Final report

1.1 Project details

Project title	IEA Wind Task 36 Forecasting Danish Consortium
Project identification (program abbrev. and file)	Journalnr.: 64015-0559
Name of the programme which has funded the project	EUDP
Project managing company/institution (name and adress)	DTU Wind Energy Frederiksborgvej 399 4000 Roskilde
Project partners	DTU Elektro DTU Compute Dansk Meteorologisk Institut ENFOR A/S Garrad Hassan Danmark ApS Vestas Wind Systems A/S Energinet.dk
CVR (central business register)	30060946
Date for submission	22 March 2019

1.2 Short description of project objective and results

1.2.1 English description

The project supports Danish participation in IEA Wind Task 36 *Forecasting for Wind Power*. Most Danish research organisations and commercial providers of wind power forecasts are members of the task. The participants supported the work of the IEA Task, contributed to various texts, data sets collections, conference publications, journal publications and reports. The IEA Task has three work packages, all of which have Danish participation or leadership: WP1 improves the Numerical Weather Predictions which form the basis of all wind power forecasts. WP2 deals with benchmarking of the forecasts. WP3 extends best practice in the use of the forecasts.
The main results of this phase were 3 peer reviewed journal publications and a Recommended Practice on Forecast Solution Selection, making the process of establishing a new or renewing a forecasting system smoother, an information portal, and a set of use cases for probabilistic forecasting.

1.2.2 Danish description

Projektet samler den danske indsats i IEA Wind Task 36 *Forecasting for Wind Power*. Danmark er det land i verden med den længste erfaring med vindkraftforudsigelser i el-nettet, og store dele af konsortiet har været med fra starten. Projektets støtte betyder at Danmarks stemme bliver hørt i IEA Wind, og at de nyeste informationer verden rundt bliver inkorporeret for at beholde den førende danske position.
Hovedresultaterne er 3 peer reviewed journal publikationer og en *Recommended Practice*

som understøtter processen i at enten sætte et nyt forudsigelses system op, eller at forny en eksisterende system, samt assistance til at teste prognoser og evaluere prognoser eller prognose systemer. Den danske fingeraftryk er tydeligt i resultatet, takke været EUDP støtten. Projektets deltagere samarbejdede også omkring meteorologiske modellers udvikling og den optimale brug af prognoserne hos slutbrugerne. En vidensportal samler mange informationer omkring vindkraft forudsigelser.

1.3 Executive summary

Wind power forecasts have been used in Denmark for over 25 years. In a grid like the Danish, with more than 40% of wind energy in the grid on a yearly basis, and nearly 150% of demand covered by wind in some hours of the year, the safe operation of the grid would not be possible without the forecasts. Since wind energy’s share is increasing in many countries in the world, an IEA Wind Task was started on the topic after a Topical Expert Meeting in Milano in 2013. The International Energy Agency (IEA) was founded in 1972 as the OECD countries’ answer to the oil crisis, investigating energy usage and alternatives to oil. One of the Technological Collaboration Programmes is in wind energy, and Task 36 Forecasting for Wind Power was started in 2016. This EUDP project is the funding vehicle for the Danish consortiums participation in the first phase of Task 36.

