 Glaubert [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 Open-
FOAM 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 OpenFOAM v.2.1.1 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 the 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
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling, Aerodynamic design, Vattenfall Nordic
Authors: Cavar, D. (Intern), Réthoré, P. (Intern), Bechmann, A. (Intern), Sørensen, N. N. (Intern), Martinez, B. (Ekstern), Zahle, F. (Intern), Berg, J. (Intern), Kelly, M. C. (Intern)
Pages: 55–70
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Main Research Area: Technical/natural sciences

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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.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design, Delft University of Technology
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Number of pages: 6
Publication date: 2016

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 for 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.

General information
State: Published
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Number of pages: 7
Publication date: 2016
Conference: The Science of Making Torque from Wind, Munich, Germany, 05/10/2016 - 05/10/2016
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

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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.
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.

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 high wind 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 active 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.

General information
State: Published
Organisations: Department of Wind Energy, Wind Energy Systems, Energinet.dk
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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.

General information
State: Published
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Volume: 753
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
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Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Sandal, K. (Intern), Verbart, A. (Intern), Stolpe, M. (Intern)
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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
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Organisations: Department of Wind Energy, Wind Turbines, RAMBØLL Wind
Authors: Passon, P. (Ekstern), Branner, K. (Intern)
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Scopus rating (2015): SJR 0.735 SNIP 1.011 CiteScore 0.89
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.
ENGINEERING, INSTRUMENTS, WIND TURBINE, CLASSIFICATION, TRANSFORM, Neural networks, LVQ, Condition monitoring, Planetary gear, FPGA, Signal processing, Condensed Matter Physics, Applied Mathematics, Application programs, Data acquisition, Efficiency, Field programmable gate arrays (FPGA), Gears, Hardware, Losses, Machinery, Reconfigurable hardware, Safety engineering, Wind turbines, Data acquisition system, Engineering applications, Environmental conditions, Hardware implementations, Learning vector quantization algorithms, Non-stationary condition, Planetary Gears, Pre-processing algorithms
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
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BFI (2014): BFI-level 2
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Scopus rating (2013): SJR 0.361 SNIP 0.564 CiteScore 0.83
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
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Scopus rating (2012): SJR 0.378 SNIP 0.526 CiteScore 0.78
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.428 SNIP 0.841 CiteScore 0.87
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.302 SNIP 0.629
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 0.346 SNIP 0.571
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.348 SNIP 0.54
Scopus rating (2007): SJR 0.563 SNIP 0.658
Connection of OWPPs to HVDC networks using VSCs and Diode Rectifiers: an Overview

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.

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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)
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Connection of OWPPs to HVDC networks using VSCs and Diode Rectifiers: an Overview

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Number of pages: 1
Publication date: 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.
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
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- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 2
- Scopus rating (2016): CiteScore 4.82 SJR 1.402 SNIP 2.053
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 2
- Scopus rating (2015): SJR 1.53 SNIP 2.18 CiteScore 4.09
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 2
- Scopus rating (2014): SJR 1.67 SNIP 2.538 CiteScore 4.08
- BFI (2013): BFI-level 2
- Scopus rating (2013): SJR 1.59 SNIP 2.828 CiteScore 3.92
- ISI indexed (2013): ISI indexed yes
- Web of Science (2013): Indexed yes
- BFI (2012): BFI-level 2
- Scopus rating (2012): SJR 1.559 SNIP 2.706 CiteScore 3.36
- ISI indexed (2012): ISI indexed yes
- Web of Science (2012): Indexed yes
- BFI (2011): BFI-level 2
- Scopus rating (2011): SJR 1.443 SNIP 2.499 CiteScore 3.23
- ISI indexed (2011): ISI indexed yes
- BFI (2010): BFI-level 2
- Scopus rating (2010): SJR 1.553 SNIP 2.241
- BFI (2009): BFI-level 2
- Scopus rating (2009): SJR 1.536 SNIP 1.976
- BFI (2008): BFI-level 2
- Scopus rating (2008): SJR 1.388 SNIP 1.853
- Scopus rating (2007): SJR 1.222 SNIP 2.188
- Web of Science (2007): Indexed yes
Coordinated Control Scheme for Ancillary Services from Offshore Wind Power Plants to AC and DC Grids

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 the ancillary service requirements of both AC and DC grids, is proposed in this paper. In particular, control strategies for onshore frequency control, fault ride-through 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.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning, Indian Institute of Technology, Guwahati
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Number of pages: 5
Publication date: 2016

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.
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.
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
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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)
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Scopus rating (2016): CiteScore 3.33 SJR 2.449 SNIP 1.429
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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
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.
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)
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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
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 unexpanding 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
Damage approach: A new method for topology optimization with local stress constraints

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.
Data needs and computational requirements for asset management decision making. Internal deliverable ID5.2.1

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.
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.

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Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Biel, A. (Intern), Toftegaard, H. L. (Intern)
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**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 61400-1standard 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 Havskere 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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State: Published
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.

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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 Liders to demonstrate the benefits of synchronised scanning Liders in such experimental surroundings for the first time. The dualLidar 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.

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 (1.2.0.286), 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.

General information
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Organisations: Department of Wind Energy, Austrian Academy of Sciences, Technical University in Zvolen, Friedrich Schiller University, University of Salzburg, Universiteit Twente
Authors: Niederheiser, R. (Ekstern), Mokros, M. (Ekstern), Lange, J. (Intern), Petschko, H. (Ekstern), Prasicek, G. (Ekstern), Elberink, S. O. (Ekstern)
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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.
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.
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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Main Research Area: Technical/natural sciences

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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 surrogateoptimization 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.

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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)
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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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Authors: McGugan, M. (Intern)
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Editors: Ostachowicz, W., McGugan, M., Schröder-Hinrichs, J., Luczak, M.
ISBN (Print): 978-3-319-39094-9
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.

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.

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.
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.
Determinant 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)
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This document is a scientific publication discussing the determination of the cohesive strength for interfaces in composite materials, focusing on novel experimental approaches and mathematical modeling techniques.
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.

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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.172 SNIP 1.989 CiteScore 2.19
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
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.
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.
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 ≤ 0.3) where compressible approaches are often limited and at large Reynolds numbers (Re ≥ 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 × 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 × 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.
Dislocation-based plasticity and strengthening mechanisms in sub-20 nm lamellar structures in pearlitic steel wire

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 10^16 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.
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.

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling
Authors: Volker, P. (Intern), Badger, J. (Intern), Hahmann, A. N. (Intern)
Publication date: 2016

Host publication information
Title of host publication: EMS Annual Meeting Abstracts
Volume: 13
Main Research Area: Technical/natural sciences
Electronic versions:
EMS2016_512.pdf
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

Host publication information
Title of host publication: Proceedings. 14th International Workshop on Large-Scale Integration of Wind Power into Power Systems as well as on Transmission Networks for Offshore Wind Power Plants
Publisher: Energynautics GmbH
Editors: Betancourt, U., Ackermann, T.
ISBN (Print): 978-3-9816549-1-2
Main Research Area: Technical/natural sciences
Conference: 14th International Workshop on Large Scale Integration of Wind Power into Power Systems as well as on Transmission Networks for Offshore Wind Power Plants, Brussels, Belgium, 20/10/2015 - 20/10/2015
Source: PublicationPreSubmission
Source-ID: 120719096
Publication: Research - peer-review › Article in proceedings – Annual report year: 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
Organisations: Department of Wind Energy, Wind turbine loads & control, Aerodynamic design
Authors: Mirzaei, M. (Intern), Meyer Forsting, A. R. (Intern), Troldborg, N. (Intern)
Number of pages: 24
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Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.383
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.24 SNIP 0.373 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.253 SNIP 0.344 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.231 SNIP 0.272 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.28 SNIP 0.354 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.292 SNIP 0.352 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.344
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.253 SNIP 0.321
BFI (2008): BFI-level 1
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
Effect of Carrier to Noise Ratio 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

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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
State: Published
Organisations: Meteorology & Remote Sensing, Meteorology, Department of Wind Energy, Resource Assessment Modelling, University of Western Ontario
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Pages: 237-254
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Main Research Area: Technical/natural sciences

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Publication: Research - peer-review → Journal article – Annual report year: 2017

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)
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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
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 ∙ 10^6, despite the variable chord length.
Effects of spark plasma sintering conditions on the anisotropic thermoelectric properties of bismuth antimony telluride

Bismuth antimony telluride (Bi$_x$Sb$_{2-x}$Te$_3$, 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 Bi$_{0.4}$Sb$_{1.6}$Te$_3$ 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.

General information
State: Published
Organisations: Department of Energy Conversion and Storage, Electrofunctional materials, Department of Wind Energy, Materials science and characterization, Technical University of Denmark, Fraunhofer Institute for Material and Beam Technology
Authors: Han, L. (Intern), Hegelund Spangsdorf, S. (Ekstern), Van Nong, N. (Intern), Le, T. H. (Intern), Zhang, Y. (Intern), Pham, H. N. (Intern), Chen, Y. (Intern), Roch, A. (Ekstern), Stepien, L. (Ekstern), Pryds, N. (Intern)
Number of pages: 9
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Main Research Area: Technical/natural sciences

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Scopus rating (2016): CiteScore 3.06 SJR 0.875 SNIP 0.743
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.959 SNIP 0.837 CiteScore 3.42
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.114 SNIP 0.965 CiteScore 3.87
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.117 SNIP 0.903 CiteScore 3.74
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
Scopus rating (2012): SJR 0.863 SNIP 0.603 CiteScore 2.4
ISI indexed (2012): ISI indexed no
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Source-ID: 2305565403
Publication: Research - peer-review › Journal article – Annual report year: 2016
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).
Enhancement of fracture resistance of composite laminates by the creation of multiple delaminations
Cohesive zone modelling 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

Host publication information
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ISBN (Electronic): 9783000533877
Main Research Area: Technical/natural sciences
Conference: 17th European Conference on Composite Materials, ECCM 2016, Munich, Germany, 26/06/2016 - 26/06/2016
Source: Scopus
Source-ID: 85018551674
Publication: Research - peer-review › Article in proceedings – Annual report year: 2017

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 modeling, biochemical 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, derisive model accuracies. The ESA STSE funded project SSTDV:R.EX.-IM.A.M. aimed at characterising the regional extent 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
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing
Authors: Karagali, I. (Intern)
Number of pages: 1
Publication date: 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 demised model accuracies [2, 1]. The ESA STSE project SSTDV/R.EX.-IM.A.M. focused on different aspects.

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing
Authors: Karagali, I. (Intern)
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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 overestimated. 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.

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling , Meteorology & Remote Sensing
Authors: Floors, R. R. (Intern), Hahmann, A. N. (Intern), Peña, A. (Intern), Karagali, I. (Intern)
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Publication information
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.
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.
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
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.

**General information**

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Organisations: Department of Wind Energy, Fluid Mechanics, Wind turbine loads & control, Technical University of Denmark, DHI Hørsholm
Authors: Pegalajar Jurado, A. M. (Intern), Hansen, A. M. (Ekstern), Laugesen, R. (Ekstern), Mikkelsen, R. F. (Intern), Borg, M. (Intern), Kim, T. (Intern), Heilskov, N. F. (Ekstern), Bredmose, H. (Intern)
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Scopus rating (2010): SJR 0.288 SNIP 0.344
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
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BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.265 SNIP 0.294
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.257 SNIP 0.39
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.267 SNIP 0.284
Web of Science (2006): Indexed yes
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 ±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.

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Authors: Larsen, T. J. (Intern), Kim, T. (Intern)
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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
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BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.389 SNIP 0.704 CiteScore 0.61
ISI indexed (2013): ISI indexed yes
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Scopus rating (2012): SJR 0.511 SNIP 1.002 CiteScore 0.76
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.617 SNIP 1.074 CiteScore 0.71
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.787 SNIP 1.546
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.387 SNIP 1.23
BFI (2008): BFI-level 1
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.

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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.24 SNIP 0.373 CiteScore 0.35
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 = 2·10^5) 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.
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.

General information
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Organisations: Department of Wind Energy, Composites and Materials Mechanics, University of Manchester, LM Wind Power
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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.

General information
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Authors: Okulov, V. (Intern), Sørensen, J. N. (Intern), Shen, W. Z. (Intern)
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Web of Science (2016): Indexed yes
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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.

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling, Laboratoire d’Études en Géophysique et Océanographie Spatiales
Authors: Badger, M. (Intern), Pena Diaz, A. (Intern), Hahmann, A. N. (Intern), Mouche, A. (Ekstern), Hasager, C. B. (Intern)
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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.946 SNIP 1.428 CiteScore 2.62
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.962 SNIP 1.516 CiteScore 2.47
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
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ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.672 SNIP 1.258 CiteScore 2.17
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.813 SNIP 1.197
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Scopus rating (2006): SJR 1.698 SNIP 1.425
Scopus rating (2005): SJR 1.941 SNIP 1.413
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Scopus rating (2003): SJR 2.221 SNIP 1.597
Scopus rating (2002): SJR 2.046 SNIP 1.572
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Bibliographical note
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
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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)
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BFI (2014): BFI-level 1
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Scopus rating (2013): SJR 0.231 SNIP 0.272 CiteScore 0.25
ISI indexed (2013): ISI indexed no
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BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.28 SNIP 0.354 CiteScore 0.33
ISI indexed (2012): ISI indexed no
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Scopus rating (2011): SJR 0.292 SNIP 0.352 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.344
Web of Science (2010): Indexed yes
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Scopus rating (2009): SJR 0.253 SNIP 0.321
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 (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 Maximum (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.

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Organisations: Department of Wind Energy, Resource Assessment Modelling, Meteorology & Remote Sensing
Authors: Rathmann, O. S. (Intern), Hansen, B. O. (Intern), Larsen, X. G. (Intern), Kelly, M. C. (Intern), Berg, J. (Intern), Bechmann, A. (Intern), Sempreviva, A. M. (Intern), Ejsing Jærgensen, H. (Intern)
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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 ±80° 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.
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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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.

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.
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 $\varepsilon_{xx}(xx)$, 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.

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.
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.

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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.

**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.

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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.

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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.

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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.
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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.

Free material optimization for laminated plates and shells
Free Material Optimization (FMO) is a powerful approach for conceptual optimal design of composite structures. The design variable in FMO is the entire elastic material tensor which is allowed to vary almost freely over the design domain. The imposed requirements on the tensor are that it is symmetric and positive semidefinite. Most of today's studies on FMO focus on models for two- and three-dimensional structures. The objective of this article is to extend existing FMO models and methods to laminated plate and shell structures, which are used in many engineering applications. In FMO, the resulting optimization problem is generally a non convex semidefinite program with many matrix inequalities which requires special-purpose optimization methods. The FMO problems are efficiently solved by a primal-dual interior point method developed and implemented by the authors. The quality of the proposed FMO models and the method are supported by several large-scale numerical experiments.

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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.

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 Hz. 10-min cup anemometer data are used to estimate the spectrum from about $1 \text{ yr}^{-1}$ to 0.05 min $^{-1}$; in addition, using 20-Hz sonic anemometer data, an ensemble of 1-day spectra covering the range 1 day $^{-1}$ to 10 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 $-2$ slope, followed by a $-2/3$ slope, which can be described by $S(f) = a_1 f^{-2/3} + a_2 f^{-2}$, 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 Hz, which is useful in determining the necessary sample duration when measuring turbulence statistics in the boundary layer.
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 Lidars
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.

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Scopus rating (2013): SJR 1.167 SNIP 1.981 CiteScore 3.01  
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**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.
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.
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
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Main Research Area: Technical/natural sciences

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Scopus rating (2016): SJR 2.157 SNIP 1.669 CiteScore 3.2
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Web of Science (2015): Indexed yes
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BFI (2013): BFI-level 1
Scopus rating (2013): SJR 2.036 SNIP 1.557 CiteScore 3
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 2.126 SNIP 1.923 CiteScore 3.04
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 2.095 SNIP 1.886 CiteScore 3.29
ISI indexed (2011): ISI indexed yes
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
Publication date: 2016
Main Research Area: Technical/natural sciences

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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
Authors: Poulsen, T. (Forskerdatabase), Hasager, C. B. (Intern)
Number of pages: 23
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Main Research Area: Technical/natural sciences

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Article number: 437
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Web of Science (2018): Indexed yes
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
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.
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

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)
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Publication date: 2016
Main Research Area: Technical/natural sciences
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**DOIs:**

10.1002/we.1878
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
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Organisations: Department of Wind Energy, Resource Assessment Modelling, Department of Electrical Engineering, Center for Electric Power and Energy, Electricity markets and energy analytics, Integration & Planning, VESTAS Wind Systems A/S
Authors: Davis, N. (Intern), Pinson, P. (Intern), Hahmann, A. N. (Intern), Clausen, N. (Intern), Žagar, M. (Ekstern)
Pages: 1503-1518
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Main Research Area: Technical/natural sciences

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BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.196 SNIP 2.086 CiteScore 3.06
Web of Science (2015): Indexed yes
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Scopus rating (2014): SJR 1.272 SNIP 3.75 CiteScore 3.42
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BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.275 SNIP 2.464 CiteScore 2.75
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Scopus rating (2012): SJR 1.126 SNIP 2.39 CiteScore 2.36
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Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.024 SNIP 2.718 CiteScore 2.49
ISI indexed (2011): ISI indexed yes
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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
Pages: 37-47
Publication date: 2016
Main Research Area: Technical/natural sciences

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Volume: 151
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Ratings:
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 the whole wind speed range.

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Organisations: Department of Wind Energy, Integration & Planning, KU Leuven
Number of pages: 7
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Main Research Area: Technical/natural sciences
Frequency Control, Inertial Response, Temporary Overloading, Wind Power Plants
DOIs:
10.1109/PSCC.2016.7540914
Source: PublicationPreSubmission
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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.
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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Main Research Area: Technical/natural sciences
Conference: 16th International Symposium on Transport Phenomena and Dynamics of Rotating Machinery, Honolulu, Hawaii, United States, 10/04/2016 - 10/04/2016
Trailing edge noise, TNO model

**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**

State: Published
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)
Pages: 114-129
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Scopus rating (2016): CiteScore 3.13 SJR 1.653 SNIP 2.458
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.693 SNIP 2.558 CiteScore 2.79
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 2.169 SNIP 2.913 CiteScore 2.74
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.

**General information**

State: Published
Organisations: Department of Wind Energy, Materials science and characterization, Chinese Academy of Sciences
Authors: Zheng, X. H. (Ekstern), Zhang, H. W. (Ekstern), Huang, X. (Intern), Hansen, N. (Intern), Lu, K. (Ekstern)
Number of pages: 8
Pages: 52-59
Publication date: 2016
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Philosophical Magazine Letters
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.
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.

Influence of the curing cycles on the fatigue performance of unidirectional glass fiber reinforced epoxy composites

Wind turbines, Probabilistic modelling, Extreme turbulence, Load alleviation control systems, Structural reliability, Environmental contours

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Source: PublicationPreSubmission
Source-ID: 117857881
Publication: Research - peer-review › Journal article – Annual report year: 2016
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.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Haselbach, P. U. (Intern), Branner, K. (Intern)
Pages: 136–154
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Scopus rating (2016): CiteScore 2.39 SJR 1.247 SNIP 1.676
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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.619 SNIP 2.214 CiteScore 2.28
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Scopus rating (2013): SJR 1.483 SNIP 2.047 CiteScore 2.25
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Web of Science (2013): Indexed yes
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ISI indexed (2012): ISI indexed yes
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.

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control, Aerodynamic design, Resource Assessment Modelling, University of Agder
Authors: Larsen, G. C. (Intern), Vereist, D. R. (Intern), Bertagnolio, F. (Intern), Ott, S. (Intern), Chougule, A. S. (Ekstern)
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
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 wind turbines 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.

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Organisations: Department of Wind Energy, Integration & Planning, Energinet.dk
Authors: Das, K. (Intern), Sørensen, P. E. (Intern), Hansen, A. D. (Intern), Abildgaard, H. (Ekstern)
Number of pages: 163
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Volume: 0058
Main Research Area: Technical/natural sciences
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Source: PublicationPreSubmission
Source-ID: 125376549
Publication: Research › Ph.D. thesis – Annual report year: 2016

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.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics
Authors: Sørensen, J. N. (Intern)
Number of pages: 6
Pages: 1-6
Publication date: 2016

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Title of host publication: General Momentum Theory for Horizontal Axis Wind Turbines
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Publisher: Springer International Publishing
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Chapter: 1

Series: Research Topics in Wind Energy
ISSN: 2196-7806
Main Research Area: Technical/natural sciences
DOIs: 10.1007/978-3-319-22114-4_1
Source: FindIt
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.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Raghavalu Thirumalai, D. P. (Intern), Legstrup Andersen, T. (Intern), Bech, J. I. (Intern), Lilholt, H. (Intern)
Pages: 627-644
Publication date: 2016
Main Research Area: Technical/natural sciences
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.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design
Authors: Fischer, A. (Intern), Aagaard Madsen , H. (Intern)
Pages: 1567-1583
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Scopus rating (2016): CiteScore 3.37 SJR 1.104 SNIP 2.306
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Scopus rating (2015): SJR 1.196 SNIP 2.086 CiteScore 3.06
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.272 SNIP 3.75 CiteScore 3.42
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.275 SNIP 2.464 CiteScore 2.75
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.126 SNIP 2.39 CiteScore 2.36
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Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.024 SNIP 2.718 CiteScore 2.49
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.487 SNIP 2.013
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.124 SNIP 1.448
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.826 SNIP 1.559
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.053 SNIP 1.453
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.637 SNIP 1.689
Investigation of wake interaction using full-scale lidar measurements and large eddy simulation: Investigation of wake interaction using full-scale lidar measurements and LES

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.

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control, Aerodynamic design, Fluid Mechanics, Test and Measurements, Meteorology & Remote Sensing
Authors: Machefaux, E. (Intern), Larsen, G. C. (Intern), Troldborg, N. (Intern), Hansen, K. S. (Intern), Angelou, N. (Intern), Mikkelsen, T. (Intern), Mann, J. (Intern)
Pages: 1535-1551
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Main Research Area: Technical/natural sciences

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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.37 SJR 1.104 SNIP 2.306
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.196 SNIP 2.086 CiteScore 3.06
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.272 SNIP 3.75 CiteScore 3.42
Web of Science (2014): Indexed yes
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 responsible 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 environment 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 contribution to the development of the vortex model of the rotor:“The second step in the development 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 aerodynamicists 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**

State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Kyushu University, University of Calgary
Authors: Fukumoto, Y. (Ekstern), Okulov, V. (Intern), Wood, D. H. (Ekstern)
Number of pages: 1
Publication date: 2016
Main Research Area: Technical/natural sciences
Helical vorte, Propeller theory, Sandi Kawada

Electronic versions:
Fukumoto_Okulov_Wood.pdf
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2016

**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.

**General information**

State: Published
Organisations: Department of Wind Energy, Materials science and characterization, Harbin Institute of Technology
Authors: Du, Y. (Ekstern), Fan, G. (Ekstern), Yu, T. (Intern), Hansen, N. (Intern), Geng, L. (Ekstern), Huang, X. (Intern)
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Main Research Area: Technical/natural sciences

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BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.39 SJR 1.666 SNIP 1.832
Web of Science (2016): Indexed yes
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.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics
Authors: Sessarego, M. (Intern), Ramos Garcia, N. (Intern), Shen, W. Z. (Intern), Sørensen, J. N. (Intern)
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BFI conference series: European Academy of Wind Energy : The Science of Making Torque from Wind (5010078)
Main Research Area: Technical/natural sciences

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Web of Science (2016): Indexed yes
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Scopus rating (2015): SJR 0.24 SNIP 0.373 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.253 SNIP 0.344 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.231 SNIP 0.272 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.28 SNIP 0.354 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.292 SNIP 0.352 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.344
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.253 SNIP 0.321
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.265 SNIP 0.294
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.257 SNIP 0.39
Web of Science (2007): Indexed yes
Latest Developments of Negative Sequence Extensions for Generic RMS Models of Wind Turbines

General information
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Authors: Fortmann, J. (Ekstern), Schaube, F. (Ekstern), Mendonca, A. (Ekstern), Morales, A. (Ekstern), Göksu, Ö. (Intern), Sørensen, P. E. (Intern)
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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
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This paper was presented at the 15th Wind Integration Workshop and published in the workshop’s proceedings
Publication: Research - peer-review › Article in proceedings – Annual report year: 2016

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.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design, ECN, Centro Nacional de Energías Renovables, Delft University of Technology, Centre for Renewable Energy Sources, LM Wind Power, National Technical University of Athens, University of Glasgow, University of Oldenburg, Fraunhofer Gesellschaft, University of Stuttgart, University of Liverpool, Politecnico di Milano
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)
Number of pages: 16
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Volume: 753
Publisher: IOP Publishing Ltd
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 1.5x10^6. 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.
Lidar-based maps for flow modeling in complex forested terrain

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Aerodynamic design
Authors: Dellwik, E. (Intern), van der Laan, P. (Intern)
Number of pages: 2
Publication date: 2016
Main Research Area: Technical/natural sciences
Electronic versions:
Lidar_based_maps.pdf
Source: PublicationPreSubmission
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Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2016

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.
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.

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)
Number of pages: 37
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Publication Information
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Series: DTU Wind Energy LC I
Number: 088(EN)
Main Research Area: Technical/natural sciences
DTU Wind Energy LC I-088(EN), LC-I-088, LC-I-088(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
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**

State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Fernandez Garcia, S. (Intern), Courtney, M. (Intern)
Number of pages: 37
Publication date: 2016

**Publication information**

Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy LC I
Number: 100
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

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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.

**General information**

State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Fernandez Garcia, S. (Intern), Courtney, M. (Intern)
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Publication date: 2016

**Publication information**

Publisher: DTU Wind Energy
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**Bibliographical note**

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Publication: Research › Report – Annual report year: 2017

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**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**

State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Kock, C. W. (Intern), Federici, P. (Intern)
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
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Vesth, A. (Intern), Kock, C. W. (Intern)
Number of pages: 366
Publication date: 2016

Publication information
Publisher: DTU Wind Energy
Original language: English
Series: DTU Wind Energy WTT I
Number: 1143(EN)
Main Research Area: Technical/natural sciences
DTU Wind Energy WTT I-1143(EN), WTT-I-1143, WTT-I-1143(EN)

Bibliographical note
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Publication: Research › Report – Annual report year: 2016

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
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Kock, C. W. (Intern), Federici, P. (Intern)
Number of pages: 344
Publication date: 2016

Publication information
Publisher: DTU Wind Energy
Original language: English
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
Issue number: 11
ISSN (Print): 2072-4292
Ratings:
Web of Science (2018): Indexed yes
Web of Science (2017): Indexed yes
Scopus rating (2016): CiteScore 3.56 SJR 1.31 SNIP 1.661
Web of Science (2016): Indexed yes
Scopus rating (2015): SJR 1.339 SNIP 1.691 CiteScore 3.76
Web of Science (2015): Indexed yes
Scopus rating (2014): SJR 1.28 SNIP 1.886 CiteScore 3.23
Web of Science (2014): Indexed yes
Scopus rating (2013): SJR 1.167 SNIP 1.981 CiteScore 3.01
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
Scopus rating (2012): SJR 0.999 SNIP 1.645 CiteScore 2.36
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.498 SNIP 1.268 CiteScore 1.3
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.315 SNIP 0.531
Original language: English
coherent Doppler LiDAR, multi-Doppler LiDAR, WindScanner, wind energy
Electronic versions:
remotesensing_08_00896.pdf
DOIs:
10.3390/rs8110896
Source: FindIt
Source-ID: 2348554448
Publication: Research - peer-review › Journal article – Annual report year: 2017
**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, Delft 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
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Main Research Area: Technical/natural sciences

**Publication information**

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Long_term_research_challenges.pdf
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10.5194/wes-1-1-2016
Links:
http://www.wind-energ-sci.net/1/1/2016/

**Bibliographical note**

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Source: PublicationPreSubmission
Source-ID: 120923997
Publication: Research - peer-review › Journal article – Annual report year: 2016

**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.
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.
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.

General information

State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics
Number of pages: 432
Publication date: 2016

Publication information

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ISBN (Print): 978-3-319-39094-9
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Main Research Area: Technical/natural sciences
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10.1007/978-3-319-39095-6

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Matrices for natural fiber composites

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics, Complutense University
Authors: Dominguez, J. C. (Ekstern), Oliet, M. (Ekstern), Alonso, M. V. (Ekstern), Madsen, B. (Intern)
Pages: 93-126
Publication date: 2016

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Publisher: C R C Press LLC
Editor: Campilho, R.
ISBN (Electronic): 978-1-4822-3901-0
Main Research Area: Technical/natural sciences
Source: PublicationPreSubmission
Source-ID: 118113324
Publication: Research - peer-review › Book chapter – Annual report year: 2016

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: 64
Publication date: 2016

Publication information
Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy WTT I
Number: 1177
Main Research Area: Technical/natural sciences

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

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

Publication information
Publisher: DTU Wind Energy
Original language: English
Measurement System and Calibration report
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
State: Published
Organisations: Department of Wind Energy, Test and Measurements
Authors: Vesth, A. (Intern), Kock, C. W. (Intern)
Number of pages: 266
Publication date: 2016
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 $\varepsilon = 0.30\%$ and $\varepsilon = 0.50\%$ 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.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Pereira, G. F. (Intern), McGugan, M. (Intern), Mikkelsen, L. P. (Intern)
Number of pages: 10
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Main Research Area: Technical/natural sciences

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Journal: Polymer Testing
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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.82 SJR 0.82 SNIP 1.582
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.928 SNIP 1.629 CiteScore 2.58
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.023 SNIP 2.02 CiteScore 2.46
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.877 SNIP 1.956 CiteScore 2.17
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.859 SNIP 1.839 CiteScore 1.91
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.992 SNIP 1.811 CiteScore 2.12
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.099 SNIP 1.835
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.883 SNIP 1.39
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
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/or 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

Publication information

Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
D71_1_Review_blade_design_revised.pdf
Source: PublicationPreSubmission
Source-ID: 125463062
Publication: Research - peer-review › Report – Annual report year: 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 crystallites 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.

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
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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
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.91 SJR 1.179 SNIP 1.179
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.231 SNIP 1.332 CiteScore 1.78
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.671 SNIP 1.877 CiteScore 2.06
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.481 SNIP 1.63 CiteScore 1.9
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.419 SNIP 1.706 CiteScore 1.76
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.508 SNIP 1.703 CiteScore 1.78
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.688 SNIP 1.802
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.608 SNIP 1.53
Web of Science (2009): Indexed yes
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.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Test and Measurements, IT Service
Authors: Vasiljevic, N. (Intern), Lea, G. (Intern), Hansen, P. (Intern), Jensen, H. M. (Intern)
Number of pages: 15
Publication date: 2016

Publication information
Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy E
Number: 0105
Main Research Area: Technical/natural sciences
DTU Wind Energy E-0105, DTU Wind Energy E-105
Electronic versions:
Mobile_network_architecture.pdf
Source: PublicationPreSubmission
Source-ID: 120315719
Publication: Research › Report – Annual report year: 2016

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.

General information
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Organisations: Department of Wind Energy, Wind turbine loads & control
Authors: Hansen, M. H. (Intern)
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Publication date: 2016
Main Research Area: Technical/natural sciences

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Journal: Wind Energy Science
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DOIs:
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.
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.

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Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, Department of Wind Energy, Composites and Materials Mechanics
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Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
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, $F_x$, showed both higher absolute values and variation than the chordwise force component, $F_z$, for every inflow angle considered. For this reason, the present paper focused on modelling of the $F_x$ and not the $F_z$ whereas $F_z$ 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.

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Organisations: Department of Wind Energy, Aerodynamic design
Authors: Skrzypinski, W. R. (Intern), Gaunaa, M. (Intern), Heinz, J. C. (Intern)
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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.

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State: Published
Organisations: Resource Assessment Modelling, Department of Wind Energy, Aerodynamic design, North China Electric Power University
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BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.24 SNIP 0.373 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.253 SNIP 0.344 CiteScore 0.32
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.
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 parameters associated with 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.
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.
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
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Pages: 31–39
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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.

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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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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: Federici, P. (Intern), Kock, C. W. (Intern)
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.

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Authors: Federici, P. (Intern), Kock, C. W. (Intern)
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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, snakelike 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 effect of 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 of damage resistance. (C) 2016 Elsevier Ltd. All rights reserved.

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Organisations: Department of Wind Energy, Composites and Materials Mechanics, Risø National Laboratory for Sustainable Energy
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  BFI (2009): BFI-level 2
  Scopus rating (2009): SJR 1.253 SNIP 1.878
  BFI (2008): BFI-level 2
  Scopus rating (2008): SJR 1.086 SNIP 1.7
  Web of Science (2008): Indexed yes
  Scopus rating (2007): SJR 1.271 SNIP 2.207
  Scopus rating (2006): SJR 1.258 SNIP 2.138
  Scopus rating (2005): SJR 1.045 SNIP 1.695
  Web of Science (2005): Indexed yes
  Scopus rating (2004): SJR 1.013 SNIP 1.309
  Scopus rating (2003): SJR 1.129 SNIP 1.348
  Scopus rating (2002): SJR 1.392 SNIP 1.107
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  Scopus rating (1999): SJR 0.756 SNIP 0.896

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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.
New direct drive technologies of INNWIND.EU: Superconducting vs. Pseudo Direct Drive

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Authors: Abrahamsen, A. B. (Intern)
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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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- Scopus rating (2012): SJR 0.28 SNIP 0.354 CiteScore 0.33
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- Scopus rating (2011): SJR 0.292 SNIP 0.352 CiteScore 0.43
- ISI indexed (2011): ISI indexed no
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- Web of Science (2010): Indexed yes
- BFI (2009): BFI-level 1
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- BFI (2008): BFI-level 1
- Scopus rating (2008): SJR 0.265 SNIP 0.294
- Web of Science (2008): Indexed yes
- Scopus rating (2007): SJR 0.257 SNIP 0.39
- Web of Science (2007): Indexed yes
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- Web of Science (2006): Indexed yes
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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 imperfection size may be too conservative. Copyright © 2015 John Wiley & Sons, Ltd.

General information
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Scopus rating (2013): SJR 1.275 SNIP 2.464 CiteScore 2.75
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
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Scopus rating (2012): SJR 1.126 SNIP 2.39 CiteScore 2.36
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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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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.
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 humpback 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: Kobaek, C. M. (Ekstern), Hansen, M. O. L. (Intern)
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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.253 SNIP 0.344 CiteScore 0.32
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Scopus rating (2013): SJR 0.231 SNIP 0.272 CiteScore 0.25
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Scopus rating (2011): SJR 0.292 SNIP 0.352 CiteScore 0.43
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Scopus rating (2010): SJR 0.288 SNIP 0.344
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Scopus rating (2008): SJR 0.265 SNIP 0.294
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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BFI conference series: European Academy of Wind Energy : The Science of Making Torque from Wind (5010078)
Main Research Area: Technical/natural sciences
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.

