Possible power of down-regulated offshore wind power plants

This paper proposes a method for real-time estimation of the possible power of an offshore wind power plant when it is down-regulated. The main purpose of the method is to provide an industrially applicable estimate of the possible (or reserve) power. The method also yields a real-time power curve, which can be used for operation monitoring and wind farm control. Currently, there is no verified approach regarding estimation of possible power at wind farm scale. The key challenge in possible power estimation at wind farm level is to correct the reduction in wake losses, which occurs due to the down-regulation. Therefore, firstly, the 1-second wind speeds at the upstream turbines are estimated, since they are not affected by the reduced wake. Then they are introduced into the wake model, adjusted for the same time resolution, to correct the wake losses. To mitigate the uncertainties due to dynamic changes within the large offshore wind farms, the algorithm is updated at every turbine downstream, considering the local axial and lateral turbulence effects. The PossPOW algorithm uses only 1-Hz turbine data as inputs and provides possible power output. The algorithm is trained and validated in Thanet and Horns Rev-I offshore wind farms under nominal operation, where the turbines are following the optimum power curve. The results indicate that the PossPOW algorithm performs well; in the Horns Rev-I wind farm, the strict power system requirements are met more than 70% of the time over the 24-hour data set on which the algorithm was evaluated.
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 2
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BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.18 SJR 1.051 SNIP 1.834
Web of Science (2017): Impact factor 2.938
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BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.37 SJR 1.079 SNIP 2.316
Web of Science (2016): Impact factor 2.725
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.06 SJR 1.201 SNIP 2.165
Web of Science (2015): Impact factor 2.891
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.42 SJR 1.209 SNIP 3.688
Web of Science (2014): Impact factor 3.069
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.75 SJR 1.235 SNIP 2.486
Web of Science (2013): Impact factor 2.556
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.36 SJR 1.062 SNIP 2.297
Web of Science (2012): Impact factor 1.436
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
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Scopus rating (2011): CiteScore 2.49 SJR 0.892 SNIP 2.582
Web of Science (2011): Impact factor 1.768
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.364 SNIP 2.026
Web of Science (2010): Impact factor 1.716
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 0.885 SNIP 1.439
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.743 SNIP 1.555
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.942 SNIP 1.42
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.586 SNIP 1.653
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.273 SNIP 0.827
Web of Science (2005): Indexed yes
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Web of Science (2004): Indexed yes
Web of Science (2003): Indexed yes
Data-driven Wake Modelling for Reduced Uncertainties in short-term Possible Power Estimation: Paper

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

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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 0.32 SJR 0.264 SNIP 0.352
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 0.25 SJR 0.245 SNIP 0.293
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
Large Scale Offshore Wake Impact on the Danish Power System

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

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

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

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Source-ID: 149534425
Research output: Research › Conference abstract for conference – Annual report year: 2018

Uncertainties and Wakes for Short-term Power Production of a Wind Farm
Similar to the conventional power plants, the wind farms are expected to contribute to the grid stability and communicate with the system operators regarding the potential power production on much shorter time scales than AEP or even 10-min. Additionally, increasing interest to aerodynamic control of wind farms, both in the research community and in the industry, necessitates the wake models to be more accurate and reliable at shorter intervals. In this study, we discuss the uncertainties attached to an engineering wake model derived for 1-sec turbine data, and investigate the methods for reducing the uncertainty of such an application via further training the model for the wind farm and the time period in question using the historical data.

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

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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
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 SMARTÉOLE planned for the second semester of 2017.
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.

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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.

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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.

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Possible Improvements for Present Wind Farm Models Used in Optimal Wind Farm Controllers
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Scanflow: High-resolution full-scale wind field measurements of the ECN’s 2.5 MW aerodynamic research wind turbine using DTU’s 3D WindScanner and SpinnerLidar for IRPWind’s and EERA’s benchmark
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.

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.

Contributors: Giebel, G., Cline, J., Frank, H. P., Shaw, W., Pinson, P., Hodge, B., Kariniotakis, G., Madsen, J., Möhrlen, C.

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Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 0.35 SJR 0.252 SNIP 0.374
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Design tool for offshore wind farm cluster planning

In the framework of the FP7 project EERA DTOC: Design Tool for Offshore wind farm Cluster, a new software supporting the planning of offshore wind farms was developed, based on state-of-the-art approaches from large scale wind potential to economic benchmarking. The model portfolio includes WASP, FUGA, WRF, Net-Op, LCoE model, CorWind, FarmFlow, EeFarm and grid code compliance calculations. The development is done by members from European Energy Research Alliance (EERA) and guided by several industrial partners. A commercial spin-off from the project is the tool 'Wind & Economy'. The software has been compared and validated to a wide extent. Around 10 wake models have been compared to SCADA data from the Horns Rev 1 offshore wind farm in the North Sea, and the Lillgrund and Rødsand-2 wind farms in the Baltic Sea. The Rødsand-2 wind farm is located nearby the Nysted-1 wind farm, thus an investigation of the wake influence between dual operation twin farms was possible. Furthermore both micro- and mesoscale wake models have been compared to satellite-based wind farm wake data in the North Sea. Regarding the planning of the electrical grid, both inter-array and long-distance cables were modelled by the software and several tests were performed. The calculations include the smoothing effect on produced energy between wind farms located in different regional wind zones and the short time scales relevant for assessing balancing power. The grid code compliance was tested for several cases and the results are useful for wind farm planning of the grid and necessary components and controls.

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Design tool for offshore wind farm cluster planning

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Design tool for offshore wind farm clusters

The Design Tool for Offshore wind farm Clusters (DTOC) is a software tool to facilitate the optimised design of both, individual and clusters of offshore wind farms. DTOC is developed with the support of an EC funded FP7 project with contributions from science partners from the European Energy Research Alliance (EERA) and a number of industrial partners. The approach has been to develop a robust, efficient, easy to use and flexible tool, which integrates software relevant for planning offshore wind farms and wind farm clusters and supports the user with a clear optimization workflow. The software includes wind farm wake models, energy yield models, inter-array and long cable and grid component models, grid code compliance and ancillary services models. The common score for evaluation in order to compare different layouts is levelized cost of energy (LCoE). The integrated DTOC software is developed within the project using open interface standards and is now available as the commercial software product Wind&Economy.
EERA-DTOC cost optimized farm design

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EERA –DTOC planning tool for large offshore wind farms

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Experimental verification of a real-time power curve for down-regulated offshore wind power plants

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Contributors: Giebel, G., Göçmen Bozkurt, T., Sørensen, P. E., Réthoré, P., Poulsen, N. K., Mirzaei, M., Skjelmose, M. R.
, Kristoffersen, J. R.
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Importance of detailed meteorological information for smart city development

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Organisations: Department of Wind Energy, Meteorology, Wind Energy Systems
Contributors: Davis, N., Badger, J., Giebel, G., Hahmann, A. N., Sempreviva, A. M.
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Limited area forecasting for wind energy scheduling

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Contributors: Rosgaard, M. H., Hahmann, A. N., Madsen, H., Giebel, G., Sørensen, P. E., Nielsen, H. A., Nielsen, T. S.
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Peer-reviewed: No
Event: Poster session presented at UCD Energy Institute and Electricity Research Centre Annual Symposium, Dublin, Ireland.
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Limited_area_forecasting_poster.pdf

The new IEA Wind Task 36 on Wind Power Forecasting

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 weather centres with an interest and/or large projects on wind forecast improvements (NOAA, DWD, ...), 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.

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Turbine Control Strategies for Wind Farm Power Optimization
In recent decades there has been increasing interest in green energies, of which wind energy is the most important one. In order to improve the competitiveness of the wind power plants, there are ongoing researches to decrease cost per energy unit and increase the efficiency of wind turbines and wind farms. One way of achieving these goals is to optimize the power generated by a wind farm. One optimization method is to choose appropriate operating points for the individual wind turbines in the farm. We have made three models of a wind farm based on three different control strategies. Basically, the control strategies determine the steady state operating points of the wind turbines. Except the control strategies of the individual wind turbines, the wind farm models are similar. Each model consists of a row of 5MW reference wind turbines. In the models we are able to optimize the generated power by changing the power reference of the individual wind turbines. We use the optimization setup to compare power production of the wind farm models. This paper shows that for the most frequent wind velocities (below and around the rated values), the generated powers of the wind farms are different. This means that choosing an appropriate control strategy for the individual wind turbines will result in an increased power production of the wind farm.

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Weather Intelligence for Renewable Urban Areas Gaps, Challenges and future perspectives

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A threshold analysis to use CSRF data for storm impact studies

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EERA DTOC wake results offshore

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Energy Yield Prediction of Offshore Wind Farm Clusters at the EERA-DTOC European Project
A new integrated design tool for optimization of offshore wind farm clusters is under development in the European Energy Research Alliance – Design Tools for Offshore wind farm Cluster project (EERA DTOC). The project builds on already
established design tools from the project partners and possibly third-party models. Wake models have been benchmarked on the Horns Rev and, currently, on the Lilgrund wind farm test cases. Dedicated experiments from ‘BARD Offshore 1’ wind farm will using scanning lidars will produce new data for the validation of wake models. Furthermore, the project includes power plant interconnection and energy yield models all interrelated with a simplified cost model for the evaluation of layout scenarios. The overall aim is to produce an efficient, easy to use and flexible tool - to facilitate the optimised design of individual and clusters of offshore wind farms. A demonstration phase at the end of the project will assess the value of the integrated design tool with the help of potential end-users from industry. This abstracts summarizes the objectives and preliminary results of work package 3. In order to provide an accurate value of the expected net energy yield, the offshore wind resource assessment process has been reviewed as well as the sources of uncertainty associated to each step. Methodologies for the assessment of offshore gross annual energy production are analyzed based on the Fino 1 test case. Measured data and virtual data from Numerical Weather Prediction models have been used to calculate long term wind speed, wind profile and gross energy.
Estimation of the Possible Power of a Wind Farm

It seems possible to increase competitiveness of wind power plants by offering grid services (also called ancillary services) and enter the wind power plants into the ancillary market. One of the ancillary services is called reserve power, the differential capacity between the generated power and the available power in the farm. The total amount of energy that a wind farm can potentially generate is called possible power. It is very important for a wind farm owner to have a relatively accurate estimate of the possible power of the wind farm in order to be able to trade the reserve power. In this paper the possible power calculated based on the estimated effective wind speed of a down regulated wind farm (the industry standard) is compared against the calculated possible power based on the algorithm presented in the paper. The latter takes into account the effect of the wakes of down regulated turbines and therefore gives a more accurate measure of the possible power. It is shown that for an interval of wind speeds the difference between these two can increase the uncertainty in the estimate of the possible power of the down regulated wind farm.

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BFI (2014): BFI-level 1
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BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 0.05 SJR 0.142 SNIP 0.078
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BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.121 SNIP 0.054
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.111 SNIP 0.032
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.109 SNIP 0.033
Scopus rating (2007): SJR 0.107 SNIP 0.021
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Scopus rating (2005): SJR 0.103 SNIP 0.014
Evaluating winds and vertical wind shear from Weather Research and Forecasting model forecasts using seven planetary boundary layer schemes

The existence of vertical wind shear in the atmosphere close to the ground requires that wind resource assessment and prediction with numerical weather prediction (NWP) models use wind forecasts at levels within the full rotor span of modern large wind turbines. The performance of NWP models regarding wind energy at these levels partly depends on the formulation and implementation of planetary boundary layer (PBL) parameterizations in these models. This study evaluates wind speeds and vertical wind shears simulated by the Weather Research and Forecasting model using seven sets of simulations with different PBL parameterizations at one coastal site over western Denmark. The evaluation focuses on determining which PBL parameterization performs best for wind energy forecasting, and presenting a validation methodology that takes into account wind speed at different heights. Winds speeds at heights ranging from 10 to 160 m, wind shear, temperatures, and surface turbulent fluxes from seven sets of hindcasts are evaluated against observations at Høvsøre, Denmark. The ability of these hindcast sets to simulate mean wind speeds, wind shear, and their time variability strongly depends on atmospheric static stability. Wind speed hindcasts using the Yonsei University PBL scheme compared best with observations during unstable atmospheric conditions, whereas the Asymmetric Convective Model version 2 PBL scheme did so during near-stable and neutral conditions, and the Mellor–Yamada–Janjic PBL scheme prevailed during stable and very stable conditions. The evaluation of the simulated wind speed errors and how these vary with height clearly indicates that for wind power forecasting and wind resource assessment, validation against 10 m wind speeds alone is not sufficient. Copyright © 2012 John Wiley & Sons, Ltd.
Evaluation of Dynamical Downscaling Resolution Effect on Wind Energy Forecast Value for a Wind Farm in Central Sweden

For any energy system relying on wind power, accurate forecasts of wind fluctuations are essential for efficient integration into the power grid. Increased forecast precision allows end-users to plan day-ahead operation with reduced risk of penalties which in turn supports the feasibility of wind energy. The present study aims to quantify value added to wind energy forecasts in the 12-48 hour leadtime by downscaling global numerical weather prediction (NWP) data from the National Centers for Environmental Prediction Global Forecast System (GFS) using the limited-area NWP model described in Skamarock et al. (2008).