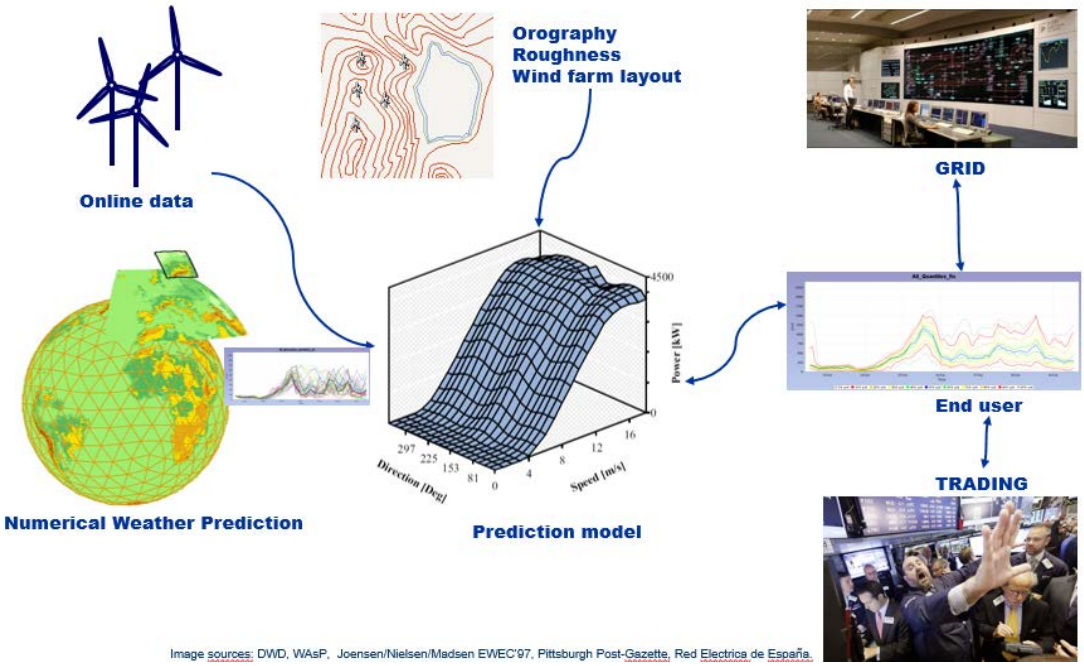


Figure 1: The data flow in a wind power forecasting system.

Wind power forecasts have a data flow (see Figure 1) consisting of three parts: meteorological forecasts of wind speed and direction (and possibly other meteorological variables of influence), the conversion of those wind speeds to power with a tuning coming from online data from the wind farms, and the optimal use of the available information at the end users. Task 36 is built up along the same lines: Work Package (WP) 1 revolves around the Numerical Weather Prediction (NWP) used as input to the power forecasts, WP2 deals with the power conversion aspects and issues between forecast vendors and clients, and WP3 aims at creating the best value from the information, especially the probabilistic forecasts, for the end users.

While the EUDP project only financed one out of 13 participating countries (AT, CN, DE, DK, ES, FI, FR, IE, NO, PT, SE, UK, US), the funding meant that the Danish impact in the Task was well above the purely numerical representation, and several WPs and sub-tasks were driven forward by Danish participants. Especially the largest result, the Recommended Practice, would not have been possible without the Danish participation. Therefore, the EUDP funding contributed greatly to keeping the Danish influence in wind power forecasting alive.

As mentioned, the largest result is the Recommended Practice on Forecast Solution Selection. It is composed of three parts, one generically discussing the Forecast Solution Selection Process, the second more specifically addressing Design and Execution of Benchmarks and Trials, and the third detailing the Evaluation for Forecasts and Forecast Solutions. The

distinction is here made between the forecasts themselves, and the forecast solution as the complete package bought from a forecasting vendor.
Other results of phase 1 include the setup of an information portal for forecasting, including a list of meteorological masts of more than 100m height (useable for verification of wind speed forecasts near the hub height of modern turbines), a list of most currently running and completed research projects in wind power forecasting, a list of publically available datasets for benchmarking or development of forecasts, a list of meteorological experiments with datasets useful for the development or verification of weather predictions, and, resulting from a workshop in Barcelona, a list of future research issues. Additionally, we mapped the current use of probabilistic forecasts at end users, wrote two papers on the use of probabilistic forecasting, organised a workshop together with Task 32 on minute scale forecasting using lidars, and started a discussion on uncertainty propagation through the full model chain. Finally, a workshop at Risø exclusively for the Danish consortium concluded the first phase of the Task.

IEA Task 36, and the Danish consortium, are going into another phase 2019-2021. Amongst other things, we will look into how to quantify the value of forecasts, get ahead with the uncertainty propagation, convert the experiences with the Recommended Practice into a version 2, build NWP benchmarks, and start up on standardisation.

1.4 Project objectives

The main objective of the EUDP project was to ensure a significant participation of Danish actors in the IEA Forecasting Task. This goal was well fulfilled. Especially the participation of WEPROG (Corinna Möhrlen, co-lead of WP3) and DTU Elektro (Jakob Messner, co-lead of WP2) was instrumental not only for the EUDP project, but for the wider IEA Task in general. While an assessment of effort is difficult in an IEA Task where there is no central hour registration, no significant document was written without significant Danish participation or even Danish lead.
Having said that, many activities in the IEA Task were led by or depended on input from other countries' participants, which were not always able to secure funding for their collaboration. This led to some sub-tasks being not tackled at all, or only quite rudimentary. Additionally, some partners also in the Danish consortium were too busy with day-to-day affairs (Energinet especially) or embarked on a new R&D strategy where there was no room for this project (Vestas). Some other partners (especially WEPROG) were able to take over some of the activities, but not all sub-tasks in the IEA Task did get the same attention. The sub-tasks which delivered what they promised were 1.1, 1.2, 2.1, 2.2, 3.1. The sub-tasks which were re-defined during the project, but delivered were 1.4, 2.4, and 3.5. Sub-tasks suffering from lack of international collaborators were 1.3, 2.3, 3.2, 3.3, 3.4 and 3.6. The results of the first and second category are reported in chapter 1.5, the changes from the original plan of the second and third category are discussed here.