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**Organisations:** Department of Wind Energy, Fluid Mechanics, University of Stuttgart, National Renewable Energy Laboratory, Fraunhofer Institute for Wind Energy and Energy System Technology (IWES), DHI Horsholm, 4subsea, GE Renewable Energy, DNV GL, Institute for Energy Technology, IFP Energies nouvelles, PRINCIPIA, Universidad de Cantabria, Marine Technology Centre, Norwegian University of Science and Technology, Politecnico di Milano, University of Ulsan, Knowledge Centre Wind turbine Materials and Constructions, WavEC – Offshore Renewables  
**Authors:** Robertson, A. N. (Ekstern), Wendt, F. (Ekstern), Jonkman, J. M. (Ekstern), Popko, W. (Ekstern), Borg, M. (Intern), Bredmose, H. (Intern), Schlutter, F. (Ekstern), Oqvist, J. (Ekstern), Bergua, R. (Ekstern), Harries, R. (Ekstern), Yde, A. (Intern), Nygaard, T. A. (Ekstern), de Vaal, J. B. (Ekstern), Oggiano, L. (Ekstern), Bozonnet, P. (Ekstern), Bouy, L. (Ekstern), Barrera Sanchez, C. (Ekstern), Guanche Garcia, R. (Ekstern), Bachynski, E. E. (Ekstern), Tu, Y. (Ekstern), Bayati, I. (Ekstern), Borisade, F. (Ekstern), Shin, H. (Ekstern), van der Zee, T. (Ekstern), Guerinel, M. (Ekstern)  
**Number of pages:** 20  
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**Volume:** 94
OffshoreDC 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)
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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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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 dependence 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.
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
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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)
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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.253 SNIP 0.344 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.231 SNIP 0.272 CiteScore 0.25
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 Díaz, A. (Intern), Réthoré, P. (Intern), van der Laan, P. (Intern)
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Bibliographical note
This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.
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.

General information
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Organisations: Department of Wind Energy, Fluid Mechanics, Cranfield University, University of Texas
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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 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.

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.
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
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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)
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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.

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.
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
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 \( \langle 111 \rangle + \langle 100 \rangle \) 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 \( \langle 111 \rangle \) -oriented regions than in \( \langle 100 \rangle \) -oriented regions. Recovery during annealing at 715 °C reduces the energy stored in the deformed microstructure. This reduction is more pronounced in the \( \langle 111 \rangle \) -oriented regions. Orientation-dependent recrystallisation takes place in the recovered microstructure, leading to strengthening of the \( \langle 111 \rangle \) fibre texture component at the expense of the \( \langle 100 \rangle \) fibre texture component.
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.991 SNIP 1.407 CiteScore 2.2
ISI indexed (2012): ISI indexed yes
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BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.941 SNIP 1.393 CiteScore 2.05
ISI indexed (2011): ISI indexed yes
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BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.965 SNIP 1.097
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.842 SNIP 0.963
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.68 SNIP 0.772
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.623 SNIP 0.869
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.545 SNIP 0.799
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.554 SNIP 0.887
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.574 SNIP 0.999
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.678 SNIP 1.055
Scopus rating (2002): SJR 0.662 SNIP 0.879
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.735 SNIP 1.026
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.732 SNIP 1.027
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 0.788 SNIP 1.075
Original language: English
Electronic versions:
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Perdigão CFD Grid Study

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling
Authors: Bechmann, A. (Intern)
Number of pages: 22
Publication date: 2016

Publication information
Publisher: DTU Wind Energy
ISBN (Electronic): 978-87-93278-78-3
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.
Performance and wake conditions

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.

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
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Source-ID: 2372091967
Publication: Research - peer-review › Article in proceedings – Annual report year: 2017
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 has 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.

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.
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Scopus rating (2015): SJR 0.24 SNIP 0.373 CiteScore 0.35
Web of Science (2015): Indexed yes
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Scopus rating (2014): SJR 0.253 SNIP 0.344 CiteScore 0.32
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BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.28 SNIP 0.354 CiteScore 0.33
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Scopus rating (2011): SJR 0.292 SNIP 0.352 CiteScore 0.43
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BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.253 SNIP 0.321
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Web of Science (2006): Indexed yes

Original language: English

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

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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
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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: Göğmen, T. (Intern), Giebel, G. (Intern), Sørensen, P. E. (Intern), Poulsen, N. K. (Intern)
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Publication date: 2016

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Main Research Area: Technical/natural sciences
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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), Villanueva, H. (Intern)
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Number: 1136(EN)
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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
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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
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Original language: English

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Main Research Area: Technical/natural sciences
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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: Federici, P. (Intern), Vesth, A. (Intern)
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: Federici, P. (Intern), Kock, C. W. (Intern)
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Publisher: DTU Wind Energy
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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
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Organisations: Department of Wind Energy, Test and Measurements
Authors: Gómez Arranz, P. (Intern), Villanueva, H. (Intern)
Number of pages: 97
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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.

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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.
Power Curve Measurements
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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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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
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Organisations: Department of Wind Energy, Test and Measurements
Authors: Vesth, A. (Intern), Villanueva, H. (Intern)
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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.
Power Curve Measurements, quantify 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.
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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Authors: Gómez Arranz, P. (Intern), Vesth, A. (Intern)
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Publication: Research › Report – Annual report year: 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.

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

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Organisations: Department of Wind Energy, Test and Measurements
Authors: Villanueva, H. (Intern), Vesth, A. (Intern)
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Publication: Research › Report – Annual report year: 2016

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%.

**General information**

State: Published
Organisations: Department of Wind Energy, Aerodynamic design
Authors: Meyer Forsting, A. R. (Intern)
Number of pages: 1
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Event: Poster session presented at Wind Europe Summit 2016, Hamburg, Germany.
Main Research Area: Technical/natural sciences
Electronic versions: alrf_WindEurope_2016.pdf

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**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.

**General information**

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Organisations: Department of Electrical Engineering, Center for Electric Power and Energy, Department of Wind Energy, Integration & Planning, Technical University of Denmark, Dong Energy Wind Power A/S, VESTAS Wind Systems A/S
Authors: Zeni, L. (Ekstern), Eriksson, R. (Intern), Goumalatsos, S. (Ekstern), Altin, M. (Intern), Sørensen, P. E. (Intern), Hansen, A. (Intern), Kjær, P. (Ekstern), Hesselbæk, B. (Ekstern)
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Power performance optimization and loads alleviation with active flaps using individual flap control

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.

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Department of Wind Energy, Aerodynamic design, Technical University of Denmark
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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 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 resynched 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.

General information
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Organisations: Department of Wind Energy, Integration & Planning, University of Edinburgh
Authors: Aitken, M. (Ekstern), Haggett, C. (Ekstern), Rudolph, D. P. (Intern)
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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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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, University of Auckland, University of Salford
Authors: Bradley, S. (Intern), Mikkelsen, T. K. (Intern), Hünerbein, S. V. (Ekstern), Legg, M. (Ekstern)
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Presolving and regularizing 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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Authors: Kelly, M. C. (Intern), Troen, I. (Intern)
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Scopus rating (2008): SJR 0.826 SNIP 1.559
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.053 SNIP 1.453
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.637 SNIP 1.689
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.287 SNIP 0.9
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.
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 power systems.

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Authors: Hansen, A. D. (Intern), Altin, M. (Intern), Iov, F. (Forskerdatabase)
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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.
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.

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling, China Meteorological Administration
Authors: Hasager, C. B. (Intern), Astrup, P. (Intern), Zhu, R. (Ekstern), Chang, R. (Ekstern), Badger, M. (Intern), Hahmann, A. N. (Intern)
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Real time turbulence and wind gust estimation from wind lidar observations using the turbulence reconstruction method

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Authors: Rottner, L. (Ekstern), Suomi, I. (Ekstern), Rieutord, T. (Ekstern), Baehr, C. (Ekstern), Gryning, S. (Intern)
Number of pages: 1
Publication date: 2016
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 A degrees C to 220 A degrees 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.
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.

General information
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.

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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)
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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.
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
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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 100 kW 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 S 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 metromological 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.
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 wind 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.
Residual Strains and Their Relation to the Fatigue Damage Evolution in Composite Materials

The fatigue performance of unidirectional 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.

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 IARge 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.
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
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Main Research Area: Technical/natural sciences

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BFI (2017): BFI-level 1
BFI (2016): BFI-level 1
Original language: English
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Review_of_defense.pdf
Links:
http://www.cigre.org/content/download/67847/3167288/version/7/file/CSE005.pdf
Source: PublicationPreSubmission
Source-ID: 127330591
Publication: Research - peer-review › Journal article – Annual report year: 2016

**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 replace MX, 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 9–12 wt-%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)
Pages: 126-137
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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.43 SJR 0.814 SNIP 0.812
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.632 SNIP 0.764 CiteScore 1.1
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
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.
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

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Journal: Journal of Physics: Conference Series (Online)
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BFI (2017): BFI-level 1
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BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.383
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.24 SNIP 0.373 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.253 SNIP 0.344 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.231 SNIP 0.272 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
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.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, von Karman Institute for Fluid Dynamics
Authors: Barlas, E. (Intern), Buckingham, S. (Ekstern), van Beeck, J. (Ekstern)
Number of pages: 17
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Journal: Boundary-Layer Meteorology
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Satellite data used in the New European Wind Atlas

General information
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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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Conference: The Science of Making Torque from Wind, Munich, Germany, 05/10/2016 - 05/10/2016
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BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.383
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.24 SNIP 0.373 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.253 SNIP 0.344 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.231 SNIP 0.272 CiteScore 0.25
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

General information
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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Integration & Planning, Energy research Centre of the Netherlands - ECN, Energy Research Centre of the Netherlands
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ScanFlow_IRPWIND_Hasager_et_al2016_new.pdf
Links:
http://www.irpwindconf.eu/ (Webpage for conference)
Publication: Research › Sound/Visual production (digital) – Annual report year: 2016

Scanning lidars for atmospheric boundary-layer research

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling
Authors: Dellwik, E. (Intern), Floors, R. R. (Intern)
Number of pages: 1
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Host publication information
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
Source: PublicationPreSubmission
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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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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
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.17 SJR 1.999 SNIP 1.798
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.276 SNIP 2.046 CiteScore 5.03
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.647 SNIP 2.63 CiteScore 5.7
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.54 SNIP 2.593 CiteScore 5.02
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.998 SNIP 2.25 CiteScore 4.25
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.609 SNIP 2.043 CiteScore 4
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.814 SNIP 2.725
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.729 SNIP 2.313
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.106 SNIP 1.444
Scopus rating (2007): SJR 0.913 SNIP 1.481
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.875 SNIP 1.306
Web of Science (2006): Indexed yes
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)
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Publication date: 2016
Main Research Area: Technical/natural sciences

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BFI (2017): BFI-level 1
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.21 SJR 0.163 SNIP 0.236
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.179 SNIP 0.217 CiteScore 0.18
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.165 SNIP 0.191 CiteScore 0.17
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.16 SNIP 0.173 CiteScore 0.16
ISI indexed (2013): ISI indexed no
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.17 SNIP 0.176 CiteScore 0.14
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.153 SNIP 0.141 CiteScore 0.12
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)
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Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.383
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.24 SNIP 0.373 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
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
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Number: 1151(EN)
Main Research Area: Technical/natural sciences
DTU Wind Energy WTT I-1151(EN), WTT-I-1151, WTT-I-1151(EN)
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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Scopus rating (2016): CiteScore 3.37 SJR 1.104 SNIP 2.306
SmallWind - Market Analysis and prospects

General information
State: Published
Authors: Friis, P. (Intern), Conti, D. (Intern), Brinch, M. (Intern), Enevoldsen, S. W. (Forskerdatabase), Bro, K. (Ekstern), Lauridsen, C. (Ekstern), Høgenhaven, U. (Ekstern), Pinholdt, L. (Ekstern)

Wind Energy, Smart rotor, Fatigue, Trailing edge flaps, Power generation

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Source-ID: 2265333133
Publication: Research - peer-review › Journal article – Annual report year: 2015
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 Nørrekaer Eng 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.

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.
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.
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
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)
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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)
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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.
Stress and strain gradient in the deformed metallic surface

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Organisations: Department of Wind Energy, Materials science and characterization
Authors: Zhang, X. (Intern)
Number of pages: 21
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Source: PublicationPreSubmission
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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
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 oceanic 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

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Organisations: Department of Wind Energy, Materials science and characterization
Authors: Hansen, N. (Intern), Zhang, X. (Intern), Huang, X. (Intern)
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Electronic versions:
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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.
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

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Ten Years of Boundary-Layer and Wind-Power Meteorology at Høvsøre, Denmark
Operational since 2004, the National Centre for Wind Turbines at Høvsøre, Denmark has become a reference research site for wind-power meteorology. In this study, we review the site, its instrumentation, observations, and main research programs. The programs comprise activities on, inter alia, remote sensing, where measurements from lidars have been compared extensively with those from traditional instrumentation on masts. In addition, with regard to wind-power
meteorology, wind-resource methodologies for wind climate extrapolation have been evaluated and improved. Further, special attention has been given to research on boundary-layer flow, where parametrizations of the length scale and wind profile have been developed and evaluated. Atmospheric turbulence studies are continuously conducted at Høvsøre, where spectral tensor models have been evaluated and extended to account for atmospheric stability, and experiments using microscale and mesoscale numerical modelling.

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Web of Science (2017): Indexed Yes
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Scopus rating (2016): CiteScore 2.65 SJR 1.517 SNIP 1.315
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.814 SNIP 1.268 CiteScore 2.32
Web of Science (2015): Indexed yes
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Web of Science (2014): Indexed yes
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Scopus rating (2013): SJR 1.736 SNIP 1.619 CiteScore 2.4
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.918 SNIP 1.627 CiteScore 2.12
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Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.389 SNIP 1.354 CiteScore 1.9
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.613 SNIP 1.209
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.902 SNIP 1.299
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.803 SNIP 1.622
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.519 SNIP 1.494
Testing of self-similarity and helical symmetry in vortex generator flow simulations

Vortex generators (VGs) are used increasingly by the wind turbine industry as flow control devices to improve rotor blade performance. According to experimental observations, the vortices generated by VGs have previously been observed to be self-similar for both the axial ($u_z$) and azimuthal ($u_\theta$) velocity components. Furthermore, the measured vortices have been observed to obey the criteria for helical symmetry. These are powerful results, as it reduces the highly complex 3-D flow to merely four parameters and therefore significantly facilitates the modeling of this type of flow, which in a larger perspective can assist in parametric studies to increase the total power output of wind turbines. In this study, corresponding computer simulations using Reynolds-averaged Navier–Stokes equations have been carried out and compared with the experimental observations. The main objective is to investigate how well the simulations can reproduce these aspects of the physics of the flow, i.e., investigate if the same analytical model can be applied and therefore significantly facilitate the modeling of this type of flow, which in a larger perspective can assist in parametric studies to increase the total power output of wind turbines. This is especially interesting since these types of flows are notoriously difficult for the turbulence models to predict correctly. Using this model, parametric studies can be significantly reduced, and moreover, reliable simulations can substantially reduce the costs of the parametric studies themselves. Copyright © 2015 John Wiley & Sons, Ltd.

General information
State: Published
Organisations: Department of Mechanical Engineering, Fluid Mechanics, Coastal and Maritime Engineering, Department of Wind Energy, Aeroelastic Design, University of the Basque Country, Polytechnic University of Catalonia
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Number of pages: 10
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Main Research Area: Technical/natural sciences

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The application of J integral to measure cohesive laws under large-scale yielding

A method is developed to obtain the mode I cohesive law of elastic-plastic materials using a Double Cantilever Beam sandwich specimen loaded with pure bending moments. The approach is based on the validity of the J integral for
materials having a non-linear stress-strain relationship without unloading of any material point. This assumption is not met exactly as there is a small where the material unloads. To examine the error of the method, a numerical parameter study is performed for a wide range of material and specimen parameters. The error of the method is below 16% and thus the method can be used to measure cohesive laws including their shape. (C) 2016 Elsevier Ltd. All rights reserved.
The collection of the main issues for wind farm optimisation in complex terrain

The paper aims at establishing the collection of the main issues for wind farm optimisation in complex terrain. To make wind farm cost effective, this paper briefly analyses the main factors influencing wind farm design in complex terrain and sets up a series of mathematical model that includes micro-siting, collector circuits, access roads design for optimization problems. The paper relies on the existing one year wind data in the wind farm area and uses genetic algorithm to optimize the micro-siting problem. After optimization of the turbine layout, single-source shortest path algorithm and minimum spanning tree algorithm are used to optimize collector circuits and access roads. The obtained results can provide important guidance for wind farms construction.

General information
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Organisations: Department of Wind Energy, Fluid Mechanics, Hohai University
Authors: Xu, C. (Ekstern), Chen, D. (Ekstern), Han, X. (Ekstern), Pan, H. (Ekstern), Shen, W. Z. (Intern)
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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.253 SNIP 0.344 CiteScore 0.32
The fence experiment - a first evaluation of shelter models

We present a preliminary evaluation of shelter models of different degrees of complexity using full-scale lidar measurements of the shelter on a vertical plane behind and orthogonal to a fence. Model results accounting for the distribution of the relative wind direction within the observed direction interval are in better agreement with the observations than those that correspond to the simulation at the center of the direction interval, particularly in the far-wake region, for six vertical levels up to two fence heights. Generally, the CFD results are in better agreement with the observations than those from two engineering-like obstacle models but the latter two follow well the behavior of the observations in the far-wake region.

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling
Authors: Peña, A. (Intern), Bechmann, A. (Intern), Conti, D. (Intern), Angelou, N. (Intern), Mann, J. (Intern)
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The fence experiment – full-scale lidar-based shelter observations

We present shelter measurements of a fence from a field experiment in Denmark. The measurements were performed with three lidars scanning on a vertical plane downwind of the fence. Inflow conditions are based on sonic observations of a nearby mast. For fence-undisturbed conditions, the lidars’ measurements agree well with those from the sonics and, at the mast position, the average inflow conditions are well described by the logarithmic profile. Seven cases are defined based on the 5 relative wind direction to the fence, the fence porosity, and the inflow conditions. The larger the relative direction, the lower is the shelter. For the case with the largest relative directions, no shelter is observed in the far wake (distances 6 fence heights downwind of the fence). When comparing a near-neutral to a stable case, a stronger shelter effect is noticed. The shelter is highest below ≈1.46 fence heights and can sometimes be observed at all downwind positions (up to 11 fence heights). Below the fence height, the porous fence has a lower impact on the flow close to the fence compared to the solid fence. Velocity 10 profiles in the far wake converge onto each other using the self-preserving forms from two-dimensional wake analysis.
The fence experiment – full-scale lidar-based shelter observations

We present shelter measurements of a fence from a field experiment in Denmark. The measurements were performed with three lidars scanning on a vertical plane downwind of the fence. Inflow conditions are based on sonic anemometer observations of a nearby mast. For fence-undisturbed conditions, the lidars’ measurements agree well with those from the sonic anemometers and, at the mast position, the average inflow conditions are well described by the logarithmic profile. Seven cases are defined based on the relative wind direction to the fence, the fence porosity, and the inflow conditions. The larger the relative direction, the lower the effect of the shelter. For the case with the largest relative directions, no sheltering effect is observed in the far wake (distances > 6 fence heights downwind of the fence). When comparing a near-neutral to a stable case, a stronger shelter effect is noticed. The shelter is highest below ≈ 1.46 fence heights and can sometimes be observed at all downwind positions (up to 11 fence heights downwind). Below the fence height, the porous fence has a lower impact on the flow close to the fence compared to the solid fence. Velocity profiles in the far wake converge onto each other using the self-preserving forms from two-dimensional wake analysis.

The Finite-Bladed Betz Rotor

The finite-bladed optimum Betz rotor is treated. It is only recently that a complete description of this rotor has been derived. In the chapter, a full analytical solution to the Betz rotor problem will be given, and the results will be compared to other optimum rotor models, both with respect to performance and resulting rotor geometry. It is here shown that for tip speed ratios greater than three, all models result in the same geometry at the outer part of the rotor, whereas the inner
part always is different, both with respect to plan form and with respect to twist distribution.

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Authors: Sørensen, J. N. (Intern)
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Chapter: 9
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The influence of fully nonlinear wave forces on aero-hydro-elastic calculations of monopile wind turbines
The response of an offshore wind turbine tower and its monopile foundation has been investigated when exposed to linear and fully nonlinear irregular waves on four different water depths. The investigation focuses on the consequences of including full nonlinearity in the wave kinematics. The linear and nonlinear irregular wave realizations are calculated using the fully nonlinear potential flow wave model OceanWave3D [1]. The linear and nonlinear wave realizations are compared using both a static analysis on a fixed monopile and dynamic calculations with the aeroelastic code Flex5 [2]. The conclusion from this analysis is that linear wave theory is generally sufficient for estimating the fatigue loading, but wave nonlinearity is important in determining the ultimate design loads.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Department of Mechanical Engineering, Fluid Mechanics, Coastal and Maritime Engineering
Authors: Schløer, S. (Intern), Bredmose, H. (Intern), Bingham, H. B. (Intern)
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BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.49 SJR 1.655 SNIP 2.636
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.618 SNIP 2.602 CiteScore 2.77
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.431 SNIP 3.026 CiteScore 2.18
The influence of removing sizing on strength and stiffness of conventional and high modulus E-glass fibres

Two types of E-glass fibres, a conventional and a high modulus where the last one in the following will be denoted as ECR-glass fibre, were investigated regarding density, diameter, stiffness and strength. The fibres were analysed as pristine and after sizing removal treatments. The sizing was removed by either burning at 565 °C or soxhlet extraction with acetone. It was found that the density and the stiffness increased after removing the sizing by the two removal treatments whereas the diameter did not change significantly. The strength of the fibres decreased after burning as the sizing, protecting against water and fibre-fibre damage, had been removed. The strength of the fibres after extraction was not significantly different from the strength of the pristine fibres despite removing the sizing. This indicates that the bonded part of sizing is still protecting the glass fibre surface.
The Lidar Cyclops Syndrome Bypassed: 3D Wind Field Measurements from a Turbine mounted Lidar in combination with a fast CFD solver

Although a single Lidar can scan the line-of-sight projected wind components at multiple points upwind in front of a rotating wind turbine, it is in principle not possible to resolve all three wind components of the wind velocity vectors simultaneously from a single lidar. This is known as the “Lidar Cyclops syndrome” with reference to the one-eyed Cyclops in old Greek mythology. However, by feeding a single lidar’s line-of-sight (LOS) rotor plane scanned wind speeds to a fast CFD solver, it has been possible to determine the entire 3D velocity vectors at each measurement point consistent with a single lidars LOS wind speed measurements. This talk will show it is possible to calculate the axial wind components in the measurement plane upwind in the rotor plane. The axial wind component is the most important for steering and control of the turbine, but also the transverse and the vertical wind component can easily be calculated simultaneously in a consistent manner. The linearized CFD model used is a linearized Fourier version of Navier-Stokes equations (LINCOM) which conserves mass and momentum. Following a full rotor plane lidar scan consisting of 400 LOS wind speed measurements The LINCOM CFD model is extremely fast solved for all three wind components, cf. the figures below. A 400 measurement point rotor plane scan with the DTU SpinnerLidar can be obtained in less than 1 s and the 3D LINCOM solver can then calculate the three wind components in a split second. As such, this methodology can be used in real-time for determination of the axial inflow from a single lidar scanning instrument mounted on the turbine. It has not escaped our notice that the methodology can be used for real-time advanced feed-forward control of turbines.
The model chain and the full scale spectrum of the boundary layer wind

In the European Union project: "The New European Wind Atlas [1, 2]" the model chain is a central research area. In a recent study [3] we looked into the resolution issue of linking the mesoscale models with the turbulence models by performing spectral analysis on extensive mean meteorological data and high frequency sonic anemometer data from the 100m meteorological mast at Danish test station Høvsøre. Datasets from the offshore wind farm Horns Rev were also analyzed. The conclusions from the analysis are given below. In the present study we complement and extend the analysis using a new dataset from the test station Østerild.

General information

State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, University of Oldenburg
Authors: Mikkelsen, T. K. (Intern), Astrup, P. (Intern), van Dooren, M. F. (Ekstern)
Publication date: 2016
Main Research Area: Technical/natural sciences

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ISARS_2016_Cyclope_Buster_DTU_Wind_Energy.pdf
Source: PublicationPreSubmission
Source-ID: 130314932
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2017

Thermal recycling and re-manufacturing of glass fibre thermosetting composites

The impact of using thermally recycled glass fibre in re-manufactured composites was investigated. A unidirectional glass fibre thermosetting composite laminate was manufactured. The matrix in one part of the laminate was burnt off to recover the glass fibres. These recycled glass fibres were used to manufacture a new composite laminate with the same fibre architecture as the pristine one. The fibres, the matrix and the composite laminates were thoroughly characterised and analysed. The results show that good materials quality was obtained for both laminates. A difference in fibre packing behaviour was observed in the composites with the pristine and the recycled fibres, which lead to a lower fibre volume fraction in the latter one. The Young's modulus of the composites was not changed by the recycling process, if the lower fibre volume fraction is taken into account. However, a marked drop in the maximum stress of the composites was reported, which was found to be related to the loss in maximum stress of the fibres.

General information

State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling
Authors: Larsén, X. G. (Intern), Lundtang Petersen, E. (Intern), Larsen, S. E. (Intern), Kristensen, L. (Intern)
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Event: Abstract from WindEurope 2016, Hamburg, Germany.
Main Research Area: Technical/natural sciences

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Thermal recycling and re-manufacturing of glass fibre thermosetting composites

The impact of using thermally recycled glass fibre in re-manufactured composites was investigated. A unidirectional glass fibre thermosetting composite laminate was manufactured. The matrix in one part of the laminate was burnt off to recover the glass fibres. These recycled glass fibres were used to manufacture a new composite laminate with the same fibre architecture as the pristine one. The fibres, the matrix and the composite laminates were thoroughly characterised and analysed. The results show that good materials quality was obtained for both laminates. A difference in fibre packing behaviour was observed in the composites with the pristine and the recycled fibres, which lead to a lower fibre volume fraction in the latter one. The Young's modulus of the composites was not changed by the recycling process, if the lower fibre volume fraction is taken into account. However, a marked drop in the maximum stress of the composites was reported, which was found to be related to the loss in maximum stress of the fibres.

General information

State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics
Authors: Fraisse, A. (Intern), Beauson, J. (Intern), Brøndsted, P. (Intern), Madsen, B. (Intern)
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Journal: I O P Conference Series: Materials Science and Engineering
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BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.39 SJR 0.187 SNIP 0.499
The RUNE Experiment—A Database of Remote-Sensing Observations of Near-Shore Winds

We present a comprehensive database of near-shore wind observations that were carried out during the experimental campaign of the RUNE project. RUNE aims at reducing the uncertainty of the near-shore wind resource estimates from model outputs by using lidar, ocean, and satellite observations. Here, we concentrate on describing the lidar measurements. The campaign was conducted from November 2015 to February 2016 on the west coast of Denmark and comprises measurements from eight lidars, an ocean buoy and three types of satellites. The wind speed was estimated based on measurements from a scanning lidar performing PPIs, two scanning lidars performing dual synchronized scans, and five vertical profiling lidars, of which one was operating offshore on a floating platform. The availability of measurements is highest for the profiling lidars, followed by the lidar performing PPIs, those performing the dual setup, and the lidar buoy. Analysis of the lidar measurements reveals good agreement between the estimated 10-min wind speeds, although the instruments used different scanning strategies and measured different volumes in the atmosphere. The campaign is characterized by strong westerlies with occasional storms.

General information

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Web of Science (2017): Indexed Yes
Scopus rating (2016): CiteScore 3.56 SJR 1.31 SNIP 1.661
Web of Science (2016): Indexed yes
Scopus rating (2015): SJR 1.339 SNIP 1.691 CiteScore 3.76
Web of Science (2015): Indexed yes
Scopus rating (2014): SJR 1.28 SNIP 1.886 CiteScore 3.23
Web of Science (2014): Indexed yes
Scopus rating (2013): SJR 1.167 SNIP 1.981 CiteScore 3.01
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
Three-dimensional local residual stress and orientation gradients near graphite nodules in ductile cast iron

A synchrotron technique, differential aperture X-ray microscopy (DAXM), has been applied to characterize the microstructure and analyze the local mesoscale residual elastic strain fields around graphite nodules embedded in ferrite matrix grains in ductile cast iron. Compressive residual elastic strains are measured with a maximum strain of $\sim 6.5 \times 10^{-4}$ near the graphite nodules extending into the matrix about 20 μm, where the elastic strain is near zero. The experimental data are compared with a strain gradient calculated by a finite element model, and good accord has been found but with a significant overprediction of the maximum strain. This is discussed in terms of stress relaxation during cooling or during storage by plastic deformation of the nodule, the matrix or both. Relaxation by plastic deformation of the ferrite is demonstrated by the formation of low energy dislocation cell structure also quantified by the DAXM technique.
Three-dimensional viscous-inviscid coupling method for wind turbine computations

In this paper, a computational model for predicting the aerodynamic behavior of wind turbine wakes and blades subjected to unsteady motions and viscous effects is presented. The model is based on a three-dimensional panel method using a surface distribution of quadrilateral sources and doublets, which is coupled to a viscous boundary layer solver. Unlike Navier-Stokes codes that need to solve the entire flow domain, the panel method solves the flow around a complex geometry by distributing singularity elements on the body surface, obtaining a faster solution and making this type of codes suitable for the design of wind turbines. A free-wake model has been employed to simulate the wake behind a wind turbine by using vortex filaments that carry the vorticity shed by the trailing edge of the blades. Viscous and rotational effects inside the boundary layer are taken into account via the transpiration velocity concept, applied using strip theory with the cross sectional angle of attack as coupling parameter. The transpiration velocity is obtained from the solution of the integral boundary layer equations with extension for rotational effects. It is found that viscosity plays a very important role in the predictions of blade aerodynamics and wake dynamics, especially at high angles of attack just before and after boundary layer separation takes place. The present code is validated in detail against the well-known MEXICO experiment and a set of non-rotating cases. Copyright © 2014 John Wiley & Sons, Ltd.
Timoshenko beam element with anisotropic cross-sectional properties

Beam models are used for the aeroelastic time and frequency domain analysis of wind turbines due to their computational efficiency. Many current aeroelastic tools for the analysis of wind turbines rely on Timoshenko beam elements with classical cross-sectional properties (EA, EI, etc.). Those cross-sectional properties do not reflect the various couplings arising from the anisotropic behaviour of the blade material. A two-noded, three-dimensional Timoshenko beam element was therefore extended to allow for anisotropic cross-sectional properties. For an uncoupled beam, the resulting shape functions are identical to the original formulation. The new element was implemented into a co-rotational formulation and validated against natural frequencies and several static load cases of previous works.

Toward an engineering model for the aerodynamic forces acting on wind turbine blades in quasisteady standstill and blade installation situations

The crossflow principle is one of the key elements used in engineering models for prediction of the aerodynamic loads on wind turbine blades in standstill or blade installation situations, where the flow direction relative to the wind turbine blade has a component in the direction of the blade span direction. In the present work, the performance of the crossflow principle is assessed on the DTU 10MW reference blade using extensive 3D CFD calculations. Analysis of the computational results shows that there is only a relatively narrow region in which the crossflow principle describes the aerodynamic loading well. In some conditions the deviation of the predicted loadings can be quite significant, having a large influence on for instance the integral aerodynamic moments around the blade centre of mass; which is very important for single blade installation applications. The main features of these deviations, however, have a systematic behaviour on all force components, which in this paper is employed to formulate the first version of an engineering correction method to the crossflow principle applicable for wind turbine blades. The new correction model improves the agreement with CFD results for the key aerodynamic loads in crossflow situations. The general validity of this model for other blade shapes should be investigated in subsequent works.
Trailing vorticity modeling for aeroelastic wind turbine simulations in stand still

Current fast aeroelastic wind turbine codes suitable for certification lack an induction model for standstill conditions. A trailing vorticity model previously used as addition to a blade element momentum theory based aerodynamic model in normal operation has been extended to allow computing the induced velocities in standstill. The model is validated against analytical results for an elliptical wing in constant inflow and against stand still measurements from the NREL/NASA Phase...
VI unsteady experiment. The extended model obtains good results in case of the elliptical wing, but underpredicts the steady loading for the Phase VI blade in attached flow. The prediction of the dynamic force coefficient loops from the Phase VI experiment is improved by the trailed vorticity modeling in both attached flow and stall in most cases. The exception is the tangential force coefficient in stall, where the codes and measurements deviate and no clear improvement is visible.

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control, Aerodynamic design, National Renewable Energy Laboratory
Authors: Pirrung, G. (Intern), Aagaard Madsen, H. (Intern), Schreck, S. (Ekstern)
Number of pages: 11
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BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.383
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.24 SNIP 0.373 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.253 SNIP 0.344 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.231 SNIP 0.272 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.28 SNIP 0.354 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.292 SNIP 0.352 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.344
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.253 SNIP 0.321
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.265 SNIP 0.294
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.257 SNIP 0.39
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.267 SNIP 0.284
Web of Science (2006): Indexed yes
Original language: English
Electronic versions:
Truss optimization with discrete design variables: a critical review

This review presents developed models, theory, and numerical methods for structural optimization of trusses with discrete design variables in the period 1968 – 2014. The comprehensive reference list collects, for the first time, the articles in the field presenting deterministic optimization methods and meta heuristics. The field has experienced a shift in focus from deterministic methods to meta heuristics, i.e. stochastic search methods. Based on the reported numerical results it is however not possible to conclude that this shift has improved the competences to solve application relevant problems. This, and other, observations lead to a set of recommended research tasks and objectives to bring the field forward. The development of a publicly available benchmark library is urgently needed to support development and assessment of existing and new heuristics and methods. Combined with this effort, it is recommended that the field begins to use modern methods such as performance profiles for fair and accurate comparison of optimization methods. Finally, theoretical results are rare in this field. This means that most recent methods and heuristics are not supported by mathematical theory. The field should therefore re-focus on theoretical issues such as problem analysis and convergence properties of new methods.

General information
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Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Stolpe, M. (Intern)
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Volume: 53
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
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
Uncertainty in vertical extrapolation of wind statistics: shear-exponent and WAsP/EWA methods

This report provides formulations for estimation of uncertainties involved in vertical extrapolation of winds, as well as the total uncertainty incurred when winds observed at one height are extrapolated to turbine hub height for wind resource assessment. This includes new derivations for uncertainties inherent in determination of (wind) shear exponents, and subsequent vertical extrapolation of wind speeds. The report further outlines application of the theory and results of Kelly & Troen (2014-6) for gauging the uncertainty inherent in use of the European Wind Atlas (EWA) / WAsP method for vertical extrapolation. Lastly, a section has been added that compares the uncertainty in the two aforementioned methods. The independently-derived forms corresponding to each vertical extrapolation method give uncertainty estimates that are essentially the same for small vertical extrapolations (\( \Delta z_{\text{pred}} / \Delta z_{\text{obs}} \)); for larger extrapolations, WAsP-based extrapolation leads to smaller estimated uncertainties than the shear-extrapolation method.

A primary motivation for—and part of—this work is the creation of a standard for uncertainty estimation and reporting, which is known as the IEC61400-15. The author is actively contributing to this emerging standard, and the work herein thus far constitutes (most of) the vertical extrapolation portion of the IEC 61400-15 draft.