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Evaluation of Dynamical Downscaling Resolution Effect on Wind Energy Forecast Value for a Wind Farm in Central Sweden

For any energy system relying on wind power, accurate forecasts of wind fluctuations are essential for efficient utilisation in the power grid. Statistical wind power prediction tools [1] use numerical weather prediction (NWP) model data along with measurements and can correct magnitude errors operationally. It is, however, entirely up to the NWP input to describe the timing of fluctuations correctly.

Wind power is nonlinearly transformed wind speed, and the two are monotonically dependent up till wind speeds of ~25m/s, which is the typical wind farm cut-out. Thus, an improvement in the correlation accuracy metric evaluated for wind speed data consistently translates to an improvement for wind power. For two time series describing the temporal development of the same variable, though by different means, it is assumed that phase errors account for most of the departure from perfect correlation between the two time series.

Results on limited-area NWP model performance, with focus on the 12th to 48th forecast hour horizon relevant for Elnspot auction bidding on the Nord Pool Spot market [2], are presented.

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Evaluation of Dynamical Downscaling Resolution Effect on Wind Energy Forecast Value for a Wind Farm in Central Sweden

For any energy system relying on wind power, accurate forecasts of wind fluctuations are essential for efficient utilisation in the power grid. Statistical wind power prediction tools [1] use numerical weather prediction (NWP) model data along with measurements and can correct magnitude errors operationally. It is, however, entirely up to the NWP input to describe the timing of fluctuations correctly.

Wind power is nonlinearly transformed wind speed, and the two are monotonically dependent up till wind speeds of ~25m/s, which is the typical wind farm cut-out. Thus, an improvement in the correlation accuracy metric evaluated for wind speed data consistently translates to an improvement for wind power. For two time series describing the temporal development of the same variable, though by different means, it is assumed that phase errors account for most of the departure from perfect correlation between the two time series.

Results on limited-area NWP model performance, with focus on the 12th to 48th forecast hour horizon relevant for Elspot auction bidding on the Nord Pool Spot market [2], are presented.

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Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Department of Wind Energy, Meteorology, Wind Energy Systems, ENFOR A/S
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Evaluation of Dynamical Downscaling Resolution Effect on Wind Energy Forecast Value for a Wind Farm in Central Sweden

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Weather radars – the new eyes for offshore wind farms?
Offshore wind fluctuations are such that dedicated prediction and control systems are needed for optimizing the management of wind farms in real-time. In this paper, we present a pioneer experiment – Radar@Sea – in which weather radars are used for monitoring the weather at the Horns Rev offshore wind farm, in the North Sea. First, they enable the collection of meteorological observations at high spatio-temporal resolutions for enhancing the understanding of meteorological phenomena that drive wind fluctuations. And second, with the extended visibility they offer, they can provide relevant inputs to prediction systems for anticipating changes in the wind fluctuation dynamics, generating improved wind power forecasts and developing specific control strategies. However, integrating weather radar observations into automated decision support systems is not a plug-and-play task, and it is important to develop a multi-disciplinary approach linking meteorology and statistics. Here, (i) we describe the settings of the Radar@Sea experiment, (ii) we report the experience gained with these new remote sensing tools, (iii) we illustrate their capabilities with some concrete meteorological events observed at Horns Rev and (iv) we discuss the future perspectives for weather radars in wind energy. Copyright © 2013 John Wiley & Sons, Ltd.

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Web of Science (2016): Impact factor 2.725
Wind-Climatic Estimation Based on Mesoscale and Microscale Modeling: Statistical-Dynamical Downscaling for Wind Energy Applications

This paper demonstrates that a statistical dynamical method can be used to accurately estimate the wind climate at a wind farm site. In particular, postprocessing of mesoscale model output allows an efficient calculation of the local wind climate required for wind resource estimation at a wind turbine site. The method is divided into two parts: 1) preprocessing, in which the configurations for the mesoscale model simulations are determined, and 2) postprocessing, in which the data from the mesoscale simulations are prepared for wind energy application. Results from idealized mesoscale modeling experiments for a challenging wind farm site in northern Spain are presented to support the preprocessing method. Comparisons of modeling results with measurements from the same wind farm site are presented to support the postprocessing method. The crucial element in postprocessing is the bridging of mesoscale modeling data to microscale modeling input data, via a so-called generalization method. With this method, very high-resolution wind resource mapping can be achieved.

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Organisations: Department of Wind Energy, Meteorology, Wind Energy Systems, Deutscher Wetterdienst
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Web of Science (2017): Indexed yes
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Web of Science (2016): Impact factor 2.365
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Scopus rating (2015): CiteScore 2.68 SJR 1.764 SNIP 1.364
Web of Science (2015): Impact factor 2.463
Web of Science (2015): Indexed yes
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Web of Science (2014): Impact factor 2.54
Web of Science (2014): Indexed yes
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Wind resource assessment and wind power forecasting

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Wind Speed Estimation and Parameterization of Wake Models for Downregulated Offshore Wind Farms
The estimation of possible (or available) power of a downregulated offshore wind farm is the content of the PossPOW project (See PossPOW Poster ID: 149). The main challenges of this estimation process are:
1) to determine the free stream equivalent wind speed at the turbine level since the accuracy of nacelle anemometers are in question and power curve derivation is no longer applicable during downregulation
2) to apply a real-time wake model which can calculate the power production as if the wind farm was operating normally even in short downregulation periods. However, most existing wake models have only been used to acquire long term, statistical information and verified using 10-min averaged data
The proposed methodologies to overcome those challenges are presented in this poster.
Wind Speed Estimation and Parametrization of Wake Models for Downregulated Offshore Wind Farms within the scope of PossPOW Project

With increasing installed capacity, wind farms are requested to downregulate more frequently, especially in the offshore environment. Determination and verification of possible (or available) power of downregulated offshore wind farms are the aims of the PossPOW project (see PossPOW.dtu.dk). Two main challenges encountered in the project so far are the estimation of wind speed and the recreation of the flow inside the downregulated wind farm as if it is operating ideally. The rotor effective wind speed was estimated using power, pitch angle and rotational speed as inputs combined with a generic Cp model. The results have been compared with Horns Rev-I dataset and NREL 5MW simulations under both downregulation and normal operation states. For the real-time flow recreation, the GCLarsen single wake model was re-calibrated using a 1-s dataset from Horns Rev and tested for the downregulated period. The re-calibrated model has to be further parametrized to include dynamic effects such as wind direction variability and meandering also considering different averaging time scales before implemented in full scale wind farms.
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ISI indexed (2011): ISI indexed no
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Scopus rating (2010): SJR 0.288 SNIP 0.351
Web of Science (2010): Indexed yes
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Scopus rating (2008): SJR 0.264 SNIP 0.301
Web of Science (2008): Indexed yes
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Web of Science (2006): Indexed yes
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EERA-DTOC: Design tools for off-shore wind farm clusters including new results on wake bench

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Energy yield prediction of offshore wind farm clusters at the EERA-DTOC European project
A new integrated design tool for optimization of offshore wind farm clusters is under development in the European Energy Research Alliance – Design Tools for Offshore wind farm Cluster project (EERA DTOC). The project builds on already established design tools from the project partners and possibly third-party models. Wake models have been benchmarked on the Horns Rev and, currently, on the Lilgrund wind farm test cases. Dedicated experiments from ‘BARD Offshore 1’ wind farm will using scanning lidars will produce new data for the validation of wake models. Furthermore, the project includes power plant interconnection and energy yield models all interrelated with a simplified cost model for the evaluation of layout scenarios. The overall aim is to produce an efficient, easy to use and flexible tool - to facilitate the optimised design of individual and clusters of offshore wind farms. A demonstration phase at the end of the project will assess the value of the integrated design tool with the help of potential end-users from industry.
This abstracts summarizes the objectives and preliminary results of work package 3. In order to provide an accurate value of the expected net energy yield, the offshore wind resource assessment process has been reviewed as well as the sources of uncertainty associated to each step.

Methodologies for the assessment of offshore gross annual energy production are analyzed based on the Fino 1 test case. Measured data and virtual data from Numerical Weather Prediction models have been used to calculate long term wind speed, wind profile and gross energy.

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Implementation of a Model Output Statistics based on meteorological variable screening for short-term wind power forecast
A combination of physical and statistical treatments to post-process numerical weather predictions (NWP) outputs is needed for successful short-term wind power forecasts. One of the most promising and effective approaches for statistical treatment is the Model Output Statistics (MOS) technique. In this study, a MOS based on multiple linear regression is proposed: the model screens the most relevant NWP forecast variables and selects the best predictors to fit a regression equation that minimizes the forecast errors, utilizing wind farm power output measurements as input. The performance of the method is evaluated in two wind farms, located in different topographical areas and with different NWP grid spacing. Because of the high seasonal variability of NWP forecasts, it was considered appropriate to implement monthly stratified MOS. In both wind farms, the first predictors were always wind speeds (at different heights) or friction velocity. When friction velocity is the first predictor, the proposed MOS forecasts resulted to be highly dependent on the friction velocity–wind speed correlation. Negligible improvements were encountered when including more than two predictors in the regression equation. The proposed MOS performed well in both wind farms, and its forecasts compare positively with an actual operative model in use at Risø DTU and other MOS types, showing minimum BIAS and improving NWP power forecast of around 15% in terms of root mean square error. Further improvements could be obtained by the implementation of a more refined MOS stratification, e.g. fitting specific equations in different synoptic situations. Copyright © 2012 John Wiley & Sons, Ltd.

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Offshore Wind Farm Clusters - Towards new integrated Design Tool
In EERA DTC testing of existing wind farm wake models against four validation data test sets from large offshore wind farms is carried out. This includes Horns Rev-1 in the North Sea, Lillgrund in the Baltic Sea, Roedsand-2 in the Baltic Sea and from 10 large offshore wind farms in Northern European Seas using satellite remote sensing.

PossPOW: possible Power of Downregulated Offshore Wind Power Plants

PossPOW: Possible Power of Downregulated Offshore Wind Power Plants
POSSPOW: Possible Power of Offshore Wind Power Plants

Introduction
In recent years, the very large offshore wind farms were designed as wind power plants, including possibilities to contribute to the stability of the grid by offering grid services (also called ancillary services). One of those services is reserve power, which is achieved by down-regulating the wind farm from its maximum possible power. The power can be ramped up quite quickly, but the influence of wakes makes it difficult to assess the exact amount of down-regulation available to sell. Currently, Transmission System Operators (TSOs) have no real way to determine exactly the possible power of a down-regulated wind farm.

Approach
The technology we want to develop draws together models from various disciplines, including wake modelling of large offshore wind farms, aerodynamic models for wind turbines, stochastic model estimation and computer simulations. During the project, the findings will be verified on some of the large offshore wind farms owned by Vattenfall, and possibly in a DONG Energy wind farm too. Dedicated experiments to the wind flow in large offshore wind farms are planned.