1.4.1 Sub-task 1.3 Common NWP benchmark

The IEA Task concentrated on collaboration and sharing of learnings from national forecast improvement projects, and on the data collection in sub-tasks 1.1 and 1.2, but did not emphasise a common benchmark. This is deferred to phase II. Vestas had promised to do benchmarks on own data, but pulled out of the project before starting the work.

1.4.2 Sub-task 1.4 Conference session on Danish way

Since the Danish participants were quite active during many of the meetings and conferences we had, starting from the workshop in Barcelona on future issues, a special session on Denmark was deemed unnecessary. Instead, we ran a webinar on the Danish experience with Lasse Borup of Energinet as the main speaker, which now is also on the IEA Task YouTube channel. Since a survey amongst Danish stakeholders found that essentially all stakeholders in Denmark already were on the main IEA Task mailing list, and since they already felt well-informed through the mailings in English, a specific Dan-

ish dissemination effort was dropped and converted into the webinar as an outreach activity.

1.4.3 Sub-task 2.3 Uncertainty propagation

Vestas initially had a role in the task, but pulled essentially out of the project during half time. Up until then, due to difficulties of finding the right sub-task lead in the IEA collaboration, and due to the fact that we concentrated on providing links to existing benchmarks in sub-task 1.4, the collaboration with the WakeBench platform was not necessary. The sub-task was then redefined to aim at a paper describing the uncertainty propagation, which had some input from DTU Wind Energy, but the paper is currently work in progress and essentially was deferred to phase II of the Task.

1.4.4 Sub-task 2.4 Benchmark test cases

DTU Elektro collected many publically available benchmark cases and made them available on the information portal of the website. However, since we did not immediately saw the contribution which our own benchmark case could bring to the field, it was decided to concentrate on other issues and not to set up a specific benchmark within the consortium.

1.4.5 Sub-task 3.2 Knowledge sharing from demonstration projects

Again, due to a lack of international leadership, the knowledge sharing did not evolve into a paper or report, but was done by some talks at the general IEA Task meetings.

1.4.6 Sub-tasks 3.3, 3.4 and 3.6

The three sub-tasks did not go forward in the IEA Task, but had no Danish participation anyway.

1.4.7 Sub-task 3.5 Communication of forecast products, and standardisation

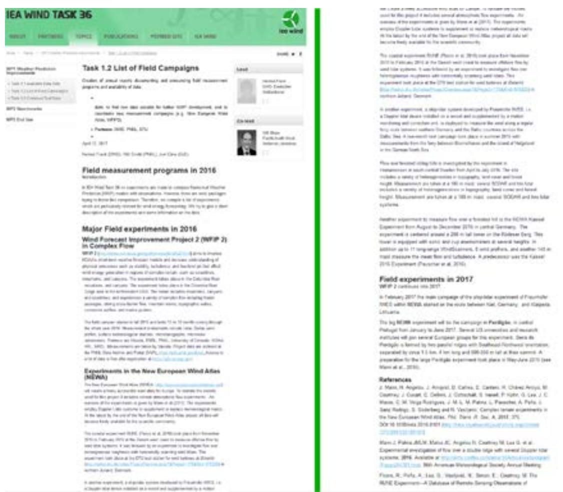
Partly, this sub-task was present in the discussions about the Recommended Practice, and partly it was taken up as an issue on the final Danish workshop at Risø in December 2018.

1.5 Project results and dissemination of results

1.5.1 Information portal

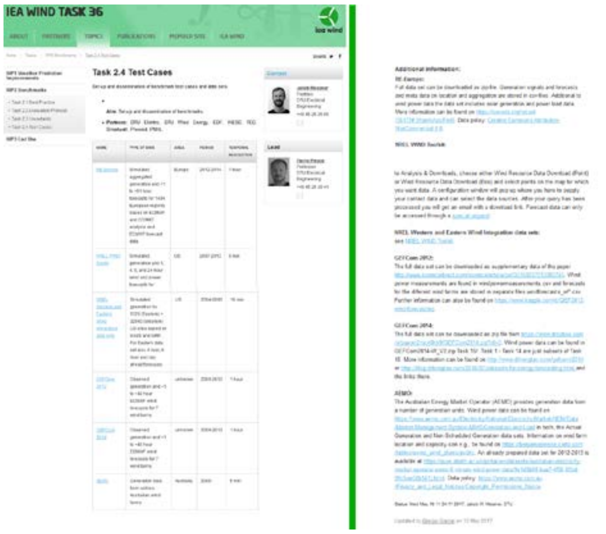
The project website www.ieawindforecasting.dk was built with an overview of the envisaged sub-tasks and work packages. However, over time it developed into an information portal on many issues related to wind power forecasting.