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling
Authors: Kelly, M. C. (Intern)
Number of pages: 13
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Original language: English

Series: DTU Wind Energy E
Number: 0121
Main Research Area: Technical/natural sciences
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Electronic versions:
Uncertainty Quantification of the Real-Time Reserves for Offshore Wind Power Plants

In order to retain the system stability, the wind power plants are required to provide ancillary services. One of those services is reserve power. Here in this study, we focus on the real-time reserves which can be traded in the balancing markets and are currently used for compensation under mandatory downregulation stated by the transmission system operators (TSOs). The PossPOW project (Possible Power of down-regulated Offshore Wind power plants) developed a real-time power curve of available power for offshore wind farms for use during down-regulation. The follow-up Concert project (control and uncertainties in real-time power curves of offshore wind power plants) aims to quantify and finally reduce the uncertainty in reserve power, bringing the PossPOW algorithm and the state of the art forecasting methods together. The experiments designed to test the available power estimated by the PossPOW algorithm are used to quantify data based, objective uncertainty of the real-time reserves. The results show that the developed algorithm reduces the bias in the wind farm scale available power up to 6% where the uncertainty is improved by approximately 10% for the secondwise calculations. For 30-sec provision case, due to the characteristics of the experiment, circular block bootstrapping is implemented to increase the number of samples. The PossPOW reserve power is shown to have significantly less mean error and uncertainty compared to the good industry practice applied globally.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning
Authors: Göçmen, T. (Intern), Giebel, G. (Intern), Réthoré, P. (Intern), Murcia Leon, J. P. (Intern)
Number of pages: 5
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
Electronic versions:
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Source: PublicationPreSubmission
Source-ID: 132272659
Publication: Research - peer-review › Paper – Annual report year: 2017

Understanding IEC standard wind turbine models using SimPowerSystems

This article describes and exemplifies the IEC 61400-27 generic wind turbine models through an interactive multimedia learning environment - Matlab SimPowerSystems. The article aims help engineers with different backgrounds to get a better understanding of wind turbine dynamics and control by easily conducting different study simulations in the SimPowerSystems platform.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning
Authors: Das, K. (Intern), Hansen, A. D. (Intern), Sørensen, P. E. (Intern)
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Main Research Area: Technical/natural sciences
Publication information
Journal: Wind Engineering
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ISSN (Print): 0309-524X
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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.267 SNIP 0.515 CiteScore 0.58
This report is a deliverable (D3.11) of the UniTTe project. It describes the setup of the first measurement campaign (MC1) regarding the met masts and wind turbine measurements during the period where measurements were taken with the short range WindScanner and the SpinnerLidar. Set up and measurements with the remote sensing instruments are described in another report (D3.12). Analysis of the data is the focus of several other publications within the project. The purpose of these two reports is to provide the necessary information about the measurements for the data analysis.
UniTTe MC2 Nørrekær Enge Measurement System & Calibration report
This Measurement System & Calibration report is describing DTU's measurement system installed at a SIEMENS 2.3/93. The turbine is owned by Vattenfall and is placed at Nørrekær Enge as number four in a row of 13 turbines. The measurement campaign is a part of work package 3 in the Unitte research project which is managed by DTU and funded by Innovation Fund Denmark.

General information
State: Published
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Authors: Vignaroli, A. (Intern), Kock, C. W. (Intern)
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Main Research Area: Technical/natural sciences
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Source-ID: 126945133
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URANS simulations of separated flow with stall cells over an NREL S826 airfoil
A series of wind tunnel measurements and oil flow visualization was recently carried out at the Technical University of Denmark in order to investigate flow characteristics over a 14% thick NREL S826 airfoil at low Reynolds numbers. This paper aims at presenting numerical simulations of the same airfoil using unsteady Reynolds-averaged Navier-Stokes (URANS) approach. Results of the simulations are demonstrated in terms of mean flow velocity, lift and drag, as well as pressure distribution, and validated against available experimental data. The simulations are carried out with a wide computational domain (with a span-to-chord ratio of 5) and it is illustrated that the URANS approach is capable of predicting 3D spanwise structures, known as stall cells.

General information
State: Published
Organisations: Department of Wind Energy, Fluid Mechanics, Cranfield University
Authors: Sarlak Chivae, H. (Intern), Nishino, T. (Ekstern), Sørensen, J. N. (Intern)
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Use of micro-tomography for validation of method to identify interfacial shear strength from tensile tests of short regenerated cellulose fibre composites

The interfacial shear strength of short regenerated cellulose fibre/polylactide composites was characterized by means of an industry-friendly adhesion test method. The interfacial shear strength was back-calculated from the experimental tensile stress-strain curves of composites by using a micro-mechanical model. The parameters characterizing the microstructure of the composites, e.g. fibre length and orientation distributions, used as input in the model were obtained by micro-tomography. The investigation was carried out on composites with untreated and surface treated fibres with various fibre weight contents (5wt%, 10wt%, and 15wt% for untreated fibres, and 15wt% for treated fibres). The properties of fibres were measured by an automated single fibre tensile test method. Based on these results, the efficiency of the fibre treatment to improve fibre/matrix adhesion is evaluated, and the applicability of the method to measure the interfacial shear strength is discussed. The results are compared with data from previous work, and with other results from the literature.
Using High-Fidelity Computational Fluid Dynamics to Help Design a Wind Turbine Wake

We describe the process of using large-eddy simulations of wind turbine wake flow to help design a wake measurement campaign. The main goal of the experiment is to measure wakes and wake deflection that result from intentional yaw misalignment under a variety of atmospheric conditions at the Scaled Wind Farm Technology facility operated by Sandia National Laboratories in Lubbock, Texas. Prior simulation studies have shown that wake deflection may be used for wind-plant control that maximizes plant power output. In this study, simulations are performed to characterize wake deflection and general behavior before the experiment is performed to ensure better upfront planning. Beyond characterizing the expected wake behavior, we also use the large-eddy simulation to test a virtual version of the lidar we plan to use to measure the wake and better understand our lidar scan strategy options. This work is an excellent example of a “simulation-in-the-loop” measurement campaign.

General information
State: Published
Authors: Churchfield, M. J. (Ekstern), Wang, Q. (Ekstern), Scholbrock, A. (Ekstern), Herges, T. (Ekstern), Mikkelsen, T. K. (Intern), Sjöholm, M. (Intern)
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Journal: Journal of Physics: Conference Series (Online)
Using Pretwist to Reduce Power Loss of Bend-Twist Coupled Blades

Bend-twist coupling of wind turbine blades is known as a means to reduce the structural loads of the turbine. While the load reduction is desirable, bend-twist coupling also leads to a decrease in the annual energy production of the turbine. The reduction is mainly related to a no longer optimal twist distribution along the blade due to the coupling induced twist. Some of the power loss can be compensated by pretwisting the blade. This paper presents a pretwisting procedure for large blade deflections and investigates the effect of pretwisting on blade geometry, annual energy production, and fatigue load for the DTU 10 MW Reference Wind Turbine. The analysis was carried out by calculating the nonlinear steady state rotor deflection in an uniform inflow over the operational range of the turbine. The steady state power curve together with a Rayleigh wind speed distribution has been used to estimate the annual energy production. The turbine model was then linearised around the steady state and the power spectral density of the blade response, which was computed from transfer functions and the wind speed variations in the frequency domain, was used to estimate the fatigue loads by a spectral method.
Using Remote Sensing Data for Integrating different Renewable Energy Sources at Coastal Site in South Italy

Italian coastal sites have the advantage of favorable climatic conditions to use mixed renewable energy sources, such as solar and wind. Harbors are safe places to install wind turbines where wind conditions are almost offshore. Space-borne remote sensing can provide information to determine solar and wind energy production potential cheaper than usual observational activity to identify and assess suitable areas. Here, we present a case study for both energy resources assessment from satellite in harbors.

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Organisations: Department of Wind Energy, Resource Assessment Modelling, University of Calabria
Authors: Calaudi, R. (Ekstern), Feudo, T. L. (Ekstern), Calidonna, C. R. (Ekstern), Sempreviva, A. M. (Intern)
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BFI (2013): BFI-level 1
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Web of Science (2013): Indexed yes
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Scopus rating (2011): SJR 0.918 SNIP 1.505 CiteScore 2.42
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Scopus rating (2010): SJR 0.433 SNIP 0.957
Using SST and land cover data from EO Missions for improved mesoscale modelling of the coastal zone

Existing wind measurements in near-shore and offshore areas are sparse and scarce, therefore simulations from state-of-the-art meso-scale models are used for wind resource predictions. In coastal and near-shore areas, models are inaccurate and uncertain, mainly because of numerical approximations, which do not resolve the large changes in local topographic features and atmospheric stability well [1]. The accuracy of modelled wind resource predictions can be improved by using local wind measurements to calibrate the models. RUNE investigated cost-effective measurement solutions for improving the wind resource modelling of coastal areas. The wind over a coastal area was measured by land-based LIDAR systems [6], an offshore LIDAR buoy and satellite radar remote sensing (SAR and scatterometers). Simulations using the Weather Research & Forecasting (WRF) meso-scale model were performed. The aim was to evaluate the uncertainty of the modelled wind in the coastal zone and further improve it. Moreover, LIDAR measurements were used to evaluate the wind speed retrieval from high resolution SAR systems (Sentinel-1 and TerraSAR-X). The WRF model used a high-resolution satellite SST reanalysis product from the Danish Meteorological Institute (DMI), specifically developed for the North Sea and Baltic Sea region. To improve the physical description of the domain, the elevation, topography and land use, the CORINE land cover database and the SRTM elevation database are used as boundary conditions; with a spatial resolution of 100 m to 250 m, the CORINE land cover information represent a more accurate classification of land uses for the entire domain. SST, land cover, and elevation information from Earth Observation platforms are unique due to their extended spatial coverage and resolution, such that they can be implemented in the meso-scale model to better represent the actual conditions in the study area. Such improvements are expected to strengthen the model’s ability to represent land-sea and air-sea interactions, the atmospheric stability and the local topographic features that partly affect the coastal zone.

Utilisation of real-scale renewable energy test facility for validation of generic wind turbine and wind power plant controller models

This article presents an example of application of a modern test facility conceived for experiments regarding the integration of renewable energy in the power system. The capabilities of the test facility are used to validate dynamic simulation models of wind power plants and their controllers. The models are based on standard and generic blocks. The successful validation of events related to the control of active power (control phenomena in
Validation of a CFD model with a triple-lidar system upstream of a wind turbine in complex terrain

General information
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Organisations: Department of Wind Energy, Aerodynamic design, Resource Assessment Modelling, Meteorology & Remote Sensing
Validation of an Aero-Acoustic Wind Turbine Noise Model Using Advanced Noise Source Measurements of a 500kW Turbine

The measurement of a 500 kW stall-regulated wind turbine is investigated. Microphones located relatively close to the wind turbine are used to measure its acoustic emission. The operational conditions of the turbine, such as wind speed, are simultaneously monitored. In parallel, a wind turbine rotor noise model is presented. It includes the main sources of aeroacoustic noise from wind turbines: turbulent inflow, trailing edge and stall noise. The noise measured by one microphone located directly downstream of the wind turbine is compared to the model predictions at the microphone location. A good qualitative agreement is found. When wind speed increases, the rotor noise model shows that at high frequencies the stall noise becomes dominant. It also shows that turbulent inflow noise is dominant at low frequencies for all wind speeds and that trailing edge noise is dominant at low wind speeds and at frequencies above 200 Hz.

Validation of buoyancy driven spectral tensor model using HATS data

We present a homogeneous spectral tensor model for wind velocity and temperature fluctuations, driven by mean vertical shear and mean temperature gradient. Results from the model, including one-dimensional velocity and temperature spectra and the associated co-spectra, are shown in this paper. The model also reproduces two-point statistics, such as coherence and phases, via cross-spectra between two points separated in space. Model results are compared with observations from the Horizontal Array Turbulence Study (HATS) field program (Horst et al. 2004). The spectral velocity tensor in the model is described via five parameters: the dissipation rate ($\varepsilon$), length scale of energy-containing eddies ($L$), a turbulence anisotropy parameter ($\Gamma$), gradient Richardson number ($R_i$) representing the atmospheric stability and the rate of destruction of temperature variance ($\eta_\theta$).
In this paper we report the results of a workshop organised by the Delft University of Technology in 2014, aiming at the comparison between different state-of-the-art numerical models for the simulation of wind turbine wakes. The chosen benchmark case is a wind tunnel measurement, where stereoscopic Particle Image Velocimetry was employed to obtain the velocity field and turbulence statistics in the near wake of a two-bladed wind turbine model and of a porous disc, which mimics the numerical actuator used in the simulations. Researchers have been invited to simulate the experimental case based on the disc drag coefficient and the inflow characteristics. Four large eddy simulation (LES) codes from different institutions and a vortex model are part of the comparison. The purpose of this benchmark is to validate the numerical
predictions of the flow field statistics in the near wake of an actuator disc, a case that is highly relevant for full wind farm applications. The comparison has shown that, despite its extreme simplicity, the vortex model is capable of reproducing the wake expansion and the centre line velocity with very high accuracy. Also all tested LES models are able to predict the velocity deficit in the very near wake well, contrary to what was expected from previous literature. However, the resolved velocity fluctuations in the LES are below the experimentally measured values. © 2016 Elsevier Ltd. All rights reserved.
Validation of long-range scanning lidars deployed around the Høvsøre Test Station

This report describes validation tests performed on the long-range scanning lidars prior to deployment in the RUNE campaign. Position and speed accuracy tests have been performed at a range of 5km from the Høvsøre met mast. This range is typical of ranges for near-coastal resource measurements. The accuracy of the beam positioning was checked by comparing the predicted position to the position found from hard-target returns from the mast. Radial speeds measured by the lidar were also found to be in close agreement with the mast measured wind speeds projected in the line of sight direction.

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Validation of Superelement Modelling of Complex Offshore Support Structures

Modern large MW wind turbines today are installed at larger water depth than applicable for traditional monopile substructure. It appears that foundation types such as jacket and tripod are gaining more popularity for these locations. For certification purposes, a full set of design load calculations consisting of up to thousands design load cases needs to be evaluated. However, even the simplest aero-elastic model of such structures has many more DOFs than monopile, resulting in excessive computation burden. In order to deal with this problem, the superelement method has been introduced for modelling such structures. One superelement method has been proven very promising in the previous project of Wave Loads [1] and a fundamental question in such DOFs reduction methods is which modes that are essential and which modes can be neglected. For the jacket structure, the introduction of a gravity-buoyancy mode (GB mode) demonstrates that this mode is needed for accurate load simulation. A case study is performed in this report to validate the proposed method based on a reference wind turbine on a jacket foundation.
Validation of the actuator line and disc techniques using the New MEXICO measurements

Actuator line and disc techniques are employed to analyse the wake obtained in the New MEXICO wind turbine experiment. The New MEXICO measurement campaign done in 2014 is a follow-up to the MEXICO campaign, which was completed in 2006. Three flow configurations in axial flow condition are simulated and both computed loads and velocity fields around the rotor are compared with detailed PIV measurements. The comparisons show that the computed loadings are generally in agreement with the measurements under the rotor's design condition. Both actuator approaches under-predicted the loading in the inboard part of blade in stall condition as only 2D airfoil data were used in the simulations. The predicted wake velocities generally agree well with the PIV measurements. In the experiment, PIV measurements are also provided close to the hub and nacelle. To study the effect of hub and nacelle, numerical simulations are performed both in the presence and absence of the hub geometry. This study shows that the large hub used in the experiment has only small effects on overall wake behaviour.
Value Assessment of Distribution Network Reconfiguration: A Danish Case Study

Distribution network reconfiguration is a mechanism that can improve the distribution system performance from multiple perspectives. In the context of smart grid wherein the degrees of automation and intelligence are high, the potential value of network reconfiguration can be significant. This paper presents a case study-based analysis to explore the potential value of reconfiguration in detail. The study is performed using a 10kV distribution grid of Denmark, while reconfiguration is applied to minimize the energy losses under both normal and post-fault conditions. The results show that although the reconfiguration is performed to achieve a single objective, the overall network performance is improved. In addition, the value achieved by reconfiguration can be very sensitive to the reconfiguration frequency and the associated cost.

General information
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Organisations: Department of Wind Energy, Integration & Planning, Department of Electrical Engineering, Center for Electric Power and Energy, Energy system operation and management
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Variability in large-scale wind power generation

The paper demonstrates the characteristics of wind power variability and net load variability in multiple power systems based on real data from multiple years. Demonstrated characteristics include probability distribution for different ramp durations, seasonal and diurnal variability and low net load events. The comparison shows regions with low variability (Sweden, Spain and Germany), medium variability (Portugal, Ireland, Finland and Denmark) and regions with higher variability (Quebec, Bonneville Power Administration and Electric Reliability Council of Texas in North America; Gansu, Jilin and Liaoning in China; and Norway and offshore wind power in Denmark). For regions with low variability, the maximum 1 h wind ramps are below 10% of nominal capacity, and for regions with high variability, they may be close to 30%. Wind power variability is mainly explained by the extent of geographical spread, but also higher capacity factor causes higher variability. It was also shown how wind power ramps are autocorrelated and dependent on the operating output level. When wind power was concentrated in smaller area, there were outliers with high changes in wind output, which were not present in large areas with well-dispersed wind power. Copyright © 2015 John Wiley & Sons, Ltd.
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BFI (2014): BFI-level 2
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Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
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Web of Science (2010): Indexed yes
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Scopus rating (2009): SJR 1.124 SNIP 1.448
Web of Science (2009): Indexed yes
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Scopus rating (2008): SJR 0.826 SNIP 1.559
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Web of Science (2007): Indexed yes
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Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.287 SNIP 0.9
Web of Science (2005): Indexed yes
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Variation of Extreme and Fatigue Design Loads on the Main Bearing of a Front Mounted Direct Drive System

The drivetrain of a 10 MW wind turbine has been designed as a direct drive transmission with a superconducting generator mounted in front of the hub and connected to the main frame through a King-pin stiff assembly by DNV-GL. The aeroelastic design loads of such an arrangement are evaluated based on the thrust and bending moments at the main bearing, both for ultimate design and in fatigue. It is found that the initial superconductor generator weight of 363 tons must be reduced by 25% in order not to result in higher extreme loads on main and yaw bearing than the reference 10 MW geared reference drive train. A weight reduction of 50% is needed in order to maintain main bearing fatigue damage equivalent to the reference drive train. Thus a target mass of front mounted superconducting direct drive generators is found to be between 183-272 tons.

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Web of Science (2016): Indexed yes
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Web of Science (2015): Indexed yes
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Scopus rating (2014): SJR 0.253 SNIP 0.344 CiteScore 0.32
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Web of Science (2013): Indexed yes
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Scopus rating (2012): SJR 0.28 SNIP 0.354 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 0.344
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.253 SNIP 0.321
BFI (2008): BFI-level 1
Variation of Extreme and Fatigue Design Loads on the Main Bearing of a Front Mounted Direct Drive System

The drivetrain of a 10 MW wind turbine has been designed as a direct drive transmission with a superconducting generator mounted in front of the hub and connected to the main frame through a King-pin stiff assembly by DNV-GL. The aeroelastic design loads of such an arrangement are evaluated based on the thrust and bending moments at the main bearing, both for ultimate design and in fatigue. It is found that the initial superconductor generator weight of 363 tons must be reduced by 25% in order not to result in higher extreme loads on main and yaw bearing than the reference 10 MW geared reference drive train. A weight reduction of 50% is needed in order to maintain main bearing fatigue damage equivalent to the reference drive train. Thus a target mass of front mounted superconducting direct drive generators is found to be between 183-272 tons.

Variation of Loads on Offshore Wind Turbine Drivetrains During Measured Shutdown Events

This paper investigates the frequency of normal shutdowns to be used in the design stage of wind turbines based on measurements at an offshore wind farm and seeks to quantify their impact on the fatigue loads on the drivetrain and tower top. The measured shutdowns observed on an instrumented multi-megawatt wind turbine located at an offshore wind farm are correlated with corresponding observations of shutdowns on surrounding wind turbines. The observed wind turbines have multiple shutdowns at high mean wind speeds due to wind speed variations near cut-out. Through the use of an Inverse First Order Reliability Model (IFORM), the expected annual frequency of normal shutdowns at cut-out is put forth. A simulation model of the wind turbine is set up in the aeroelastic software HAWC2 based on which observed shutdowns are simulated along with normal operation. The simulated tower top moments are compared with the measured loads, thereby quantifying the amplification in the loads due to the shutdown action. The IFORM-determined frequency of shutdowns at cut-out mean wind speed is used as an input to the fatigue load computations in the drivetrain, by which the resulting damage equivalent loads (DELs) are analyzed to quantify their coefficient of variation for varying site-specific wind conditions under both normal operation and with shutdowns.
Variations of the Wake Height over the Bolund Escarpment Measured by a Scanning Lidar

The wake zone behind the escarpment of the Bolund peninsula in the Roskilde Fjord, Denmark, has been investigated with the help of a continuous-wave Doppler lidar. The instrument measures the line-of-sight wind speed 390 times per second in highly resolved 7-m tall profiles by rapidly changing the focus distance and beam direction. The profiles reveal the detailed and rapidly changing structure of the wake induced by the Bolund escarpment. The 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. The wake increases by 10–70% when the wind direction deviates ±15° from perpendicular depending on the distance to the edge and to a lesser degree on the method by which the wake height is determined. This finding is supported by a comparison with in situ measurements acquired on the Bolund peninsula.
Vertical Axis Wind Turbine Design Load Cases Investigation and Comparison with Horizontal Axis Wind Turbine

The paper studies the applicability of the IEC 61400-1 ed.3, 2005 International Standard of wind turbine minimum design requirements in the case of an onshore Darrieus VAWT and compares the results of basic Design Load Cases (DLCs) with those of a 3-bladed HAWT. The study is based on aerelastic computations using the HAWC2 aero-servo-elastic code. A 2-bladed 5 MW VAWT rotor is used based on a modified version of the DeepWind rotor. For the HAWT simulations, the NREL 3-bladed 5 MW reference wind turbine model is utilized. Various DLCs are examined including normal power production, emergency shut down and parked situations, from cut-in to cut-out and extreme wind conditions. The ultimate
and 1 Hz equivalent fatigue loads of the blade root and turbine base bottom are extracted and compared in order to give an insight of the load levels between the two concepts. According to the analysis the IEC 61400-1 ed.3 can be used to a large extent with proper interpretation of the DLCs and choice of parameters such as the hub-height. In addition, the design drivers for the VAWT appear to differ from the ones of the HAWT. Normal operation results in the highest tower bottom and blade root loads for the VAWT, where parked under storm situation (DLC 6.2) and extreme operating gust (DLC 2.3) are more severe for the HAWT. Turbine base bottom and blade root edgewise fatigue loads are much higher for the VAWT compared to the HAWT. The interpretation and simulation of DLC 6.2 for the VAWT lead to blade instabilities, while extreme wind shear and extreme wind direction change are not critical in terms of loading of the VAWT structure. Finally, the extreme operating gust wind condition simulations revealed that the emerging loads depend on the combination of the rotor orientation and the time stamp that the frontal passage of gust goes through the rotor plane.

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Very short term wind power forecasting using shore-based scanning lidar observations over the Danish North Sea

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Voltage Control Support and Coordination between Renewable Generation Plants in MV Distribution Systems

This paper focusses on voltage control support and coordination between renewable generation plants in medium voltage distribution systems. An exemplary benchmark grid in Denmark, including a number of flexible ReGen plants providing voltage control functionality, is used as a base case. First, voltage sensitivity analysis is performed to quantify node voltage variations due to injections of reactive power for given operational points of the network. The results are then used to develop an adaptive voltage droop control method, where various droop settings are allocated to each ReGen plant according to the sensitivity indices of corresponding node voltages and the location of respective ReGen plants in the distribution system. Case studies are performed in time-domain to analyze the impact of voltage fluctuations due to active power variations of ReGen plants in order to verify the performance of the obtained voltage droop settings. The main outcome of this study is the provision of a generic guidance on how to coordinate the voltage stability support capabilities of ReGen plants in a distribution system with large ReGen penetration in order to ensure a resilient voltage controlled distribution system.

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Organisations: Department of Wind Energy, Integration & Planning, Aalborg University
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Vortex-induced vibrations on a modern wind turbine blade

This article investigates the aero-elastic response of the DTU 10-MW RWT blade in deep stall conditions with angles of attack in the vicinity of 90 degrees. The simulations were conducted with the high-fidelity fluid–structure interaction simulation tool HAWC2CFD employing the multi-body-based structural model of HAWC2 and the incompressible computational fluid dynamics solver EllipSys3D. The study utilizes detached eddy simulation computations and considers the three-dimensional blade geometry including blade twist and taper. A preliminary frequency analysis of the load variations on a stiff blade showed that an inclined inflow with a velocity component along the blade axis can trigger a spanwise correlated vortex shedding over large parts of the blade. Moderate wind speeds were sufficient to generate vortex shedding with frequencies close to the first edgewise eigenfrequency of the blade. Aero-elastic computations of the elastic blade confirmed the findings of the frequency analysis. Inflow conditions with inclination angles between $\Psi = 20^\circ$ and $\Psi = 55^\circ$ and relatively low to moderate wind speeds between $V = 16$ and $V = 26$ m s$^{-1}$ were sufficient to trigger severe edgewise blade vibrations with blade tip amplitudes of several metres. The investigated inflow conditions are considered realistic and might occur when the wind turbine is idling or standing still and the yaw system is unable to align the wind turbine with the incoming wind. Copyright © 2016 John Wiley & Sons, Ltd.

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Authors: Heinz, J. C. (Intern), Sørensen, N. N. (Intern), Zahle, F. (Intern), Skrzypinski, W. R. (Intern)
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Scopus rating (2013): SJR 1.275 SNIP 2.464 CiteScore 2.75
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Scopus rating (2012): SJR 1.126 SNIP 2.39 CiteScore 2.36
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BFI (2011): BFI-level 2
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Wake dynamics in offshore wind farms

Wind turbines within offshore wind farms spend considerable time operating in the wake of neighboring wind turbines. An important contribution to the loads on a wake-affected wind turbine is the slow movement of the wake from the upstream wind turbine across the rotor of the wake-affected wind turbine. A new approach to this so called wake meandering is proposed. Beside the advantage of higher physical realism, the new approach also offers practical advantages compared to the current state-of-the-art method.

An input to the new meandering approach is the time evolution of the so called spectral velocity tensor. An improved such spectral tensor is therefore developed, which, for neutral atmospheric stratification, predicts spatial correlations comparably to the Mann spectral tensor and temporal coherence significantly better than previously existing models, including the Mann model, which is incapable of predicting any temporal correlations beyond those that follows from the application of Taylor's frozen turbulence hypothesis. As part of the framework a spectral tensor for Lagrangian correlations in space and time is also developed and validated versus measurements of isotropic turbulence. Combined, the models reproduce the cross-over point between Eulerian and Lagrangian temporal covariances. The applications of the Lagrangian spectral tensor, e.g. in the fields of dispersion and mixing, deserve further investigation.

The values of the input parameters of the spectral tensor are shown to be uniquely determined by the friction velocity, the shear and the dissipation of turbulent kinetic energy, all of them physical properties of the flow. If local equilibrium between the turbulent kinetic energy produced by shear and the turbulent kinetic energy dissipated as heat is assumed, then, for neutral atmospheric stratification, the friction velocity and the mixing length determine the spectral tensor.

The developed spectral tensor also depends on a dimensionless quantity, which would be beneficial to determine with higher accuracy. An experiment with this objective, studying the ratio between different components of the cross-spectra at known shear, is proposed. Future work could also include investigating if a Rapid Distortion formulation that also includes a term for buoyancy effects is needed in order to make accurate predictions for non-neutral atmospheric stratification.

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Wind turbine loads & control
Authors: de Mare, M. T. (Intern), Mann, J. (Intern), Larsen, G. C. (Intern), Jensen, L. E. (Ekstern)
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Publication information
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Wake flow characteristics at high wind speed

Wake flow characteristic at high wind speeds is the main subject of this paper. Although the wake losses decrease at high wind speeds it has been found in a recent study that for multiple wake inflow the increase in loading due to wake effects are substantial even at wind speeds well above rated power. In the present study we simulate the wake flow for a row of turbines with the wind aligned with the row using a simplified approach. The velocity deficit, being a function of the thrust coefficient, is simulated based on the BEM solution for wake expansion. An axis-symmetric boundary layer equation model (the same as implemented in the DWM model) is subsequently used to develop the deficit down to the next turbine, and then the approach is successively repeated. Simulation results for four different spacing's in a row with eight turbines show that there are two major flow regimes. In the first flow regime comprising the first turbines in a row the local mean wind speed over the rotor disc is found to decrease linearly from turbine to turbine for the turbines operating at maximum power but also to some extend extend below rated power. The second flow regime is characterized by a constant local equilibrium wind speed. Based on the present results the equilibrium wind speed normalized with the inflow wind speed varies from about 0.4 for a spacing of 3D to slightly above 0.6 for a 9D spacing at an ambient turbulence intensity equal 6%. It is also found that for a turbine in the intersection region between the two flow regimes a strong variation in power and thrust occur, e.g. going from almost zero power to rated power for a wind speed change of 4m/s. Another result is that the inflow profile to the last turbine in the row at a wind speed of 16m/s for a spacing of 3D shows a variation over the profile from around 3m/s to 16m/s, which explains the high loading observed at high wind. Two models for merging wakes are tested, and one works best below rated power and another shows excellent performance around 14m/s. Finally, power measurements from the Lillgrund wind farm in a row with a 4.3D spacing and for wind speeds from 8-14m/s are used to validate the modeling setup.

Wake Influence on Dynamic Load Characteristics of Offshore Floating Wind Turbines

Because the flow conditions of an offshore floating wind turbine and onshore fixed wind turbine differ, it is debatable whether the aerodynamic load predictions of an offshore floating wind turbine using the conventional blade-element momentum theory, which does not consider the dynamic wake effects, are accurate. Although a generalized dynamic wake method has been developed to consider the dynamic wake effect, it is only stable for lightly loaded wind turbines at high wind speeds. In contrast to the blade-element momentum theory and generalized dynamic wake method, the unsteady vortex lattice method can inherently represent the nonuniform flow effects of the trailing wake from the turbine blades. This paper aims to determine the wake influence of offshore floating wind turbines at low-wind-speed conditions by comparing three wake models: the blade-element momentum theory, generalized dynamic wake method, and unsteady vortex lattice method. The Offshore Code Comparison Collaboration Hywind model is chosen for offshore floating wind-turbine simulation. Results show that the blade-element momentum theory underestimates the rotor torque and speed. Moreover, although responses of the generalized dynamic wake method and unsteady vortex lattice method agree well at moderate wind speeds, the generalized dynamic wake method predicts higher induction factor than that of the blade-element momentum theory and unsteady vortex lattice method at low wind speeds. At low wind speeds, the blade flapwise bending moment, rotor torque, and tower side-to-side bending moment calculated by the blade-element momentum theory are considerably different from those obtained by the unsteady vortex lattice method.
Wind-speed observations from tall towers are used in combination with observations up to 600 m in altitude from a Doppler wind lidar to study the long-term conditions over suburban (Hamburg), rural coastal (Høvsøre) and marine (FINO3) sites. The variability in the wind field among the sites is expressed in terms of mean wind speed and Weibull distribution shape-parameter profiles. The consequences of the carrier-to-noise-ratio (CNR) threshold-value choice on the wind-lidar observations are revealed as follows. When the wind-lidar CNR is lower than a prescribed threshold value, the observations are often filtered out as the uncertainty in the wind-speed measurements increases. For a pulsed heterodyne Doppler lidar, use of the traditional –22 dB CNR threshold value at all measuring levels up to 600 m results in a ≈7 % overestimation in the long-term mean wind speed over land, and a ≈12 % overestimation in coastal and marine environments. In addition, the height of the profile maximum of the shape parameter of the Weibull distribution (so-called reversal height) is found to depend on the applied CNR threshold; it is found to be lower at small CNR threshold values. The reversal height is greater in the suburban (high roughness) than in the rural (low roughness) area. In coastal areas the reversal height is lower than that over land and relates to the internal boundary layer that develops downwind from the coastline. Over the sea the shape parameter increases towards the sea surface. A parametrization of the vertical profile of the shape parameter fits well with observations over land, coastal regions and over the sea. An applied model for the dependence of the reversal height on the surface roughness is in good agreement with the observations over land.
What is the critical height of leading edge roughness for aerodynamics?

In this paper the critical leading edge roughness height is analyzed in two cases: 1) leading edge roughness influencing the lift-drag ratio and 2) leading edge roughness influencing the maximum lift. The analysis was based on wind tunnel...
measurements on the airfoils NACA0015, Risoe-B1-18 and Risoe-C2-18 and at three different Reynolds numbers with two
different leading edge roughness tape heights. Firstly, an analysis of the momentum thickness as function of Reynolds
number was carried out based on the boundary layer theory by Thwaites. Secondly, the wind tunnel measurements
combined with panel code predictions of the boundary layer momentum thickness created the basis for determining the
impact of roughness on the aerodynamic performance. The critical heights were related to the Reynolds numbers and
thereby the size of the wind turbines.

General information
State: Published
Organisations: Department of Wind Energy, Aerodynamic design, Power Curve ApS
Authors: Bak, C. (Intern), Gaunaa, M. (Intern), Olsen, A. S. (Intern), Kruse, E. K. (Ekstern)
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ISI indexed (2013): ISI indexed no
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Scopus rating (2012): SJR 0.28 SNIP 0.354 CiteScore 0.33
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Scopus rating (2011): SJR 0.292 SNIP 0.352 CiteScore 0.43
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Scopus rating (2010): SJR 0.288 SNIP 0.344
Web of Science (2010): Indexed yes
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Scopus rating (2008): SJR 0.265 SNIP 0.294
Web of Science (2008): Indexed yes
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Why the Coriolis force turns a wind farm wake to the right 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 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 fresh momentum from above into the wind farm, which is not observed for the interaction between the Coriolis force and a roughness change.

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Authors: van der Laan, P. (Intern), Sørensen, N. N. (Intern)
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Scopus rating (2011): SJR 0.292 SNIP 0.352 CiteScore 0.43
ISI indexed (2011): ISI indexed no
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Scopus rating (2010): SJR 0.288 SNIP 0.344
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BFI (2009): BFI-level 1
Wind and solar energy curtailment: A review of international experience

Greater penetrations of variable renewable generation on some electric grids have resulted in increased levels of curtailment in recent years. Studies of renewable energy grid integration have found that curtailment levels may grow as the penetration of wind and solar energy generation increases. This paper reviews international experience with curtailment of wind and solar energy on bulk power systems in recent years, with a focus on eleven countries in Europe, North America, and Asia. It examines levels of curtailment, the causes of curtailment, curtailment methods and use of market based dispatch, as well as operational, institutional, and other changes that are being made to reduce renewable energy curtailment. (C) 2016 Elsevier Ltd. All rights reserved.
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.

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 information

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Original language: English
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.

Wind Atlas of Bay of Bengal with Satellite Wind Measurement
The objective of this study is to obtain appropriate offshore location in the Bay of Bengal, Bangladesh for further development of wind energy. Through analyzing the previous published works, no offshore wind energy estimation has been found here. That is why, this study can be claimed as the first footstep towards offshore wind energy analysis for this region.

Generally, it is difficult to find offshore wind data relative to the wind turbine hub heights, therefore a starting point is necessary to identify the possible wind power density of the region. In such scenario, Synthetic aperture radars (SAR) have proven useful. In this study, SAR based dataset- ENVISAT ASAR has been used for Wind Atlas generation.