Main body of abstract
Modern wind turbines have a SCADA signal called possible power. In normal operation, this would be the actual power, but during down-regulation it would give the possible power given the current wind regime. In a down-regulated wind farm, the sum of the possible and actual power during down-regulation is not the same as the regulation power reserve in that wind farm, since turbines downwind of down-regulated turbines see more wind that would be there without the regulation. Wake modelling is necessary in order to take into account that the wakes will change when the wind farm is down regulated. The PossPOW project will not develop new wake models, but adjust the Dynamic Wake Meandering model and/or Fuga for real-time use.

The proposed technique is to use the same wake model for two steps to calculate possible power in a down regulated case:
1. First, the ambient flow will be derived in the actual down regulated case, using wind turbines thrusts from the down regulated wind turbines. This is an inverse way of using wake models, using the wake flow as input and the ambient flow as output.
2. Secondly, the wake flow in the possible power case will be derived from the ambient flow derived in 1, using wind turbines thrusts in the possible power case. This is the normal way of using wake models, using the ambient flow as input and wake flow as output.

Conclusion
The poster presents a new Danish project on the possible power from a down-regulated wind farm. Project partners are DTU, Vestas, Siemens, Vattenfall and DONG. We aim at a verified and internationally accepted way to determine the possible power of a down-regulated offshore wind farm, taking into account the meteorology and wake effects. Along the way, we also aim at improving the use of wake models for real-time cases. Please see posspow.dtu.dk.
Using forecast information for storm ride-through control

Using probabilistic forecast information in control algorithms can improve the performance of wind farms during periods of extreme winds. This work presents a wind farm supervisor control concept that uses probabilistic forecast information to ride-through a storm with softer ramps of power. Wind speed forecasts are generated with a statistical approach (i.e. time series models). The supervisor control is based on a set of logical rules that consider point forecasts and predictive densities to ramp-down the power of the wind farm before the storm hits. The potential of this supervisor control is illustrated with data from the Horns Rev 1 wind farm, located in the North Sea. To conclude, an overview of ongoing and future research in the Radar@Sea experiment is given. This experiment aims at improving offshore wind power predictability and controllability through the increased use of meteorological information, and particularly weather radar images.
Integrated Wind Power Planning Tool
This poster presents the Public Service Obligation (PSO) funded project PSO 10464 "Integrated Wind Power Planning Tool". The project goal is to integrate a Numerical Weather Prediction (NWP) model with statistical tools in order to assess wind power fluctuations, with focus on short term forecasting for existing wind farms, as well as long term power system planning for future wind farms.

General information
State: Published
Contributors: Rosgaard, M. H., Hahmann, A. N., Nielsen, T. S., Madsen, H., Giebel, G., Sørensen, P. E.
Number of pages: 1
Publication date: 2012
Peer-reviewed: Yes
Event: Poster session presented at EWEA 2012 - European Wind Energy Conference & Exhibition, Copenhagen, Denmark.
Keywords: EWEA 2012
Electronic versions:
Integrated Wind Power Planning Tool

This poster describes the status as of April 2012 of the Public Service Obligation (PSO) funded project PSO 10464 "Integrated Wind Power Planning Tool". The project goal is to integrate a meso scale numerical weather prediction (NWP) model with a statistical tool in order to better predict short term power variation from off shore wind farms, as well as to conduct forecast error assessment studies in preparation for later implementation of such a feature in an existing simulation model. The addition of a forecast error estimation feature will further increase the value of this tool, as its output can be fed into any type of system model or decision-making problem that wish to account for forecast errors in the planning process, rather than assume perfect forecasts.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology, Department of Applied Mathematics and Computer Science, Dynamical Systems, Wind Energy Systems, ENFOR A/S
Contributors: Rosgaard, M. H., Hahmann, A. N., Nielsen, T. S., Madsen, H., Giebel, G., Sørensen, P. E.
Number of pages: 1
Publication date: 2012
Peer-reviewed: Yes
Event: Poster session presented at European Geosciences Union General Assembly 2012, Vienna, Austria.
Electronic versions:
prod21359755681462.EGU2012_13636_presentation.pdf
Research output: Research - peer-review › Poster – Annual report year: 2013

Integrated Wind Power Planning Tool

This poster presents the current state of the public service obligation (PSO) funded project PSO 10464, with the working title "Integrated Wind Power Planning Tool". The project commenced October 1, 2011, and the goal is to integrate a numerical weather prediction (NWP) model with purely statistical tools in order to assess wind power fluctuations, with focus on long term power system planning for future wind farms as well as short term forecasting for existing wind farms. Currently, wind power fluctuation models are either purely statistical or integrated with NWP models of limited resolution. With regard to the latter, one such simulation tool has been developed at the Wind Energy Division, Risø DTU, intended for long term power system planning. As part of the PSO project the inferior NWP model used at present will be replaced by the state-of-the-art Weather Research & Forecasting (WRF) model. Furthermore, the integrated simulation tool will be improved so it can handle simultaneously 10-50 times more turbines than the present 300, as well as additional atmospheric parameters will be included in the model. The WRF data will also be input for a statistical short term prediction model to be developed in collaboration with ENFOR A/S; a danish company that specialises in forecasting and optimisation for the energy sector. This integrated prediction model will allow for the description of the expected variability in wind power production in the coming hours to days, accounting for its spatio-temporal dependencies, and depending on the prevailing weather conditions needed by the WRF output.

The output from the integrated prediction tool constitute scenario forecasts for the coming period, which can then be fed into any type of system model or decision making problem to be solved. The high resolution of the WRF results loaded into the integrated prediction model will ensure a high accuracy data basis is available for use in the decision making process of the Danish transmission system operator, and the need for high accuracy predictions will only increase over the next decade as Denmark approaches the goal of 50% wind power based electricity in 2020, from the current 20%.

General information
State: Published
Organisations: Department of Wind Energy, Wind Energy Systems, Meteorology, Department of Applied Mathematics and Computer Science, Dynamical Systems, ENFOR A/S
Contributors: Rosgaard, M. H., Giebel, G., Nielsen, T. S., Hahmann, A. N., Sørensen, P. E., Madsen, H.
Number of pages: 1
Pages: EGU2012-13636
Publication date: 2012
Peer-reviewed: Yes

Publication information
Journal: Geophysical Research Abstracts
Volume: 14
ISSN (Print): 1607-7962
Ratings:
Web of Science (2014): Indexed yes
ISI indexed (2013): ISI indexed no
On the Predictability of Hub Height Winds

Wind energy is a major source of power in over 70 countries across the world, and the worldwide share of wind energy in electricity consumption is growing. The introduction of significant amounts of wind energy into power systems makes accurate wind forecasting a crucial element of modern electrical grids. These systems require forecasts with temporal scales of tens of minutes to a few days in advance at wind farm locations. Traditionally these forecasts predict the wind at turbine hub heights; this information is then converted by transmission system operators and energy companies into predictions of power output at wind farms. Since the power available in the wind is proportional to the wind speed cubed, even small wind forecast errors result in large power prediction errors. Accurate wind forecasts are worth billions of dollars annually; forecast improvements will result in reduced costs to consumers due to better integration of wind power into the power grid and more efficient trading of wind power on energy markets.

This thesis is a scientific contribution to the advancement of wind energy forecasting with mesoscale numerical weather prediction models. After an economic and theoretical overview of the importance of wind energy forecasts, this thesis continues with an analysis of wind speed predictions at hub height using the Weather Research and Forecasting (WRF) model. This analysis demonstrates the need for more detailed analyses of wind speeds and it is shown that wind energy forecasting cannot be reduced solely to forecasting winds at hub height. Calculating only the power output from hub height winds can result in erroneous estimates due to the vertical wind shear in the atmospheric boundary layer (PBL). Results show that the accuracy of modeled wind conditions and wind profiles in the PBL depends on the PBL scheme adopted and is different under varying atmospheric stability conditions, among other modeling factors. This has important implications for wind energy applications: shallow stable boundary layers can result in excessive wind shear, which is detrimental for wind energy applications. This is particularly relevant with offshore facilities, which represent a significant portion of new wind farms being constructed. Furthermore, a novel aspect to this study is the presentation of a verification methodology that takes into account wind at different heights where turbines operate.

The increasing number of wind farm deployments represents a novel and unique data source for improving mesoscale wind forecasts for wind energy applications. These new measurements include nacelle wind speeds and the turbines’ angle of rotation into the wind (yaw angles). This thesis continues with an extensive description of this new data set and its challenges in data assimilation, focusing on data from the Horns Rev I wind farm. Since wind farm data are such a dense data set there is need to derive representative information from the measurements, i.e., thin the data. Different thinning strategies and their impact on improving wind forecasts for wind power predictions are investigated with the WRF Four-Dimensional Data Assimilation system. The median of the whole wind farm was found to be the most successful thinning strategy. Nacelle winds and yaw angles are a promising data set to improve wind predictions downstream of a wind farm as well as at the wind farm itself: Their impact lasted up to 5 hours and depends on time of the day, forecast lead time and weather situation.
Short Term Wind Power Forecasting

State: Published
Organisations: Wind Energy Systems, Department of Wind Energy, Deutscher Wetterdienst
Contributors: Giebel, G., Denhard, M.
Publication date: 2012

Host publication information
Title of host publication: Electric Power Systems: Advanced Forecasting Techniques and Optimal Generation Scheduling
Publisher: CRC Press
ISBN (Print): 978-1439893944
Source: orbit
Source-ID: 312288
Research output: Research - peer-review › Book chapter – Annual report year: 2012

State of the Art in Wind Power Forecasting

General information
State: Published
Organisations: Department of Wind Energy, Wind Energy Systems
Contributors: Giebel, G.
Publication date: 2012
Media of output: Power Point Presentation

Event information
Event: SafeWind Workshop
Location: Paris, France
Electronic versions:
swind_finalwokshop_2012_paris_dtu_wind.pdf

Bibliographical note
Talk on the final workshop of the SafeWind project.
Number of pages: 53
Source: dtu
Source-ID: u::6899
Research output: Research › Sound/Visual production (digital) – Annual report year: 2013

Variability and smoothing effect of wind power production compared to load variability in the Nordic countries

This paper analyses the variability of load, wind power production and their combination in the Nordic countries during 2009-11, based on real data measured from large-scale wind power. The results show that wind and load variations are not correlated between the countries, which is beneficial from the viewpoint of wind integration. The smoothing effect is shown as reduction of variability from a single country to Nordic wide wind power. The impact of wind power on the variability that the system sees is depicted by analysing the variability of net load with different wind power penetration levels. The timing of ramps, and occurrence of high wind and low load are studied. With current wind penetration, low production levels (2-5 % of installed wind power) can occur in a single country during peak loads, but in the Nordic region the production during peak loads does not fall to so low levels (minimum 14 % during 10 highest peaks).