Since wind power needs wind forecasts near hub height of the modern turbines, but the standard verification height of the World Meteorological Organization is 10m above ground, we collected a list of masts with online data available from 100m above ground or higher, including how to get access to the data. In a next step in phase II, the data will be used operatively at some met institutes to run alongside their usual real-time quality verification scores.

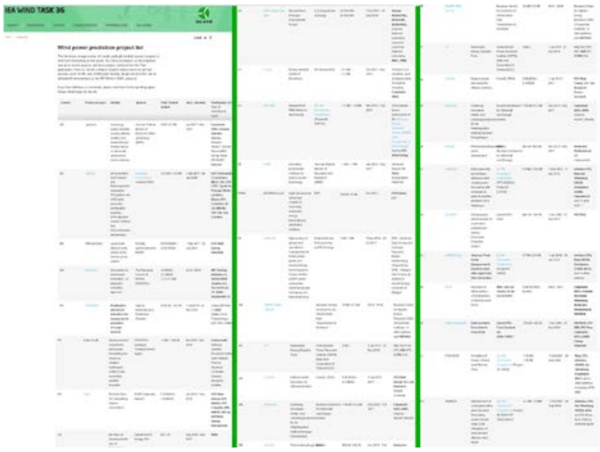


For larger effort in the further development of NWP models, larger datasets from dedicated measurement campaigns are required. Typically, those are prepared in other funded projects, but (sometimes after an embargo period to use the data within the project itself) are being opened up for third parties to use. Some of those measurement campaigns are listed here.

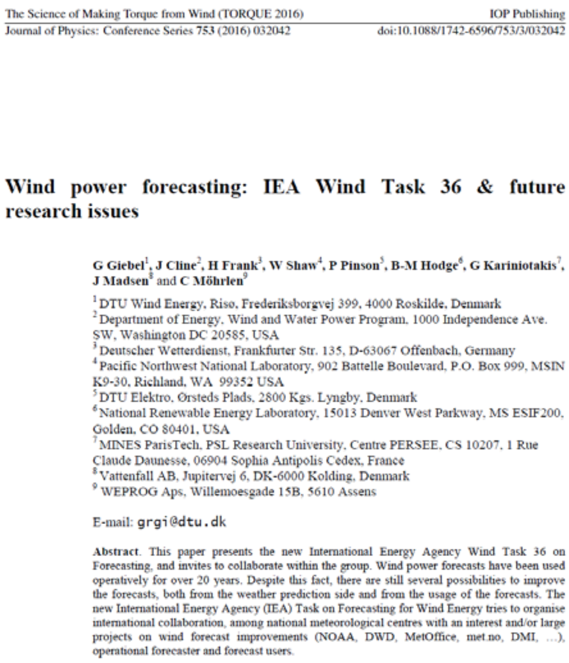
The development of power forecasting models also needs access to power data, alongside the meteorological data. Several forecasting competitions and benchmarks were performed, and some of those still have the datasets publically available. Those previous efforts are listed in a separate page. They include for example the campaigns under the New European Wind Atlas (Perdigao, the Baltic Ferry experiment, the Kassel mast etc), and the Wind Forecast Improvement Project 2 with its large mesoscale measurement campaign in the Columbia Gorge.



Over the years, there were many projects on forecasting since the 1990ies. Most of those projects, especially the currently running ones done in the partner countries, are listed here, with a total public funding of over 30 million euros. Where still available, links to the project websites are provided.



1.5.2 *Future issues for forecasting research*



The Science of Making Torque from Wind (TORQUE 2016) IOP Publishing
Journal of Physics: Conference Series 753 (2016) 032042 doi:10.1088/1742-6596/753/3/032042

Wind power forecasting: IEA Wind Task 36 & future research issues

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Abstract. 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.