Furthermore, a comparative study has been performed with Global Wind Atlas (GWA) to determine a potential offshore wind farm. Additionally, the annual energy production of that offshore windfarm has been analyzed by combining SAR, GWA and ASCAT datasets.

Through ASAR based Wind Atlas and GWA comparison, some differences has been found as less sampled ASAR datasets were achieved for some nodes. Thus, Weibull statistical analysis are performed to have a better Weibull fitting and accurate estimation of Annual Energy production (AEP). The study summarizes that, satellite datasets can be a very useful method to detect potential zone if compared with any long time statistical result and bathymetry data together. In this study, all three datasets comprises similar AEP at the coastal area which indicates beneficiary pace for future wind energy sector of Bangladesh.
Wind energy in the electric power system
The ongoing increase in renewable power generation causes a parallel overall decrease in conventional power generation
from, in particular, fossil and nuclear power plants. Apart from providing market-based active power schedules, these
power plants are crucial for offering ancillary services in order to guarantee a reliable stable power supply at any instant in
time. Substituting these plants with renewable generation units requires the latter to be capable of providing these ancillary
services. The state of the art is that grid codes are used to define the way wind turbines and wind farms have to behave
when connected to the power system. In this way, they already incorporate basic ancillary services. However, frequency
control is normally not provided as a regular reserve, because this would require reserving parts of the available wind
capacity as stand-by capacity. Within R&D institutes, such control options were demonstrated and assessed for wind
power plant clusters.
Wind farm efficiency assessed by WRF with a statistical-dynamical approach

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.

General information
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Organisations: Department of Wind Energy, Resource Assessment Modelling
Authors: Volker, P. (Intern), Badger, J. (Intern), Hahmann, A. N. (Intern)
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Wind generator projects based on MgB2 superconductors

General information
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Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Abrahamsen, A. B. (Intern)
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Wind gust measurements using pulsed Doppler wind-lidar: comparison of direct and indirect techniques

The measurements of wind gusts, defined as short duration wind speed maxima, have traditionally been limited by the height that can be reached by weather masts. Doppler lidars can potentially provide information from levels above this and thereby fill this gap in our knowledge. To measure the 3D wind vector, we need information from at least three different lines of sight pointing towards different directions. The instrument sensitivity depends on the amount of aerosol present and the velocity measurement uncertainty is directly related to the amount of signal. With the commercial lidars traditionally used today it takes several seconds to measure each line of sight with sufficient sensitivity and therefore the temporal resolution of the wind measurement is of the order of tens of seconds, which is not sufficient for gusts. Here we deploy a fast scanning lidar (temporal resolution for a scan is 3.9 s) which can provide high resolution turbulent measurements, both in the vertical direction, and potentially in the horizontal direction. In this study we explore different strategies of wind lidar measurements to measure the wind speed maxima. We use a novel stochastic turbulence reconstruction model, driven by the Doppler lidar measurements, which uses a non-linear particle filter to estimate the small-scale turbulent fluctuations. The first results show that the reconstruction method can reproduce the wind speed maxima measured by the sonic anemometer if a low-pass filter with a cut-off frequency similar to the lidar measurement frequency is applied to the sonic data. These results from the reconstructed wind are better than the maxima derived directly from the wind lidar measurements. However, the maxima of the raw sonic anemometer signal are still higher than the maxima of the reconstructed winds. This gap between the maxima can potentially be filled by using information about the particle velocity distributions within the turbulence model.

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling, Finnish Meteorological Institute
Wind power forecasting: IEA Wind Task 36 & future research issues
This paper presents the new International Energy Agency Wind Task 36 on Forecasting, and invites to collaborate within the group. Wind power forecasts have been used operatively for over 20 years. Despite this fact, there are still several possibilities to improve the forecasts, both from the weather prediction side and from the usage of the forecasts. The new International Energy Agency (IEA) Task on Forecasting for Wind Energy tries to organise international collaboration, among national meteorological centres with an interest and/or large projects on wind forecast improvements (NOAA, DWD, MetOffice, met.no, DMI,...), operational forecaster and forecast users. The Task is divided in three work packages: Firstly, a collaboration on the improvement of the scientific basis for the wind predictions themselves. This includes numerical weather prediction model physics, but also widely distributed information on accessible datasets. Secondly, we will be aiming at an international pre-standard (an IEA Recommended Practice) on benchmarking and comparing wind power forecasts, including probabilistic forecasts. This WP will also organise benchmarks, in cooperation with the IEA Task WakeBench. Thirdly, we will be engaging end users aiming at dissemination of the best practice in the usage of wind power predictions. As first results, an overview of current issues for research in short-term forecasting of wind power is presented.
Wind power variability and power system reserves

General information
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Organisations: Department of Wind Energy, Integration & Planning, Resource Assessment Modelling
Authors: Sørensen, P. E. (Intern), Litong-Palima, M. (Intern), Hahmann, A. N. (Intern), Heunis, S. (Ekstern), Ntusi, M. (Ekstern), Hansen, J. C. (Intern)
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Source-ID: 131158371
Publication: Research › Sound/Visual production (digital) – Annual report year: 2017
**Wind resource assessment using the WAsP software (DTU Wind Energy E-0135)**

These course notes are intended for the three-week course 46200 Planning and Development of Wind Farms given each year at the Technical University of Denmark. The purpose of the course notes is to give an introduction to wind resource assessment and siting issues using the WAsP suite of programs.

### General information
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- **Authors:** Mortensen, N. G. (Intern)
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**Wind resources at turbine height from Envisat and Sentinel-1 SAR**

A comprehensive database with ocean wind fields has been built up at the Technical University of Denmark (DTU) through consistent processing of Synthetic Aperture Radar (SAR) observations from Envisat (2002-12) and Sentinel-1 (2014-present). The archived wind fields cover the European seas up to 100 km from the coastline. They can be seen as a series of snapshots showing the instantaneous wind conditions for the areas most relevant for offshore wind power generation. Through statistical processing, these instantaneous snapshots are combined to give maps of the offshore wind resources for the standard output level of 10 m above the sea surface. This presentation demonstrates the effects of two recent improvements related to satellite-based wind resource mapping:

1) The number of satellite samples has increased dramatically since the launch of Sentinel-1A/B
2) A new method looks promising for routine extrapolation of wind fields to the height of modern wind turbines

At DTU, wind maps are retrieved in near-real-time from ESA’s L1 SAR products using the SAROPS processing tool developed by the US National Oceanic and Atmospheric Administration (NOAA). The geophysical model function CMOD5.N is used to obtain the equivalent neutral wind speed. A correction is applied to compensate for lower radar backscatter at HH polarization compared to VV polarization. Ancillary data used for the SAR-wind processing include wind directions from the Global Forecast System (GFS) and ice mask data from the US National Ice Center.

Once the instantaneous wind maps are stored in our database, they can be organized as time series in order to calculate wind resources for any point location or area. Since the time series comprises data from both Envisat and Sentinel-1, a check of the data calibration against one or more independent data sources is needed. Based on the calibrated time series, a Weibull fit is made to calculate the mean wind speed, Weibull scale and shape parameters, and the wind power density. The spatial grid of the output wind resource maps is 0.02 degrees in latitude and longitude. To extrapolate the 10-m wind resource maps from SAR to higher levels within the atmospheric boundary layer, we estimate a wind profile for each grid cell in the maps. Simulations from the Weather Research and Forecasting (WRF) model are used to correct this profile for long-term atmospheric stability effects. Accounting for atmospheric stability allows us to estimate the wind speed at different levels with greater accuracy compared to methods that assume a neutral atmospheric boundary layer. For the Northern European seas, the inclusion of atmospheric stability increases the mean wind speed at 100 m on the order of 0.5m/s.

The SAR-based wind resource maps are used in the New European Wind Atlas – an EU-funded project where European nations work together to produce an updated and validated wind atlas for Europe.

### General information
- **State:** Published
- **Organisations:** Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling
- **Authors:** Badger, M. (Intern), Hasager, C. B. (Intern), Pena Diaz, A. (Intern), Hahmann, A. N. (Intern), Volker, P. (Intern)
- **Number of pages:** 1
- **Publication date:** 2016
- **Event:** Paper presented at ESA Living Planet Symposium 2016, Prague, Czech Republic.
- **Main Research Area:** Technical/natural sciences
Wind tunnel testing of the DeepWind demonstrator in design and tilted operating conditions

The DeepWind Project aims at investigating the feasibility of a new floating vertical-axis wind turbine (VAWT) concept, whose purpose is to exploit wind resources at deep-water offshore sites. The results of an extensive experimental campaign on the DeepWind reduced scale demonstrator are here presented for different wind speeds and rotor angular velocities, including also skewed flow operation due to a tilted rotor arrangement. To accomplish this, after being instrumented to measure aerodynamic power and thrust (both in streamwise and transversal directions), a troposkien three-bladed rotor was installed on a high precision test bench, whose axis was suitable to be inclined up to 15° with respect to the design (i.e. upright) operating condition. The experiments were performed at the large scale, high speed wind tunnel of the Politecnico di Milano (Italy), using a “free jet” (open channel) configuration. The velocity field in the wake of the rotor was also fully characterized by means of an instrumented traversing system, to investigate the flow distribution downstream of the test section. Special care is taken in the description of the experimental set-up and of the measured data, so that the present results can be used as a benchmark for the validation of simulation models.
Wind Turbine Blades: An End of Life Perspective

In 2016, the first offshore windfarm constructed in the world—located in Denmark, near Ravnsborg—is turning 25 years old, and will soon be decommissioned. After decommissioning, most of the material of the turbine can be recycled; only the composite materials found in the blades represent a challenge. This part looks at end of life solutions for this material. Wind turbine blade structure and material are described. The ends of life solutions existing and under development are detailed.

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Authors: Beauson, J. (Intern), Brøndsted, P. (Intern)
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Wind Turbine Noise Propagation Modelling: An Unsteady Approach

Wind turbine sound generation and propagation phenomena are inherently time dependent, hence tools that incorporate the dynamic nature of these two issues are needed for accurate modelling. In this paper, we investigate the sound propagation from a wind turbine by considering the effects of unsteady flow around it and time dependent source
characteristics. For the acoustics modelling we employ the Parabolic Equation (PE) method while Large Eddy Simulation (LES) as well as synthetically generated turbulence fields are used to generate the medium flow upon which sound propagates. Unsteady acoustic simulations are carried out for three incoming wind shear and various turbulence intensities, using a moving source approach to mimic the rotating turbine blades. The focus of the present paper is to study the near and far field amplitude modulation characteristics and time evolution of Sound Pressure Level (SPL).

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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.253 SNIP 0.344 CiteScore 0.32
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BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.231 SNIP 0.272 CiteScore 0.25
ISI indexed (2013): ISI indexed no
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BFI (2012): BFI-level 1
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BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.292 SNIP 0.352 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.344
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.253 SNIP 0.321
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.265 SNIP 0.294
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.257 SNIP 0.39
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.267 SNIP 0.284
Web of Science (2006): Indexed yes
Original language: English
Electronic versions:
Wind_turbine_noise_propagation_modelling.pdf
Wind Turbine Performance Measurements by Means of Dynamic Data Analysis

The state of the art power performance measurement method refers to the IEC61400-12-1 standard from 2005 [1]. A method for faster power curves was proposed by researchers at Oldenburg university in 2004. The method was called Langevin power curve method and advantages was claimed to be that power curves could be made faster with 1Hz dataset. In the FastWind project the Langevin power curve method was used on real power curve measurement datasets with the purpose to evaluate the method for practical use.

A practical guide to application of the method to real power curve measurement data was made. The study showed that the method has a range of parameter settings that the user must consider. Additionally to the wind speed binning power binning is needed but power binning size is not specified. Determination of drift in each bin is described with a general formula but in practice several additional tools have been developed by authors to try to make the drift field and fixed point determination more robust. A sensitivity analysis with nacelle lidar data showed drift determination was not very dependent on the time steps applied, leading to use of time steps of 2-3 points for each dataset. Power bin size should be fixed. Data averaging with 5 sec data was more distinct for determination of the fixed points than 2 and 1 sec data. With the nacelle lidar the Langevin method seemed to produce a power curve that was comparable to the IEC power curve.

Analysis of the Langevin method with spinner anemometer data showed that fixed points were very sensitive to bin size and to requirement of minimum amount of data in each bin. The Langevin method failed to produce acceptable robust power curves comparable to the IEC power curve. Simple binned averaging of data with shorter time averages gave better results than the Langevin power curve method.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing
Authors: Friis Pedersen, T. (Intern), Wagner, R. (Intern), Demurtas, G. (Intern)
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Original language: English

Series: DTU Wind Energy E
Volume: 0082
Main Research Area: Technical/natural sciences
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Bibliographical note
Wind turbine power performance measurement with the use of spinner anemometry

The spinner anemometer was patented by DTU in 2004 and licenced to ROMO Wind in 2011. By 2015 the spinner anemometer was installed on several hundred wind turbines for yaw misalignment measurements. The goal of this PhD project was to investigate the feasibility of use of spinner anemometry for power performance measurements. First development of spinner anemometer was related to calibration of yaw misalignment measurements. Here the first innovation was made in the spinner anemometer mathematical model, introducing a new calibration constant, $k_a = k_1/k_2$. This constant was found to be directly related to measurements of inflow angle (yaw misalignment and flow inclination). The calibration of the constant was based on yawing the stopped turbine several times in and out of the wind comparing the varying inflow angle measurement with the yaw position sensor. The calibration for inflow angle measurements was further improved with an innovation step to calibrate without use of the yaw position sensor, saving cost and time of installing the additional yaw sensor. The so called "wind speed response method" was validated by comparing 27 different calibration tests to the fist methods. This method is now used as default in commercial calibrations. To evaluate the power performance of a wind turbine with the use of spinner anemometry, an experiment was organized in collaboration with Romo Wind and Vattenfall. A met-mast was installed close to two wind turbines equipped with spinner anemometers at a flat wind farm site. A procedure to calibrate
the spinner anemometer for wind speed measurements was developed to determine the $k_1$ calibration constant, and the IEC61400-12-2 standard was used to measure the nacelle transfer function (NTF). The power curves of the two wind turbines with use of met-mast and spinner anemometer were then compared. Application of the NTF from one turbine to the other was made with a difference of only 0.38% in AEP. Different methods of analysis of fast sampled measurements such as the Langevin power curve were tested, concluding that the method of bins (IEC61400-12-1) was the most simple and robust method, and could also be applied directly to fast sampled measurements. The probability distribution of wind speed was playing a major role in being able to complete a power curve measurement in short time.

General information
State: Published
Organisations: Meteorology & Remote Sensing, Department of Wind Energy
Authors: Demurtas, G. (Intern), Friis Pedersen, T. (Intern), Wagner, R. (Intern)
Number of pages: 135
Publication date: 2016

Publication information
Publisher: DTU Wind Energy
Original language: English

Series: DTU Wind Energy PhD
Number: 0063(EN)
Main Research Area: Technical/natural sciences
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Electronic versions: Wind_turbine_power_performance.pdf

Relations
Projects:
Wind turbine power performance measurement with the use of spinner anemometry
Publication: Research › Ph.D. thesis – Annual report year: 2016

Wind turbine wake measurement in complex terrain
SCADA data from a wind farm and high frequency time series measurements obtained with remote scanning systems have been analysed with focus on identification of wind turbine wake properties in complex terrain. The analysis indicates that within the flow regime characterized by medium to large downstream distances (more than 5 diameters) from the wake generating turbine, the wake changes according to local atmospheric conditions e.g. vertical wind speed. In very complex terrain the wake effects are often "overruled" by distortion effects due to the terrain complexity or topology.

General information
State: Published
WP8 Detailed Blade Modelling Implemented in Aero-Elastic load simulation

General information
State: Published
Organisations: Department of Wind Energy, Wind turbine loads & control, Wind Turbine Structures and Component Design
Authors: Larsen, T. J. (Intern), Blasques, J. P. A. A. (Intern), Hansen, A. M. (Intern), Berring, P. (Intern)
Pages: 80-106
Publication date: 2016

Host publication information
Title of host publication: Torsional Stiffening of Wind Turbine Blades – Mitigating leading edge damages : EUDP project 64013-0115 – Final report
Publisher: Bladena
Main Research Area: Technical/natural sciences
Electronic versions: LEX_Final_report.pdf
Source: PublicationPreSubmission
Source-ID: 127688399
Publication: Research › Report chapter – Annual report year: 2016

WRF idealized-roughness response: PBL scheme and resolution dependence

General information
State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling
Authors: Kelly, M. C. (Intern), Volker, P. (Intern)
Number of pages: 17
Publication date: 2016

Publication Information
Media of output: Power Point Presentation
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions: Kelly2016_EMS_WRF_z0eff_PBL_Dx_.pdf
Source: PublicationPreSubmission
Source-ID: 142118049
Publication: Research › Sound/Visual production (digital) – Annual report year: 2017

WRF Mesoscale Pre-Run for the Wind Atlas of Mexico

This report documents the work performed by DTU Wind Energy for the project “Atlas Eólico Mexicano” or the Wind Atlas of Mexico. This document reports on the methods used in “Pre-run” of the windmapping project for Mexico. The interim mesoscale modeling results were calculated from the output of simulations using the Weather, Research and Forecasting (WRF) model. We document the method used to run the mesoscale simulations and to generalize the WRF model wind climatologies. A separate section covers the preliminary validation of the WRF simulations against tall mast observations.

General information
State: Published
**X-ray based micromechanical finite element modeling of composite materials**

This is a study of a uni-directional non-crimp fabric reinforced epoxy composite material typically used as the load carrying laminate in wind turbine blades. Based on a 3D x-ray tomography scan, the bundle and fibre/matrix structure of the composite is segmented. This segmentation is used in a multi-scale finite element model bridging the gap from the individual fibers organized in bundles to the stitched non-crimp fabric used for building up the load carrying laminates.

**General information**

State: Published

Organisations: Department of Wind Energy, Composites and Materials Mechanics, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Statistics and Data Analysis


Number of pages: 4

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BFI conference series: Nordic Seminar on Computational Mechanics (5010906)

Main Research Area: Technical/natural sciences

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http://www.chalmers.se/en/conference/nscm29/Pages/default.aspx

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**Polarization Diversity Image-Reject Homodyne Receiver for Directional Radial Velocity Measurements in Light Detection and Ranging (LIDAR) Instruments**

The present invention relates to an improved method and a LIDAR system comprising an emitter for emission of a coherent electromagnetic EM signal and a transmitting optical arrangement configured to transmit the electromagnetic signal towards a measurement area. By the method and system, detection of both the polarized and depolarized backscattered EM signal is obtained, whereby an improved signal-to-noise ratio is obtained.

**General information**

State: Published

Organisations: Department of Wind Energy, Test and Measurements, Meteorology

Authors: Foroughi Abari, F. (Intern), Mikkelsen, T. K. (Intern), Mann, J. (Intern), Pedersen, A. T. (Intern), Peucheret, C. (Ekstern), Sjöholm, M. (Intern)

Publication date: 2 Apr 2015

**Publication information**


IPC: G01S17/58, G01S17/88, G01S7/48, G01S7/491, G01S7/499
Analysis of wind turbine aerodynamics and aeroelasticity using vortex-based methods
Momentum analysis through Blade Element Momentum (BEM) and Computational Fluid Dynamics (CFD) are the two major paths commonly followed for wind turbine aerodynamic and aeroelastic research. Instead, the current PhD thesis focuses on the application of vortex-based methods. Vortex-based methods are understood as both simple vortex models and advanced numerical vortex methods. Prandtl's tip-loss factor and Coleman's yaw model are examples of features that were obtained using simple vortex models and implemented in BEM-based codes. Low-order vortex lattice codes and high-order vortex particle methods have regained interest in wind energy applications over the last two decades. The current work derives and illustrates some of the potential benefits of vortex-based analyses. The two key wake geometries used in this study to derive simple vortex models are the cylindrical and helical wake models. Both models can be attributed to the work of Joukowski. They are further studied in this thesis. The cylindrical wake model is detailed for the finite-tip speed ratio case. A superposition of such models is used to investigate the effect of wake rotation. A proper implementation of this effect in BEM codes is suggested. The application to yawed conditions leads to the derivation of a new yaw model applicable in BEM codes. Further applications of the cylindrical wake model considered include the study of unsteady inflow and sheared inflow. The helical wake model is used to derive a new-tip loss factor intended to be used in BEM implementations. The current thesis also presents the implementation of a vortex code to further investigate wind turbine aerodynamics. The code consists of both low-order and high-order formulations. The implementation features are described and illustrated through different validation cases. Analytical results, measurements and CFD simulations are used for comparison and validation. Low-order methods are used to validate the simple vortex models. The vortex particle method is applied to model a turbulent field and investigate the impact of a wind turbine on the inflow turbulence. The code is coupled to the in-house aero-servo-elastic code in order to obtain a "next generation" aeroelastic simulation tool.
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https://www.youtube.com/watch?v=pUMT8Mn1IfQ
Publication: Communication › Sound/Visual production (digital) – Annual report year: 2015

DTU Wind Energy - Innovation

General information
State: Published
Organisations: Department of Wind Energy
Authors: Thomsen, K. (Intern)
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Publication information
Media of output: YouTube video
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Original language: English
Publisher: DTU Wind Energy
Main Research Area: Technical/natural sciences
Links:
https://www.youtube.com/watch?v=yuoYl8po0I4
Publication: Communication › Sound/Visual production (digital) – Annual report year: 2015

DTU Wind Energy - Loads

General information
State: Published
Organisations: Department of Wind Energy, Aeroelastic Design
Authors: Larsen, T. J. (Intern)
Publication date: 27 Mar 2015

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Media of output: YouTube video
Size: 1:43 min.
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Publisher: DTU Wind Energy
Main Research Area: Technical/natural sciences
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https://www.youtube.com/watch?v=HURQde7iquA
Publication: Communication › Sound/Visual production (digital) – Annual report year: 2015

DTU Wind Energy - Preferred Project Partner

General information
State: Published
Organisations: Department of Wind Energy
Authors: Madsen, P. H. (Intern)
Publication date: 27 Mar 2015

Publication information
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Original language: English
Publisher: DTU Wind Energy
Main Research Area: Technical/natural sciences
Links:
https://www.youtube.com/watch?v=esBKB87XR0
Publication: Communication › Sound/Visual production (digital) – Annual report year: 2015
46200 Planning and Development of Wind Farms: Wind resource assessment using the WAsP software

These course notes are intended for the three-week course 46200 Planning and Development of Wind Farms given each year at the Technical University of Denmark. The purpose of the course notes is to give an introduction to wind resource assessment and siting issues using the WAsP suite of programs.
Åbenhed, dialog og inddragelse: Afrapportering af deltema 3 i SEP/WIND2050-miniprojekt

Formålet med delundersøgelsen vedrørende temaet 'Åbenhed, dialog og inddragelse' er at diskutere den måde, som relationen mellem borgere, developere og myndigheder i dag iscenesættes i de nuværende planlægningsprocedurer – herunder gennem den etablerede praksis for borgerinddragelse og gennem de formelle høringssystemer m.m. Baseret på foreløbige observationer i Sydjylland vil vi også diskutere, hvilke udfordringer der måske kan være i forhold til nye forsøg med en mere samarbejdssorienteret relation til borgere, som blandt andet Aarhus Kommune og Kalundborg Kommune eksperimenterer med, og vi vil pege på nogle faktorer ved developeres' praksisser, forretningsmodeller og ejerskabsstrukturer, der har betydning for denne interaktion.

A consistent method for finite volume discretization of body forces on collocated grids applied to flow through an actuator disk

This paper describes a consistent algorithm for eliminating the numerical wiggles appearing when solving the finite volume discretized Navier-Stokes equations with discrete body forces in a collocated grid arrangement. The proposed method is a modification of the Rhie-Chow algorithm where the force in a cell is spread on neighboring cells by applying equivalent pressure jumps at the cell faces. The method shows excellent results when applied for simulating the flow through an actuator disk, which is relevant for wind turbine wake simulations. © 2015 Elsevier Ltd. All rights reserved.
A Coupled Atmospheric and Wave Modeling System for Storm Simulations

This study aims at improving the simulation of wind and waves during storms in connection with wind turbine design and operations in coastal areas. For this particular purpose, we investigated the Coupled-Ocean-Atmosphere-Wave-Sediment Transport (COAWST) Modeling System which couples the Weather Research and Forecasting (WRF) Model with the third-generation ocean wave model SWAN. This study investigates mainly two issues: spatial resolution and the wind-wave interface parameter roughness length ($z_0$). To study the impact of resolution, the nesting function for both WRF and SWAN is used, with spatial resolution ranging from 25km to 2km. Meanwhile, the atmospheric forcing data of different spatial resolution, with one about 100km (FNL) and the other about 38km (CFSR) are both used. In addition, bathymetry data of
different resolutions (1arc-minute and 30arc-seconds) are used. We used three approaches to parametrize \( z_0 \). The results are validated through QuikScat data and point measurements from an open ocean site Ekosk and a coastal, relatively shallow water site Horns Rev. It is found that the modeling system captures in general better strong wind and strong wave characteristics for open ocean condition than for the coastal condition. With the current model setup, using high spatial resolution gives better results for strong winds both for the open ocean and coastal sites. The significant wave height (\( H_{m0} \)) is very sensitive to the model resolution and bathymetry data for the coastal zone. In addition, using Janssen (1991) \( z_0 \) expression gives better results of the significant wave height under high sea state conditions.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology, DHI Hørsholm
Authors: Du, J. (Intern), Larsén, X. G. (Intern), Bolanos, R. (Ekstern)
Number of pages: 9
Publication date: 2015

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Publisher: European Wind Energy Association (EWEA)
Main Research Area: Technical/natural sciences
Conference: EWEA Offshore 2015 Conference, Copenhagen, Denmark, 10/03/2015 - 10/03/2015
Electronic versions:
A_Coupled_Atmospheric_and_Wave_Modeling_System_paper.pdf. Embargo ended: 10/03/2016
Publication: Research - peer-review › Article in proceedings – Annual report year: 2015

A Critical Evaluation of Structural Analysis Tools used for the Design of Large Composite Wind Turbine Rotor Blades under Ultimate and Cycle Loading
Rotor blades for 10-20MW wind turbines may exceed 120m. To meet the demanding requirements of the blade design, structural analysis tools have been developed individually and combined with commercial available ones by blade designers. Due to the various available codes, understanding and estimating the uncertainty introduced in the design calculations by using these tools is needed to allow assessment of the effectiveness of any future design modification. For quantifying the introduced uncertainty a reference base was established within INNWIND.EU in which the several structural analysis concepts are evaluated. This paper shows the major findings of the comparative work performed by six organizations (universities and research institutes) participating in the benchmark exercise. The case concerns a 90m Glass/Epoxy blade of a horizontal axis 10MW wind turbine. The detailed blade geometry, the material properties of the constitutive layers and the aero-elastic loads formed the base by which global and local blade stiffness and strength are evaluated and compared. Static, modal, buckling and fatigue analysis of the blade were performed by each partner using their own tools; fully in-house developed or combined with commercially available ones, with its specific structural analysis approach (thin wall theory and finite element models using beam, shell or solid elements) and their preferable analysis type (linear or geometrical non-linear). Along with sectional mass and stiffness properties, the outcome is compared in terms of displacements, stresses, strains and failure indices at the ply level of the blade structure, eigen-frequencies and eigen-modes, critical buckling loads and Palmgren-Miner damage indices due to cycle loading. Results indicate that differences between estimations range from 0.5% to even 40%, depending on the property compared. Modelling details, e.g. load application on the numerical models and assumptions, e.g. type of analysis, lead to these differences. The paper covers these subjects, presenting the modelling uncertainty derived.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbines, Centre for Renewable Energy Sources, National Renewable Energy Center, Knowledge Centre Material and Constructions, Politecnico di Milano, University of Patras
Active gust load alleviation system for flexible aircraft: Mixed feedforward/feedback approach

Lightweight flexible blended-wing-body (BWB) aircraft concept seems as a highly promising configuration for future high capacity airliners which suffers from reduced stiffness for disturbance loads such as gusts. A robust feedforward gust load alleviation system (GLAS) was developed to alleviate the gust loading. This paper focuses on designing a feedback controller which would improve the robust performance of the feedforward controller in reducing the peaks in wing root moments at very short gust lengths. The simulation results show that when the new feedback compensator is engaged with the feedforward controller, the performance of the GLAS system is improved significantly in terms of reduction in wing root moments for shorter as well as for longer gusts. This reduction in the wing root moment's peak provides potential structural benefits and weight savings.
Addressing Spatial Variability of Surface-Layer Wind with Long-Range WindScanners

This paper presents an analysis of mean wind measurements from a coordinated system of long-range WindScanners. From individual scan patterns the mean wind field was reconstructed over a large area, and hence it highlights the spatial variability. From comparison with sonic anemometers, the quality of the WindScanner data is high, although the fidelity of the estimated vertical velocity component is significantly limited by the elevation angles of the scanner heads. The system of long-range WindScanners presented in this paper is close to being fully operational, with the pilot study herein serving not only as a proof of concept but also verifying expectations of reliable wind measurements over arbitrary three-dimensional volumes, in future sustained meteorological campaigns.

General information

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Organisations: Department of Wind Energy, Meteorology, Test and Measurements
Authors: Berg, J. (Intern), Vasiljevic, N. (Intern), Kelly, M. C. (Intern), Lea, G. (Intern), Courtney, M. (Intern)
Number of pages: 10
Pages: 518-527
Publication date: 2015
Main Research Area: Technical/natural sciences

Publication information

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Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 1.521 SNIP 1.425 CiteScore 2.37
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.522 SNIP 1.406 CiteScore 2.23
Adequacy of operating reserves for power systems in future European wind power scenarios

Wind power generation is expected to increase in Europe by large extent in future. This will increase variability and uncertainty in power systems. Imbalances caused due to uncertainty in wind power forecast can trigger frequency instability in the system. These imbalances are handled using operating reserves. To study the effects of these imbalances, anticipated wind scenarios for European power systems are modelled for 2020 and 2030. Wind power forecasts for different time scales and real-time available wind power are modelled. Based on these studies, this paper qualitatively analyzes the adequacy of primary and secondary reserves requirements for future European power systems. This paper also discusses the challenges due to the uncertainty in wind power forecasts and their possible solutions for wind installation scenarios for 2020 and 2030.
Aerodynamic Benchmarking of the Deepwind Design

The aerodynamic benchmarking for the DeepWind rotor is conducted comparing different rotor geometries and solutions and keeping the comparison as fair as possible. The objective for the benchmarking is to find the most suitable configuration in order to maximize the power production and minimize the blade solicitation and the cost of energy. Different parameters are considered for the benchmarking study. The DeepWind blade is characterized by a shape similar to the Troposkien geometry but asymmetric between the top and bottom parts: this shape is considered as a fixed parameter in the benchmarking process. 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 considering different blade profiles belonging to the symmetric NACA airfoil family. (C) 2015 Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license.

General information
State: Published
Organisations: Department of Wind Energy, Wind Energy Systems
Authors: Das, K. (Intern), Litong-Palima, M. (Intern), Maule, P. (Intern), Sørensen, P. E. (Intern)
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Electronic versions:
Adequacy_of_Operating_Reserves.pdf
DOIs:
10.1109/PESGM.2015.7286548

Relations
Projects:
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Source: FindIt
Source-ID: 276300372
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General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements, Aeroelastic Design, Università degli Studi di Padova
Authors: Bedona, G. (Ekstern), Schmidt Paulsen, U. (Intern), Aagaard Madsen, H. (Intern), Belloni, F. (Ekstern), Castelli, M. R. (Ekstern), Benini, E. (Ekstern)
Number of pages: 6
Pages: 677-682
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Conference: 7th International Conference on Applied Energy, Abu Dhabi, United Arab Emirates, 28/03/2015 - 28/03/2015
Main Research Area: Technical/natural sciences

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Journal: Energy Procedia
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Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.16 SJR 0.467 SNIP 0.586
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.365 SNIP 0.561 CiteScore 0.92
Aerodynamic noise characterization of a full-scale wind turbine through high-frequency surface pressure measurements

The aim of this work is to investigate and characterize the high-frequency surface pressure fluctuations on a full-scale wind turbine blade and in particular the influence of the atmospheric turbulence. As these fluctuations are highly correlated to the sources of both turbulent inflow noise and trailing edge noise, recognized to be the two main sources of noise from wind turbines, this work contributes to a more detailed insight into noise from wind turbines. The study comprises analysis and interpretation of measurement data that were acquired during an experimental campaign involving a 2 MW wind turbine with a 80 m diameter rotor as well as measurements of an airfoil section tested in a wind tunnel. The turbine was extensively equipped in order to monitor the local inflow onto the rotating blades. Further a section of the 38 m long blade was instrumented with 50 microphones flush-mounted relative to the blade surface. The measurements of surface pressure spectra are compared with the results of two engineering models for trailing edge noise and for turbulent inflow noise. The measured pressure fluctuations are related to the local inflow angle and are also compared to measurements in a wind tunnel on a copy of the blade section of the full scale blade. Computational Fluid Dynamics calculations were conducted to investigate the influence of the inflow conditions on the airfoil and blade sections aerodynamics and aeroacoustics. Comparisons between measurement data and model results show the influence of atmospheric turbulence. The different noise generation mechanisms can be identified and the influence of various parameters can be consistently reproduced by the models.