General information
State: Published
Number of pages: 6
Publication date: 2012

Host publication information
Title of host publication: Proceedings of 11th International Workshop on Large-Scale Integration of Wind Power into Power Systems
Keywords: Wind integration, Reserve allocation, Power system operations, Wind power
Electronic versions:
Variability_and_smoothing_effect.pdf
Wind Power Forecasting Error Distributions: An International Comparison

Wind power forecasting is essential for greater penetration of wind power into electricity systems. Because no wind forecasting system is perfect, a thorough understanding of the errors that may occur is a critical factor for system operation functions, such as the setting of operating reserve levels. This paper provides an international comparison of the distribution of wind power forecasting errors from operational systems, based on real forecast data. The paper concludes with an assessment of similarities and differences between the errors observed in different locations.
Autonomous aerial sensors for wind power meteorology

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Wind Energy Division, Wind Energy Systems, Test and Measurements, Eberhard-Karls-Universität Tübingen, University of Bergen, Aalborg University, DELTA - a Part of FORCE Technology
Contributors: Giebel, G., Schmidt Paulsen, U., Reuder, J., la Cour-Harbo, A., Thomsen, C., Mølgaard, J. L., Bange, J.
Publication date: 2011

Host publication information
Title of host publication: Proceedings
Publisher: European Wind Energy Association (EWEA)
Keywords: Remote sensing and measurement technique
Electronic versions:
Giebel_poster_EWEA2011presentation.pdf
Giebel_paper_EWEA2011presentation.pdf
Source: orbit
Source-ID: 276178
Research output: Research › Article in proceedings – Annual report year: 2011

Autonomous Aerial Sensors for Wind Power Meteorology

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Wind Energy Division, Wind Energy Systems, Test and Measurements, University of Bergen, Aalborg University, University of Tübingen, DELTA - a Part of FORCE Technology
Contributors: Giebel, G., Schmidt Paulsen, U., Reuder, J., la Cour-Harbo, A., Bange, J., Thomsen, C., Mølgaard, J.
Pages: EGU2011-9907
Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: Geophysical Research Abstracts
Volume: 13
ISSN (Print): 1607-7962
Ratings:
Web of Science (2014): Indexed yes
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
BFI (2009): BFI-level 1
Original language: English
Keywords: Wind power meteorology
URLs:
http://www.geophysical-research-abstracts.net/gra_volume_13.pdf
Source: orbit
Source-ID: 276586
On the impact of the assimilation of nacelle winds and yaw angles with WRF-FDDA and WRF-DART for short-term wind energy predictions

Several kinds of observations are used today in operational NWP models with the aim of better forecasts by improving the analyses used by models. With the ongoing numerous offshore deployments of wind farms, especially in Europe (e.g., Denmark, UK, and Germany), but also in the US, a new set of measurements becomes available: wind speeds measured on the nacelle of a wind turbine (located at about 70 m above the sea surface) and the turbine yaws (a proxy for wind direction), which are used by the turbine control system for optimal operation of the wind turbine. In this study we explore the potential of nacelle wind speeds and turbine yaws as a new set of observations to be assimilated into the Weather Research and Forecasting (WRF) Model. We present two assimilation strategies and their impact on 0-6 h forecasts for the large Danish offshore wind farm Horns Rev I. These strategies include nudging (Four Dimensional Data Assimilation, FDDA) and the Ensemble Kalman Filter (Data Assimilation Research Testbed, DART). Since offshore wind farms are generally near the coast, nacelle wind speeds and yaws constitute also a promising data set to improve wind forecasts inland.

General information
State: Published
Organisations: Wind Energy Division, Meteorology, Risø National Laboratory for Sustainable Energy, Wind Energy Systems
Publication date: 2011

On the Impact of the Assimilation of Nacelle Winds and Yaw Angles With WRF-FDDA and WRF-DART for Short-Term Wind Energy Predictions

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Wind Energy Systems, National Center for Atmospheric Research
Publication date: 2011
Peer-reviewed: No
Keywords: Wind power meteorology
Electronic versions:
On the Impact.pdf
Source: orbit
Source-ID: 284724
Research output: Research › Poster – Annual report year: 2011

The State-Of-The-Art in Short-Term Prediction of Wind Power: A Literature Overview, 2nd edition

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G., Brownsword, R., Kariniotakis, G., Denhard, M., Draxl, C.
Number of pages: 109
Publication date: 2011
Wind fluctuations over the North Sea

Climatological patterns in wind speed fluctuations with periods of 1 min to 10 h are analysed using data from a meteorological mast in the Danish North Sea. Fluctuations on these time scales are of particular relevance to the effective management of the power supply from large wind farms. The Hilbert-Huang transform (HHT) is shown to be an effective tool for analysing long time series of wind speed observations, as it describes the time-evolving spectral information in the time series. By binning and averaging the time-evolving spectrum, the average spectral behaviour of the wind speed under a certain class of conditions can be found. Here, the HHT is applied to create conditional spectra which demonstrate patterns in the occurrence of severe wind variability. It is shown that wind fluctuations over the North Sea are more severe for westerly flow than for easterly flow, and that severe fluctuations are often observed in the vicinity of precipitation. The most severe wind fluctuations occur in the autumn and winter seasons, and are slightly more common when the pressure tendency is rising. Further, it is found that the wind is more variable for atmospherically unstable conditions than for stable conditions. Copyright © 2010 Royal Meteorological Society
Wind Power Meteorology - An Overview

General information
State: Published
Organisations: Wind Energy Systems, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Meteorology, University of Illinois
Contributors: Giebel, G., Sempreviva, A. M., Roy, S. B.
Pages: EGU2011-13457
Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: Geophysical Research Abstracts
Volume: 13
ISSN (Print): 1607-7962
Ratings:
Autonomous Aerial Sensors for Wind Power Meteorology

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Wind Energy Division, Meteorology, Test and Measurements, Aalborg University, DELTA - a Part of FORCE Technology, Eberhard-Karls-Universität Tübingen, University of Bergen
Contributors: Giebel, G., Schmidt Paulsen, U., Reuder, J., la Cour-Harbo, A., Thomsen, C., Bange, J.
Publication date: 2010

Host publication information
Title of host publication: EWEC 2010 Proceedings online
Publisher: European Wind Energy Association (EWEA)
Keywords: Wind energy, Wind power meteorology
Electronic versions:
Giebel_poster_ewec_2010.pdf
Giebel_paper_ewec_2010.pdf
Source: orbit
Source-ID: 262227
Research output: Research › Article in proceedings – Annual report year: 2010

Autonomous Aerial Sensors for Wind Power Meteorology

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Wind Energy Division, Meteorology, Test and Measurements, Aalborg University, DELTA - a Part of FORCE Technology, Technical University of Braunschweig, Navionics, University of Bergen
Contributors: Giebel, G., Schmidt Paulsen, U., Reuder, J., la Cour-Harbo, A., Thomsen, C., Bange, J., Buschmann, M.
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: Geophysical Research Abstracts
Issue number: EGU2010-9498
ISSN (Print): 1607-7962
Ratings:
Web of Science (2014): Indexed yes
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
Idealised simulations of open cellular convection and horizontal wind fluctuations over the North Sea

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Mathematical Statistics, Department of Informatics and Mathematical Modeling
Contributors: Vincent, C. L., Hahmann, A. N., Pinson, P., Giebel, G.
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: Geophysical Research Abstracts
Issue number: EGU2010-11025
ISSN (Print): 1607-7962
Ratings:
Web of Science (2014): Indexed yes
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
BFI (2009): BFI-level 1
Original language: English
Keywords: Wind power meteorology, Wind Energy
Electronic versions:
EGU2010-11025.pdf
Source: orbit
Source-ID: 271133
Research output: Research - peer-review » Conference article – Annual report year: 2010

Resolving Nonstationary Spectral Information in Wind Speed Time Series Using the Hilbert-Huang Transform
This work is motivated by the observation that large-amplitude wind fluctuations on temporal scales of 1–10 h present challenges for the power management of large offshore wind farms. Wind fluctuations on these scales are analyzed at a meteorological measurement mast in the Danish North Sea using a 4-yr time series of 10-min wind speed observations. An adaptive spectral analysis method called the Hilbert–Huang transform is chosen for the analysis, because the nonstationarity of time series of wind speed observations means that they are not well described by a global spectral analysis method such as the Fourier transform. The Hilbert–Huang transform is a local method based on a nonparametric and empirical decomposition of the data followed by calculation of instantaneous amplitudes and frequencies using the Hilbert transform. The Hilbert–Huang transformed 4-yr time series is averaged and summarized to show climatological patterns in the relationship between wind variability and time of day. First, by integrating the Hilbert spectrum along the frequency axis, a scalar time series representing the total variability within a given frequency range is calculated. Second, by calculating average spectra conditional to time of day, the time axis of the Hilbert spectrum is “remapped” to show climatological patterns. Third, the daily patterns in wind variability and wind speed are compared for the four seasons of the year. It is found that the most intense wind variability occurs in autumn even though the strongest observed wind speeds occur in winter.

General information
State: Published
Organisations: Wind Energy Educational Programme, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Meteorology, Mathematical Statistics, Department of Informatics and Mathematical Modeling
Contributors: Vincent, C. L., Giebel, G., Pinson, P., Madsen, H.
Pages: 253-267
Validation of boundary-layer winds from WRF mesoscale forecasts with applications to wind energy forecasting

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Contributors: Draxl, C., Hahmann, A. N., Pena Diaz, A., Giebel, G.
Publication date: 2010
Peer-reviewed: No
Keywords: Wind power meteorology, Wind Energy
Source: orbit
Source-ID: 270705
Research output: Research › Poster – Annual report year: 2010

Validation of Boundary-Layer Winds from WRF Mesoscale Forecasts with Applications to Wind Energy Forecasting

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Publication date: 2010

Host publication information
Title of host publication: Proceedings
Keywords: Wind power meteorology, Wind Energy
Electronic versions:
Poster_055_GiebelDraxel.pdf
Source: orbit
Source-ID: 270589
Research output: Research › Article in proceedings – Annual report year: 2010
Adding Forecasts to the IEC 61400-25 Communication Standard

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Wind Energy Systems
Contributors: Giebel, G., Gehrke, O.
Number of pages: 740
Pages: 725-728
Publication date: 2009

Host publication information
Title of host publication: Proceedings
Publisher: Energynautics GmbH
Editors: Betancourt, U., Ackermann, T.
Keywords: Wind energy systems, Wind energy
Source: orbit
Source-ID: 251362
Research output: Research › Article in proceedings – Annual report year: 2009

Characterisation of wind variability at the Horns Reef wind farm

General information
State: Published
Organisations: Wind Energy Educational Programme, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Meteorology, Mathematical Statistics, Department of Informatics and Mathematical Modeling
Contributors: Vincent, C. L., Giebel, G., Pinson, P.
Pages: 179-183
Publication date: 2009

Host publication information
Title of host publication: EWEC 2009 Scientific proceedings
Publisher: EWEC
Keywords: Wind energy, Meteorology
Source: orbit
Source-ID: 240456
Research output: Research - peer-review › Article in proceedings – Annual report year: 2009

Communication of wind power forecast uncertainty: towards a standard

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Contributors: Pinson, P., Madsen, H., Nielsen, H. A. O. T. 3., Nielsen, T. S., Giebel, G., Lange, M.
Publication date: 2009

Publication information
Original language: English
(EU project Anemos.plus, Deliverable Report D-1.10).
Keywords: Wind energy, Meteorology
Electronic versions:
anemos.plus.deliverable_D-1.10.pdf
Source: orbit
Source-ID: 251724
Research output: Research › Report – Annual report year: 2009

Integrating wind: Developing Europe's power market for the large-scale integration of wind power

General information
State: Published
Integrating Wind. Developing Europe’s power market for the large-scale integration of wind power: Executive Summary

General information
State: Published
Number of pages: 12
Publication date: 2009

Prediction of waves, wakes and offshore wind - the results of the POWWOW project

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Mathematical Statistics, Department of Informatics and Mathematical Modeling, Instituto National de Engenharia e Technologia Industrial, Institut für Solarenergieforschung
Publication date: 2009
Spectral verification of a mesoscale ensemble

General information
State: Published
Contributors: Vincent, C. L., Draxl, C., Giebel, G., Pinson, P., Jørgensen, J., Möhrlen, C.
Publication date: 2009

Host publication information
Title of host publication: EWEC 2009 Proceedings online
Publisher: EWEC
Keywords: Wind energy, Meteorology
Electronic versions:
2009_15.pdf
Source: orbit
Source-ID: 241165
Research output: Research › Article in proceedings – Annual report year: 2009

Variability forecasts for wind farms using high resolution initial conditions

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Mathematical Statistics, Department of Informatics and Mathematical Modeling
Contributors: Draxl, C., Vincent, C. L., Hahmann, A. N., Giebel, G., Pinson, P.
Number of pages: 740
Pages: 719-724
Publication date: 2009

Host publication information
Title of host publication: Proceedings
Publisher: Energynautics GmbH
Editors: Betancourt, U., Ackermann, T.
Keywords: Wind energy, Meteorology
Source: orbit
Source-ID: 251361
Research output: Research › Article in proceedings – Annual report year: 2009

Wind. Developing Europe’s power market for the large-scale integration of wind power: Final report

General information
State: Published
Number of pages: 104
Publication date: 2009

Publication information
Publisher: European Wind Energy Association (EWEA)
Original language: English
Keywords: Climate and energy systems, Energy systems analysis
Source: orbit
Source-ID: 254223
Research output: Research › Report – Annual report year: 2009
Best practice in the use of short-term forecasting - Results from 2 workshops organized by the POW/WOW Coordination Action

General information
State: Published
Contributors: Giebel, G., Pinson, P., Fochen, U., Lange, M., Meyer, R., Kariniotakis, G.
Publication date: 2008

Host publication information
Title of host publication: Proceedings of the European Wind Energy Conference 2008
Source: orbit
Source-ID: 223273
Research output: Research › Article in proceedings – Annual report year: 2008

Connecting the offshore wind and wave resource calculations

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G., Pontes, T., Barthelmie, R. J., Sempreviva, A. M., Lange, B., Sood, A.
Publication date: 2008

Host publication information
Title of host publication: Conference proceedings (online)
Publisher: European Wind Energy Association (EWEA)
Source: orbit
Source-ID: 232720
Research output: Research › Article in proceedings – Annual report year: 2008

Forecasting of wind generation: recent advances and future challenges

General information
State: Published
Publication date: 2008

Host publication information
Title of host publication: Proceedings of the European Wind Energy Conference 2008
Source: orbit
Source-ID: 223281
Research output: Research › Article in proceedings – Annual report year: 2008

Forecasting of wind generation - The wind power of tomorrow on your screen today!