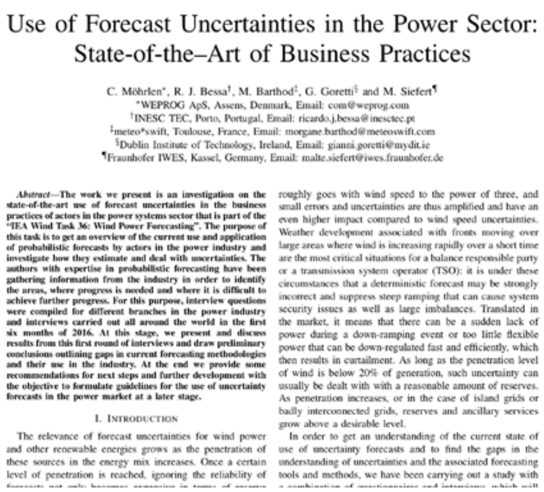
One of the first activities of IEA Task 36 was a public workshop in Barcelona (9 June, 2016), where the state of the art and future research issues were discussed. Main ways forward were:

- Nowcast (especially for difficult situations, thunderstorms, small lows, …)
- Sub 1 hour temporal resolution
- Meteorology below 1km spatial resolution
- Stability issues, especially with daily pattern / (Nightly) Low level jets
- Icing
- Farm-Farm interaction / quality of direction forecast
- Short-term ensembles
- Ramps and other extremes
- Spatio-temporal forecasting

- Rapid Update Models (hourly, with hourly data assimilation)
- Use of probabilistic forecasts and quality of the extreme quantiles
- Do DSOs need different forecasts than TSOs?
- Penalties for bad performance? Incentives for improved perf.?
- Seasonal forecasting? What's the business case?
- Data assimilation (with non-linear Kalman filters, 4D Var, …)

WEPROG gave a talk on the workshop, and several other Danish participants framed the discussions and the final document.

1.5.3 Mapping of current usage of probabilistic forecasting



Use of Forecast Uncertainties in the Power Sector: State-of-the–Art of Business Practices

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Abstract—**The work we present is an investigation on the state-of-the-art use of forecast uncertainties in the business practices of actors in the power systems sector that is part of the "IEA Wind Task 36: Wind Power Forecasting". The purpose of this task is to get an overview of the current use and application of probabilistic forecasts by actors in the power industry and investigate how they estimate and deal with uncertainties. The authors with expertise in probabilistic forecasting have been gathering information from the industry in order to identify the areas, where progress is needed and where it is difficult to achieve further progress. For this purpose, interview questions were compiled for different branches in the power industry and interviews carried out all around the world in the first six months of 2016. At this stage, we present and discuss results from this first round of interviews and draw preliminary conclusions outlining gaps in current forecasting methodologies and their use in the industry. At the end we provide some recommendations for next steps and further development with the objective to formulate guidelines for the use of uncertainty forecasts in the power market at a later stage.**

I. Introduction

The relevance of forecast uncertainties for wind power and other renewable energies grows as the penetration of these sources in the energy mix increases. Once a certain level of penetration is reached, ignoring the reliability of

roughly goes with wind speed to the power of three, and small errors and uncertainties are thus amplified and have an even higher impact compared to wind speed uncertainties. Weather development associated with fronts moving over large areas where wind is increasing rapidly over a short time are the most critical situations for a balance responsible party or a transmission system operator (TSO): it is under these circumstances that a deterministic forecast may be strongly incorrect and suppress steep ramping that can cause system security issues as well as large imbalances. Translated in the market, it means that there can be a sudden lack of power during a down-ramping event or too little flexible power that can be down-regulated fast and efficiently, which then results in curtailment. As long as the penetration level of wind is below 20% of generation, such uncertainty can usually be dealt with with a reasonable amount of reserves. As penetration increases, or in the case of island grids or badly interconnected grids, reserves and ancillary services grow above a desirable level.

In order to get an understanding of the current state of use of uncertainty forecasts and to find the gaps in the understanding of uncertainties and the associated forecasting tools and methods, we have been carrying out a study with

Early in the project, we started to map the current knowledge about and actual use of probabilistic forecasts at end users. To this aim, WEPROG (and French partner MeteoSwift) developed a questionnaire, interviewed 24 participants, and analysed the answers. 71% of participants knew something about probabilistic forecasting, but only 21% used any kind of uncertainty information in their operation. Generally, as wind power penetration increased, the interest in probabilistic forecasts also increased. The most common applications were reserve allocation, trading and dispatch, and situational awareness and risk assessment. But the spread between respondents was large.

A separate chapter on Denmark analysed the market structure and participant composition, and found that many of the small CHP plant owners had electricity trading only as a relatively small side business, and were not investing in forecast improvements. Generally, the market had low price volatility at low prices, so the potential incentive for improved forecasts was small for all market participants.