General information
State: Published
Organisations: Department of Wind Energy, Aeroelastic Design
Authors: Bertagnolio, F. (Intern), Aagaard Madsen, H. (Intern), Bak, C. (Intern), Troldborg, N. (Intern), Fischer, A. (Intern)
Pages: 729-766
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Main Research Area: Technical/natural sciences

Publication information
Journal: The International Journal of Aeroacoustics
Volume: 14
Issue number: 5-6
ISSN (Print): 1475-472X
Ratings:
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
Aerodynamic performance of wind turbine under different yaw angles

A typical dynamic characteristic of horizontal axis wind turbine shows up under yaw condition. Prediction accuracy is low for momentum-blade element theory and related engineering prediction model. In order to improve the prediction accuracy of dynamic load characteristics, the whole wind turbine models, based on the experiment about MEXICO (model experiments in controlled conditions) rotor in 2006, are established by three-dimensional software called Pro/E. under different yaw conditions, i.e. yaw angle of 0, 15, 30 and 45 degree. ICEM CFD (integrated computer engineering and manufacturing code for computational fluid dynamics) is applied to grid division. The rotating domain containing rotor part is meshed into hexahedral grids, and the static domain containing part of wheel hub, tower and outflow field is meshed into tetrahedral grids. When the grid size of the first layer of blade surface is set as $5 \times 10^{-6}$ m to ensure the first dimensionless size near the wall $Y^+ < 0.5$ on the wall, the 2 numbers of grids are determined by the error of axial load on the airfoil in the 60% section of blades, which respectively are 6 572 451 and 2 961 385. The aerodynamic performance of models under rated condition is simulated by ANSYS CFX with the turbulence model of SST (shear stress transport), high resolution is chosen as advection scheme, and transient rotor stator as the domain interface method. The results are converted into data, processed and analyzed by MATLAB. Finally the following conclusions are drawn. The distributions of pressure coefficients along the airfoil chord in different blade sections calculated by CFD method are in good agreement with the experimental measurements, and the error on the suction surface of airfoil is mainly caused by stall separation occurring on the pressure surface of airfoil. With the increasing of yaw angle, the pressure coefficients of the suction side are increasing and the location of minimum pressure coefficient moves to airfoil trailing edge slightly. For the pressure side, the pressure coefficients increase at first and then decrease, and the location of maximum pressure coefficient moves to airfoil leading edge slightly. The axial load coefficients and tangential load coefficients of blades first decrease and then increase and then decrease again with the increase of the azimuthal angle. With the increase of the yaw angle, the axial and tangential load coefficients are both reduced. When the yaw angle is within 30°, the relative error of axial load coefficients is in the range of $\pm 5\%$ and the relative error of tangential load coefficients is in the range of $\pm 15\%$. CFD method is higher than BEM (blade element momentum) method in forecasting accuracy of dynamic load calculation. Under yaw condition, the hysteresis characteristic of airfoil lift and drag in blade root is more remarkable than blade tip, while the variation range of the angle of attack in blade root is much less than that in blade tip. This characteristic must be considered when BEM method is used to predict wind turbine performance. For axial inflow condition, CFD method can well predict the average speed, but restricted by turbulence model and the wake model, CFD calculation did not show the velocity characteristics of rotating vortex shedding from wind turbine impeller under yaw condition. The study provides a data support to build up the forecast model on the engineering and provides the basis for wind turbine design under yaw condition.
Aerodynamic response of an airfoil section undergoing pitch motion and trailing edge flap deflection: a comparison of simulation methods

The study presents and compares aerodynamic simulations for an airfoil section with an adaptive trailing edge flap, which deflects following a smooth deformation shape. The simulations are carried out with three substantially different methods: a Reynolds-averaged Navier–Stokes solver, a viscous–inviscid interaction method and an engineering dynamic stall model suitable for implementation in aeroelastic codes based on blade element momentum theory. The aerodynamic integral forces and pitching moment coefficients are first determined in steady conditions, at angles of attack spanning from attached flow to separated conditions and accounting for the effects of flap deflection; the steady results from the Navier–Stokes solver and the viscous–inviscid interaction method are used as input data for the simpler dynamic stall model. The paper characterizes then the dynamics of the unsteady forces and moments generated by the airfoil undergoing harmonic pitching motions and harmonic flap deflections. The unsteady aerodynamic coefficients exhibit significant variations over the corresponding steady-state values. The dynamic characteristics of the unsteady response are predicted with an excellent agreement among the investigated methods at attached flow conditions, both for airfoil pitching and flap deflection. At high angles of attack, where flow separation is encountered, the methods still depict similar overall dynamics, but larger discrepancies are reported, especially for the simpler engineering method. Copyright © 2014 John Wiley & Sons, Ltd.
Aerodynamics of wind turbines

Aerodynamics of Wind Turbines is the established essential text for the fundamental solutions to efficient wind turbine design. Now in its third edition, it has been substantially updated with respect to structural dynamics and control. The new control chapter now includes details on how to design a classical pitch and torque regulator to control rotational speed and power, while the section on structural dynamics has been extended with a simplified mechanical system explaining the phenomena of forward and backward whirling modes. Readers will also benefit from a new chapter on Vertical Axis Wind Turbines (VAWT).

Topics covered include increasing mass flow through the turbine, performance at low and high wind speeds, assessment of the extreme conditions under which the turbine will perform and the theory for calculating the lifetime of the turbine. The classical Blade Element Momentum method is also covered, as are eigenmodes and the dynamic behaviour of a turbine.

The book describes the effects of the dynamics and how this can be modelled in an aeroelastic code, which is widely used in the design and verification of modern wind turbines. Furthermore, it examines how to calculate the vibration of the whole construction, as well as the time varying loads and global case studies.
Aero-Elastic Optimization of a 10 MW Wind Turbine

This article describes a multi-disciplinary optimization and analysis tool for wind turbines that is based on the open-source framework OpenMDAO. Interfaces to several simulation codes have been implemented which allows for a wide variety of problem formulations and combinations of models. In this article concurrent aerelastic optimization of a 10 MW wind turbine rotor is carried out with respect to material distribution and planform. The optimizations achieve up to 13% mass reduction while maintaining the same power production compared to the baseline DTU 10MW RWT.

Aggregated wind power plant models consisting of IEC wind turbine models

The common practice regarding the modelling of large generation components has been to make use of models representing the performance of the individual components with a required level of accuracy and details. Owing to the rapid increase of wind power plants comprising large number of wind turbines, parameters and models to represent each individual wind turbine in detail makes it necessary to develop aggregated wind power plant models considering the simulation time for power system stability studies. In this paper, aggregated wind power plant models consisting of the IEC 61400-27 variable speed wind turbine models (type 3 and type 4) with a power plant controller is presented. The performance of the detailed benchmark wind power plant model and the aggregated model are compared by means of simulations for the specified test cases. Consequently, the results are summarized and discussed in terms of model accuracy, simulation time and modeling assumptions.
Airfoil Trailing Edge Noise Generation and Its Surface Pressure Fluctuation

In the present work, Large Eddy Simulation (LES) of turbulent flows over a NACA 0015 airfoil is performed. The purpose of such numerical study is to relate the aerodynamic surface pressure with the noise generation. The results from LES are validated against detailed surface pressure measurements where the time history pressure data are recorded by the surface pressure microphones. After the flow-field is stabilized, the generated noise from the airfoil Trailing Edge (TE) is predicted using the acoustic analogy solver, where the results from LES are the input. It is found that there is a strong relation between TE noise and the aerodynamic pressure. The results of power spectrum density show that the fluctuation of aerodynamic pressure is responsible for noise generation.

A LiDAR method of canopy structure retrieval for wind modeling of heterogeneous forests

The difficulty of obtaining accurate information about the canopy structure is a current limitation towards higher accuracy in numerical predictions of the wind field in forested terrain. The canopy structure in computational fluid dynamics is specified through the frontal area density and this information is required for each grid point in the three-dimensional computational domain. By using raw data from aerial LiDAR scans together with the Beer-Lambert law, we propose and test a method to calculate and grid highly variable and realistic frontal area density input. An extensive comparison with ground-based measurements of the vertically summed frontal area density (or plant area index) and tree height was used to optimize the method, both in terms of plant area index magnitude and spatial variability. The resolution of the scans was in general low.
A morphing trailing edge flap system for wind turbine blades

The development of a morphing trailing edge system for wind turbines, also called a flap system, is presented. The functionality is simple as the flap deflection is controlled by pressurized air or a fluid in a number of voids in the flap made of an elastic material. It is thus a robust system as no mechanical or metal parts are used. The prototypes tested in the laboratory and on a blade section in a wind tunnel in the period from 2007-2010 demonstrated the functionality and the aerodynamic performance of the flap concept. In a recent research and development project INDUFLAP from 2011-2014 the flap system has been further developed in corporation with the industrial partners Hydratech Industries (DK) and Rehau (DE). A new trailing edge flap design with spanwise voids (channels) and with a chord of 15cm suitable for a 1m chord blade section was developed. It was then manufactured by extrusion and glued together with a load carrying part with a connector part that allows an easy attachment on the blade section. After tests in the laboratory the flap was mounted on a 2m long blade section mounted on a newly developed test rig. A 10m long boom with the blade section was installed on a 100kW turbine hub where the original blades were taken down. It means that the flap system was tested under realistic rotating conditions with real atmospheric turbulent inflow and with a g loading up to 10g which represents the conditions on the outer part of a MW turbine blade. The measured performance of the flap system shows that 3 deg. flap deflection gives the same lift change as 1 deg. pitch of the whole blade section.

General information
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Analysis of Two-Dimensional Inflow Measurements by Lidar-Based Wind Scanners

The DTU led UniTTe project (unitte.dk) wants to establish lidars for power and load estimations for modern wind turbines. As these novel methods rely on scanning the flow upstream of the turbine, they come under the influence of the turbine induction zone [2], which develops due to the pressure jump induced by the turbine. Modeling and understanding the induction zone is key to establishing lidars as an industry standard for power and load estimations. Successfully modelling the upstream effects of the turbine, though, necessitates validation via measurements. The in-house developed short-range WindScanner system (windscanner.eu) is able to capture the entire wind field upstream by combining three synchronised lidars [1] and thus presents the ideal measurement tool for validating numerical models or other lidar systems. This paper presents the challenges and methods in post-processing two-dimensional wind fields acquired by WindScanner like lidar systems for model validation purposes.

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Analytical velocity field in just a sec

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Ancillary services from renewable power plants- RePlan project perspective

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An efficient and accurate method for computation of energy release rates in beam structures with longitudinal cracks
This paper proposes a novel, efficient, and accurate framework for fracture analysis of beam structures with longitudinal cracks. The three-dimensional local stress field is determined using a high-fidelity beam model incorporating a finite element based cross section analysis tool. The Virtual Crack Closure Technique is used for computation of strain energy release rates. The devised framework was employed for analysis of cracks in beams with different cross section geometries. The results show that the accuracy of the proposed method is comparable to that of conventional three-dimensional solid finite element models while using only a fraction of the computation time.

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An evaluation of the WindEye wind lidar
Prevision of the wind field by remote sensing wind lidars has the potential to improve the performance of wind turbines. The functionality of a WindEye lidar developed by Windar Photonics A/S (Denmark) for the wind energy market was tested in a two months long field experiment. The WindEye sensor measures the wind speed along two beams to determine the wind direction of the incoming wind field. The field experiment utilized two sonic anemometers located in the two centers of the measurement volumes of the WindEye as reference instruments. It was found that the WindEye measured the wind direction with a high accuracy during the whole campaign.

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A New Coordinated Voltage Control Scheme for Offshore AC Grid of HVDC Connected Offshore Wind Power Plants
This paper proposes a coordinated voltage control scheme (CVCS) which enhances the voltage ride through (VRT) capability of an offshore AC grid comprised of a cluster of offshore wind power plants (WPP) connected through AC cables to the offshore voltage source converter based high voltage DC (VSC-HVDC) converter station. Due to limited short circuit power contribution from power electronic interfaced variable speed wind generators and with the onshore main grid decoupled by the HVDC link, the offshore AC grid becomes more vulnerable to dynamic voltage events. Therefore, a short circuit fault in the offshore AC Grid is likely to have significant implications on the voltage of the offshore AC grid, hence on the power flow to the onshore mainland grid. The proposed CVCS integrates individual local reactive power control of wind turbines and of the HVDC converter with the secondary voltage controller at offshore grid level. This secondary voltage controller controls the voltage at the pilot bus, the bus with the highest short circuit capacity in the offshore AC grid. By maintaining voltage at the pilot bus, reflecting the voltage variations of the entire offshore zone, the voltage profile of the offshore grid is indirectly maintained. During steady state operation, the secondary AC voltage controller generates reactive power references for individual wind turbines (WTs) based on their participation factors (PFs) and available reactive power margins, while during dynamic voltage events; the secondary voltage controller generates additional reactive power reference signals for WTs and the HVDC converter, to enhance VRT capability of the offshore AC network. The Participation Factor of each WT is calculated from their dV / dQ sensitivities w.r.t. the pilot bus. The WT and the HVDC converter control is modified to accommodate additional reactive power reference from the secondary controller, while maintaining their local VRT capability. A detailed model of 800 MW VSC-HVDC connected OWPP cluster developed in DigSILENT platform is considered in this study. VSC-HVDC transmission system operates at +/- 320 kV with active power balance (hence DC voltage) control assigned to the onshore converter, while frequency and AC voltage control at the offshore substation assigned to the offshore converter.

General information
A new DTU-lead European Research Infrastructure for 3D Wind Field Measurements using Space and Time Synchronized WindScanners

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A new method to estimate the uncertainty of AEP of offshore wind power plants applied to Horns Rev 1
The present article proposes a framework for validation of stationary wake models that wind developers can use to predict the energy production of a wind power plant more accurately. The application of this framework provides a new way to quantify the uncertainty of annual energy production predictions. Additionally this methodology enables the fair comparison of different wake models. Furthermore the methodology enables the estimation of how much information can be obtained from a measurement dataset to quantify model inadequacy. In the present work the proposed framework is applied to the Horns Rev 1 offshore wind power plant. The model uncertainty of a modified N. O. Jensen wake model under uncertain undisturbed flow conditions was studied. Evidence of model inadequacy is found in terms of a bias in the predicted AEP distribution. It was found that the use of the official power curve compensates the errors in the wake model, as a consequence a larger uncertainty of the overall model is predicted. Furthermore a study of wake model benchmarking based on filtered flow cases indicates that measurement uncertainty in the wind speed and wind direction is large enough to obtain any evidence of model inaccuracy even for the simplest wake models.

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An improved k-ε model applied to a wind turbine wake in atmospheric turbulence

An improved k-ε turbulence model is developed and applied to a single wind turbine wake in a neutral atmospheric boundary layer using a Reynolds averaged Navier–Stokes solver. The proposed model includes a flow-dependent Cμ that is sensitive to high velocity gradients, e.g., at the edge of a wind turbine wake. The modified k-ε model is compared with the original k-ε eddy viscosity model, Large-Eddy Simulations and field measurements using eight test cases. The comparison shows that the velocity wake deficits, predicted by the proposed model are much closer to the ones calculated by the Large-Eddy Simulation and those observed in the measurements, than predicted by the original k-ε model.

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An overview of recent research on AM and OAM of wind turbine noise

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A phase-field simulation study of irregular grain boundary migration during recrystallization
We present simulation results based on a phase-field model that describes the migration of recrystallization boundaries into spatially varying deformation energy fields. Energy fields with 2-dimensional variations representing 2 sets of dislocation boundaries lying at equal, but opposite, angles to the moving boundary are considered. The simulations show that the shape and overall migration rate of the recrystallization front is considerably affected by spatial variations in the deformation microstructure. It is seen that, depending on characteristics of the variations in the deformation microstructure, highly asymmetrical protrusions and retrusions can develop on the migrating recrystallization front resulting in a migration velocity considerably larger than that expected from standard recrystallization models. It is also seen that, when the wavelength of the variations in a deformation microstructure along the grain boundary is larger than the wavelength of the variations in the direction of migration, parts of the boundary show a stop-and-go type of migration, resulting in a lower overall migration rate. These simulations thus reproduce and explain many of the typical features...
observed in recrystallization experiments. They give new insights in the way deformation microstructures can affect the migration behavior of recrystallization boundaries and can lead to a stop-and-go type of migration of the recrystallization boundary even in pure materials.

General information
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Main Research Area: Technical/natural sciences

Application of lidars for assessment of wind conditions on a bridge site
Wind measurement techniques based on remote optical sensing, extensively applied in wind energy, have been exploited in civil engineering only in a limited number of studies. The present paper introduces a novel application of wind lidars in bridge engineering, and presents the findings from the pilot measurement campaign on the Lysefjord Bridge in the South-West Norway. A single long-range pulsed WindScanner lidar and two short-range continuous-wave WindScanner lidars were deployed, in addition to five sonic anemometers installed on the bridge itself, the latter for long-term wind characterization. The paper presents a promising comparison of the measurements obtained by the three different sets of instruments, and discusses their complementary value.

General information
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Organisations: Department of Wind Energy, Test and Measurements, Meteorology, University of Stavanger, Christian Michelsen Research, University of Bergen
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Applications of Telecommunication Transceiver Architectures in All-Fiber Coherent Detection Lidars

Coherent detection lidars have evolved over time and gradually become the de facto instruments for high resolution measurement of atmospheric boundary layer winds. The earlier versions of these lidars were bulky, expensive, and suffered from vulnerability to environmental effects such as temperature and vibrations. However, with the advent of fiber-optic communications a new class of stable, cost-effective, and low-maintenance optical components became available to the lidar community. Coherent detection lidars share many similarities with the high-speed fiber-optic communications. As a result, the new fiber-optic technology was quickly adopted in these lidars. Although coherent detection lidars, especially all-fiber coherent detection lidars, have benefited from the technology available in coherent fiber-optic communications, a considerable gap (in both research and technology) seems to exist between the two. In this thesis, I have presented some of the advances in fiber-optic transceivers, originally developed for high-speed data transmission, and shown how they can be integrated in micropulse and continuous-wave all-fiber coherent detection lidars. Applications of Telecommunication Transceiver Architectures in All-Fiber Coherent Detection Lidars. In Paper I a new short-range all-fiber coherent Doppler lidar employing an image-reject homodyne receiver is described and demonstrated. In Paper II two different approaches to signal processing, necessary for the estimation of mean velocity from the spectra, are discussed and the associated advantages and disadvantages such as the signal to noise ratio and signal processing overhead are
discussed. The performance of the system proposed paper I is put to test in a real measurement campaign the results of which are discussed in Paper III. In Paper IV a patent-pending long-range polarization-diversity coherent Doppler lidar is presented. The system benefits from an improved transmit power (thanks to the availability of two erbium-doped fiber amplifiers separated in polarization) while having the ability to detect the depolarized backscatter signals. The ability to detect the degree of depolarization enables the characterization of aerosol types associated with each measurement range. Eventually, it is shown in Paper V that by adopting the image-reject homodyne receiver in an all-fiber coherent detection lidar, the spectrum of the Rayleigh or the spontaneous Rayleigh-Brillouin scattering (depending on the operating conditions) can be resolved. The system benefits from an eye-safe 1.5μm laser and can provide simultaneous measurements of temperature, pressure, and wind. The focus of the paper in Paper V is the temperature measurement capability of the system, provided as the proof of concept through numerical simulations.

**General information**

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**A primal-dual interior point method for large-scale free material optimization**

Free Material Optimization (FMO) is a branch of structural optimization in which the design variable is the elastic material tensor that is allowed to vary over the design domain. The requirements are that the material tensor is symmetric positive semidefinite with bounded trace. The resulting optimization problem is a nonlinear semidefinite program with many small matrix inequalities for which a special-purpose optimization method should be developed. The objective of this article is to propose an efficient primal-dual interior point method for FMO that can robustly and accurately solve large-scale problems. Several equivalent formulations of FMO problems are discussed and recommendations on the best choice based on the results from our numerical experiments are presented. Furthermore, the choice of search direction is also investigated numerically and a recommendation is given. The number of iterations the interior point method requires is modest and increases only marginally with problem size. The computed optimal solutions obtain a higher precision than other available special-purpose methods for FMO. The efficiency and robustness of the method is demonstrated by numerical experiments on a set of large-scale FMO problems.

**General information**

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BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.32 SNIP 1.485 CiteScore 1.56
A probabilistic analysis of the dynamic response of monopile foundations: Soil variability and its consequences

The reliability of offshore wind turbines is highly influenced by the uncertainties related to the subsoil conditions. Traditionally, the evaluation of the dynamic structural behaviour is based on a computational model with deterministic soil properties. Using this approach, however, provides limited insight into the variation of the estimate of the inherent modal properties and loads. In this paper, a comprehensive study is performed on the dynamic behaviour of an offshore wind turbine installed on a monopile foundation. Based on consistent lumped-parameter models calibrated to semi-analytical impedance functions of a monopile embedded in a stochastic linear viscoelastic soil layer, fully coupled aero-hydro-elastic simulations are conducted in the nonlinear multi-body code Hawc2. The probabilistic analysis accounts for the uncertainty of soil properties (e.g. damping and stiffness) and relies on a Monte Carlo method facilitating the derivation of the probability densities of the modal properties and the fatigue loading. The main conclusion of the presented work is that the dynamic structural behaviour of the wind turbine and its support structure is strongly affected by the stochastic soil properties. Lognormal and Gumbel distributed modal damping and accumulated side-side fatigue damage equivalent moments with a coefficient of variation of 30% and 8%, respectively, are observed.

General information
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Organisations: Department of Wind Energy, VESTAS Wind Systems A/S, Aalborg University
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A qualitative analytical investigation of geometrically nonlinear effects in wind turbine blade cross sections

This paper analytically investigates the Brazier effect on asymmetric thin-walled sections subject to biaxial bending. In the latter case a torsional moment – in this paper referred to as Brazier torsion – is induced, which proved to be a vital part of the solution. By means of a generic cross section, that was inspired by a wind turbine blade, it is demonstrated that geometric nonlinear effects can induce an in-plane opening deformation in re-entrant corners that may decrease the fatigue life. The opening effect induces Mode-I stress intensity factors which exceed the threshold for fatigue crack growth at loads well below the load-carrying capacity of the beam.

The findings in this paper are twofold: Firstly, the investigated analysis procedure can be integrated into the design process of wind turbine blade cross sections. Secondly, the proposed approach serves as a basis for computationally efficient numerical analysis approaches of structures that comprise complex geometry and anisotropic material behaviour – such as wind turbine rotor blades.
A signal pre-processing algorithm designed for the needs of hardware implementation of neural classifiers used in condition monitoring

Gearboxes have a significant influence on the durability and reliability of a power transmission system. Currently, extensive research studies are being carried out to increase the reliability of gearboxes working in the energy industry, especially with a focus on planetary gears in wind turbines and bucket wheel excavators. In this paper, a signal pre-processing algorithm designed for condition monitoring of planetary gears working in non-stationary operation is presented. The algorithm is dedicated for hardware implementation on Field Programmable Gate Arrays (FPGAs). The purpose of the algorithm is to estimate the features of a vibration signal that are related to failures, e.g. misalignment and unbalance. These features can serve as the components of an input vector for a neural classifier. The approach proposed here has several important benefits: it is resistant to small speed fluctuations up to 7%, it can be performed in real-time conditions and its implementation does not require many resources of FPGAs.

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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
A six-beam method to measure turbulence statistics using ground-based wind lidars

A so-called six-beam method is proposed to measure atmospheric turbulence using a ground-based wind lidar. This method requires measurement of the radial velocity variances at five equally spaced azimuth angles on the base of a scanning cone and one measurement at the centre of the scanning circle, i.e. using a vertical beam at the same height. The scanning configuration is optimized to minimize the sum of the random errors in the measurement of the second-order moments of the components (u;v;w) of the wind field. We present this method as an alternative to the so-called velocity azimuth display (VAD) method that is routinely used in commercial wind lidars, and which usually results in significant averaging effects of measured turbulence. In the VAD method, the high frequency radial velocity measurements are used instead of their variances. The measurements are performed using a pulsed lidar (WindScanner), and the derived turbulence statistics (using both methods) such as the u and v variances are compared with those obtained from a reference cup anemometer and a wind vane at 89m height under different atmospheric stabilities. The measurements show that in comparison to the reference cup anemometer, depending on the atmospheric stability and the wind field component, the six-beam method measures between 85 and 101% of the reference turbulence, whereas the VAD method measures between 66 and 87% of the reference turbulence.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements, Meteorology
Authors: Sathe, A. (Intern), Mann, J. (Intern), Vasiljevic, N. (Intern), Lea, G. (Intern)
Pages: 729-740
Publication date: 2015
A smart rotor configuration with linear quadratic control of adaptive trailing edge flaps for active load alleviation

The paper proposes a smart rotor configuration where adaptive trailing edge flaps (ATEFs) are employed for active alleviation of the aerodynamic loads on the blades of the NREL 5 MW reference turbine. The flaps extend for 20% of the blade length and are controlled by a linear quadratic (LQ) algorithm based on measurements of the blade root flapwise bending moment. The control algorithm includes frequency weighting to discourage flap activity at frequencies higher than 0.5 Hz. The linear model required by the LQ algorithm is obtained from subspace system identification; periodic disturbance signals described by simple functions of the blade azimuthal position are included in the identification to avoid biases from the periodic load variations observed on a rotating blade. The LQ controller uses the same periodic disturbance signals to handle anticipation of the loads periodic component. The effects of active flap control are assessed with aeroelastic simulations of the turbine in normal operation conditions, as prescribed by the International Electrotechnical Commission standard. The turbine lifetime fatigue damage equivalent loads provide a convenient summary of the results achieved with ATEF control: 10% reduction of the blade root flapwise bending moment is reported in the simplest control configuration, whereas reductions of approximately 14% are achieved by including periodic loads anticipation. The simulations also highlight impacts on the fatigue damage loads in other parts of the structure, in particular, an increase of the blade torsion moment and a reduction of the tower fore-aft loads. Copyright © 2014 John Wiley & Sons, Ltd.
Assessment of consistent two-equation closure for forest flows

Two-equation closure is a pragmatic compromise between simple first-order and more complex higher-order closure schemes for modelling atmospheric flows with CFD. However, the problem of treating plant drag has seriously limited the use of such closures in many applications. Recently a consistent closure implementing those effects was developed through consideration of the behaviour of the supplementary equation for the length-scale-determining variable in different turbulent flows (Sogachev et al., 2012: Boundary Layer Meteor., 145, 307-327). Being consistent with the canonical flow regimes of grid turbulence and wall-bounded flow, the closure suggested is also valid for homogeneous shear flows commonly observed inside tall vegetative canopies. The present work assess the plant drag closure by comparing results of two different CFD models against observations derived over the forested area of Østerild in Denmark. Part of the forest was cut in 2011, and this provided a unique opportunity for testing models allowing two scenarios for land use and corresponding observation datasets (2008 – 2013). The numerical experiments show that the treatment of plant drag in the closure has universality and can be applied for any twoequation closure. Results derived by different CFD models with k-epsilon and k-omega closure are similar and in good comparison with observations. Overall, numerical results show that the closure performs well, opening new possibilities for application to tasks related to the atmospheric boundary layer—where it is important to adequately account for the influences of vegetation.

General information

State: Published
Organisations: Department of Wind Energy, Resource Assessment Modelling, Meteorology & Remote Sensing
Authors: Sogachev, A. (Intern), Cavar, D. (Intern), Bechmann, A. (Intern), Ejsing Jørgensen, H. (Intern)
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Main Research Area: Technical/natural sciences
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EWEA_2015_full_paper.pdf
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Assessment of extreme design loads for modern wind turbines using the probabilistic approach

There is a large drive to reduce the cost of energy of wind energy generators. Various tracks are being considered such as enhanced O&M strategies through condition monitoring, increased manufacturing efficiency through higher production volumes and increased automation, improved resource assessment through turbine-mounted real-time site assessment technologies, improved components reliability by increased laboratory testing, increased number of prototype test turbines before serial production, larger rotor and tower concepts for both onshore and offshore installations, advanced drive train designs, advanced load alleviation control systems, extensive industrialization and modularization of components, cost-out programs, increased components redundancies where possible, etc [Schwabe, P., Lensink, S., Hand, 2011]. Twenty five years ago an offshore wind turbine consisted of 2/3 of the total capital cost (excluding foundations), today this value has dropped down to roughly 30-40% [IRENA, 2012, CleanEnergyPipeline, 2014]. Wind turbine manufacturers and researchers have indeed delivered on the promise of cost reduction, but the question remains: can we do more?

The research in this thesis aimed to contribute to the larger objective of reducing cost of energy through the implementation and application of uncertainty quantification and probabilistic methodologies on specific areas of design of wind turbines, namely: (a) aerofoil aerodynamic lift and drag, (b) load alleviation control features and (3) fusion of output from multi-fidelity aero-servo-elastic simulators. Why uncertainty quantification and probabilistic methodologies? Because such methodologies provide tools that makes it possible to design a wind turbine to a specific probability of failure, which means wind turbines are as strong as necessary, but no stronger [Veldkamp, 2006].

The original contributions of this research were:
- A comprehensive list of sources of uncertainties affecting the prediction of extreme loads on a wind turbine. Such a list is indeed subjective and subject to scrutiny and updating depending on a researcher’s, scientist’s and engineer’s background, know-how and experiences.
- A fully encompassing stochastic model of aerofoil aerodynamic lift and drag coefficients, followed by a quantification of
the effect of aerodynamic uncertainties on the extreme loads and an optimization of the partial safety factors.

- An in-depth analysis of how advanced load alleviation control features such as cyclic pitch, individual pitch, static thrust limiter, condition based thrust limiter and an active tower vibration damper affect the structural reliability of a multi-megawatt wind turbine blade and tower when the extreme turbulence model is uncertain. The novelty is in the subsequent cost and reliability based optimization of the load partial safety factor, turbine geometry, controller failure rate and structural reliability metrics of a large multi-megawatt wind turbine equipped with advanced load alleviation control features. The objective here was to investigate how the load partial safety factors are affected by the performance of various configurations of advanced load alleviation control features to limit the excursion of extreme loads above a certain threshold.

- A detailed implementation of a model fusion technique called co-Kriging to predict the extreme response in the presence of non-stationary noise in the output (i.e. the magnitude of noise varies as a function of the input variables) in the case when the low and high-fidelity aero-servo-elastic simulators of the same wind turbine are implemented by two independent engineers (i.e. human error and uncertainty in the modelling and input assumptions are implicitly included). We demonstrate the co-Kriging methodology to fuse the extreme blade root flapwise bending moment of a large multi-megawatt wind turbine by using two aero-servo-elastic simulators, FAST [Jonkman and Buhl, 2005] and BLADED ([Bossanyi, 2003b], [Bossanyi, 2003a]).

The main findings of the work and their implications were:

- The assessment of uncertainties in the aerodynamic lift and drag were done through a heuristic based stochastic model which replicates the uncertainties in airfoil characteristics by parameterizing the lift and drag coefficients polar curves. In the IEC61400-1 design standard for wind turbines, a value of 10% for the coefficient of variation (COV) on the uncertainty related to the assessment of the aerodynamic lift and drag coefficients is used. The findings in this research indicate that while this value is appropriate for certain structural components such as blade tip flapwise and main shaft tilt and yaw moments, it is conservative for components such as blade root flapwise, edgewise and tower. An overall assessment of uncertainties in the aerodynamic static lift and drag coefficients showed (a) a tangible reduction in the load partial safety factor for a blade and (b) generally a larger impact on extreme loads during power production compared to stand-still.

Therefore, the way forward is for wind turbine manufactures to further update the stochastic model by integrating their own data to assess the impact of the aerodynamic uncertainty on their specific wind turbine. The stochastic model can also be used as a tool for a probabilistic design and risk mitigation in the early stages of the aerodynamic design of a wind turbine rotor.

- Large uncertainties in the extreme turbulence model can be significantly mitigated through the use of advanced load control features. The magnitude, scatter and shape of the annual maximum distribution of the loads is dependent on the performance of the load alleviation control features such as individual pitch control and condition based thrust limiter to limit the excursion of extreme loads above a certain threshold. The reduction in the mean of the annual maximum load distribution and the coefficient of variation due to the action of advanced load alleviation control features in turn translated into a higher structural reliability level in the face of uncertainties in the extreme turbulence model.

- The probabilistic cost and reliability based optimization methodology showed that a tangible reduction in the load partial safety factors can be achieved when advanced load alleviation control features are used while maximizing the benefits versus costs and while maintaining acceptable target probability of failure. However, some configurations of advanced load alleviation control features yield annual maximum load distribution with very low coefficient of variation (i.e. on the order of 2.3%); in this case the model and statistical sources of uncertainties dominate the reliability analysis resulting in higher load partial safety factors. It was shown that the benefits were maximized when the annual failure rate of advanced load alleviation control features is around 103. A key finding is that the overall probability of failure of the structure-control system is far dominated by the annual failure rate of the control system. This means that decreasing the annual failure rate of the control system would have a larger impact than improving the reliability of the structure.

- Assuming that the output of the high-fidelity (BLADED) and low-fidelity (FAST) aero-servo-elastic simulators follow similar trends as a function of an independent variables (i.e. bending moment as a function of wind speed), the co-Kriging based methodology fused the “noisy” extreme flapwise bending moment at the blade root of a large wind turbine from a low fidelity and a high-fidelity aero-servo-elastic simulators; the co-Kriging predictions compared well with validation data. Therefore, the way forward is to fuse output from multiple aero-servo-elastic simulators in order to reduce model uncertainties and refine the probability of failure of the wind turbine structure.
Assessment of Gearbox Operational Loads and Reliability under High Mean Wind Speeds

This paper investigates the dynamic loads occurring in the drivetrain of wind turbines with a focus on offshore applications. Herein a model of the gearbox of the 5 MW wind turbine is presented. The model is developed in a multi-body framework using commercial software MSC ADAMS. Validation of the model was based on the experimental data provided by NREL for 750 kW prototype gearbox. Failures of gearboxes caused by high dynamic loads have a significant influence on the cost of operation of wind farms. For these reasons in the study, the probability of failure of the gearbox working in an offshore wind turbine that operates in storm conditions with mean wind speeds less than 30 m/s is presented. In the study, normal shut-downs of a wind turbine in storm conditions were investigated. The analysis were conducted for two storm control strategies and different wind conditions from an extreme operating gust, normal turbulence model and extreme turbulence model. In the paper, loads in the planetary gear are quantified as well as the torsional moments in the main shaft. On the basis of simulation results the annual probability of failure of the gearbox in a wind turbine with soft storm controller is calculated, and compared with the one had the gearbox working in a wind turbine operating with hard storm controller. In the study, it was found that normal shut-downs do not have a significant influence on the ultimate loads in the gearbox, since they are related mostly to the gusts occurring during turbulence. Application of the storm controller with reduction of the wind turbine power allowed the decrease of the probability of failure for ultimate stresses.

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Web of Science (2013): Indexed yes
Scopus rating (2012): SJR 0.425 SNIP 0.563 CiteScore 1.08
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Web of Science (2012): Indexed yes
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ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.433 SNIP 0.957
Web of Science (2009): Indexed yes
Assessment of wind conditions at a fjord inlet by complementary use of sonic anemometers and lidars

Wind velocity measurement devices based on the remote optical sensing, lidars, are extensively applied in wind energy research and wind farm operation. The present paper demonstrates the relevance and potential of lidar measurements for other wind-sensitive structures such as long-span bridges. In a pilot study in Lysefjord, Norway, a pulsed long-range lidar and two short-range WindScanners were installed at the bridge site, together with a long-term monitoring system based on sonic anemometers. The deployment of the two types of lidars is described in more details and the complementary value of the data from all three types of the instruments is illustrated. The emphasis is on the lidars’ potential to map the wind conditions along the whole span of a bridge in a complex terrain, as opposed to "point" measurements achievable by sonic anemometers. The challenging balance between the spatial and temporal resolution of the data is discussed.

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Organisations: Department of Wind Energy, Test and Measurements, Meteorology, University of Stavanger, University of Bergen, Christian Michelsen Research
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  Scopus rating (2012): SJR 0.425 SNIP 0.563 CiteScore 1.08
  ISI indexed (2012): ISI indexed no
  Web of Science (2012): Indexed yes
  Scopus rating (2011): SJR 0.918 SNIP 1.505 CiteScore 2.42
  ISI indexed (2011): ISI indexed no
  Web of Science (2009): Indexed yes

Original language: English
Assessment of wind turbine drive-train fatigue loads under torsional excitation

This paper establishes validated models that can accurately account for the dynamics of the gearbox, along with the external dynamics that excite the system. A drive-train model implementation is presented where the gearbox and generator are coupled to the wind turbine structure in a dynamic simulation environment. The wind turbine is modelled using HAWC2 (Horizontal Axis Wind turbine simulation Code 2nd generation) and the gearbox is described using lumped parameters in MATLAB/Simulink. Each component in the gearbox model includes rotational and translational degree-of-freedom (DOF), which allows the computation of the bearing and gear-mesh loads. The proposed models are validated by experiments from a 750 kW test-rig. The drive-train model is configured for a 5 MW power capacity and coupled to the corresponding wind turbine and load simulations are carried out under turbulent wind following the guidelines from the IEC 61400-1 standard. Fatigue analysis shows the effect in the bearing damage equivalent loads, when including a detailed drive-train model in the overall wind turbine simulation for a 20 year period. Results show a higher level of damage (up to 180%) when the detailed model is used in comparison to a simplified approach for load calculation. It is found that some of the wind turbine modes can have negative consequences on the life-time of the planetary bearings. © 2015 Elsevier Ltd. All rights reserved.
Assessment Report on Innovative Rotor Blades (MAREWINT WP1,D1.3)

The offshore wind energy industry faces many challenges in the short to medium term if it is to meet the ambitions of the global community for sustainable energy supply in the future. Not least among these challenges is the issue of rotor blades. Innovative design for “smart” rotor blades with embedded sensors and actuation are being developed that will deliver an improved whole-life performance, and a structural health management based operational concept.