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Contributors: Pinson, P., Giebel, G., Madsen, H.
Pages: 32-35
Publication date: 2008
Peer-reviewed: Unknown

Publication information
Journal: Windtech International
Volume: 4
Issue number: 8
ISSN (Print): 1574-2415
Ratings:
HRensemble project progress in applying short-range ensemble forecasts for offshore wind power

General information
State: Published
Publication date: 2008

Host publication information
Title of host publication: Proceedings of the European Wind Energy Conference 2008
Source: orbit
Source-ID: 223276
Research output: Research › Article in proceedings – Annual report year: 2008

HRensemble project progress in applying short-range ensemble forecasts for offshore wind power

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Publication date: 2008

Host publication information
Title of host publication: Conference proceedings (online)
Publisher: European Wind Energy Association (EWEA)
Source: orbit
Source-ID: 232718
Research output: Research › Article in proceedings – Annual report year: 2008

Planning of offshore wind farms

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G., Hasager, C. B.
Publication date: 2008
Peer-reviewed: No
Event: Abstract from Seminar at Croatia HEP-TSO, Zagreb (HR), 6 Oct.
Source: orbit
Source-ID: 232844
Research output: Research › Conference abstract for conference – Annual report year: 2008

POWwow - Workshops and virtual laboratories supporting wind research

General information
State: Published
Uncertainty on predicted cross border flows caused by wind forecast errors

General information
State: Published
Organisations: Wind Energy Systems, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Meteorology
Contributors: Cutululis, N. A., Sørensen, P. E., Giebel, G., Korpås, M., Warland, L.
Number of pages: 616
Pages: 70-76
Publication date: 2008

Virtual laboratories for short-term forecasting and other benchmarks of the POW

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Mathematical Statistics, Department of Informatics and Mathematical Modeling
Contributors: Giebel, G., Pinson, P., Perez, I., Lozano, S., Kariniotakis, G., Von Bremen, L., Sood, A.
Publication date: 2008

A variance analysis of the capacity displaced by wind energy in Europe
Wind energy generation distributed all over Europe is less variable than generation from a single region. To analyse the benefits of distributed generation, the whole electrical generation system of Europe has been modelled including varying penetrations of wind power. The model is chronologically simulating the scheduling of the European power plants to cover the demand at every hour of the year. The wind power generation was modelled using wind speed measurements from 60 meteorological stations, for 1 year. The distributed wind power also displaces fossil-fuelled capacity. However, every assessment of the displaced capacity (or a capacity credit) by means of a chronological model is highly sensitive to single events. Therefore the wind time series was shifted by integer days against the load time series, and the different results were aggregated. The some set of results is shown for two other options, one where the pump storage plants are used more aggressively and the other where all German nuclear plants are shut off NCEP/NCAR reanalysis data have been used to recreate the same averaged time series from a data set spanning 34 years. Through this it is possible to set the year studied in detail into a longer-term context. The results are that wind energy can contribute more than 20% of the European demand without significant changes in the system and can replace conventional capacity worth about 10% of the installed wind power capacity. The long-term reference shows that the analysed year is the worst case for wind power
Scopus rating (2009): SJR 0.885 SNIP 1.439
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.743 SNIP 1.555
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.942 SNIP 1.42
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.586 SNIP 1.653
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.273 SNIP 0.827
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.525 SNIP 0.845
Web of Science (2004): Indexed yes
Web of Science (2003): Indexed yes
Web of Science (2002): Indexed yes
Web of Science (2001): Indexed yes
Web of Science (2000): Indexed yes
Original language: English
Keywords: large-scale integration, dispersed turbine systems, complementary power plant, fossil fuel power generation
Electronic versions:
208_ftp.pdf
DOIs:
10.1002/we.208
Source: orbit
Source-ID: 216698
Research output: Research - peer-review › Journal article – Annual report year: 2007

**Best practice in short-term forecasting - A users guide**

**General information**
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Wind Energy Division, Meteorology
Contributors: Giebel, G., Kariniotakis, G.
Number of pages: 5
Publication date: 2007

**Host publication information**
Title of host publication: Conference proceedings (online)
Place of publication: Brussels
Publisher: European Wind Energy Association (EWEA)
URLs:
Source: orbit
Source-ID: 216386
Research output: Research › Article in proceedings – Annual report year: 2007

**CONMOW: Condition Monitoring for Offshore Wind Farms**

**General information**
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Wind Energy Division, Meteorology
Pages: 118-122
Publication date: 2007

**Host publication information**
Title of host publication: Scientific proceedings
Publisher: European Wind Energy Association (EWEA)
URLs:
Ensemble predictions: Understanding uncertainties

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Wind Energy Division, Meteorology
Publication date: 2007

Host publication information
Title of host publication: Conference proceedings (online)
Place of publication: Brussels
Publisher: European Wind Energy Association (EWEA)
URLs:

Ensemble predictions: Understanding uncertainties

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Meteorology, Wind Energy Division, Mathematical Statistics, Department of Informatics and Mathematical Modeling, Danish Meteorological Institute
Publication date: 2007

Host publication information
Title of host publication: Proceedings of the American Wind Power Conference 2007
Place of publication: Los Angeles, California
Publisher: American WindPower
URLs:
http://www2.imm.dtu.dk/pubdb/views/publication_details.php?id=5240

Hohe Anteile an Windenergie im Energiemix der Zukunft: Potenziale, Verfügbarkeit, Technik

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G.
Publication date: 2007
Peer-reviewed: No
Event: Abstract from Energiepolitische Gespräche im Landtag, Kiel (DE)
URLs:

Intelligent wind power prediction systems: Final report

General information
Offshore wind resource assessment in European seas, state-of-the-art: A survey within the FP6 "POW'WOW" coordination action project

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Contributors: Sempreviva, A. M., Barthelmie, R. J., Giebel, G., Lange, B., Sood, A.
Publication date: 2007

Host publication information
Title of host publication: Conference proceedings (online)
Place of publication: Brussels
Publisher: European Wind Energy Association (EWEA)
Source: orbit
Source-ID: 216377
Research output: Research › Article in proceedings – Annual report year: 2007

POW'WOW - Virtual laboratories and best practice guides for the prediction of waves, wakes and offshore wind

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Realisable scenarios for a future electricity supply based 100% on renewable energies

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Wind Energy Division, Meteorology
Contributors: Czisch, G., Giebel, G.
Pages: 186-195
Publication date: 2007

Host publication information
Title of host publication: Energy solutions for sustainable development. Proceedings
Publisher: Risø National Laboratory
Editors: Senderberg Petersen, L., Larsen, H.
ISBN (Print): 978-87-550-3603-1
(Denmark. Forskningscenter Risoe. Risoe-R; No. 1608(EN)).
Keywords: Risø-R-1608(EN), Risø-R-1608
Electronic versions:
ris_r_1608.pdf
Source: orbit
Source-ID: 216418
Research output: Research - peer-review › Article in proceedings – Annual report year: 2007

Reliable power, wind variability and offshore grids in Europe

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Contributors: Hurley, B., Hughes, P., Giebel, G.
Publication date: 2007

Host publication information
Title of host publication: Renewable electricity and the grid. The challenge of variability
Volume: Chapter 10
Place of publication: London
Publisher: Earthscan
Editor: Boyle, G.
ISBN (Print): 978-1-8440-7418-1
Source: orbit
Source-ID: 215451
Research output: Research - peer-review › Book chapter – Annual report year: 2007

Report on the use of stability parameters and mesoscale modelling in short-term prediction

In this report investigations using atmospheric stability measures to improve wind speed predictions at wind farm sites are described. Various stability measures have been calculated based on numerical weather prediction model output. Their ability to improve the wind speed predictions is assessed at three locations. One of the locations is in complex terrain. Mesoscale modelling has been carried out using KAMM at this location. The characteristics of the measured winds are captured well by the mesoscale modelling. It can be seen that the atmospheric stability plays an important role in determining how the flow is influence by the terrain. A prediction system employing a look-up table approach based on wind class simulations is presented. The mesoscale modelling results produced by KAMM were validated using an alternative mesoscale model called WRF. A good agreement in the results of KAMM and WRF was found. It is shown that including a stability parameter in physical and/or statistical modelling can improve the wind speed predictions at a wind farm site. A concept for the inclusion of a stability measure in the WPPT prediction system is presented, and the testing of the concept is outlined.
The POWWOW project: A coordination action on wave, wakes and offshore wind

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G.
Publication date: 2007

Host publication information
Title of host publication: Geophysical Research Abstracts (CD-ROM)
Publisher: EGU
Source: orbit
Source-ID: 220696
Research output: Research › Conference abstract in proceedings – Annual report year: 2007

Towards smart integration of wind generation

General information
State: Published
Contributors: Giebel, G., Meibom, P., Pinson, P., Kariniotakis, G.
Publication date: 2007

Host publication information
Title of host publication: Proc. of the 2007 Nordic Wind Power Conference
Source: orbit
Source-ID: 209987
Research output: Research › Article in proceedings – Annual report year: 2007

TradeWind Deliverable 2.2: Forecast error of aggregated wind power
This report is written in fulfilment of Task 2.3 in the TradeWind project (EU sponsored, under the Intelligent Energy Europe initiative): Wind Power Integration and Exchange in the Trans-European Power Market. The Task description is as follows:
Task 2.3: Forecast error of aggregated wind power
Estimates of forecast error of aggregated production for time horizons of intraday and dayahead markets in future will be produced. This will be done by reference to published studies of forecasting for wind generation, and from internal knowledge of WP2 participants. Modelling of wind power fluctuations for aggregated wind generation capacity

General information
Analysis of HIRLAM including turbulent kinetic energy

General information
State: Published
Organisations: Wind Energy Systems, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Contributors: Boone, A., Giebel, G., Sattler, K., Feddersen, H.
Number of pages: 35
Publication date: 2006

Publication information
Original language: English
URLs:
http://www.risoe.dtu.dk/rispubl/NEI/nei-dk-4553.pdf
Source: orbit
Source-ID: 309252
Research output: Research › Report – Annual report year: 2006

Analysis of the results of an on-line wind power quantile forecasting system

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Wind Energy Systems
Contributors: Nielsen, H., Yates, D., Madsen, H., Nielsen, T., Badger, J., Giebel, G., Landberg, L., Sattler, K., Feddersen, H.
Number of pages: 31
Publication date: 2006

Publication information
Original language: English
Electronic versions:
nei_dk_4551.pdf
Source: orbit
Source-ID: 309254
Research output: Research › Report – Annual report year: 2006
Common access to wind turbine data for condition monitoring the IEC 61400-25 family of standards