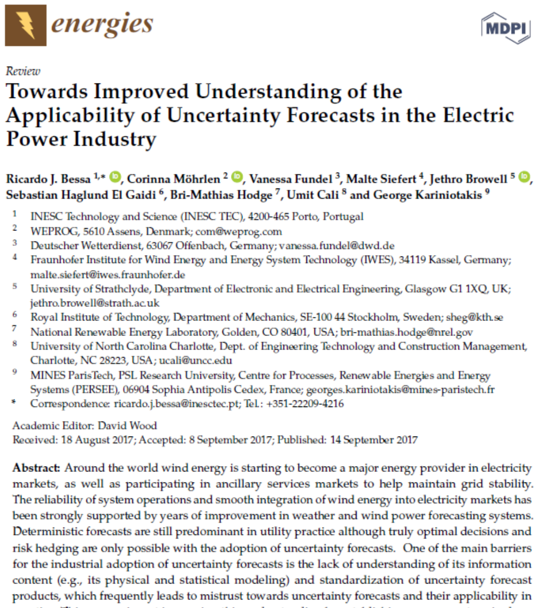
A set of guidelines for the use of probabilistic forecasting concluded the paper. This set of guidelines was then continued in a two separate publications (see the next section).

1.5.4 Use cases for probabilistic forecasting

The Task wrote two papers about uncertainty forecasting, a somewhat more popular article in IEEE Power and Energy Magazine, and a scientific article of 48 pages in the journal Energies.

The IEEE paper took its outset in the German EWeLiNE and the US WFIP2 forecasting research projects, and discussed the merits of probabilistic forecasts in various uses. They distinguish between confidence intervals derived from historical accuracy of the forecasts, and a forward looking forecast uncertainty, which takes the weather situation into account, e.g. using an ensemble of meteorological forecasts. It also introduces the metrics used to judge the quality of probabilistic forecasts, and how to assess their value, which has to be problem-specific.

The journal paper "aims at improving this understanding by establishing a common terminology and reviewing the methods to determine, estimate, and communicate the uncertainty in weather and wind power forecasts. This conceptual analysis of the state of the art highlights that: (i) end-users should start to look at the forecast's properties in order to map different uncertainty representations to specific wind energy-related user requirements; (ii) a multidisciplinary team is required to foster the integration of stochastic methods in the industry sector. A set of recommendations for standardization and improved training of operators are provided along with examples of best practices." In contrast to the popular article, the journal article also contains formulae and a more thorough explanation of the various metrics, the mathematics behind weather uncertainty forecasts, the history and generation of ensemble forecasts, an exhaustive list of references, and an overview of how to communicate the uncertainty to the user. Use cases from many countries in reserve requirements and unit commitment, participation in electricity markets, predictive grid management, maintenance scheduling of wind power plants and long-term portfolio planning are also discussed in detail. A long list of recommendations concludes the paper.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Review

Towards Improved Understanding of the Applicability of Uncertainty Forecasts in the Electric Power Industry

Ricardo J. Bessa [1,*], Corinna Möhrlen [2], Vanessa Fundel [3], Malte Siefert [4], Jethro Browell [5], Sebastian Haglund El Gaidi [6], Bri-Mathias Hodge [7], Umit Cali [8] and George Kariniotakis [9]

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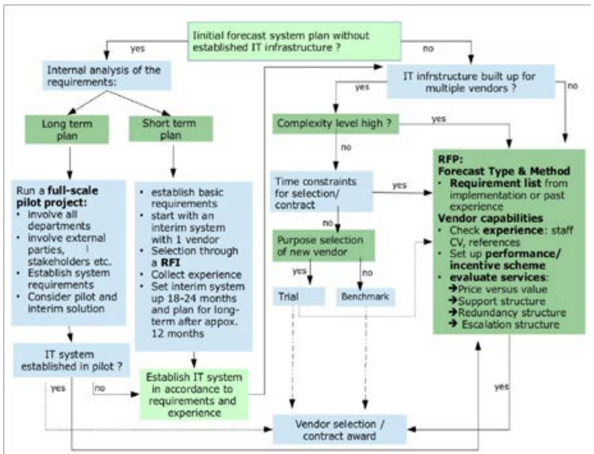
Abstract: Around the world wind energy is starting to become a major energy provider in electricity markets, as well as participating in ancillary services markets to help maintain grid stability. The reliability of system operations and smooth integration of wind energy into electricity markets has been strongly supported by years of improvement in weather and wind power forecasting systems. Deterministic forecasts are still predominant in utility practice although truly optimal decisions and risk hedging are only possible with the adoption of uncertainty forecasts. One of the main barriers for the industrial adoption of uncertainty forecasts is the lack of understanding of its information content (e.g., its physical and statistical modeling) and standardization of uncertainty forecast products, which frequently leads to mistrust towards uncertainty forecasts and their applicability in

WEPROG contributed significantly to both papers, and others commented. On the issue of methods for probabilistic forecasting, DTU Compute worked on stochastic differential equations as an efficient way to describe both the conditional uncertainty and the persistence of forecast errors, and a paper on evaluation of multivariate probabilistic wind power forecasts is in preparation.