In this report, the work of two early stage researchers within the Initial Training Network MAREWINT is presented that support the innovative concept development for wind turbine blades. This covers models and experiments with damage measurement systems embedded within the composite material/structure and numerical methods investigating the effects of leading and trailing edge flaps on modifying the aerodynamic loads on the operating rotor.

General information
State: Published
Organisations: Department of Wind Energy, Composites and Materials Mechanics, University of Glasgow
Authors: McGugan, M. (Intern), Leble, V. (Ekstern), Pereira, G. F. (Intern)
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Bibliographical note
Work Package report/deliverable for the MAREWINT project (FP7-PEOPLE-2012-ITN, nr.309395)
A statistical methodology for the estimation of extreme wave conditions for offshore renewable applications

Accurate estimation of extreme wave conditions is critical for offshore renewable energy activities and applications. The use of numerical wind and wave models gives a credible and convenient way of monitoring the general atmospheric and sea state conditions, especially in the absence of sufficient observational networks. However, when focusing on the study of non-frequent cases, in particular over coastal areas, increased uncertainty in the model outputs and accordingly in the reliability of the estimation of extreme waves becomes an important issue. The current study introduces a methodology to validate and post-process outputs from a high resolution numerical wave modeling system for extreme wave estimation based on the significant wave height. This approach is demonstrated through the data analysis at a relatively deep water site, FINO 1, as well as a relatively shallow water area, coastal site Horns Rev, which is located in the North Sea, west of Denmark. The post-processing targets at correcting the modeled time series of the significant wave height, in order to match the statistics of the corresponding measurements, including not only the conventional parameters such as the mean and standard deviation, but also a new parameter, the second-order spectral moment. This second-order spectral moment is essential for extreme value estimation but has so far been neglected in relevant studies. The improved model results are utilized for the estimation of the 50-year values of significant wave height as a characteristic index of extreme wave conditions. The results from the proposed methodology seem to be in a good agreement with the measurements at both the relatively deep, open water and the shallow, coastal water sites, providing a potentially useful tool for offshore renewable energy applications. © 2015 Elsevier Ltd. All rights reserved.
A study on rotational augmentation using CFD analysis of flow in the inboard region of the MEXICO rotor blades

This work presents an analysis of data from existing as well as new full-rotor computational fluid dynamics computations on the MEXICO rotor, with focus on the flow around the inboard parts of the blades. The boundary layer separation characteristics on the airfoil sections in the inboard parts of the rotor are analysed using the pressure and the skin friction data at a range of angles of attack. These data are used to gain insight on the relative behaviour of separated boundary layers in 3D flow compared with 2D flow. It has been found that separation on airfoils in rotating flows is different from that in 2D flows in two respects: (i) there is a chord-wise postponement (or delay) of the separation point, and (ii) the angle of attack at which separation is initiated is higher in 3D compared with 2D. Comments are made on the mechanism of stall delay, and the main differences between the skin friction and pressure distribution behaviours in 2D and 3D rotating flows are highlighted. Copyright © 2014 John Wiley & Sons, Ltd.

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Organisations: Department of Wind Energy, Aeroelastic Design
Authors: Guntur, S. (Intern), Sørensen, N. N. (Intern)
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Web of Science (2018): Indexed yes
A novel Active Flap System (AFS) has been developed at DTU Wind Energy, as a result of a 3-year R&D project following almost 10 years of innovative research in this field. The full scale AFS comprises an active deformable trailing edge has been tested at the unique rotating test facility at the Risø Campus of DTU Wind Energy in Denmark. The design and instrumentation of the wing section and the AFS are described. The general description and objectives of the rotating test rig at the Risø campus of DTU are presented, along with an overview of sensors on the setup and the test cases. The
Automatic penalty continuation in structural topology optimization

Structural topology optimization problems are often modelled using material interpolation schemes to produce almost solid-and-void designs. The problems become non convex due to the use of these techniques. Several articles introduce continuation approaches in the material penalization parameter to reduce the risks of ending in local minima. However, the numerical performance of continuation methods has not been studied in detail. The first purpose of this article is to benchmark existing continuation methods and the classical formulation with fixed penalty parameter in structural topology optimization. This is done using performance profiles on 225 minimum compliance and 150 compliant mechanism design problems. The results show that continuation methods generally find better designs. On the other hand, they typically require a larger number of iterations. In the second part of the article this issue is addressed. We propose an automatic continuation method, where the material penalization parameter is included as a new variable in the problem and a constraint guarantees that the requested penalty is eventually reached. The numerical results suggest that this approach is an appealing alternative to continuation methods. Automatic continuation also generally obtains better designs than the classical formulation using a reduced number of iterations.
AVATAR: AdVanced Aerodynamic Tools for lArge Rotors

An EERA (European Energy Research Alliance) consortium started an ambitious EU FP7 project AVATAR (AdVanced Aerodynamic Tools for lArge Rotors) in November 2013. The project lasts 4 years and is carried out in a consortium with 11 research institutes and two industry partners. The motivation for the AVATAR project lies in the fact that future 10 to 20 MW turbine design model analysis will importantly violate known validity limits of today’s aerodynamic and aero-elastic models in aspects like compressibility and Reynolds number effects, laminar/turbulent transition and separation effects, all in combination with a much more complex fluid-structure interaction. Further complications enter by the possible use of active or passive flow devices. AVATAR’s main aim is then to develop enhancements for aerodynamic and aero-elastic models suitable for large (10MW+) wind turbines analysis. The turbine modelling improvements will be demonstrated on a new 10MW reference turbine design model description. The first results from the AVATAR project are presented in this paper.

General information
State: Published
Averaged cov-driven subspace identification for modal analysis of a modified troposkien blade with displacement measurement

An operational modal analysis study has been carried out on a 1-kW, vertical-axis wind turbine rotor blade, using a stereo vision technique. Numerical simulation has also been carried out and results were compared to classical modal analysis and OMA results. The displacement time series used in the analysis are very short because of limitations in the image acquisition system. Short time series are not fully qualified for OMA and analyzing the data needs a proper method. Covariance driven Stochastic Subspace Identification method (SSI-cov) has been used for short time series like earthquakes. In the SSI-cov method, a block Toeplitz matrix is formed which contains output correlation functions. 10 displacement time series have been recorded with 187 Hz sampling rate, and about 3 time series were chosen to be analyzed. The block Toeplitz matrix of 3 time series are averaged out and the procedure how to analyze short time series is described in this paper. For OMA validation, a classical modal analysis is done with signals from accelerometers mounted on the blade. The blade is exited with a hammer. The natural frequencies are estimated by picking the peaks from the FRFs (Frequency Response Function) obtained at different points. Finally the natural frequencies and mode shapes obtained from classical modal analysis and OMA results are compared to numerical simulations of the blade with COMSOL.

A versatile stereo photogrammetry based technique for measuring fracture mode displacements in structures

The measurement of fracture mode displacements in structures which are susceptible to cracking such as adhesive joints in composite components – is becoming increasingly important. Such measurements are essential for the understanding of the root causes for specific fracture damage types. Furthermore, they can be used to assess the remaining life span of a structure for its safe operation. A new version of a previously devised small displacement measurement system (SDMS) is used to measure local relative displacements (LRDs) at the trailing edge of a wind turbine blade. A purpose-made automated image processing software (AIPS) allows a rapid and reliable evaluation of a multitude of subsequently taken measurements at a high-precision level. The SDMS is used to measure the LRDs at three different locations close to the trailing edge of a wind turbine rotor blade. In addition, complementary measurements obtained by linear transducers are compared with the associated LRD component obtained by the SDMS. The 3D LRD measurements showed to be in good agreement with the predictions of non-linear finite element analysis. The paper closes with a brief discussion of the proposed measurement approach and the nature of LRDs as they appear in close vicinity to trailing edge joints.
A wind-wave coupled mesoscale modelling system for coastal extreme wind and wave conditions

**General information**
State: Published
Organisations: Department of Wind Energy, Meteorology
Authors: Larsén, X. G. (Intern)
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Basic Principles and Evidences of Wind Turbine Noise Generation Mechanisms

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Organisations: Department of Wind Energy, Aeroelastic Design
Authors: Bertagnolio, F. (Intern), Aagaard Madsen, H. (Intern), Fischer, A. (Intern), Bak, C. (Intern)
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Benchmarking optimization solvers for structural topology optimization

The purpose of this article is to benchmark different optimization solvers when applied to various finite element based structural topology optimization problems. An extensive and representative library of minimum compliance, minimum volume, and mechanism design problem instances for different sizes is developed for this benchmarking. The problems are based on a material interpolation scheme combined with a density filter. Different optimization solvers including Optimality Criteria (OC), the Method of Moving Asymptotes (MMA) and its globally convergent version GCMMA, the interior point solvers in IPOPT and FMINCON, and the sequential quadratic programming method in SNOPT, are benchmarked on the library using performance profiles. Whenever possible the methods are applied to both the nested and the Simultaneous Analysis and Design (SAND) formulations of the problem. The performance profiles conclude that general solvers are as efficient and reliable as classical structural topology optimization solvers. Moreover, the use of the exact Hessians in SAND formulations, generally produce designs with better objective function values. However, with the benchmarked implementations solving SAND formulations consumes more computational time than solving the corresponding nested formulations.

**General information**
State: Published
Organisations: Department of Wind Energy, Wind Turbines
Authors: Rojas Labanda, S. (Intern), Stolpe, M. (Intern)
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Publication date: 2015
Main Research Area: Technical/natural sciences

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Volume: 52
Boundary Fractal Analysis of Two Cube-oriented Grains in Partly Recrystallized Copper
The protrusions and retrusions observed on the recrystallizing boundaries affect the migration kinetics during recrystallization. Characterization of the boundary roughness is necessary in order to evaluate their effects. This roughness has a structure that can be characterized by fractal analysis, and in this study the so-called "Minkowski sausage" method is adopted. Hereby, two cube-oriented grains in partly recrystallized microstructures are analyzed and quantitative information regarding the dimensions of protrusions/retrusions is obtained.

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BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.172 SNIP 0.281 CiteScore 0.22
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Scopus rating (2013): SJR 0.183 SNIP 0.256 CiteScore 0.16
ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 0.161 SNIP 0.203 CiteScore 0.14
ISI indexed (2012): ISI indexed no
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Boundary migration during recrystallization: experimental observations
Quantitative analysis of boundary migration during recrystallization is a key task to understand the recrystallization process and to improve recrystallization models. In the last 25-30 years, quantification of boundary migration has mostly been conducted in term of average growth rates in many materials. This type of analysis has largely been based on the assumption that all or groups of recrystallizing grains grow in the same uniform manner, therefore the results represent average growth behaviors on a macro scale. Recently, significant efforts have been made to quantify the boundary migration during recrystallization on local grain scales, using different advanced experimental characterization and computer simulation techniques. This paper aims at summarizing these recent achievements with focus on the potentials...
of the various advanced experimental characterization techniques. Suggestions for new experimental and simulation work important for advancing the current understanding of local boundary migration are finally discussed.

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Organisations: Department of Wind Energy, Materials science and characterization
Authors: Zhang, Y. (Intern), Juul Jensen, D. (Intern)
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**Broadband Trailing-Edge Noise Predictions - Overview of BANC-III Results**

The Third Workshop on Benchmark Problems for Airframe Noise Computations, BANCIII, was held on 14-15 June 2014 in Atlanta, Georgia, USA. The objective of this workshop was to assess the present computational capability in the area of physics-based prediction of different types of airframe noise problems and to advance the state-of-the-art via a combined effort. This documentation summarizes the results from workshop category 1 which focuses on the prediction of broadband turbulent boundary-layer trailing-edge noise and related source quantities. Since the forerunner BANC-II workshop identified some room for improvements in the achieved prediction quality BANC-III relies on the same test cases, namely 2D NACA0012 and DU96-W-180 airfoil sections in a uniform flow. Compared to BANC-II particularly the scatter among predictions for the DU96-W180 test case could be significantly reduced. However, proposed adaptations of previously applied computational methods did not systematically improve the prediction quality for all requested parameters. The category 1 workshop problem remains a challenging simulation task due to its high requirements on resolving and modeling of turbulent boundary-layer source quantities.

**General information**

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Organisations: Department of Wind Energy, Aerodynamic design, German Aerospace Center, Vestas Technology UK Ltd., University of Stuttgart, wavePRO, Politecnico di Torino, Metacomp Technologies, Inc.
Calculation of depleted wind resources near wind farms

Traditional wind resource maps include wind distribution, energy density and potential power production without wake effects. Adding wake effect to such maps is feasible by means of a new method based on Fourier transformation, and the extra computational work is comparable to that of the basic wind resource map. The method is mainly intended for mapping inter-farm wake effects. It will work for all linear wake models and may even be extended to complex terrain by certain simplifying assumptions. The method is implemented for the Park model and Fuga models. A test example shows that these models predict different wake development on an inter-farm length scale.

Calibration of a spinner anemometer for yaw misalignment measurements

The spinner anemometer is an instrument for yaw misalignment measurements without the drawbacks of instruments mounted on the nacelle top. The spinner anemometer uses a non-linear conversion algorithm that converts the measured wind speeds by three sonic sensors on the spinner to horizontal wind speed, yaw misalignment and flow inclination angle. The conversion algorithm utilizes two constants that are specific to the spinner and blade root design and to the mounting positions of the sonic sensors on the spinner. One constant, $k_2$, mainly affects the measurement of flow angles, while the
other constant, \( k_1 \), mainly affects the measurement of wind speed. The ratio between the two constants, \( k_\alpha = k_2/k_1 \), however, only affects the measurement of flow angles. The calibration of \( k_\alpha \) is thus a basic calibration of the spinner anemometer. Theoretical background for the non-linear calibration is derived from the generic spinner anemometer conversion algorithm. Five different methods were evaluated for calibration of a spinner anemometer on a 500 kW wind turbine. The first three methods used rotor yaw direction as reference angular, while the wind turbine, was yawed in and out of the wind. The fourth method used a hub height met-mast wind vane as reference. The fifth method used computational fluid dynamics simulations. Method 1 utilizing yawing of the wind turbine in and out of the wind in stopped condition was the preferred method for calibration of \( k_\alpha \). The uncertainty of the yaw misalignment calibration was found to be 10%, giving an uncertainty of 1° at a yaw misalignment of 10°. © 2014 The Authors. Wind Energy published by John Wiley & Sons, Ltd.

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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.

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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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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 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.

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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.

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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.

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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.

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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.

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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.

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Publication: Research › Report – Annual report year: 2015

**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 calibration concerns the 10 minute mean wind speed measurements. The comparison of the lidar measurements of the wind direction with that from wind vanes is also given.

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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.

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.
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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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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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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Carbon nanotube reinforced hybrid composites: Computational modeling of environmental fatigue and usability for wind blades

The potential of advanced carbon/glass hybrid reinforced composites with secondary carbon nanotube reinforcement for wind energy applications is investigated here with the use of computational experiments. Fatigue behavior of hybrid as well as glass and carbon fiber reinforced composites with and without secondary CNT reinforcement is simulated using multiscale 3D unit cells. The materials behavior under both mechanical cyclic loading and combined mechanical and environmental loading (with phase properties degraded due to the moisture effects) is studied. The multiscale unit cells are generated automatically using the Python based code. 3D computational studies of environment and fatigue analyses of multiscale composites with secondary nano-scale reinforcement in different material phases and different CNTs arrangements are carried out systematically in this paper. It was demonstrated that composites with the secondary CNT reinforcements (especially, aligned tubes) present superior fatigue performances than those without reinforcements, also under combined environmental and cyclic mechanical loading. This effect is stronger for carbon composites, than for hybrid and glass composites.
The potential of carbon nanotube reinforcement of metallic binders for the improvement of quality and efficiency of diamond cutting wheels is studied. The effect of multi-walled carbon nanotube (MWCNT) reinforcement on the mechanical properties i.e., hardness, Young modulus, strength and deformation behavior of copper and iron based binder for diamond cutting wheels is investigated experimentally and numerically. Computational micromechanical studies were carried out to clarify the mechanisms of the MWCNT material strengthening. It is demonstrated that the adding of MWCNTs leads to the decrease of grain size of the structural constituents of the binder, what in turn leads to the improved simultaneously hardness, Young modulus, plastic extension, bending strength and performances of the metallic binders. Comparing service properties of diamond end-cutting drill bits with and without MWCNT one observed the drastic increase of the cutting speed as a result of MWCNT reinforcement.
Characterization and biological depectinization of hemp fibers originating from different stem sections

The wide variation of mechanical properties of natural fibers limits their applications in matrix composites. The aim of this study is to evaluate the properties of hemp fibers from different stem sections (top, middle and bottom) and to assess fungal retting pretreatment of hemp from different stem sections with the white rot fungi Phlebia radiata Cel 26 and Ceriporiopsis subvermispora. For the untreated hemp fibers, no apparent difference in tensile behavior for fiber bundles from different stem sections was observed, and more than 90% tested samples demonstrated plastic flow behavior. Fiber strength and stiffness were highest for the fibers from the top and middle stem sections. These properties were related to the compositional make up and morphological properties of hemp fibers, notably the secondary fiber cell contents. In fungal retting, there was a strong dependence of depectinization selectivity on stem section, which decreased from bottom to top presumably due to the significantly higher lignin content in the bottom section than in the top section (middle section was in between). Consequently, the fungal retting caused a lower reduction in strength of fibers from the bottom section than in those from the top stem section, and essentially reversed the influence of stem section on fiber tensile strength through depectinization selectivity. At whole hemp stem level, the fungal retting with P. radiata Cel 26 exhibited better mechanical properties with an ultimate tensile strength, strain and stiffness of 736 MPa, 2.3% and 42 GPa, respectively, while fibers treated with C. subvermispora exhibited lower mechanical properties of 573 MPa, 1.9% and 40 GPa, respectively. The study thus also showed that less variable and high strength fibers may be produced using the dependence of depectinization selectivity on stem section for composite application.
Characterization and influence of deformation microstructure heterogeneity on recrystallization

The microstructure resulting from plastic deformation of metals typically contains heterogeneity on several length scales. This is also true for samples deformed to large strains, where an important form of heterogeneity is in the variation in microstructural refinement by high angle boundaries. A methodology for quantifying this type of heterogeneity based on the identification of areas classified as low misorientation regions (LMRs) is described, and some parameters for quantification of both the extent and length scale of LMRs are presented. It is then shown how this approach can be used to investigate the early stages of recrystallization in samples deformed to large strains, by direct comparison of electron...
backscatter diffraction (EBSD) maps of the same area before and after annealing. Methods for estimation of the stored energy of deformation from EBSD data are also surveyed and the problems of each for quantification of the local variation in stored energy are discussed, where it is concluded that a method based on the summation of the contributions from individual boundary segments is considered to be the best suited at present for characterization of the local variation in stored energy on the scale of the dislocation boundary features.

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**Organisations:** Department of Wind Energy, Materials science and characterization, Tsinghua University

**Authors:** Godfrey, A. (Ekstern), Mishin, O. V. (Intern), Yu, T. (Intern)

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**Characterization of blade throw from a 2.3MW horizontal axis wind turbine upon failure**

The present work concerns aerodynamics of thrown objects from a 2.3 MW Horizontal Axis Wind Turbine (HAWT), as a consequence of blade failure. The governing set of ordinary differential equations for the flying objects are derived and numerically solved using a 4th order Runge-Kutta time advancing discretization technique and the sensitivity of the throw distance to the size of fragment, incoming wind velocity, and release tip speed and height are investigated both qualitatively and quantitatively. Computations suggest that the tip speed, at the release moment, is the most influential parameter for determining the throw distance and it is shown that when the turbine is operating in normal operating conditions (tip speed ratios of about 7 - with hub height velocity of 10m/s, resulting in blade tip speeds of about 70m/s), the fragments thrown from the turbine can reach between 100m and 500m, depending on their size. Thereafter, throw distance picks up exponentially with the tip speed. By comparing the throw distance calculations with and without dynamic stall model being active, it is concluded that dynamic stall does not play a major role in throw distances.

**General information**

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Characterization of boundary roughness of two cube grains in partly recrystallized copper

Protrusions and retrusions typically form on recrystallizing boundaries and thus the boundaries often appear rough. Characterization of the boundary roughness is necessary in order to evaluate the effects of protrusions and retrusions on boundary migration. In the current work, a variable termed area integral invariant is employed to provide quantitative information of individual protrusions/retrusions on boundaries surrounding two selected recrystallizing grains in partly recrystallized copper as well as of the overall roughness of the boundaries.
An Al-1.08 vol.% Si alloy was cold rolled to a reduction of 98% (εvM = 4.5) and then annealed at different temperatures up to 210°C (0.52 Tm) for different times. The deformed structure is characterized by a nanoscale lamellar structure with the presence of Si particles of coarse (> 1 μm), medium (100 nm - 1 μm) and fine (< 100 nm) sizes in the microstructure. Deformation zones are formed around the coarse Si particles and the boundary spacing is finer in the deformation zone than in the matrix. The medium Si particles have little effect on the morphology and boundary spacing. The fine Si particles are aligned along the lamellar boundaries indicating a stabilizing effect on the structural refinement during cold rolling. After annealing, enhanced recovery occurs in the deformation zones around the coarse Si particles. However the reduction in stored energy during recovery and the pinning effect of fine Si particles on the boundary migration prevent the advantage of particle stimulated nucleation (PSN) of coarse Si particles in the nanoscale lamellar structure. This study also demonstrates an important effect of the fine particles in delaying both recovery and recrystallization processes. This effect diminishes with increasing annealing temperature and coarsening the fine particles especially at triple junctions.

**General information**

State: Published
Organisations: Department of Wind Energy, Materials science and characterization, Chongqing University
Authors: Huang, T. (Ekstern), Wu, G. (Ekstern), Huang, X. (Intern), Hansen, N. (Intern)
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Publication: Research - peer-review › Conference article – Annual report year: 2015
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. SAR wind retrievals give uniquely detailed spatial information on offshore wind fields. Wind maps can be retrieved from SAR observations at resolutions finer than 1 km. The high resolution make SAR images suitable for wind retrievals in the coastal zone, but the Geophysical Model Functions (GMF) for the wind retrieval are tuned for open sea conditions [1]. DTU routinely retrieves SAR wind fields from the Sentinel-1A satellite using APL/NOAA’s SAROPS system with GFS model wind directions as input. For the presented cases CMOD5.n is used. Ground-based scanning lidar located on land can also cover near shore areas. 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) was established. The lidar measurement campaign started November 2015 and ended in February 2016 at the Danish North Sea coast at around 56.5° N, 8.2° E. 107 satellite SAR scenes were collected during the same period.

Combined effect of rapid nitriding and plastic deformation on the surface strength, toughness and wear resistance of steel 38CrMoAlA

The combined treatment of pressurized gas nitriding and cold rolling is proposed as a new approach to rapid preparation of a strong and tough nitried layer for steel 38CrMoAlA. The microstructural characteristics and properties of the modified surface layer in comparison with those of the conventionally gas nitried sample have systematically been evaluated. The results show that the hardness and toughness of the nitried surface layer can be significantly improved by the combined treatment. Especially, the wear resistance of nitried surface layer under heavy loads was greatly enhanced. It can provide a new approach to rapidly preparing a nitried layer with high strength and toughness.

Combined effect of rapid nitriding and plastic deformation on the surface strength, toughness and wear resistance of steel 38CrMoAlA

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Combined Structural Optimization and Aeroelastic Analysis of a Vertical Axis Wind Turbine

Floating offshore wind energy poses challenges on the turbine design. A possible solution is vertical axis wind turbines, which are possibly easier to scale-up and require less components (lower maintenance) and a smaller floating structure than horizontal axis wind turbines. This paper presents a structural optimization and aeroelastic analysis of an optimized Troposkein vertical axis wind turbine to minimize the relation between the rotor mass and the swept area. The aeroelastic behavior of the different designs has been analyzed using a modified version of the HAWC2 code with the Actuator Cylinder model to compute the aerodynamics of the vertical axis wind turbine. The combined shape and topology optimization of a vertical axis wind turbine show a minimum mass to area ratio of 1.82 kg/m² for blades with varying blade sections from a NACA 0040 at the attachment points to a NACA 0015 in the equatorial region. During an aeroelastic analysis of the wind turbine a maximum flapwise deflection of 0.45 m and a maximum edgewise deflection of 0.47 m were found. While the turbine is aeroelastically stable, an oscillation as a result of resonance reduces the fatigue life.

Committee III.2 Fatigue and Fracture

Concern for crack initiation and growth under cyclic loading as well as unstable crack propagation and tearing in ship and offshore structures. Due attention shall be paid to practical application and statistical description of fracture control methods in design, fabrication and service. Consideration is to be given to the suitability and uncertainty of physical models.

Committee IV.2 Structural Dynamics

The structure of the wind turbine is subject to dynamic loads due to wind and other environmental factors. This requires a detailed understanding of the dynamic behavior of the structure to ensure its stability and longevity. The analysis of the aeroelastic behavior of the wind turbine is crucial for predicting its dynamic response under various operating conditions.

Committee IV.3 Life Cycle Analysis

The life cycle analysis of the wind turbine is an essential aspect in determining its environmental impact and cost-effectiveness. This includes assessing the materials used, energy consumption during the manufacturing process, and the environmental effects of its operation and decommissioning. The analysis helps in identifying areas for improvement in terms of sustainability and cost efficiency.

Committee IV.4 Manufacturing and System Integration

The manufacturing process of the wind turbine plays a significant role in ensuring its quality and efficiency. The integration of the components must be carefully planned to ensure a smooth assembly process. This includes the use of advanced manufacturing technologies and the implementation of quality control measures to ensure that each component meets the required standards.

Committee V.2 Control Systems

The control systems of the wind turbine are critical for its performance and efficiency. These systems are responsible for monitoring the turbine's operation, adjusting its settings, and ensuring optimal energy output. The control systems rely on advanced algorithms and sensors to collect data and make real-time adjustments, ensuring that the turbine operates at its peak performance levels.
Comparative Environmental Sustainability Assessment of Bio-Based Fibre Reinforcement Materials for Wind Turbine Blades

Over the recent decades biomaterials have been marketed successfully supported by the common perception that biomaterials and environmental sustainability de facto represents two sides of the same coin. The development of sustainable composite materials for wind turbine blades for small-scale wind turbines have therefore partially been focused on substitution of conventional fibre materials with bio-fibres assuming that this substitution was in the better for the environment and human health. The major question is if this material substitution, taking into account a multitude of environmental impact categories, not only climate change, actually is supporting sustainable development or if the development of sustainable composite materials is more complex and perhaps even contra-intuitive due to complex trade-offs. Based on a case study 4 different types of fibres and fibre mixtures (flax, carbon, glass and flax/carbon, flax/glass mixed fibres) are compared in terms of environmental sustainability. Applying one of the most recent life cycle impact assessment methods, we demonstrate that the environmental sustainability of natural fibre based composite materials is similar or even lower, within certain impact categories, than the conventional materials. This observation may seem contra-intuitive (i.e. most people would expect the bio-based to be most sustainable), but is primarily caused by the fact that the resin demand of biobased reinforcement materials is by far larger than that of conventional reinforcement materials. Since the environmental burden of the resin in addition is comparable to that of the fibres (especially in terms human health related impacts), the higher resin demand counterbalances the environmental sustainability improvements, obtained with the application of natural fibres.
Comparative study of OMA applied to experimental and simulated data from an operating Vestas V27 wind turbine

Today, design of wind turbines is extensively done by the implementation of numerical models. These models simulate the dynamic behaviour of full-scale wind turbines which helps to ensure the structural integrity of prototypes. However, these numerical models need validation from experimental results, and in turn, numerical and analytical modelling help improve and validate new experimental techniques. Wind turbines are complex dynamic systems that consist of mutually moving substructures under high dynamic loads. At a standstill, the system can be modelled as linear time-invariant (LTI), and modal analysis requirements are thus fulfilled for the dynamic characterization. Under operation, the system cannot be considered as LTI and must be modelled as a linear periodic time-variant (LPTV) system, which allows for the application of the related theory for such systems. One of these methods is the Coleman transformation, which transforms the vibrations expressed in the blade rotating coordinates to the fixed-ground frame of reference. The application of this transformation, originally from helicopter theory, allows for the conversion of a LPTV system to a LTI system under certain assumptions, among which is the assumption of isotropic rotors. Since rotors are never completely isotropic in real life, this paper presents the application of operational modal analysis together with the Coleman transformation on both experimental data from a full-scale Vestas wind turbine with instrumented blades and nacelle, and its representative numerical model with a fully isotropic rotor. The results show that the first tower and rotor edgewise modes are well identified, and that the rotor edgewise modes can be identified from the nacelle signals. The results also uncover the challenge the excitation forces imply for the identification of flapwise modes.

General information
State: Published
Organisations: Department of Wind Energy, Aeroelastic Design, Brüel & Kjær A/S
Authors: Requeson, O. R. (Intern), Tcherniak, D. (Ekstern), Larsen, G. C. (Intern)
Number of pages: 10
Publication date: 2015

Host publication information
Comparing Fatigue Life Estimations of Composite Wind Turbine Blades using different Fatigue Analysis Tools

In this paper, fatigue lifetime prediction of NREL 5MW reference wind turbine is presented. The fatigue response of materials used in selected blade cross sections was obtained by applying macroscopic fatigue approaches and assuming uniaxial stress states. Power production and parked load cases suggested by the IEC 61400-1 standard were studied employing different load time intervals and by using two novel fatigue tools called ALBdes and BECAS+F. The aeroelastic loads were defined thought aeroelastic simulations performed with both FAST and HAWC2 tools. The stress spectra at each layer were calculated employing laminated composite theory and beam cross section methods. The Palmgren-Miner linear damage rule was used to calculate the accumulation damage. The theoretical results produced by both fatigue tools proved a prominent effect of analysed design load conditions on the estimated lifetime of the wind turbine blades and are good starting points for future fatigue analysis using other methods.

Comparing satellite SAR and wind farm wake models

The aim of the paper is to present offshore wind farm wake observed from satellite Synthetic Aperture Radar (SAR) wind fields from RADARSAT-1/-2 and Envisat and to compare these wakes qualitatively to wind farm wake model results. From some satellite SAR wind maps very long wakes are observed. These extend several tens of kilometres downwind e.g. 70 km. Other SAR wind maps show near-field fine scale details of wake behind rows of turbines. The satellite SAR wind farm wake cases are modelled by different wind farm wake models including the PARK microscale model, the Weather Research and Forecasting (WRF) model in high resolution and WRF with coupled microscale parametrization.
Comparing wall modeled LES and prescribed boundary layer approach in infinite wind farm simulations

This paper aims at presenting a simple and computationally fast method for simulation of the Atmospheric Boundary Layer (ABL) and comparing the results with the commonly used wall-modelled Large Eddy Simulation (WMLES). The simple method, called Prescribed Mean Shear and Turbulence (PMST) hereafter, is based on imposing body forces over the whole domain to maintain a desired unsteady ow, where the ground is modeled as a slip-free boundary which in return hampers the need for grid refinement and/or wall modeling close to the solid walls. Another strength of this method besides being computationally inexpensive, is high flexibility meaning that the imposed boundary layer can be read from another CFD simulation, or from site measurements. For fundamental studies focusing on the wake structures rather than ABL for example, the grid can be refined in the rotor region and any desired shear layer can be imposed to study the wake and dynamics of vortices. The methodology is used for simulation of interactions of an infinitely long wind farm with the neutral ABL. Flow statistics are compared with the WMLES computations in terms of mean velocity as well as higher order statistical moments. The results suggest that the PMST model can be used to study the wake characteristics with acceptable accu- racy, especially in the rotor region, when the computational resources are limited and yet detailed knowledge of wakes is needed.
Comparison between experiments and Large-Eddy Simulations of tip spiral structure and geometry

Results from Large-Eddy Simulations using the actuator line technique have been validated against experimental results. The experimental rotor wake, which forms the basis for the comparison, was studied in a recirculating free-surface water channel, where a helical vortex was generated by a single-bladed rotor mounted on a shaft. An investigation of how the experimental blade geometry and aerofoil characteristics affect the results was performed. Based on this, an adjustment of the pitch setting was introduced, which is still well within the limits of the experimental uncertainty. Excellent agreement between the experimental and the numerical results was achieved concerning the circulation, wake expansion and pitch of the helical tip vortex. A disagreement was found regarding the root vortex position and the axial velocity along the centre line of the tip vortex. This work establishes a good base for further studies of more fundamental stability parameters of helical rotor wakes.
Comparison of 10 MW superconducting generator topologies for direct-drive wind turbines

Large wind turbines of 10 MW or higher power levels are desirable for reducing the cost of energy of offshore wind power conversion. Conventional wind generator systems will be costly if scaled up to 10 MW due to rather large size and weight. Direct drive superconducting generators have been proposed to address the problem with generator size, because the electrical machines with superconducting windings are capable of achieving a higher torque density of an electrical machine. However, the topology to be adopted for superconducting wind generators has not yet been settled, since the high magnetic field excitation allows for lightweight non-magnetic composite materials for machine cores instead of iron. A topology would probably not be a good option for an offshore wind turbine generator if it demands a far more expensive active material cost than others, even if it has other advantages such as light weight or small iron losses. This paper is to provide a preliminary quantitative comparison of 10 MW superconducting MgB2 generator topologies from the perspective of active material. The results show that iron-cored topologies have a cheaper active material and their sizes are relatively smaller than the others.