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G., Gehrke, O., McGugan, M., Borum, K.
Pages: 157-164
Publication date: 2006

Host publication information
Title of host publication: Polymer composite materials for wind power turbines. Proceedings
Place of publication: Roskilde
Publisher: Risø National Laboratory
Editors: Lilholt, H., Madsen, B., Andersen, T., Mikkelsen, L., Thygesen, A.
ISBN (Print): 87-550-3528-0
URLs:
Source: orbit
Source-ID: 309566
Research output: Research - peer-review › Article in proceedings – Annual report year: 2006

From wind ensembles to probabilistic information about future wind power production - results from an actual application

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Nielsen, H., Nielsen, T., Madsen, H., Giebel, G., Badger, J., Landberg, L., Sattler, K., Voulund, L., Tøfting, J.
Publication date: 2006

Host publication information
Title of host publication: PMAPS 2006 (CD-ROM)
Place of publication: Stockholm
Publisher: Royal Institute of Technology
Source: orbit
Source-ID: 309519
Research output: Research › Article in proceedings – Annual report year: 2006

Next generation forecasting tools for the optimal management of wind generation

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Publication date: 2006

Host publication information
Title of host publication: PMAPS 2006 (CD-ROM)
Place of publication: Stockholm
Publisher: Royal Institute of Technology
Source: orbit
Source-ID: 309518
Research output: Research › Article in proceedings – Annual report year: 2006

POW'WOW - a coordination action on the prediction of waves, wakes and offshore wind

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G., Barthelmie, R., Sempreviva, A.
Publication date: 2006
Peer-reviewed: No

Publication information
POW'WOW. A coordination action on the prediction of waves, wakes and offshore wind

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Pages: 353-363
Publication date: 2006

Host publication information
Title of host publication: Offshore wind and other marine renewable energies in Mediterranean and European seas. Proceedings
Place of publication: Roma
Publisher: ENEA
Source: orbit
Source-ID: 309160
Research output: Research › Article in proceedings – Annual report year: 2006

POW'WOW. A coordination action on the prediction of waves, wakes and offshore wind (poster)

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Publication date: 2006

Host publication information
Title of host publication: Proceedings (online)
Place of publication: Brussels
Publisher: European Wind Energy Association (EWEA)
URLs:
Source: orbit
Source-ID: 309205
Research output: Research › Article in proceedings – Annual report year: 2006

Prediction of wind speed profiles for short-term forecasting in the offshore environment (poster)

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Short-term (30 min - 72 hrs) prediction for power output from wind farms

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G., Landberg, L., Madsen, H., Nielsen, T., Nielsen, H.
Pages: 1-19
Publication date: 2006

Short-term forecasting using advanced physical modelling - The results of the Anemos project. Results from mesoscale, microscale and CFD modelling

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G., Badger, J., Louka, P., Kallos, G., Palomares, A., Lac, C., Descombes, G.
Publication date: 2006

Wind power ensemble forecasting using wind speed and direction ensembles from ECMWF or NCEP

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Wind Energy Systems
Contributors: Nielsen, H., Madsen, H., Nielsen, T., Badger, J., Giebel, G., Landberg, L., Sattler, K., Feddersen, H.
Number of pages: 31
Publication date: 2006
A comparison of the DMI-Hirlam and DWD-Lokalmodell for short-term forecasting (poster)

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G.
Publication date: 2005

Host publication information
Title of host publication: Proceedings CD-ROM
Place of publication: Brussels
Publisher: European Wind Energy Association (EWEA)
Source: orbit
Source-ID: 307865
Research output: Research › Article in proceedings – Annual report year: 2005

Comparison of corrections to site wind speeds in the offshore environment: Value for short-term forecasting

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Barthelmie, R., Giebel, G., Jørgensen, B., Badger, J., Pryor, S., Hasager, C.
Publication date: 2005

Host publication information
Title of host publication: Proceedings CD-ROM
Place of publication: Brussels
Publisher: European Wind Energy Association (EWEA)
Source: orbit
Source-ID: 307863
Research output: Research › Article in proceedings – Annual report year: 2005

Is least cost wind power always local in Europe

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G., Nielsen, M., Hurley, B.
Pages: 280-286
Publication date: 2005

Host publication information
Title of host publication: Technologies for sustainable energy development in the long term. Proceedings
Editors: Sønderberg Petersen, L., Larsen, H.
(Denmark. Forskningscenter Risoe. Risoe-R; No. 1517(EN)).
Keywords: Risø-R-1517(EN)
Electronic versions:
ris_r_1517.pdf
Source: orbit
Source-ID: 308206
Research output: Research › peer-review › Article in proceedings – Annual report year: 2005

Short-term forecasting of wind speeds in the offshore environment

General information
What performance can be expected by short-term wind power prediction models depending on site characteristics?

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Publication date: 2005

Host publication information
Title of host publication: Proceedings CD-ROM
Place of publication: Brussels
Publisher: European Wind Energy Association (EWEA)
Source: orbit
Source-ID: 307947
Research output: Research › Article in proceedings – Annual report year: 2005

Wind farm modelling and short-term prediction

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Barthelmie, R., Giebel, G., Frandsen, S.
Publication date: 2005
Peer-reviewed: No
Event: Abstract from Off Shore Wind Energy Technologies Seminar, Beijing, China.
Source: orbit
Source-ID: 308478
Research output: Research › Conference abstract for conference – Annual report year: 2005

Wind power has a capacity credit. A catalogue of 50+ supporting studies
The capacity credit of wind power in a grid has received quite some attention in the past. In the early days of wind power, the capacity credit, or rather the perceived lack thereof, was a grave concern for the large-scale development of wind power on a nation-wide basis. Therefore, a number of studies was made since the 1970ies, arriving at the conclusion that a) wind power has a capacity credit, and b) the capacity credit is around the mean wind power output for small penetrations of wind power in the grid, and drops to a value near the minimum wind power generation for larger penetrations. This paper describes some different approaches to the capacity credit of wind energy, and provides links to a large number of studies, predominantly for European countries and from the earlier years of the development. Nowadays, the capacity credit is often just a sub-topic for the larger studies on how to integrate renewables, especially intermittent renewables, in the system. The sole aim of this paper is to provide a data base of most of the available literature to the topic, and to end the discussion whether wind power has a capacity credit: all studies from research institutes, consultants and the power industry itself show that it has one.

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G.
Pages: 13
Publication date: 2005
Peer-reviewed: No
Wind Power Prediction using Ensembles

The Ensemble project investigated the use of meteorological ensemble forecasts for the prognosis of uncertainty of the forecasts, and found a good method to make use of ensemble forecasts. This method was then tried based on ensembles from ECMWF in form of a demo application for both the Nysted offshore wind farm and the whole Jutland/Funen area. The utilities used these forecasts for maintenance planning, fuel consumption estimates and over-the-weekend trading on the Leipzig power exchange. Other notable scientific results include the better accuracy of forecasts made up from a simple superposition of two NWP provider (in our case, DMI and DWD), an investigation of the merits of a parameterisation of the turbulent kinetic energy within the delivered wind speed forecasts, and the finding that a “naïve” downscaling of each of the coarse ECMWF ensemble members with higher resolution HIRLAM did not improve the error scores or the result space enough to warrant the computational effort.

A comparison of the DMI-Hirlam and DWD-Lokalmodell for short-term forecasting (poster)

ANEMOS: Development of a next generation wind power forecasting system for the large-scale integration of onshore and offshore wind farms
CleverFarm - A superSCADA system for wind farms

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Wind Energy Division
Number of pages: 57
Publication date: 2004

Publication information
ISBN (Print): 87-550-3292-3
Original language: English
(Denmark. Forskningscenter Risoe. Risø-R; No. 1444(EN)).
Keywords: Risø-R-1444, Risø-R-1444(EN)
Electronic versions:
ris_r_1444.pdf
Source: orbit
Source-ID: 307236
Research output: Research - peer-review › Report – Annual report year: 2004

Fluctuations and predictability of wind and hydropower. Deliverable 2.1

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Number of pages: 71
Publication date: 2004

Publication information
ISBN (Print): 87-550-3290-7
Original language: English
(Denmark. Forskningscenter Risoe. Risø-R; No. 1443(EN)).
Keywords: Risø-R-1443, Risø-R-1443(EN)
Electronic versions:
ris_r_1443.pdf
Source: orbit
Source-ID: 307029
Research output: Research › Report – Annual report year: 2004

IEC sets the standard

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G.
Pages: 12
Publication date: 2004
Peer-reviewed: Unknown

Publication information
Shear and stability in high met masts, and how WAsP treats it

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Wind Energy Division
Contributors: Giebel, G., Gryning, S.
Pages: 356-363
Publication date: 2004

Host publication information
Title of host publication: Proceedings
Place of publication: Delft
Publisher: Delft University of Technology
ISBN (Print): 90-76468-10-9
Source: orbit
Source-ID: 306798
Research output: Research - peer-review › Article in proceedings – Annual report year: 2004

The future of wind

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G.
Pages: 14-15
Publication date: 2004
Peer-reviewed: Unknown

Publication information
Issue number: Supplement: Wind Technology
Original language: English
Source: orbit
Source-ID: 307812
Research output: Communication › Journal article – Annual report year: 2005

The state-of-the-art in short-term prediction of wind power. A literature overview. Version 1.1

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G., Brownsword, R., Kariniotakis, G.
Number of pages: 36
Publication date: 2004

Publication information
Publisher: ANEMOS Project
Original language: English
Electronic versions:
Prediction_of_Wind_Power.pdf
Source: orbit
Source-ID: 306877
Research output: Research - peer-review › Book – Annual report year: 2004

The state-of-the-art in short-term prediction of wind power from a Danish perspective

General information
The state of the art in short-term prediction of wind power - from an offshore perspective

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Kariniotakis, G., Pinson, P., Siebert, N., Giebel, G., Barthelmie, R.
Publication date: 2004
Peer-reviewed: No
Source: orbit
Source-ID: 307469
Research output: Research › Conference abstract for conference – Annual report year: 2004

Towards next generation short-term forecasting of wind power - the ANEMOS project (poster paper)

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Publication date: 2004

Host publication information
Title of host publication: Conference proceedings (CD-ROM)
Place of publication: Washington, DC
Publisher: American Wind Energy Association (AWEA)
Source: orbit
Source-ID: 306933
Research output: Research › Article in proceedings – Annual report year: 2004

Using prediction models in other applications (PowerPoint presentation)

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G.
Publication date: 2004

Host publication information
Title of host publication: Conference proceedings (CD-ROM)
Place of publication: Washington, DC
Publisher: American Wind Energy Association (AWEA)
Source: orbit
Source-ID: 306934
Research output: Research › Conference abstract in proceedings – Annual report year: 2004
Wind power Ensemble forecasting

**General information**
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Nielsen, H., Madsen, H., Nielsen, T., Badger, J., Giebel, G., Landberg, L., Sattler, K., Feddersen, H.
Publication date: 2004

**Host publication information**
Title of host publication: Conference proceedings (CD-ROM)
Place of publication: Washington, DC
Publisher: American Wind Energy Association (AWEA)
Source: orbit
Source-ID: 306932
Research output: Research › Article in proceedings – Annual report year: 2004

Wind power forecasting using Ensembles

**General information**
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G., Badger, J., Landberg, L., Nielsen, H., Madsen, H., Sattler, K., Feddersen, H.
Publication date: 2004

**Host publication information**
Title of host publication: Conference proceedings (CD-ROM)
Place of publication: Washington, DC
Publisher: American Wind Energy Association (AWEA)
Source: orbit
Source-ID: 306931
Research output: Research › Article in proceedings – Annual report year: 2004

Effects of large-scale distribution of wind energy in and around Europe

**General information**
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G., Mortensen, N., Czisch, G.
Pages: 115-124
Publication date: 2003