1.5.5 *IEA Recommended Practice for Forecast Solution Selection*

A major result of the first phase of Task 36 was the Recommended Practice for Forecast Solution Selection, which started out as a Recommended Practice on Wind Power Forecast Evaluation. After some discussion it was clear though that the Recommended Practice should encompass the entire selection process of choosing a new or another forecast vendor. This led to writing the Recommended Practice in three parts, the first one detailing out the process from the initial deliberations to fixing the process of getting a new provider, the second part clarifying how to run a good benchmark or trial between several prospective forecast providers, and the third part going into detail on the metrics with which to judge the forecast quality.

The first part, called "Forecast Solution Selection Process", deals with the situation of someone either considering to get a forecasting system / vendor for the first time, or to possibly switch provider. It shows that for small installations, a vendor trial might be too complex and resource intensive to do, and that there must be some emphasis on what the result of the



process should be, on giving the process enough resources, and on establishing the right kind of IT system to go with it. The process is encapsulated in a flow chart.

The second part, called "Designing and Executing Forecasting Benchmarks and Trials", is about setting up a benchmark, typically to compare several vendors' accuracy and real-time performance, but it could also compare a new provider with the incumbent. Based on the long experience of the forecast vendors writing the text, a number of pitfalls were lined up, and a Forecast Trial Checklist was established, which should ensure a relatively smooth process.

Forecast Trial Checklist

--Preparation--

- ☐ Determine outcomes / objectives
- ☐ Consult expert with trial experience
- ☐ Establish timeline and winning criteria
- ☐ Decide on live or retrospective trial
- ☐ Gather metadata (use IEA checklist spreadsheet)
- ☐ Determine if adequately resourced to carry out
- ☐ Obtain historical data
- ☐ Invite Forecast Service Providers
- ☐ Distribute historical and meta-data
- ☐ Allow two weeks Q&A prior to trail start
- ☐ Begin Trial

--During Trial--

- ☐ Develop validation report
- ☐ Check interim results
- ☐ Provide interim results (if no live data being provided)
- ☐ End Trial

--Post Trial--

- ☐ Provide final results
- ☐ Notify winner(s)
- ☐ Contract with winner(s)
- ☐ Start Service

The third part, called "Evaluation of Forecasts and Forecast Solutions", deals with the assessment of forecast and forecast solution quality. It shows the most relevant metrics of forecast evaluation (a more thorough scientific paper is in preparation), but also considers the procedural aspects of forecast provision as a selling point. A main conclusion is that there is no "best" forecast evaluation metric, as it is very dependent on the use case of the user. The best would be to do a full financial analysis of the forecasts and to see which one does best for the bottom line, but the entire assessment of the value of a forecast or a "fit-for-purpose" measure is still being worked on.

WEPROG was the main driver of this work, but also DTU Elektro, Compute and Wind Energy, and ENFOR contributed.

1.5.6 Minute-scale forecasting workshop and paper

In June 2018 a collaborative forecasting workshop with Task 32 "Lidar Technology" has been held at DTU Wind Energy in Risø. The workshop attracted participants both from the Lidar community and the forecasting community where a broad range of discussions around the use of remote sensing instruments, especially lidars for the use of minute-scale forecasting, current use of lidar data and possibilities as well as limitations for the future use of these types of data in wind power forecasting. The workshop identified three applications that need minute-scale forecasts: (1) wind turbine and wind farm control, (2) power grid balancing, (3) energy trading and ancillary services. The main conclusions after the workshop were that there is a need for further investigations into the minute-scale forecasting methods for different use cases, and a cross-disciplinary exchange of different method experts should be established. Additionally, more efforts should be directed towards enhancing quality and reliability of the input measurement data.

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Article

Minute-Scale Forecasting of Wind Power—Results from the Collaborative Workshop of IEA Wind Task 32 and 36

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Abstract: The demand for minute-scale forecasts of wind power is continuously increasing with the growing penetration of renewable energy into the power grid, as grid operators need to ensure grid stability in the presence of variable power generation. For this reason, IEA Wind Tasks 32 and 36 together organized a workshop on "Very Short-Term Forecasting of Wind Power" in 2018 to discuss different approaches for the implementation of minute-scale forecasts into the power industry. IEA Wind is an international platform for the research community and industry. Task 32 tries to identify and mitigate barriers to the use of lidars in wind energy applications, while IEA Wind Task 36 focuses on improving the value of wind energy forecasts to the wind energy industry. The workshop identified three applications that need minute-scale forecasts: (1) wind turbine and wind farm control, (2) power grid balancing, (3) energy trading and ancillary services. The forecasting horizons for these applications range from around 1 s for turbine control to 60 min for energy market and grid control applications. The methods that can be applied to generate minute-scale forecasts rely on upstream data from remote sensing devices such as scanning lidars or radars, or are based on point measurements from met masts, turbines or profiling remote sensing devices. Upstream data needs to be propagated with advection models and point measurements can either be used in statistical time series models or assimilated into physical models. All methods have advantages but also shortcomings. The workshop's main conclusions were that there is a need for further investigations into the minute-scale forecasting methods for different use cases, and a cross-disciplinary exchange of different method experts should be established. Additionally, more efforts should be directed towards enhancing quality and reliability of the input measurement data.