General information
State: Published
Organisations: Department of Wind Energy, Integration & Planning, Delft University of Technology
Authors: Liu, D. (Ekstern), Polinder, H. (Ekstern), Abrahamsen, A. B. (Intern), Ferreira, J. A. (Ekstern)
Number of pages: 7
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Publication date: 2015

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Conference: IEEE International Electric Machines & Drives Conference 2015, Coeur d'Alene, ID, United States, 10/05/2015 - 10/05/2015
Comparison, Cost, Direct drive, Finite element, Magnesium diboride, Optimization, Superconducting generator, Topology, Wind turbine
DOIs:
Comparison of far wakes behind a solid disk and a three-blade rotor
A comparison of the wakes developed behind an immobile bluff body (solid disk) and a three-blade rotor at different rotational speeds is studied to find a correlation between them. LDA and PIV were applied to study the wakes behind both models in a water flume (Re ≈ 2.3·105). Everywhere in both wakes, a constant value of the Strouhal number was found to be equal to 0.23 for a three-blade rotor and 0.15 for a solid disk. This Strouhal number is in good agreement with the constants that usually characterize the wake oscillations behind immobile bluff bodies. The comparison of axial velocity deficit and rms of the velocity in both far wakes for the disk or the rotor shows a rational decay with the same power –2/3. It has good agreement with the analytical formula for the decay of the velocity deficit behind bluff bodies. A limit for using this model restricted by the turbulence level of the initial free flow was found experimentally.
Comparison of Hourly Solar Radiation from a Ground–Based Station, Remote Sensing and Weather Forecast Models at a Coastal Site of South Italy (Lamezia Terme)

The solar radiation is a critical input parameter when working with solar energy and radiation dependent surface processes. In this study, we present preliminary results from an inter-comparison between hourly values from a pyranometer, MSG-SEVIRI sensor and two meso-scale models, WRF and RAMS, in clear and cloudy sky conditions. Cloudy sky condition is the most important because the attenuation of solar radiation in the atmosphere is strongly dependent on the cloud variability. Bias and RMSE errors are evaluated at a coastal site in the Mediterranean area. These statistics show the tendency of both models to overestimate short-wave radiation.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology, Institute for Atmospheric Science and Climate
Authors: Feudo, T. L. (Ekstern), Avolio, E. (Ekstern), Gulli, D. (Ekstern), Federico, S. (Ekstern), Calidonna, C. R. (Ekstern), Sempreviva, A. M. (Intern)
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Scopus rating (2016): CiteScore 1.16 SJR 0.467 SNIP 0.586
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Web of Science (2012): Indexed yes
Scopus rating (2011): SJR 0.918 SNIP 1.505 CiteScore 2.42
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Web of Science (2009): Indexed yes
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DOIs: 10.1016/j.egypro.2015.07.884

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Comparison of measured and simulated loads for the Siemens swt2.3 operating in wake conditions at the Lillgrund Wind Farm using HAWC2 and the dynamic wake meander model
Comparison of measured and simulated loads for the Siemens SWT 2.3 operating in wake conditions at the Lilgrund Wind Farm using HAWC2 and the dynamic wake meander model

Comparison of Resource and Energy Yield Assessment Procedures 2011-2015: What have we learned and what needs to be done?

Comparison of Resource and Energy Yield Assessment Procedures 2011-2015: What have we learned and what needs to be done?

From 2011 to 2015, the European Wind Energy Association arranged four open exercises to benchmark the wind resource and wind farm energy yield assessment procedures of the wind energy industry. Two case studies were for land-based Scottish wind farms in hilly to complex terrain, and two case studies for medium- to large-scale offshore wind farms in the Irish Sea. A total of 157 submissions were received, 97 land-based and 60 offshore, and all four exercises were analysed and presented previously by DTU Wind Energy.

Results are summarised here for each of seven specific steps in the resource and energy yield assessment procedure: Site wind observation, long-term extrapolation, vertical extrapolation, horizontal extrapolation, wake modelling, technical losses estimation, uncertainty estimation and calculation. For each step and each wind farm a summary is given of the magnitude of the effects, the spread of the predictions, the methodologies used, and some general, qualitative conclusions. For one offshore wind farm, Barrow, the predicted yield was found to be 104% of the observed yield, with a spread of predictions of 3%.

Based on the results of the four case studies and the statistics of the submitted data, two prioritised lists of actions that could be taken in order to improve the overall process in the most cost-effective way are given; one for land-based and one for offshore wind farms.
Comparison of Simulations and Offshore Measurement Data of a Combined Floating Wind and Wave Energy Demonstration Platform

In this paper, results from comparisons of simulations and measured offshore data from a floating combined wind and wave energy conversion system are presented. The numerical model of the platform is based on the aeroelastic code, HAWC2, developed by DTU Wind Energy, which is coupled with a special external system that reads the output generated directly by the wave analysis software WAMIT. The main focus of the comparison is on the statistical trends of the platform motion, mooring loads, and turbine loads in measurements and simulations during different operational conditions. Finally, challenges and possible approaches for further model development and validation are discussed.
The aeroelastic code, HAWC2, developed by DTU Wind Energy, which is coupled with a special external system that reads the output generated directly by the wave analysis software, WAMIT. The model also includes models for the dynamic mooring lines as well as the turbines non-linear yaw and teeter motion behavior. The main focus on the comparison will be on the statistical trends of the platform motion, mooring loads and turbine loads in measurements and simulations during different operational conditions such as increasing wind speed, wave height and wind/wave misalignment.

General information
State: Published
Organisations: Department of Wind Energy, Aeroelastic Design, Floating Power Plant
Authors: Yde, A. (Intern), Larsen, T. J. (Intern), Hansen, A. M. (Intern), Fernandez, M. (Ekstern), Bellew, S. (Ekstern)
Pages: 721-729
Publication date: 2015

Comparison of simulations of the far wake of alpha ventus against ship-based lidar measurements

General information
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Organisations: Department of Wind Energy, Meteorology
Authors: Beck, H. (Ekstern), Trujillo, J. (Ekstern), Wolken-Möhlmann, G. (Ekstern), Gottshcall, J. (Ekstern), Schmidt, J. (Ekstern), Pena Diaz, A. (Intern), Gomes, V. (Ekstern), Lange, B. (Ekstern), Kühn, M. (Ekstern), Hasager, C. B. (Intern)
Number of pages: 1
Publication date: 2015
Event: Poster session presented at RAVE Offshore R&D Conference, Bremerhaven, Germany.
Main Research Area: Technical/natural sciences
Publication: Research › Poster – Annual report year: 2015

Projects:

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
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

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
**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 Romàn, Leonardo Andrès (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:
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
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD
New industrial paradigm for design of wind turbine blades - tip and root optimization for increasing power performance

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: Samfinansieret - Andet
Project: PhD

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: Industrial PhD
Project: PhD

High Reynolds Number Rotor 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)
Hultmark, Marcus (Ekstern)
Main Supervisor:
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)

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)  
Supervisor:  
Bak, Christian (Intern)  
Fernandez Grande, Efren (Intern)  
Main Supervisor:  
Fischer, Andreas (Intern)  

**Financing sources**  
Source: Internal funding (public)  
Name of research programme: Institut stipendie (DTU)  
Project: PhD

**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

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**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: DTU-stipendium  
Project: PhD

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**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

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**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 Ejnæ (Intern)

**Financing sources**

Source: Internal funding (public)  
Name of research programme: Samfinansieret - Andet
**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 udfømmning kan bruges som en "grøn" kunstinstallation på lige fod med forbrændingsanlægget for derved at signalere Roskildes grønne aftryk og udvikling. VIROS kommer med tre forslag til, hvorledes lokalitet 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

Documents:
VindIROSkilde_Infomøde_ByensHus_23Jan2018
VindIROSkilde_dk_Abrahamsen_1marts2017_Endelig_kort
VindIROSkilde_Abrahamsen_KMU_4April2017_kort
VindIROSkilde_KlimarådetRoskildeKommune_Abrahamsen_2November2017_omdeling
VindIROSkilde_KlimaOgMiljøUdvalget_Abrahamsen_5Dec2017_omdeling
Report_group_8_Roskilde
Report_Group11_RoskildeMunicipality
Invitation_infomøde_VindIROskilde_ByensHus_23Jan2018

**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_Groud_Clearance_public_2017-08-31

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)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

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:
Akhatov, 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 → 30/09/2019
Number of participants: 3
Phd Student:
Menke, Robert (Intern)
Supervisor:
Vasiljevic, Nikola (Intern)
Main Supervisor:
Mann, Jakob (Ekstern)
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)

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)

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
Resource Assessment Modelling
EMD International A/S
Üstün Energy Engineering LLC
Period: 01/07/2016 → 01/06/2018
Number of participants: 1
Windprosper, wind resources, Wind turbine, CFD
Acronym: Windprosper
Project participant:
Bechmann, Andreas (Intern)
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:
Serensen, Poul Ejnar (Intern)

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?
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)
Hildebrandt, Christina Berndt (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

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)
Boscán Flores, Luis Rafael (Intern)
Cutululis, Nicolaos Antonio (Intern)
Das, Kaushik (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.

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)
Thybo, Gitte Wad (Ekstern)

Bio4Self

Department of Wind Energy
Composites and Materials Mechanics
Period: 01/03/2016 → …
Number of participants: 5
Project ID: H2020
Project participant:
Beauson, Justine (Intern)
Mikkelsen, Lars Pilgaard (Intern)
Madsen, Bo (Intern)
Christensen, Jacob (Intern)
Mishnaevsky, Leon (Intern)

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, construction and operation of integrated offshore infrastructures, including an offshore grid deployment plan (roadmap) for the future offshore grid system in Europe.

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)
Sørensen, 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
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
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

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: Institut stipendie (DTU)
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)
Løgstrup 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
Period: 15/11/2015 → 14/11/2018
Number of participants: 3
Phd Student:
Simon, Elliot (Intern)
Supervisor:
Cutululis, Nicolaos Antonio (Intern)
Main Supervisor:
Courtney, Michael (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Relations
Activities:
AMS 97th Annual Meeting
Project: PhD

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
Department of Management Engineering
Systems Analysis
Energy Systems Analysis
DTU Climate Centre
Rise National Laboratory for Sustainable Energy
Department of Wind Energy
Integration & Planning
KTH - Royal Institute of Technology

Acronym: Flex4RES
Project ID: 82511

Relations
Activities:
Panel discussion: Results and take-home messages from Sustainable Energy Systems 2050
Intraday Market Asymmetries
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

Flexibility for Variable Renewable Energy Integration in the Nordic Energy System: Danish &amp; Nordic perspectives
A power system with high penetration of intermittent energy: how to regulate the marked
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)  
Sørensen, Niels N. (Intern)  
Main Supervisor:  
Bak, Christian (Intern)

**Financing sources**
Source: Internal funding (public)  
Name of research programme: Ansat eksternt  
Project: PhD

**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**
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
Energy resources, services and control
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
Acronym: SANEDI
Project participant: Sørensen, Poul Ejnar (Intern)
Marinelli, Mattia (Intern)
Litong-Palima, Marisciel (Intern)
Hahmann, Andrea N. (Intern)

Cost-effective strategies for Wind farm O&M
Department of Wind Energy
Period: 01/07/2015 → 30/06/2018
Number of participants: 3
Phd Student: Colone, Lorenzo (Intern)
Supervisor: Dimitrov, Nikolay Krasimirov (Intern)
Main Supervisor: Natarajan, Anand (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Marie Curie (EU-stipendium)
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
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 Schrøder (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

Inflow Characterization based on Remote Sensing using Pitot Tubes

Department of Wind Energy
Period: 01/02/2015 → 31/01/2018
Number of participants: 5
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)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
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 step 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 → 28/02/2018
Number of participants: 3
Phd Student:
Ardila, Oscar Gerardo Castro (Intern)
Supervisor:
Brøndsted, Povl (Intern)
Main Supervisor:
Branner, Kim (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
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: 5
Phd Student:
Olsen, Bjarke Tobias (Intern)
Supervisor:
Cavar, Dalibor (Intern)
Hahmann, Andrea N. (Intern)
Mann, Jakob (Ekstern)
Main Supervisor:
Badger, Jake (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Measuring Turbulence using Commercial Wind Lidars

Department of Wind Energy

Test and Measurements
Number of participants: 2
Project participant:
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 Martinez, Edgar (Intern)
Supervisor: Sørensen, Poul Ejnar (Intern)
Main Supervisor: Cutululis, Nicolaos Antonio (Intern)
Examiner: Giebel, Gregor (Intern)
Kariniotakis, George (Ekstern)
vvan 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 → 14/11/2017
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
Project: PhD

Development of an advanced noise propagation model for noise optimization in wind farm

Department of Wind Energy
Fracture mechanics approach to probabilistic inspection planning of offshore foundation structures for wind turbines

Department of Wind Energy

Period: 01/11/2014 → 01/02/2018
Number of participants: 6
Phd Student:
Ruiz-Munoz, Gustavo-Adolfo (Ekstern)

Supervisor:
Eder, Martin Alexander (Intern)
Niordson, Christian Frithiof (Intern)
Serensen, John Dalsgaard (Intern)
Ostergaard, Thomas (Ekstern)

Main Supervisor:
Stolpe, Mathias (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Ansat eksternt
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 Raul (Intern)
Supervisor:
Réthoré, Pierre-Elouan (Intern)
Bechmann, Andreas (Intern)
Main Supervisor:
Trolldborg, 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
Project

Adhesive Joints in Wind Turbine Blades
Department of Wind Energy
Period: 01/09/2014 → 15/11/2017
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 Raul (Intern)
Supervisor:
Bechmann, Andreas (Intern)
Aagaard Madsen, Helge (Intern)
Réthoré, Pierre-Elouan (Intern)
Main Supervisor:
Trolborg, 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)
Relations
Press / Media items:
Vindmølle-forsker: Genialt at Vattenfall køber landejendomme
Forsker: Vindmøllekonflikter skyldes misundelse
Vindmølle-modvind skal vendes til medvind
Ja tak til vindenergi - bare ikke lige her

Project

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:
Weldeyesus, Alemseged Gebrehiwot (Intern)

Design Optimization of Jacket Structures for Mass Production
Department of Wind Energy
Wind Turbines
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)

Financial sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet

Relations
Publications:
Design optimization of jacket structures for mass production
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:
Larsén, 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)  
Mishnaevsky, Leon (Intern)  
Main Supervisor: Mikkelsen, Lars Pilgaard (Intern)  
Examiner: Niordson, Christian Frithiof (Intern)  
Asp, Leif Erik (Ekstern)  
Spearing, Simon Mark (Ekstern)

**Financing sources**
Source: Internal funding (public)  
Name of research programme: Offentlig finansiering

Relations
Publications:
Fatigue Damage Evolution in Fibre Composites for Wind Turbine Blades  
Project: PhD

**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.

Department of Wind Energy

Fluid Mechanics

Resource Assessment Modelling

EMD International A/S  
Period: 01/04/2014 → 31/12/2017  
Number of participants: 6  
Wind Farms  
Acronym: FarmOpt  
Project ID: EUDP-64013-0405  
Project Manager, academic: Zhu, Wei Jun (Intern)  
Hansen, Kurt Schaldemose (Intern)  
Bechmann, Andreas (Intern)  
Larsen, Gunner Chr. (Intern)
Feng, Ju (Intern)
Project Coordinator:
Shen, Wen Zhong (Intern)

Relations
Activities:
Wind farm design in complex terrain - the FarmOpt methodology

Tree-code algorithm for large scale vortex method simulation
Department of Wind Energy
Aeroelastic Design
Period: 01/04/2014 → 01/10/2014
Number of participants: 3
Project participant:
Mercier, Philippe (Ekstern)
Supervisor:
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 → 28/09/2018
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 → 31/03/2018
Number of participants: 9
Acronym: WASA
Project participant:
Mortensen, Niels Gylling (Intern)
Hahmann, Andrea N. (Intern)
Badger, Jake (Intern)
Volker, Patrick (Intern)
Larsén, Xiaoli Guo (Intern)
Enevoldsen, Karen (Intern)
Sørensen, Steen Arne (Intern)
Cronin, Tom (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

Coordinated control of wind power plants in offshore HVDC grids

Department of Wind Energy
Period: 15/03/2014 → 14/03/2017
Number of participants: 7
Phd Student:
Sakamuri, Jayachandra N. (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

Project

**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 → 31/12/2017
**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)

Project

**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 Bjørholm (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 (Ekstern)
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
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
Aalborg University
SINTEF
Universal Foundation A/S
DONG Energy A/S
Period: 01/01/2014 → 31/12/2017
Number of participants: 7
structural optimization, wind energy, offshore support structures
Acronym: ABYSS
Number of related Ph.D. students: 6
Project participant:
Buhl, Thomas (Intern)
Bredmose, Henrik (Intern)
Zania, Varvara (Intern)
Natarajan, Anand (Intern)
Schløer, Signe (Intern)
Sørensen, John Dalsgaard (Intern)
Project Coordinator:
Stolpe, Mathias (Intern)

Financing sources
Source: Public research council
Name of research programme: Det Strategiske Forskningsråd, Programkomiteen for Bæredygtig Energi og Miljø
Amount: 21,600,000.00 Danish Kroner
Year of approval: 2013

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: UniTTe
Number of related Ph.D. students: 2
Project participant:
Fris Pedersen, Troels (Intern)
Troldborg, Niels (Intern)
Meyer Forsting, Alexander Raul (Intern)
Bechmann, Andreas (Intern)
Courtney, Michael (Intern)
Borraccino, Antoine (Intern)
Vignaroli, Andrea (Intern)
Natarajan, Anand (Intern)
Sathe, Ameya (Intern)
Dimitrov, Nikolay Krasimirov (Intern)
Project Manager, academic:
Wagner, Rozenn (Intern)

Relations
Related projects:
Modeling of Wind Turbine Inflow
Activities:
EWEA Technology Workshop
Wind Europe Summit 2016
Perdigao NEWA meeting
11th EAWE 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 $V_{\infty}$ 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, Guilin (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 udlændet
- 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)
- Sørensen, 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)  
Sørensen, 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

**Noise propagation and optimization from wind turbines in wind farm**

Department of Wind Energy  
**Period:** 01/12/2013 → 31/08/2014  
**Number of participants:** 4  
**PhD Student:**  
Menicocci, Simone (Intern)  
**Supervisor:**  
Shen, Wen Zhong (Intern)  
Sørensen, Jens Nørkær (Intern)  
**Main Supervisor:**  
Zhu, Wei Jun (Intern)  

**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 RD|I 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
Department of Wind Energy

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

Project

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)
Sørensen, Jens Nørkær (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
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:

Mouritsen, Søren (Intern)
Wagner, Rozenn (Intern)
Main Supervisor:

Friis Pedersen, Troels (Intern)
Examiner:

Hansen, Kurt Schaldemose (Intern)
Eecen, Pieter Jan (Ekstern)
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.

Rise National Laboratory for Sustainable Energy
Department of Wind Energy

Wind Energy Systems
Period: 01/09/2013 → 31/08/2017
Number of participants: 2
Power systems, Reliability, renewables
Acronym: GARPUR
Project participant:
Cutululis, Nicolaos Antonio (Intern)
Sørensen, Poul Ejnar (Intern)

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 blase add-ons.

Department of Wind Energy
Aeroelastic Design
LM Wind Power
Centro Nacional de Energias Renovables

University of Southampton
Period: 01/09/2013 → 31/08/2016
Number of participants: 3
Acronym: 43193-4610
Project participant:
Bertagnolio, Franck (Intern)
Project Manager, academic:
Bak, Christian (Intern)
Fischer, Andreas (Intern)

Statistical characterization of metal microstructures
Department of Wind Energy
Period: 01/09/2013 → 09/12/2016
Number of participants: 6
Phd Student:
Sun, Jun (Intern)
Supervisor:
Zhang, Yubin (Intern)
Main Supervisor:
Juul Jensen, Dorte (Intern)
Examiner:
Fæster, Søren (Intern)
Lauridsen, Erik Mejdal (Intern)
Moelans, Nele (Ekstern)
Financing sources
Source: Internal funding (public)
Name of research programme: Grundforskningsfonden

Relations
Publications:
Quantitative Characterization of Boundary Roughness in Metals
Project: PhD

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.

Department of Wind Energy
Aeroelastic Design
Wind Energy Systems
Liftra
Period: 01/07/2013 → 30/06/2016
Number of participants: 6
Acronym: 43195
Project participant:
Gaunaa, Mac (Intern)
Bergami, Leonardo (Intern)
Hansen, Anders Melchior (Intern)
Zahle, Frederik (Intern)
Hansen, Anca Daniela (Intern)
Barlas, Athanasios (Intern)

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.

Department of Wind Energy
Resource Assessment Modelling
Meteorology & Remote Sensing
Period: 01/07/2013 → 30/06/2017
Number of participants: 9
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:
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, Pivi (Intern)
Examiner:
Madsen, Bo (Intern)
Gamstedt, Kristofer (Ekstern)
Neagu, Cristian (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Marie Curie (EU-stipendium)
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)
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 Atmospheric 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)
Supervisor:
Berg, Jacob (Ekstern)
Main Supervisor:
Mann, Jakob (Intern)
Examiner:
Larsen, Gunner Chr. (Intern)
Aubrun, Sandrine (Ekstern)
Porté-Agel, Fernando (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: 1/3 FUU, 1/3 inst 1/3 Andet

Relations
Publications:
Flow over complex terrain. The secrets of Bolund
Project: PhD

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)
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)
Larsén, 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
Sander Plast

Liftra
Period: 01/01/2013 → 31/12/2015
Number of participants: 3
Acronym: PowerPack
Project participant:
Bak, Christian (Intern)
Gaunaa, Mac (Intern)
Zahle, Frederik (Intern)

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, Rikké 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 husstandsølger
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
**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%.

**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.

**Possible Power of Downregulated Offshore Wind power plants**
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

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
Energy resources, services and control
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)

Project

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
Linear Algebra and Optimization Seminar 2014
DCAMM 15th Internal Symposium
5th International Conference of Engineering Optimization
Project: PhD

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 Fiemming (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:
Aerodynamic and structural design of wind turbine blades

Department of Wind Energy
Period: 15/06/2012 → 30/09/2016
Number of participants: 4
Phd Student:
Hrgovan, Iva (Intern)
Supervisor:
Berggreen, Christian (Intern)
Sørensen, Jens Nørkær (Intern)
Main Supervisor:
Shen, Wen Zhong (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

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
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)
von 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

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**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

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**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  
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)

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)
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)
Réthoré, Pierre-Elouan (Intern)

Project Manager, academic:

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)
vander Laan, 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
Project
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

Project

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

RTÉ (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

Project

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:
von 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)
**Wind Power Plant System Services**

Department of Wind Energy  
Period: 15/12/2011 → 19/03/2015  
Number of participants: 7  
Phd Student:  
Basit, Abdul (Intern)  
Supervisor:  
Altin, Müfit (Intern)  
Sørensen, Poul Ejnar (Intern)  
Main Supervisor:  
Hansen, Anca Daniela (Intern)  
Examiner:  
Cutululis, Nicolaos Antonio (Intern)  
Chen, Zhe (Ekstern)  
Molina Garcia, Angel (Ekstern)

**Financing sources**

Source: Internal funding (public)  
Name of research programme: Offentlig finansiering  
Project: PhD

**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
Project

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 Stærdahl, 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:
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: Forskningsrådsfinansiering
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)
Supervisor:
Larsen, Søren Ejling (Intern)
Rasmussen, Jørgen Hvenekær (Intern)
Main Supervisor:
Branner, Kim (Intern)
Examiner:
Bredmose, Henrik (Intern)
Muskulus, Michael (Ekstern)
Tarp-Johansen, Niels Jacob (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: ErhvervsPhD-ordningen VTU
Project: PhD

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)
Prag, Sidsel-Marie Winther (Intern)
Stenbæk, Lise (Intern)
Gaunaa, Mac (Intern)
Andersen, Peter Bjørn (Intern)
Project Manager, academic:
Badger, Merete (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
Project

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)
**Validated loads prediction models for offshore wind turbines for enhanced component reliability**

Department of Wind Energy  
Period: 15/09/2011 → 19/12/2014  
Number of participants: 6  
Phd Student:  
Koukoura, Christina (Intern)  
Supervisor:  
Branner, Kim (Intern)  
Main Supervisor:  
Natarajan, Anand (Intern)  
Examiner:  
Hansen, Kurt Schaldemose (Intern)  
Bossanyi, Ervin Ashoka (Ekstern)  
Ibsen, Lars Bo (Ekstern)

**Financing sources**  
Source: Internal funding (public)  
Name of research programme: Offentlig finansiering  
Project: PhD

**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:
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)

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)
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/
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 Interconnections
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
VESTAS Wind Systems A/S

**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:
Trolldborg, 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 environment**
Department of Photonics Engineering
Risø 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)
Løvholt, Kenneth (Ekstern)
Lundgaard, Jacob (Ekstern)
Dam-Hansen, Carsten (Intern)
Poulsen, Peter Behrensedorf (Intern)
Hansen, Søren Stentoft (Intern)
Jensen, Peter (Intern)
Bak, Christian (Intern)
Harboe, René Kirstein (Ekstern)
Bentzen, Barbara (Ekstern)
Køhler, 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 neutralt 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)
Examiner:
Walther, Jens Honore (Intern)
Davidson, Lars (Ekstern)
Olesen, Niels Anker (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

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)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

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)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD
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)
Supervisor:
Kelly, Mark C. (Intern)
Main Supervisor:
Gryning, Sven-Erik (Intern)
Examiner:
Larsen, Søren Ejling (Intern)
Rutgersson, Anna (Ekstern)
Zagar, Mark (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut, samfinansiering
Project: PhD

Light Rotor

Department of Wind Energy
Aeroelastic Design
Wind Turbines
VESTAS Wind Systems A/S
Period: 01/10/2010 → 30/09/2013
Number of participants: 8
Acronym: Light Rotor
Project participant:
Bak, Christian (Intern)
Zahle, Frederik (Intern)
Kim, Taeseong (Intern)
Gaunaa, Mac (Intern)
Sørensen, Niels N. (Intern)
Hansen, Morten Hartvig (Intern)
Bitsche, Robert (Intern)
Blasques, José Pedro Albergaria Amaral (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
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)
Main Supervisor:
Sørensen, Niels N. (Intern)
Examiner:
Hansen, Martin Otto Laver (Intern)
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)
Gulstad, Line (Ekstern)
Wilczak, James M. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Marie Curie (EU-stipendium)
Project: PhD

ICEWIND: Improved forecast of wind, waves and icing
ICEWIND: Improved forecast of wind, waves and icing The ICEWIND project is funded by The Nordic Top-level research

• Overall budget 20.8 mill NOK
• Financial support TFI 12.3 mill NOK
• Ekstern finansiering 8.5 mill NOK
• Partners: 13

Nordic Energy Research, TFI-PK int 01.

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.

Department of Wind Energy
Meteorology
Wind Energy Systems
Office for Study Programmes and Student Affairs
Period: 01/09/2010 → 28/02/2015
Number of participants: 6
Acronym: ICEWIND

Project participant:

Hasager, Charlotte Bay (Intern)
Hahmann, Andrea N. (Intern)
Davis, Neil (Intern)
Badger, Merete (Intern)
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

Nysted 2, Wakes
The objective of this project is 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)

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)
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: 1/3 FUU, 1/3 inst 1/3 Andet
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: 
Schleer, 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

Wind Energy Systems
Period: 01/04/2010 → 31/05/2013
Number of participants: 1
Acronym: TWENTIES
Project participant:
Litong-Palima, Marisciel (Intern)

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.

Risø National Laboratory for Sustainable Energy

Department of Wind Energy

Wind Energy Systems

Department of Electrical Engineering

Center for Electric Power and Energy
Period: 01/04/2010 → 31/03/2013
Number of participants: 5
Wind power, TSO, Demonstration, Storm control, Wind turbines, Wind farms
Acronym: TWENTIES
Project participant:
Sørensen, Poul Ejnar (Intern)
Cutululis, Nicolaos Antonio (Intern)
Maule, Petr (Intern)
Litong-Palima, Marisciel (Intern)
Altiparmakis, Argyrios (Intern)

Relations
Publications:
Market and system security impact of the storm demonstration in task-forces TF2. Deliverable: D16.6
Wind power variability and power system reserve requirements at 2020 at 2030 scenarios for offshore wind power in Northern Europe
Report with data for system behaviour at storm passage with original (uncoordinated) and coordinated control
Impact of High Wind Speed Shut-down in the Danish Power System
North Sea Offshore Wind Power Variability in 2020 and 2030
Technical and economic impact analysis of the demonstrations in task-forces TF2 - Deliverable D15.2
Economic impact analysis of the demonstrations in task-forces TF1 and TF3 - Deliverable D15.1
Offshore Variability in Critical Weather Conditions in Large-Scale Wind Based Danish Power System

Offshore Wind Power Data

Spectral structure of mesoscale winds over the water

Offshore Wind Power Production in Critical Weather Conditions

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
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.

The project is part-financed by the EU European Regional Development Fund and the South Baltic Programme.

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)
Hahmann, Andrea N. (Intern)
Badger, Jake (Intern)
Peña, Alfredo (Intern)
Karagali, Ioanna (Intern)
Bingöl, Ferhat (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)
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:
Velte, 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)

DANAERO MW II: Indflydelse af atmosfære- og værvandsturbulens på MW møllers ydeevne, last og stabilitet
Department of Wind Energy
Aeroelastic Design
Test and Measurements
VESTAS Wind Systems 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
Balancing, Power system, Wind, Forecast errors
Acronym: SIMBA
Project participant:
Sørensen, Poul Ejnar (Intern)
Cutululis, Nicolaos Antonio (Intern)
Litong-Palima, Marisciel (Intern)
Maule, Petr (Intern)
Project

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)
Troldborg, Niels (Intern)
Réthoré, Pierre-Elouan (Intern)
Bechmann, Andreas (Intern)
Zahle, Frederik (Intern)
Larsen, Gunner Chr. (Intern)
Project Manager, academic:
**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

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**Adaptive Trailing Edge Flap, control for enhanced load alleviation**

Department of Wind Energy
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
Wind Energy Systems
Aalborg University
VESTAS Wind Systems A/S
Siemens Wind Power A/S
ABB Energi & Industri A/S
Siemens A/S

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
Project
Yield point phenomenon and formability of nanometals
Department of Wind Energy
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 polymens 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
**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: Forskningsrådsfinansiering  
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:  
Sørensen, Niels N. (Intern)  
Examiner:  
Mikkelsen, Robert Flemming (Intern)  
Johansen, Jeppe (Intern)  
Voutsinas, Spyros (Ekstern)

**Financing sources**

Source: Internal funding (public)  
Name of research programme: ErhvervsPhD-ordningen VTU  
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:  
Bøgh, 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)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

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
Project

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
Project: PhD

Integreter 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)
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)

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)
Heyer, 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.
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)

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:
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:
Larsén, 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)
van Dam, 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)
v 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)
Larsen, 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
Application of the spectral correction method to reanalysis data in South Africa
Validation and comparison of numerical wind atlas methods: the South African example

**Characterization and modelling of wood fibre composites**

Department of Wind Energy
Period: 15/10/2008 → 20/09/2012
Number of participants: 5
Phd Student:
Aslan, Mustafa (Intern)
Supervisor:
Madsen, Bo (Intern)
Main Supervisor:
Sørensen, Bent F. (Intern)
Examiner:
Horsewell, Andy (Intern)
Burgert, Ingo (Ekstern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: Risø (Len)
Project: PhD

**EU NORSEWinD: Northern Seas Wind Index database**
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

Department of Wind Energy

**Test and Measurements**

Meteorology
Period: 01/08/2008 → 31/07/2012
Number of participants: 14
Number of related Ph.D. students: 1
Project participant:
Mikkelsen, Torben Krogh (Intern)
Courtney, Michael (Intern)
Peña, Alfredo (Intern)
Badger, Merete (Intern)
Badger, Jake (Intern)
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)
Project Manager, organisational:
Hasager, Charlotte Bay (Intern)

Relations
Activities:
Ocean winds from satellites – applications for offshore wind energy

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

EFPO7-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
Project

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)
Andersen, Nina Juul (Ekstern)
Horstmann, Jørgen (Ekstern)
Ravn, Hans V. (Intern)
Anderson, Anton (Ekstern)
Nørgaard, Per H. (Intern)
Hansen, Anders Bavnhøj (Ekstern)
Pedersen, Jens (Ekstern)
Abildgaard, Hans (Ekstern)

Project Manager, academic: Nielsen, Lars Henrik (Intern)

Financing sources
Source: Forskningsprojekter - Miljø- og Energiministeriet
Name of research programme: Forskningsprojekter - Miljø- og Energiministeriet
Amount: 501,000.00 Danish Kroner
Documents:
ris-r-1804

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, Xiaoli Guo (Intern)
Rathmann, Ole Steen (Intern)
Nielsen, Morten (Intern)
Hummelshøj, 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
Project

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 solitid 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.

Projektdeleganter er
Risø 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
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
Risø 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.

Risø National Laboratory, Wind Energy Department Charlotte Bay Hasager (coordinator), Merete Bruun Christiansen, Ioanna Karagali
DRC-DTU Leif Toudal Pedersen, Ole Balthazar Andersen
DMI Jacob L. Høyer, Peter Viskum Jørgensen
Niels Bohr Institute at University of Copenhagen Niels Kristian Højerslev, Rune Midjord Nielsen
Institute of Geography at University of Copenhagen Michael Schultz Rasmussen
Eduspace Peter Brøgger Sørensen
ESA consultant Jürg Lichtenegger

See http://www.satelliteeye.dk

The educational material and satellite data have later been moved to www.virtuelgalathea3.dk (vg3.dk)

Satellite data see also http://galathea.dtu.dk/index_e.html (DTU Space)

Department of Wind Energy

Meteorology
Period: 01/03/2006 → 28/02/2009
Number of participants: 3
Project participant:
Hasager, Charlotte Bay (Intern)
Badger, Merete (Intern)
Karagali, Ioanna (Intern)

Project

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
Charlotte Bay Hasager (coordinator),
Torben Mikkelsen, Ioannis Antoniou, Rebecca Barthelmie, Sven-Erik Gryning, Hans E. Jørgensen, Ph.D. student Alfredo Peña

Elsam Engineering: Paul Sørensen

Department of Wind Energy
Meteorology
Test and Measurements
Period: 01/10/2005 → 31/03/2009
Number of participants: 6
Acronym: 12 MW
Project participant:
Peña, Alfredo (Intern)
Mikkelsen, Torben Krogh (Intern)
Courtney, Michael (Intern)
Antoniou, Ioannis (Intern)
Gryning, Sven-Erik (Intern)
Project Manager, organisational:
Hasager, Charlotte Bay (Intern)

Project 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
Period: 01/10/2004 → 31/03/2007
Number of participants: 4
Project participant:
Cutululis, Nicolaos Antonio (Intern)
Madsen, Henrik (Intern)
Pinson, Pierre (Intern)
Project Manager, academic:
Sørensen, Poul Ejnar (Intern)

Relations
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

Project

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 tranfer 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 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)
Adaptiv vingegeometri til reduktion af vindmøllelaster

Aeroelastic Design

Wind Energy Division

Risø National Laboratory for Sustainable Energy

Period: 01/10/2003 → 30/09/2005
Number of participants: 1
Acronym: ADAPWING
Project ID: 1110047-01
Project Manager, organisational:
Buhl, Thomas (Intern)

Financing sources
Source: Forskningsrådene - STVF
Name of research programme: Forskningsrådene - STVF
Amount: 1,500,000.00 Danish Kroner

SAR-WAKE: Offshore wake effect study from Earth Observation Synthetic Aperture Radar

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-WINFARM

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 Dellwik

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)

Project

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)

Project

EU WATERMED: WAt er use Efficiency in natural vegetation and agricultural areas by Remote sensing in the MEDiterranean basin

WATer use Efficiency in natural vegetation and agricultural areas by Remote sensing in the MEDiterranean basin

The 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 Ouazarzate 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)

Institu 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)
Project

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)

Risø 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
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., 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


Hasager, C.B.; Nielsen, N.W.; Christensen, J.H.; Søgaard, H.; Bøgh, E.; Rasmussen, M.S.; Jensen, N.O., Remote sensing images used for aggregation of the momentum roughness, z0m. Seminardag: Remote sensing anvendt i hydrologi og agrometeorologi, Københavns Universitet, København (DK), 8. Nov 2002. See abstract and poster


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)  
Project: 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  
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 (Rise), 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 Foulum.