**Host publication information**
Title of host publication: Energy technologies for Post Kyoto targets in the medium term. Proceedings
Editors: Sønderberg Petersen, L., Larsen, H.
ISBN (Print): 87-550-3203-6 (CD-ROM)
(Denmark. Forskningscenter Risoe. Risoe-R; No. 1405(EN)).
Keywords: Risø-R-1405(EN), Risø-R-1405
Electronic versions:
ris_r_1405.pdf
Source: orbit
Source-ID: 306018
Research output: Research - peer-review › Article in proceedings – Annual report year: 2003

On the stability treatment in WAsP

**General information**
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Meteorology, Wind Energy Division
Contributors: Giebel, G., Gryning, S.
Publication date: 2003
Peer-reviewed: No

**Publication information**
Journal: Geophysical Research Abstracts
State-of-the-art on methods and software tools for short-term prediction of wind energy production

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G., Landberg, L., Kariniotakis, G., Brownsword, R.
Publication date: 2003

Host publication information
Title of host publication: Proceedings CD-ROM. CD 2
Place of publication: Brussels
Publisher: European Wind Energy Association (EWEA)
Source: orbit
Source-ID: 305942
Research output: Research › Article in proceedings – Annual report year: 2003

Using ensemble forecasting for wind power

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G., Landberg, L., Badger, J., Sattler, K., Feddersen, H., Nielsen, T., Nielsen, H., Madsen, H.
Publication date: 2003

Host publication information
Title of host publication: Proceedings CD-ROM. CD 2
Place of publication: Brussels
Publisher: European Wind Energy Association (EWEA)
Source: orbit
Source-ID: 305944
Research output: Research › Article in proceedings – Annual report year: 2003

Wind resource estimation - on timescales from 12 hours to 30 years

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Landberg, L., Mortensen, N., Rathmann, O., Myllerup, L., Badger, J., Jørgensen, B., Giebel, G., Petersen, E., Højstrup, J.
Publication date: 2003

Host publication information
Title of host publication: Conference proceedings (CD-ROM)
Place of publication: Calgary
Publisher: Canadian Wind Energy Association
Source: orbit
Poor-man's ensemble forecasting for error estimation

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Landberg, L., Giebel, G., Myllerup, L., Badger, J., Madsen, H., Nielsen, T.
Publication date: 2002

Host publication information
Title of host publication: Conference proceedings (CD-ROM)
Place of publication: Washington, DC
Publisher: American Wind Energy Association (AWEA)
Source: orbit
Source-ID: 304363
Research output: Research › Article in proceedings – Annual report year: 2002

Prediction of regional wind power (poster)

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Nielsen, T., Madsen, H., Nielsen, H., Landberg, L., Giebel, G.
Publication date: 2002

Host publication information
Title of host publication: Proceedings CD-ROM
Place of publication: Brussels
Publisher: European Wind Energy Association (EWEA)
Source: orbit
Source-ID: 304231
Research output: Research › Article in proceedings – Annual report year: 2002

The CleverFarm project: Working towards an intelligent wind farm

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Publication date: 2002

Host publication information
Title of host publication: Proceedings CD-ROM
Place of publication: Brussels
Publisher: European Wind Energy Association (EWEA)
Source: orbit
Source-ID: 303898
Research output: Research › Article in proceedings – Annual report year: 2002

The CleverFarm project. Working towards an intelligent wind farm

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Publication date: 2002

Host publication information
Title of host publication: Conference proceedings (CD-ROM)
The Zephyr-project. The next generation prediction system (poster)

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G., Landberg, L., Nielsen, T., Madsen, H.
Publication date: 2002

Host publication information
Title of host publication: Proceedings CD-ROM
Place of publication: Brussels
Publisher: European Wind Energy Association (EWEA)
Source: orbit
Source-ID: 304240
Research output: Research › Article in proceedings – Annual report year: 2002

Wind energy in the liberalised market - forecast errors in a day-ahead market compared to a more flexible market mechanism

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Holttinen, H., Nielsen, T., Giebel, G.
Publication date: 2002
Peer-reviewed: No
Source: orbit
Source-ID: 304933
Research output: Research › Conference abstract for conference – Annual report year: 2002

A comparison of intra- and extraeuropean options for an energy supply with wind power

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Czisch, G., Giebel, G.
Number of pages: 4
Publication date: 2001
Peer-reviewed: No

Bibliographical note
Place of publication: München

Publisher: WIP - Renewable Energies

Pages: 69-72
Source: orbit
Source-ID: 301513
Research output: Research › Conference abstract for conference – Annual report year: 2001

Availability of wind turbines in remote places. A statistical and a real-time view
A variance analysis of the capacity displaced by wind energy in Europe

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G.
Pages: 263-266
Publication date: 2001

Host publication information
Title of host publication: Proceedings (on CD-ROM)
Place of publication: München
Publisher: WIP - Renewable Energies
Source: orbit
Source-ID: 302377
Research output: Research - peer-review › Article in proceedings – Annual report year: 2001

CleverFarm

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G., Landberg, L.
Number of pages: 28
Publication date: 2001

Host publication information
Title of host publication: Wind Energy Department: Scientific and technical progress 1999-2000
Volume: Risø-R-1239(EN)
Editors: Skrumsager, B., Larsen, G.
ISBN (Print): 87-550-2818-7
URLs:
http://www.risoe.dtu.dk/rispubl/VEA/veapdf/ris-r-1239.pdf
Source: orbit
Source-ID: 303237
Research output: Research - peer-review › Book chapter – Annual report year: 2001

CleverFarm. The intelligent wind farm

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Pages: 180-183
Publication date: 2001
Short-term prediction

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Landberg, L., Giebel, G.
Number of pages: 27
Publication date: 2001

The quality of a 48-hours wind power forecast using the German and Danish weather prediction model

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Waldl, H., Giebel, G.
Pages: 237-239
Publication date: 2001

The Zephyr-project - the next generation prediction system

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G., Landberg, L., Joensen, A., Nielsen, T., Madsen, H.
Pages: 206-209
Publication date: 2001
The Zephyr project - The next generation prediction system (poster)

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G., Landberg, L., Nielsen, T., Madsen, H.
Pages: 777-780
Publication date: 2001

Host publication information
Title of host publication: Wind energy for the new millennium. Proceedings
Place of publication: München
Publisher: WIP Renewable Energies
Editors: Helm, P., Zervos, A.
Source: orbit
Source-ID: 302920
Research output: Research › Article in proceedings – Annual report year: 2001

Working towards an intelligent wind farm

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Publication date: 2001
Peer-reviewed: No
Event: Abstract from 2001 European Wind Energy Conference and Exhibition (EWEC '01), Copenhagen, Denmark.
Source: orbit
Source-ID: 303192
Research output: Research › Conference abstract for conference – Annual report year: 2001

Zephyr and short-term wind power prediction models

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Madsen, H., Nielsen, T., Nielsen, H., Landberg, L., Giebel, G.
Pages: 244-247
Publication date: 2001

Host publication information
Title of host publication: Proceedings (on CD-ROM)
Source: orbit
Source-ID: 302381
Research output: Research - peer-review › Article in proceedings – Annual report year: 2001

Zephyr - The prediction models (poster)

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Nielsen, T., Madsen, H., Nielsen, H., Landberg, L., Giebel, G.
Pages: 868-871
Publication date: 2001

Host publication information
Title of host publication: Wind energy forthe new millennium. Proceedings
Place of publication: München
Publisher: WIP Renewable Energies
Editors: Helm, P., Zervos, A.
Source: orbit
Source-ID: 302921
A variance analysis of the capacity displaced by wind energy in Europe

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G.
Publication date: 2000
Peer-reviewed: No
Source: orbit
Source-ID: 301515
Research output: Research › Conference abstract for conference – Annual report year: 2000

CleverFarm - The intelligent wind farm

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Publication date: 2000
Peer-reviewed: No
Source: orbit
Source-ID: 301518
Research output: Research › Conference abstract for conference – Annual report year: 2000

Das Zephyr-Projekt - eine neue Phase der Kurzzeitprognose

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G., Landberg, L., Joensen, A., Nielsen, T., Madsen, H.
Pages: 158-161
Publication date: 2000

Host publication information
Title of host publication: Tagungsband
Place of publication: Wilhelmshaven
Publisher: Deutsches Windenergie-Institut GmbH
Source: orbit
Source-ID: 301279
Research output: Research › Article in proceedings – Annual report year: 2000

Einfluss des dänischen und des deutschen Wettervorschlagsmodells auf die Qualität einer 48-Stunden-Windleistungsprognose

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Waldl, H., Giebel, G.
Pages: 145-148
Publication date: 2000

Host publication information
Title of host publication: Tagungsband
Place of publication: Wilhelmshaven
Publisher: Deutsches Windenergie-Institut GmbH
Source: orbit
Source-ID: 301506
Research output: Research › Article in proceedings – Annual report year: 2000
Equalizing effects of the wind energy production in Northern Europe determined from reanalysis data

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Wind Energy Division, Wind Energy Systems
Contributors: Giebel, G.
Number of pages: 19
Publication date: 2000

Publication information
ISBN (Print): 87-550-2698-2
Original language: English
(Denmark. Forskningscenter Risoe. Risoe-R; No. 1182(EN)).
Keywords: Risø-R-1182, Risø-R-1182(EN)
Electronic versions:
ris_r_1182.pdf
Source: orbit
Source-ID: 301485
Research output: Research - peer-review › Report – Annual report year: 2000

Short-term prediction towards the 21st century
A new chapter in the continued and exiting story of short-term prediction has begun! The paper will describe a new project funded by the Danish Ministry of Energy where all the Danish utilities (Elkraft, ELsam, Eltra, and SEAS) will participate. The goal of the project is to develop and implement on-line a model combining the RISO and IMM models. This will ensure that the best forecasts are given on all prediction horizons form the very short range (0-9 hours) to the very long range (36-48 hours).

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Risø National Laboratory for Sustainable Energy
Contributors: Nielsen, T. S., Joensen, A. K., Madsen, H., Landberg, L., Giebel, G.
Pages: 371-376
Publication date: 2000

Host publication information
Title of host publication: Wind energy 1999: Wind power comes of age
Place of publication: Bury St Edmunds
Publisher: Institution of Mechanical Engineers
Editor: Hinson, P.
ISBN (Print): 1-86058-206-0
Source: orbit
Source-ID: 172496
Research output: Research - peer-review › Article in proceedings – Annual report year: 2000

The capacity credit of wind energy in Europe, estimated from reanalysis data

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G.
Publication date: 2000

Host publication information
Title of host publication: Shaping the future (CD-ROM)
Place of publication: Hannover
Publisher: EXPO 2000
Editors: Bretschneider, B., Ehrenfeld, H., Hettche, H., Oetzmann, S., Ternes, W., Walter, G.
ISBN (Print): 3-00-00642-1
Source: orbit
Source-ID: 301803
Research output: Research › Article in proceedings – Annual report year: 2000
The quality of a 48-hours wind power forecast using the German and Danish weather prediction model

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Waldl, H., Giebel, G.
Publication date: 2000
Peer-reviewed: No
Source: orbit
Source-ID: 301509
Research output: Research › Conference abstract for conference – Annual report year: 2000

The value of distributed generation in Europe to utilities

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G.
Pages: 140-144
Publication date: 2000

Host publication information
Title of host publication: Tagungsband
Place of publication: Wilhelmshaven
Publisher: Deutsches Windenergie-Institut GmbH
Source: orbit
Source-ID: 301278
Research output: Research › Article in proceedings – Annual report year: 2000

Zephyr - the next generation prediction system

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G., Landberg, L., Joensen, A., Nielsen, T., Madsen, H.
Publication date: 2000
Peer-reviewed: No
Source: orbit
Source-ID: 301514
Research output: Research › Conference abstract for conference – Annual report year: 2000

Zephyr, the short-term prediction models

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G., Landberg, L., Joensen, A., Nielsen, T., Madsen, H.
Publication date: 2000
Peer-reviewed: No
Source: orbit
Source-ID: 301511
Research output: Research › Conference abstract for conference – Annual report year: 2000

Effects of distributing wind energy generation over Europe

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G.
Pages: 417-420
Implementation of Short-term Prediction

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Risø National Laboratory for Sustainable Energy, Rutherford Appleton Laboratory, Danish Meteorological Institute, National Observatory of Athens, Elsam A/S, Elkraft Power Co Ltd., WECTEC Inc., OEM Development Corporation
Pages: 57-62
Publication date: 1999

Model output statistics applied to wind power prediction

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Risø National Laboratory for Sustainable Energy, Mathematical Statistics
Pages: 1177-1180
Publication date: 1999

Relative performance of different numerical weather prediction models for short term prediction of wind energy

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G., Landberg, L., Mönnich, K., Waldl, H.
Pages: 1078-1081
Publication date: 1999
Short-term prediction of wind farm output

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G., Joensen, A.
Publication date: 1999
Peer-reviewed: No
Event: Abstract from 1st Danish Society for Atmospheric Research Conference, Copenhagen, Denmark.
Source: orbit
Source-ID: 299835
Research output: Research › Conference abstract for conference – Annual report year: 1999

The economic value of accurate wind power forecasting to utilities

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Watson, S., Giebel, G., Joensen, A.
Pages: 1009-1012
Publication date: 1999
Host publication information
Title of host publication: Wind energy for the next millennium. Proceedings
Place of publication: London
Publisher: James and James Science Publishers
Editors: Petersen, E., Hjuler Jensen, P., Rave, K., Helm, P., Ehmann, H.
ISBN (Print): 1-902916-00-X
Source: orbit
Source-ID: 299894
Research output: Research › Article in proceedings – Annual report year: 1999

The use of reanalysis data in a capacity credit assessment of wind energy in Europe

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G.
Publication date: 1999
Peer-reviewed: No
Source: orbit
Source-ID: 299523
Research output: Research › Conference abstract for conference – Annual report year: 1999

Model output statistics in wind power forecasting

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G.
Publication date: 1998
Peer-reviewed: No
Event: Abstract from JOULE Grant Holder Workshop, Cork, Ireland.
Model output statistics in wind power forecasting

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G.
Publication date: 1998
Peer-reviewed: No
Event: Abstract from JOULE Grant Holder Workshop, London, United Kingdom.
Source: orbit
Research output: Research › Conference abstract for conference – Annual report year: 1998

European wind energy capacity effects

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Giebel, G.
Publication date: 1997
Peer-reviewed: No
Event: Abstract from JOULE training grant holder workshop, Helsinki (FI), 4-8 Sep, .
Source: orbit
Research output: Research › Conference abstract for conference – Annual report year: 1997

Projects:

OffshoreWake: 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.
Larsen, X. G., Project Participant, Department of Wind Energy, Resource Assessment Modelling
Du, J., Project Participant, Department of Wind Energy, Resource Assessment Modelling
Imberger, M., Project Participant, Department of Wind Energy, Resource Assessment Modelling
Giebel, G., Project Participant, Department of Wind Energy, Integration & Planning
Sørensen, P. E., Project Participant, Department of Wind Energy, Integration & Planning
Hasager, C. B., Project Participant, Department of Wind Energy, Meteorology & Remote Sensing
Badger, J., Project Participant, Department of Wind Energy, Resource Assessment Modelling
Volker, P., Project Participant, Department of Wind Energy, Resource Assessment Modelling
Hahmann, A. N., Project Participant, Department of Wind Energy, Resource Assessment Modelling
Imberger, M., Project Participant, Department of Wind Energy, Resource Assessment Modelling
Project ID: EUDP / ForskEL (64017-0017 / 12521
01/05/2017 → 30/04/2020
Keywords: Offshore wind, wind to power, farm wakes, sea conditions
Collaborators: Vattenfall
Project: Research

WFCT: Wind Farm Control Trials
Offshore demonstration project of wind farm control optimisation (induction & wake steering)
Simon, E., Project Participant, Department of Wind Energy, Meteorology & Remote Sensing
Hasager, C. B., Project Participant, Department of Wind Energy, Meteorology & Remote Sensing
Giebel, G., Project Participant, Department of Wind Energy, Integration & Planning
Kazda, J., Project Participant, Department of Wind Energy, Integration & Planning
Cutululis, N. A., Project Participant, Department of Wind Energy, Integration & Planning
Courtney, M., Project Participant, Department of Wind Energy, Test and Measurements
Coastal Offshore Winds, Ocean Waves and Current using Remote Sensing
Ahsbahs, T. T., PhD Student, Department of Wind Energy
Badger, M., Main Supervisor, Department of Wind Energy
Karagali, I., Supervisor, Department of Wind Energy
Kim, S. Y., Supervisor
Larsen, X. G., Supervisor, Department of Wind Energy
Giebel, G., Examiner, Department of Wind Energy
Rugaard Furevik, B., Examiner
Jacobsen, S., Examiner
Samfinansieret - Andet
01/11/2015 → 01/12/2018
Award relations: Coastal Offshore Winds, Ocean Waves and Current using Remote Sensing
Project: PhD

Impact of wind power uncertainty on electric power system reliability
Nuño Martinez, E., PhD Student, Department of Wind Energy
Cutulis, N. A., Main Supervisor, Department of Wind Energy
Serensen, P. E., Supervisor, Department of Wind Energy
Giebel, G., Examiner, Department of Wind Energy
Kariniotakis, G., Examiner
Van Herem, D., Examiner
Kariniotakis, G., Examiner
Samfinansieret - Andet
15/11/2014 → 06/09/2018
Award relations: Impact of wind power uncertainty on electric power system reliability
Project: PhD

Possible Power of Downregulated Offshore Wind power plants
Göçmen, T., PhD Student, Department of Wind Energy
Giebel, G., Main Supervisor, Department of Wind Energy
Poulsen, N. K., Supervisor, Department of Applied Mathematics and Computer Science
Serensen, P. E., Supervisor, Department of Wind Energy
Serensen, J. N., Examiner, Department of Wind Energy
Apt, J., Examiner
Johansen, K., Examiner
Apt, J., Examiner
Johansen, K., Examiner
Offentlig finansiering
15/12/2012 → 07/04/2016
Award relations: Possible Power of Downregulated Offshore Wind power plants
Project: PhD

Forecasting Wind Turbine icing Conditions
Davis, N., PhD Student, Risø National Laboratory for Sustainable Energy
Hahmann, A. N., Main Supervisor, Risø National Laboratory for Sustainable Energy
Claussen, N., Supervisor, Risø National Laboratory for Sustainable Energy
Zagar, M., Supervisor
Giebel, G., Examiner, Department of Informatics and Mathematical Modeling
Andersson, A., Examiner
Haupt, S. E., Examiner
Andersson, A., Examiner
Haupt, S. E., Examiner
Eksternt finansieret virksomhed
01/06/2011 → 05/11/2014
Award relations: Forecasting Wind Turbine icing Conditions
Project: PhD
New data assimilation techniques for short-term wind energy forecast models with a rapid update cycle
Draxl, C., PhD Student, Risø National Laboratory for Sustainable Energy
Giebel, G., Main Supervisor, Risø National Laboratory for Sustainable Energy
Hahmann, A. N., Supervisor, Risø National Laboratory for Sustainable Energy
delle Monache, L., Supervisor
Larsen, X. G., Examiner, Risø National Laboratory for Sustainable Energy
Kaas, E., Examiner
Lundquist, J. K., Examiner
Institut, samfinansiering
15/12/2008 → 25/06/2012
Award relations: New data assimilation techniques for short-term wind energy forecast models with a rapid update cycle
Project: PhD

Mesoscale Aumospheric Variability and the Variation of wind and Production for Off-shore Wind Farms
Vincent, C. L., PhD Student, Department of Wind Energy
Giebel, G., Main Supervisor, Risø National Laboratory for Sustainable Energy
Hahmann, A. N., Supervisor, Department of Wind Energy
Pinson, P., Supervisor, Department of Informatics and Mathematical Modeling
Badger, J., Examiner, Risø National Laboratory for Sustainable Energy
Barstad, I., Examiner
Knievel, J. C., Examiner
Institut/centerfinansieret
01/01/2008 → 06/04/2011
Award relations: Mesoscale Aumospheric Variability and the Variation of wind and Production for Off-shore Wind Farms
Project: PhD

ESA ResGrow: 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.
Hasager, C. B., Project Manager, Department of Wind Energy, Meteorology
Astrup, P., Project Participant, Department of Wind Energy, Meteorology
Badger, M., Project Participant, Department of Wind Energy, Meteorology
Giebel, G., Project Participant, Department of Wind Energy, Wind Energy Systems
Hahmann, A. N., Project Participant, Department of Wind Energy, Meteorology
External Project ID: ESA project
07/02/2013 → 30/09/2015
Collaborators: German Aerospace Center, TechWorks Marine, Transvalor S.A.
Project: Research

EERA-DTOC: 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.
Madsen, P. H., Project Coordinator, Department of Wind Energy
Hasager, C. B., Project Manager, Department of Wind Energy, Meteorology
Giebel, G., Project Participant, Department of Applied Mathematics and Computer Science, Department of Wind Energy, Wind Energy Systems
Réthoré, P., Project Participant, Department of Wind Energy, Aeronautical Design
Cutululis, N. A., Project Participant, Rise National Laboratory for Sustainable Energy, Department of Wind Energy, Wind Energy Systems
Badger, M., Project Participant, Department of Wind Energy, Meteorology
Hahmann, A. N., Project Participant, Department of Wind Energy, Meteorology
Peña, A., Project Participant, Department of Wind Energy, Meteorology
Badger, J., Project Participant, Department of Wind Energy, Meteorology
Volker, P., Project Participant, Department of Wind Energy, Meteorology
Karagali, I., Project Participant, Department of Wind Energy, Meteorology
Maule, P., Project Participant, Department of Wind Energy, Wind Energy Systems
ICEWIND: 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 program http://www.toppforskningsinitiativet.org/en/programmer-1/program-4/prosjekter/icewind/ Project period 1. September 2010 – 31. August 2014 • 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.

Clausen, N., Project Manager, Office for Study Programmes and Student Affairs, Department of Wind Energy, Wind Energy Systems
Hasager, C. B., Project Participant, Department of Wind Energy, Meteorology
Hahmann, A. N., Project Participant, Department of Wind Energy, Meteorology
Davis, N., Project Participant, Department of Wind Energy, Meteorology
Badger, M., Project Participant, Department of Wind Energy, Meteorology
Giebel, G., Project Participant, Department of Wind Energy, Wind Energy Systems

External Project ID: TFI-PK int 01
01/09/2010 → 28/02/2015
Project: Research

Activities:

Farm Control: Interest and Activities in DTU Wind
Period: 30 Aug 2018
Tuhfe Göçmen (Invited speaker)
Gregor Giebel (Other)
Søren Juhl Andersen (Other)
Jonas Kazda (Other)

Department of Wind Energy
Integration & Planning
Fluid Mechanics

Documents:
TuhfeGocmen_WFCinDTU

Related event
Parameter Uncertainty Reduction of the Re-calibrated Larsen Wake Model
Period: 26 Jun 2017 → 29 Jun 2017
Tuhfe Göçmen (Speaker)
Gregor Giebel (Other)
Department of Wind Energy
Integration & Planning

Description
Presentation at the Wind Energy Science Conference (WESC)
Degree of recognition: International

Documents:
Parameter Uncertainty Reduction of the Re-calibrated Larsen Wake Model

Related event
Wind Energy Science Conference 2017
26/06/2017 → 29/06/2017
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

Framework of Multi-Objective Wind Farm Controller Applicable to Real Wind Farms
Period: 28 Sep 2016
Jonas Kazda (Guest lecturer)
Tuhfe Göçmen (Guest lecturer)
Gregor Giebel (Guest lecturer)
Michael Courtney (Guest lecturer)
Nicolaos Antonio Cutululis (Guest lecturer)
Department of Wind Energy
Integration & Planning
Test and Measurements
Degree of recognition: International

Related event
Wind Europe Summit 2016
26/09/2016 → 29/09/2016
Hamburg, Germany
Activity: Talks and presentations › Conference presentations

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
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
Activity: Talks and presentations › Conference presentations