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)
Project

**WAsP development and support**
Department of Wind Energy
Meteorology
Aeroelastic Design
Period: 23/07/1987 → 31/12/2017
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)
Project

**Activities:**

*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 → …
Related journal

Atmospheric Science Letters
1530-261X
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
Central database
Activity: Research › Peer review of manuscripts

Boundary-Layer Meteorology (Journal)
Period: 2017 → …
Sven-Erik Gryning (Reviewer)
Department of Wind Energy
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
Central database
Activity: Research › Peer review of manuscripts

Climate Dynamics (Journal)
Period: 2017 → …
Sven-Erik Gryning (Reviewer)
Department of Wind Energy
Degree of recognition: International

Related journal
Climate Dynamics
0930-7575
Central database
Activity: Research › Peer review of manuscripts

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
Central database
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
BFI (2018): BFI-level 1, Scopus rating (2016): CiteScore 1.16 SJR 0.467 SNIP 0.586, ISI indexed (2013): ISI indexed no,
Web of Science (2016): Indexed yes
Central database
Activity: Research › Journal editor

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
Web of Science (2018): Indexed yes
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
Web of Science (2018): Indexed yes
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)
**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)

Resource Assessment Modelling

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

International Conference on Future Technologies for Wind Energy WindTech 2017 24-26 Oct. 2017
Period: 2017

Anna Maria Sempreviva (Panel member)

Resource Assessment Modelling

Description
Member of the International Advisory Board, Key Note speaker

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

Journal of King Saud University - Science (Journal)

Period: 2017 → …

Sven-Erik Gryning (Reviewer)

Resource Assessment Modelling

Degree of recognition: International

Related journal

Journal of King Saud University - Science

Activity: Research › Peer review of manuscripts
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 Air and Waist Management Association
1096-2247
Scopus rating (2016): CiteScore 1.73 SJR 0.669 SNIP 0.826, Web of Science (2018): Indexed yes
Local database
Activity: Research › Peer review of manuscripts

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 (2016): CiteScore 2.61 SJR 1.002 SNIP 1.92, 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 (2016): CiteScore 2.61 SJR 1.002 SNIP 1.92, 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
WindEurope 2017
28/11/2017 → 30/11/2017
Amsterdam, Netherlands
Activity: Talks and presentations › Conference presentations

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
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 (2016): CiteScore 1.28 SJR 0.659 SNIP 0.67, 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
**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**
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, toiringe.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
Degree of recognition: International
Related journal
Wind Energy Science Discussions
2366-7621
Central database
Activity: Research › Peer review of manuscripts

Multidisciplinary Design Optimization with HAWTOpt2
Period: 15 Dec 2017
Michael McWilliam (Invited speaker)
Frederik Zahle (Other)
Department of Wind Energy
Aerodynamic design
Degree of recognition: Local
Documents:
HAWTOpt2_Dec_15_2017
Related external organisation
Ørsted
Teknikerbyen 25, 2830, Virum, Denmark
Activity: Talks and presentations › Conference presentations

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 Østerlid 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
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

Lighweight 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 $\overline{V}$ 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_Vinfty_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
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
Andrea N. Hahmann (Speaker)
Niels Gylling Mortensen (Other)
Jens Carsten Hansen (Other)
Department of Wind Energy
Resource Assessment Modelling
Integration & Planning

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
Degree of recognition: International
Documents:
Xiao_Chen_ISMEM2017_3

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
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
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 Efteruddannelsen for Universitetsansatte  
30/10/2017 → 31/10/2017  
Vejle, Denmark  
Activity: Talks and presentations › Conference presentations

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  
Peter Enevoldsen  
Degree of recognition: National  
Activity: Examinations and supervision › External examination

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  
Documents:  
Presentation_WindTech2017_3

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 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
Fluid 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
WIND ENERGY DENMARK 2017
02/10/2017 → 03/10/2017
Herning, Denmark
Activity: Talks and presentations › Conference presentations

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

WIND ENERGY DENMARK 2017
02/10/2017 → 03/10/2017
Herning, Denmark
Activity: Talks and presentations › Conference presentations

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

WIND ENERGY DENMARK 2017
02/10/2017 → 03/10/2017
Herning, Denmark
Activity: Talks and presentations › Conference presentations

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

WIND ENERGY DENMARK 2017
02/10/2017 → 03/10/2017
Herning, Denmark
Activity: Talks and presentations › Conference presentations

WIND ENERGY DENMARK 2017
Period: 2 Oct 2017 → 3 Oct 2017
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  
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
Web of Science (2018): Indexed yes
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 committees, 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
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
Degree of recognition: International
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
Department of Wind Energy
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
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

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

Doppler lidar horizontal wind retrievals from a meteorological perspective
Period: 4 Sep 2017 → 8 Sep 2017
Ewan O'Connor (Speaker)
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
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

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

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
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)

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

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 (2016): CiteScore 2.5 SJR 0.691 SNIP 1.053, 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

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
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 Troldborg (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

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

Initial results from the Single-Tree Experiment

Period: 17 Jul 2017

Ebba Dellwik (Speaker)
Jakob Mann (Other)
Nikolas Angelou (Other)
Andrey Sogachev (Other)
Niels Troldborg (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
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
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
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
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)
Eliot 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
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
International Conference on Energy & Meteorology
27/06/2017 → 29/06/2017
Bari, Italy
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

Predicting free-stream wind speed in complex terrain with lidar measurements
Period: 27 Jun 2017
Alexander Raul Meyer Forsting (Speaker)
Department of Wind Energy
Aerodynamic design
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

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-hight installed cup anemometer.

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
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

Description
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.

Documents:
A_Hannesdottir_abstract_WESC2017
Links:
http://www.wesc2017.org/
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
Documents:
Bigger_is_better_noanim

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)
Jianting Du (Guest lecturer)
Poul Ejnar Sørensen (Guest lecturer)
Jesper Nielsen Nissen (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

Large scale wind farm wakes and a wind-wave-wake coupled mesoscale modeling system
Period: 26 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:
Related event

**Wind Energy Science Conference 2017**
26/06/2017 → 29/06/2017
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
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 aerelastic 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
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
Activity: Talks and presentations › Conference presentations

Power curve measurement using $V_infinity$ 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
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**

**Wind Energy Science Conference 2017**
26/06/2017 → 29/06/2017
Activity: Talks and presentations › Conference presentations

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**
26/06/2017 → 29/06/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

**Wind Energy Science Conference 2017**
26/06/2017 → 29/06/2017
Michael McWilliam (Organizer)
Department of Wind Energy
Aerodynamic design
Degree of recognition: International

**Related event**

**Wind Energy Science Conference 2017**
26/06/2017 → 29/06/2017
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 Raul Meyer Forsting (Speaker)
Department of Wind Energy
Aerodynamic design
Degree of recognition: International
Documents:
Presentation
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)
Department of Wind Energy
Resource Assessment Modelling
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
BFI (2018): BFI-level 1, Scopus rating (2016): CiteScore 2.23 SJR 0.887 SNIP 1.123, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
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
A Probabilistic Approach to CFD Validation with Field Measurements in Wind Energy
Period: 15 Jun 2017
Alexander Raul Meyer Forsting (Speaker)
Department of Wind Energy
Aerodynamic design
Degree of recognition: International
Documents:
doc_dtubeamer

UNCECOMP 2017: 2nd International Conference on Uncertainty Quantification in Computational Sciences and Engineering
15/06/2017 → 17/06/2017
Rhodes, Greece
Activity: Talks and presentations › Conference presentations

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

IEC 61400-15 meeting/workshop 11
12/06/2017 → 16/06/2017
Porto, Portugal
Activity: Membership › Membership of commitees, 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
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 Optimization
Period: 7 Jun 2017
Asger Bech Abrahamsen (Participant)
Mathias Stolpe (Participant)
Department of Wind Energy

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
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

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/

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
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:
OWE17-RogierFloors-PO026

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 Optmisation
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 Optmisation
Period: 5 Jun 2017 → 9 Jun 2017
Susana Rojas Labanda (Participant)
Mathias Stolpe (Participant)

Department of Wind Energy

Wind Turbine Structures and Component Design
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 Optimization
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 Ejsing 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 Raul 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

Royal Meteorological Society. Quarterly Journal
0035-9009
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
Activity: Research › Peer review of manuscripts

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
BFI (2018): BFI-level 2, Scopus rating (2016): CiteScore 2.5 SJR 0.691 SNIP 1.053, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Indexed in DOAJ
Central database
Activity: Research › Peer review of manuscripts
Related journal

**Monthly Weather Review**
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)

**Passive/active load alleviation**
Period: 27 Apr 2017
Flemming Rasmussen (Lecturer)
Department of Wind Energy
Aerodynamic design
Degree of recognition: International

**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**
Period: 24 Apr 2017
Ioanna Karagali (Reviewer)
Department of Wind Energy
Meteorology & Remote Sensing

**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**

**Monthly Weather Review**
0027-0644
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

**Remote Sensing of Environment**
0034-4257
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

**Remote Sensing of Environment**
0034-4257
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

**Remote Sensing of Environment**
0034-4257
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts
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 (2016): CiteScore 0.45 SJR 0.24 SNIP 0.383, 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
Indexed in DOAJ
Central database
Activity: Research › Peer review of manuscripts

**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
Resource Assessment Modelling
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 (2016): CiteScore 0.45 SJR 0.24 SNIP 0.383, 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 Ilisted 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 Lylloff (Reviewer)
Acoustic Technology
Department of Wind Energy
Aerodynamic design
Degree of recognition: International

**Related journal**
**Applied Acoustics**
0003-682X
BFI (2018): BFI-level 2, Scopus rating (2016): CiteScore 2.33 SJR 0.89 SNIP 1.651, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
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
Web of Science (2018): Indexed yes
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

American Meteorological Society. Bulletin
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 $S(z) = (u^*) \ln(z/z_0) + c(z/B)^2$. This formulation ensures maximum errors within 5% percent, up to 80% of the boundary layer height when compared to LES results.

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

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

AMS 97th Annual Meeting
Period: 22 Jan 2017 → 28 Jan 2017
Elliot Simon (Speaker)
Department of Wind Energy
Meteorology & Remote Sensing

AMS 2017: Lidar Applications to the Energy Sector
Documents:
AMS-presentation-elliot-simon-final
Elliot-AMS-Presentation-Recording
Links:
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)
Department of Wind Energy
Meteorology & Remote Sensing

Description
Supervision of MSc student
Activity: Examinations and supervision › Supervisor activities

**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

**AiAA SciTech Forum 2017; Wind Energy Symposium**
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:
AIAA_Presentation_on_AMMF
multi_fidelity_wind_turbine_optimization

Related event
2017 AIAA 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

Energies (Journal)
Period: 1 Jan 2017 → 1 Feb 2017
Patrick Volker (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Description
Manuscript energies-196457, rejected
Degree of recognition: International

Related journal
Energies
1996-1073
Indexed in DOAJ
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
IEC (International Electrotechnical Commission)
Geneva, Switzerland
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

Journal of Renewable and Sustainable Energy (Journal)
Period: 1 Jan 2017 → 1 Feb 2017
Patrick Volker (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Degree of recognition: International
Links:

Related journal
Journal of Renewable and Sustainable Energy
1941-7012
BFI (2018): BFI-level 1, Scopus rating (2016): CiteScore 1.2 SJR 0.418 SNIP 0.523, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

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
13th Deep Sea Offshore Wind R&D Conference
Period: 2016
Kasper Sandal (Participant)
Department of Wind Energy

Description
Poster presentation
Documents:
Deepwind2016_poster

Related event
13th Deep Sea Offshore Wind R&D Conference
20/01/2016 → 22/01/2016
Trondheim, Norway
Activity: Attending an event › Participating in or organising a conference

Design of large composite structures
Period: 2016
Philipp Ulrich Haselbach (Lecturer)
Department of Wind Energy

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

EGU General Assembly 2016
Period: 2016
Anna Maria Sempreviva (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
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
 Indexed in DOAJ
Central database
Activity: Research › Peer review of manuscripts

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
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

Measnet Site Assessment Working Group (External organisation)

Period: 2016 → 2017
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

Royal Meteorological Society. Quarterly Journal
0035-9009
Central database
Activity: Research › Peer review of manuscripts

Sådan kan man regne på husstandsølør
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 2016**
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
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
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
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-
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)

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 Brandsted (Speaker)

Department of Wind Energy
Composites and Materials Mechanics

Description
The objective of this project was to optimize the geometry of compression 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
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

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 Commission financed FP7 project under the program 'future emerging technologies'
Degree of recognition: International

Documents:

Cranfield_v1

Links:


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
Oral presentation given on behalf of Jianiting Du

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 Skłodowska-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 highlight the pros and cons with a resulting vote on the future drivetrain mix in 2030. Presentations: Asger B. Abrahamsen, Senior Research Scientist, DTU Wind Energy: New direct drive technologies of the INNWIND.EU project: Superconducting vs pseudo direct drive (PDF) Jesper Hansen, Coordinator of EcoSwing consortium, Envision Energy (Denmark): Superconducting direct drive development of the EcoSwing project (PDF) Hans-Joergen Thougaard, Magnet Specialist, Siemens Wind Power (Denmark): Characterization of hard magnetic materials in direct drive wind turbines (No presentation available) Anders Bach Andersen, Senior Product Manager, MHI Vestas Offshore: Selecting the optimum solution for drivetrains, seen from a wind turbine owner's perspective (PDF) Moderator: Asger Bech Abrahamsen, Senior Research Scientist, DTU Wind Energy

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.

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**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

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**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

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**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

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**Wind Europe Summit 2016**  
Period: 29 Sep 2016  
Alexander Raul 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
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 Boraccino (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_ABoraccino_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

ScanFlowHigh-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
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:
EMS2016_SingleTREE

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

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
16th EMS Annual Meeting & 11th European Conference on Applied Climatology

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

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
Fælgegruppen 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)
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
Montreal, Canada
Activity: Attending an event › Participating in or organising a conference

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

DESCOTOLO
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

Design Conditions for Tower Loads

Remote Sensing (Journal)
Period: 27 Jul 2016
Ioanna Karagali (Reviewer)
Department of Wind Energy
Meteorology & Remote Sensing
Related journal

**Remote Sensing**
2072-4292
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 / Euporias 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 / Euporias Workshop on Climate and Energy
Related event

WEMC / UK Met Office / Euporias 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 (2016): CiteScore 0.45 SJR 0.24 SNIP 0.383, 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  
Foz de Iguassu, Brazil

Alemseged Gebrehiwot Weldeyesus (Speaker)

Department of Wind Energy

Documents:  
EngOpt2016-12

Links:  
http://engopt.org/user/show_abstract.php?cod=75

Related event

5th International Conference of Engineering Optimization  
Foz de Iguassu, Brazil

Activity: Attending an event › Participating in or organising a conference

16th EMS Annual Meeting & 11th European Conference on Applied Climatology  
Period: 14 Jun 2016  
Trieste, Italy

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
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

ISARS2016
Period: 8 Jun 2016
Sven-Erik Gryning (Chairman)
Department of Wind Energy
Resource Assessment Modelling
Description
Ground-Based Remote Sensing Technology Applications

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

ECCOMAS Congress 2016
Period: 7 Jun 2016
Alexander Raul Meyer Forsting (Speaker)
Department of Wind Energy

Aerodynamic design

**Description**
Validation of a CFD model with a triple-lidar system 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

Wind field reconstruction from nacelle-mounted profiling lidars for power performance
Documents:
20160606_Naclidars_windfield_induction_ABorraccino_Vfinal

**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

**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
Resource Assessment Modelling

**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

**ISARS2016**
Period: 6 Jun 2016
Sven-Erik Gryning (Speaker)
Department of Wind Energy
Resource Assessment Modelling

**Description**
Effect of Carrier to Noise Ratio threshold 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

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

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
Activity: Talks and presentations › Conference presentations

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

Perdigao NEWA meeting
Period: 13 May 2016
Alexander Raul 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

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

27/04/2016 → 28/04/2016
Washington, DC 20024, United States
Activity: Talks and presentations › Conference presentations

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 (2016): CiteScore 0.38 SJR 0.186 SNIP 0.567, ISI indexed (2013): ISI indexed no, Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

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
Activity: Talks and presentations › Conference presentations

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 (2016): CiteScore 0.38 SJR 0.186 SNIP 0.567, ISI indexed (2013): ISI indexed no, Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

I O P Conference Series: Earth and Environmental Science (Journal)
Period: 20 Apr 2016
Ioanna Karagali (Reviewer)
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
Activity: Talks and presentations › Conference presentations

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
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
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

Følgegruppen 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

Description
SEAMLESS meeting, Barcelona

Related external organisation

Unknown external organisation
Activity: Talks and presentations › Conference presentations

Coastal Boundary Layer Development, Impacted by terrain inhomogeneity and non-ideal conditions
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

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)

Related event
12th EAWE PhD seminar on Wind Energy in Europe
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)

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
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
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
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
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
Poster 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
http://portalen.dtu.dk/institutter/DTU%20Vindenergi/Nyheder.aspx?msg=4797981f-5e04-4a53-84bc-8c2337265103&sc_lang=en
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
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

2nd International Conference on Future Technologies in Wind Energy
19/10/2015 → 21/10/2015
London, ON, Canada
Activity: Talks and presentations › Conference presentations

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 commitees, 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

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.

Documents:
Asta_EAWE_PhD_2015_Abstract

Related event

11th EAWE PhD seminar on Wind Energy in Europe
Stuttgart, Germany
Activity: Talks and presentations › Conference presentations

11th EAWE PhD seminar on Wind Energy in Europe
Period: 23 Sep 2015
Alexander Raul Meyer Forsting (Speaker)
Department of Wind Energy

Aeroelastic Design

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 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  
Documents:  
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  
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
Reduction of uncertainty of near-shore wind estimations using wind lidars and mesoscale models

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

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.

Related event

15th European Meteorological Society Annual meeting
07/09/2015 → 11/09/2015
Sofia, Bulgaria
Activity: Talks and presentations › Conference presentations

Reduction of uncertainty of near-shore wind estimations using wind lidars and mesoscale models

Period: 8 Sep 2015
Rogier Ralph Floors (Speaker)
Department of Wind Energy

Description

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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.

Related event

15th European Meteorological Society Annual meeting
07/09/2015 → 11/09/2015
Sofia, Bulgaria
Activity: Talks and presentations › Conference presentations
Meteorology

Description
Convener of session on Energy Meteorology (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
0045-7930
Central database
Activity: Research › Peer review of manuscripts

20th International Conference on Composite Materials (ICCM20)
Philipp Ulrich Haselbach (Speaker)
Department of Wind Energy
Wind Turbines

Description
Effect of trailing edge damage on fullscale wind turbine blade failure

Related event

20th International Conference on Composite Materials (ICCM20)
19/07/2015 → 24/07/2015
Copenhagen, Denmark
Activity: Talks and presentations › Conference presentations

GHRSST XVI Science Team Meeting
Ioanna Karagali (Participant)
Department of Wind Energy
Meteorology

Description
GHRSST Science Team Meeting 2015

Related event

GHRSST XVI Science Team Meeting
20/07/2015 → 24/07/2015
Noordjiwck, 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)
Department of Wind Energy

Description
Participation in panel on final conclusions from the conference
Degree of recognition: International
Links:

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
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

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 Aplied Physics Laboratory

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

11th World Congress of Structural and Multidisciplinary Optimization
Period: 9 Jun 2015
Susana Rojas Labanda (Participant)
Department of Wind Energy

**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

—

Alemseged Gebrehiwot Weldeyesus (Speaker)
Department of Wind Energy

**Related event**

11th World Congress of Structural and Multidisciplinary Optimisation
Period: 7 Jun 2015 → 12 Jun 2015
Sydney, Australia
Activity: Talks and presentations › Conference presentations

—

Niels Gylling Mortensen (Invited speaker)
Department of Wind Energy

**Related event**

Offshore CREYAP Part 2 - final results
Period: 3 Jun 2015
Helsinki, Finland
Activity: Talks and presentations › Conference presentations

—

Christian Bak (Lecturer)
Department of Wind Energy

**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

**Links:**
- http://www.unitte.dk/Nyheder/Nyhed?id=7a073a15-408a-4975-9c2a-95f0d0bed8cda (Article on UniTTe website)

## 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_kmun

**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
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.Sc students at Copenhagen University, within Niels Bohr Institute/geophysics.
Created course content, organization, and did all teaching.
Degree of recognition: International

Related external organisation

University of Copenhagen
Bülowsvej 17, 1780, 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)
Department of Wind Energy
Fluid Mechanics
Documents:
full_paper_WeijunZhu
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:

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.

Special course. Course lecturer,

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

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
IQPC Conference - Advances in Rotor Blades for Wind Turbines
Period: 24 Feb 2015
Frederik Zahle (Invited speaker)
Department of Wind Energy

**Description**
Talk on "Rotor Design Optimization Tools and Cost Models"
Workshop on aeroelastic design of wind turbines
Documents:
iqpc_hawtopt2
iqpc_casestudy

**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

**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

**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
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

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Merete Badger (Invited speaker)
Department of Wind Energy
Meteorology

**Description**
TEMPUS Lifelong Learning workshop at DTU

**Related external organisation**
Unknown external organisation
Activity: Talks and presentations › Conference presentations

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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

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Elliot Simon (Participant)
Department of Wind Energy
Meteorology & Remote Sensing

**Related event**
Winterwind 2015: International Wind Energy Conference
02/02/2015 → 06/02/2015
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**


04/02/2015 → 06/02/2015

Trondheim, Norway

Activity: Talks and presentations › Conference presentations

**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


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
Wind Turbines

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
Wind Turbines

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
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
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
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
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 Ilsenska 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.

**ESA SOLAS EO for Ocean-Atmosphere Interactions Science**
**Period:** 28 Oct 2014 → 31 Oct 2014
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

**Teaching and Learning**
**Period:** 28 Oct 2014 → 31 Oct 2014
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.

Wind Operator Congress Europe
Period: 28 Oct 2014
Torben Krogh Mikkelsen (Participant)
Department of Wind Energy
Test and Measurements

Description
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)
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 Vaisala 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 prevailed 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

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
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:
SmartRotor_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

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
Web of Science (2018): Indexed yes
Central database
Activity: Research › Peer review of manuscripts

Group for High Resolution Sea Surface Temperature (External organisation)
Period: 30 Jul 2014
Ioanna Karagali (Chairman)
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
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

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
American Meteorological Society. Bulletin
0003-0007
Central database
Activity: Research › Peer review of manuscripts

Hard Bop and Cool Jazz
Period: Jun 2014
Bonnie Ram (Lecturer)
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

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

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**The 15th GHRSST Science Team Meeting**

**Period:** 2 Jun 2014 → 6 Jun 2014  
Ioanna Karagali (Participant)

Department of Wind Energy  
Meteorology

**Description**

15th GHRSST Science Team Meeting.

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**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

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**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)

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**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

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**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.

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**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

**Related event**

**ESA SciNet 2014**
14/05/2014 → 14/05/2014
Noordwijk, Netherlands
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

**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

**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

**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)
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 (2016): CiteScore 0.21 SJR 0.163 SNIP 0.236, 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 (2016): CiteScore 0.83 SJR 0.399 SNIP 0.666, 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
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
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
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
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
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 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

**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
12/11/2013 → 13/11/2013
Stuttgart, Germany
Activity: Talks and presentations › Conference presentations

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 Meteorological 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

16/09/2013 → 20/09/2013
Vienna, Austria
Activity: Talks and presentations › Conference presentations

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

ESA Living Planet Symposium
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

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
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 (2016): CiteScore 0.83 SJR 0.399 SNIP 0.666, 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
Web of Science (2018): Indexed yes
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 GHRSSST 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
Web of Science (2018): Indexed yes
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:
Poster: Strain Gauge Application in Soft Material Testing

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
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
Period: 13 Mar 2013 → 15 Mar 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

Juan Felipe Gallego Calderon (Participant)
Department of Wind Energy
Wind Turbines

Description
Electromechanical Drive-train Simulation

Related event

DCAMM 14th Internal Symposium
Period: 13 Mar 2013 → 15 Mar 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  
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
Weather Research & Forecasting User Tutorial
Period: 28 Jan 2013 → 5 Feb 2013
Ioanna Karagali (Participant)

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)

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)

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
Wind Turbines
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 Larsen (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
BFI (2018): BFI-level 2, Scopus rating (2016): CiteScore 3.55 SJR 0.988 SNIP 1.379, ISI indexed (2013): ISI indexed yes,
Web of Science (2018): Indexed yes
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 energy. Agentschap NL en Dienst Regelingen. RVO.nl
Degree of recognition: International

**Related external organisation**

**TKI WoZ Advisory Board Meeting**
Activity: Membership » Membership of committees, 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**

**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.

**Præsentation om planerne om en vindtunnel på DTU**
Period: 18 Sep 2012
Christian Bak (Lecturer)
Department of Wind Energy
Aeroelastic Design

**Related event**

**Gå-hjem-møde for IDA, Region Sjælland**
18/09/2012 → …
Roskilde, Denmark
Activity: Talks and presentations » Conference presentations

**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**

**11th International Conference on Nanostructured Materials**
26/08/2012 → 31/08/2012
Rhodes, Greece
Activity: Talks and presentations » Conference presentations

**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

**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
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 › Conference presentations

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

**Multiscale Modelling of Complex Materials**
Period: 21 May 2012 → 25 May 2012
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.

**EWEA 2012 - European Wind Energy Conference & Exhibition**
Period: 16 Apr 2012 → 19 Apr 2012
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
9th Deep Sea Offshore Wind R&D Seminar
Period: 19 Jan 2012 → 20 Jan 2012
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 (2016): CiteScore 1.21 SJR 0.465 SNIP 0.595, Web of Science (2018): Indexed yes
Local database
Activity: Research › Peer review of manuscripts

2011 AGU Fall Meeting
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
6th Wind Energy Systems Workshop (WES Workshop); 6: 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

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)

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

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:
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

COST ACTION ES1002 Weather Intelligence for Renewable Energy
Activity: Membership › Membership of research networks or expert groups

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
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

GHRSSST XII Science Team Meeting
Period: 27 Jun 2011 → 1 Jul 2011
Ioanna Karagali (Participant)
Department of Wind Energy
Meteorology

Related event
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

Description
Presentation of results from the 1st Comparison of Resource and Energy Yield Assessment Procedures (CREYAP) exercise.

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

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

Description
Place: Rise International Energy Conference 2011, Risø (DK)

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

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

Related event
Ocean winds for wind power using stellite winds
27/04/2011 → 27/04/2011
Seminar ved Chalmers Technical University, Dept. of Earth and Space Sciences (SE)
Activity: Talks and presentations › Conference presentations

Fra atomkraft til vindenergi
Period: 13 Apr 2011
Torben Krogh Mikkelsen (Speaker)
Risø National Laboratory for Sustainable Energy
Wind Energy Division
Meteorology

**Description**
Place: Foredrag for Frederiksborg Rotary Klub Hillerød d. 13. april

**Related external organisation**
**Unknown external organisation**
Activity: Talks and presentations › Conference presentations

**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 verdensklasse**
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 commitees, 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**
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:
Karagali_poster.pdf

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.

**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

**Wind Energy (Journal)**
Period: 2009 → …
Robert Bitsche (Reviewer)
Department of Wind Energy
Wind Turbines

**Description**
Wind Energy

**Related journal**
**Wind Energy**
1095-4244
Central database
Activity: Research › Peer review of manuscripts
Wind Energy (Journal)
Period: 2009 → 2017
Xiaoli Guo Larsén (Reviewer)
Department of Wind Energy
Resource Assessment Modelling
Description
Journal of Wind Engineering & Industrial Aerodynamics
Related journal
Wind Energy
1095-4244
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 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

**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.

**Upwind spinner-based lidar measurements from the NM80 wind turbine at Tjæreborg**
Period: 25 Nov 2009
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**
Internal seminar series in the Wind Energy Division, Risø (DK)
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

**Upwind spinner-based lidar measurements from the NM80 wind turbine at Tjæreborg**
Period: 25 Nov 2009
Torben Krogh Mikkelsen (Speaker)
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: Other

2nd Advanced Training on Ocean Remote Sensing - ESA
Period: 28 Sep 2009 → 2 Oct 2009
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
28/09/2009 → 02/10/2009
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.

The electrical simulation models shall be developed to the utmost degree of independency from applied simulation tools. If simulation tool considerations are required they shall be separated in the models by a clear tool interface definition.

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 utmost 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 teh 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:
http://www.kurser.dtu.dk/46200.aspx?menulanguage=en-gb (DTU course 46200)
http://orbit.dtu.dk/services/downloadRegister/103749698/Wind_resource_assessment_using_the_WAsP_software.pdf (Course notes)

Related external organisation

Unknown external organisation
Activity: Talks and presentations › Conference presentations

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: Copenhagen, Copenhagen (DK)

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

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: Copenhagen, Copenhagen (DK)

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

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
Unknown 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
Unknown external organisation
Activity: Talks and presentations › Conference presentations

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
Central database
Activity: Research › Journal editor

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

The world expedition Galathea 3 seen from Satellite Eye; EGU2007-ES3-1TH4O-001
Period: 1 Jan 2007 → …
Merete Badger (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
Links:
http://www.wasp.dk/

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

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**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

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**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.

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**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

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**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

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**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

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**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

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**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
Bülowsvej 17, 1780, 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 ENERGY 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
Helge Aagaard Madsen (Recipient)
Risø 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)
Risø 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:

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, do talk about the new Global Wind Atlas 2.0.
Jake Badger
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

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 opslået 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

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

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

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.

**Department of Wind Energy, Meteorology & Remote Sensing**

**Media contribution (1)**

**Vindmølleparkers logistik er for omkostningstung**
30/11/2016
EnergySupply, Web
http://www.energy-supply.dk/article/view/303626/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-svaert-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
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

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

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

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

DTU vil bruge Vestas' pensionist-mølle til forskning
31/03/2015
EnergiWatch, Web
Mathias Ørsborg Johansen
http://energiwatch.dk/secure/Energinyt/Renewables/article7593957.ece

Vestas-mølle til Risø: DTU Vindenergi har investeret i en Vestas V52-mølle fra et strandet projekt i Italien, der har proportionerne til at kunne stå i DTU Risø Campus møllerække
30/03/2015
www.teknovation.dk, Web
Thore Dam Mortensen
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Ny og større forskningsvindmølle til Risø Campus: Den karakteristiske vindmølleække på DTU Risø 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_kirke.jpg

Vestas-mølle til Risø: DTU Vindenergi har investeret i en Vestas V52-mølle fra et strandet projekt i Italien, der har proportionerne til at kunne stå i DTU Risø Campus møllerække
30/03/2015
www.teknovation.dk, Web
Thore Dam Mortensen
http://www.teknovation.dk/?type=page&id=750&itemid=7010

Ny og større forskningsvindmølle til Risø Campus: Den karakteristiske vindmølleække på DTU Risø 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_kirke.jpg

Thomas Buhl
Department of Wind Energy, Wind Turbines
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
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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 vindmølleinger
Thomas Buhl
31/03/2014

Subject
Super computer, vindenergi
Department of Wind Energy, Wind Turbines

Media contribution (1)
Ny supercomputer optimerer vindmøllevinger
31/03/2014
NetAvisen, Web
William Høst-Madsen
http://navisen.dk/blog/ny-supercomputer-optimerer-vindmøllevinger/
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.
Merete Badger
01/02/2014
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*
Christian Bak
Department of Wind Energy, Aeroelastic Design

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

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

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-Lygtepael-skal-producere-egen-stroem/artikel/268269#.Uq1k8sTuJu0
Christian Bak
Department of Wind Energy, Aeroelastic Design

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
Press / Media

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

Press / Media

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

Press / Media

Dong fastholder troen på havmøller
Thomas Buhl
05/06/2012
Department of Wind Energy, Wind Turbines
Media contribution (1)

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

Media contribution (1)

DTU's nye vindtunnel kan blæse tre orkaner
25/05/2012
Ingeniøren, Print
Christian Bak
Department of Wind Energy, Aeroelastic Design
Press / Media

Hvordan kan vindmøller nedbringe en færges luftmodstand?
Mac Gaunaa
27/08/2011
Aeroelastic Design, Risø National Laboratory for Sustainable Energy, Wind Energy Division

Media contribution (1)

Hvordan kan vindmøller nedbringe en færges luftmodstand?
27/08/2011
Interview med Mac Gaunaa i Ingeniøren 'Spørg Scientariat', Print
Mac Gaunaa
Risø National Laboratory for Sustainable Energy, Wind Energy Division, Aeroelastic Design
Press / Media

Nye mega-møller
Torben J. Larsen
30/03/2011
Aeroelastic Design, Risø National Laboratory for Sustainable Energy, Wind Energy Division

Media contribution (1)

Nye mega-møller
30/03/2011
TV-interview i TV2 nyhederne, Television
http://sputnik-dyn.tv2.dk/play/nyhederne-29558/
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Torben J. Larsen
Risø National Laboratory for Sustainable Energy, Wind Energy Division, Aeroelastic Design
Press / Media

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

Media contribution (1)

Hvorfor drejer vingerne samme vej på alle vindmøller, og hvorfor ligger vindmøller altid på en række?
20/12/2010
Interview med Mac Gaunaa på videnskab.dk, Print
Danske vindmølleeksperter gør Kina miljøvenlig
Niels Gylling Mortensen
18/08/2010
Meteorology, Risø National Laboratory for Sustainable Energy, Wind Energy Division

Media contribution (1)

Danske vindmølleeksperter gør Kina miljøvenlig
18/08/2010
Interview med Niels Gylling Mortensen på videnskab.dk, Print
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Niels Gylling Mortensen
Risø National Laboratory for Sustainable Energy, Wind Energy Division, Meteorology
Press / Media

Strømninger i vandet er den største havvindmølle-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 havvindmølle-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)

Supernøjagtig måling kan øge vindproduktion markant
15/02/2010
Interview med Troels Friis Pedersen i Ingeniøren d. 15. februar 2010, Print
Troels Friis Pedersen
Risø National Laboratory for Sustainable Energy, Wind Energy Division, Aeroelastic Design
Press / Media

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)

Risø-forsøg med lynhurtige flaps på møllevinger er en succes
11/02/2010
Interview med Helge Aagaard Madsen i Ingeniøren, Print
Helge Aagaard Madsen
Risø National Laboratory for Sustainable Energy, Wind Energy Division, Aeroelastic Design
Press / Media

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
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Interview med Thomas Buhl på videnskab.dk, Print
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Thomas Buhl
Risø National Laboratory for Sustainable Energy, Wind Energy Division, Wind Turbines
Press / Media

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

Subject
Vindnenergi
Department of Wind Energy, Wind Turbines

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.
18/01/2010
http://videnskab.dk/, Web
Berit Viuf
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Flaps på mølevinger reducerer turbulensproblemer
Thomas Buhl
17/08/2009
Department of Wind Energy, Wind Turbines

Media contribution (1)

Flaps på mølevinger reducerer turbulensproblemer
17/08/2009
www.energy-supply.dk, Web
Maria Berg Badstue Pedersen
http://www.energy-supply.dk/article/view/37749/flaps_pa_mollevinger_reducerer_turbulensproblemer#.VIq3BjGG-0I
Thomas Buhl
Department of Wind Energy, Wind Turbines
Press / Media

Modvindsbil
Mac Gaunaa
06/01/2009
Aeroelastic Design, Risø National Laboratory for Sustainable Energy, Wind Energy Division

Media contribution (1)

Modvindsbil
06/01/2009
Danmarks Radio P1, Videnskaben kort, kl. 16:55, (04:37), Radio
Mac Gaunaa
Risø National Laboratory for Sustainable Energy, Wind Energy Division, Aeroelastic Design
Press / Media