Keywords: wind energy; minute-scale forecasting; forecasting horizon; Doppler lidar; Doppler radar; numerical weather prediction models

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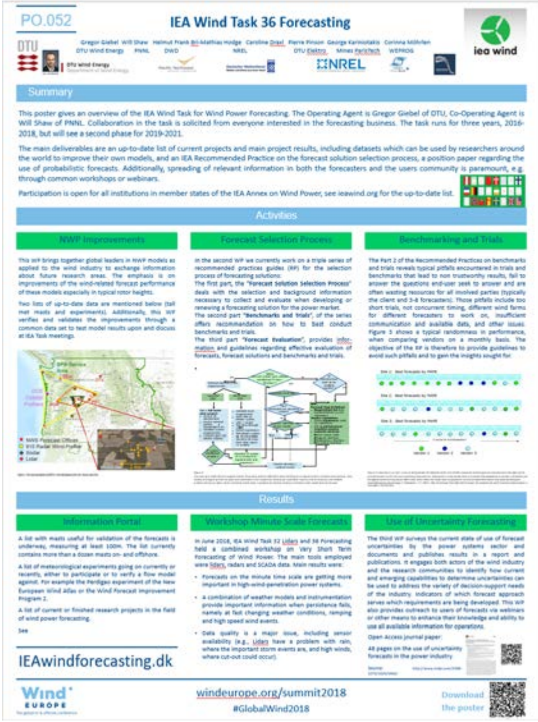
A group of 9 people from the workshop (with significant contributions from WEPROG and DTU Wind Energy) worked through the results and discussions of the workshop and wrote a review journal publication that was published in February 2019 in the open-access journal Energies.

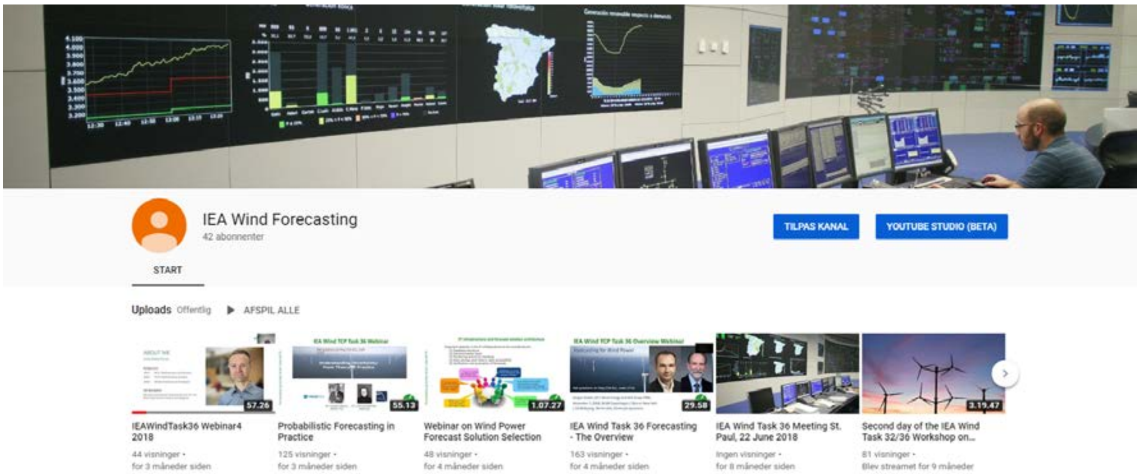
1.5.7 Dissemination and communication

There were three main dissemination channels. Most importantly, personal communication and talks or posters on conferences added new contacts to the Task mailing list, spread the word about the work performed in the Task, and made the Task well visible within the scientific and business community. As a general rule, an overview poster of the Task was delivered to most conferences where one of the WP leaders team went. Shown to the right is the latest one of phase 1, presented at the WindEurope Summit in Hamburg in September 2018. For particular Danish dissemination, we delivered handouts to the Wind Energy Denmark conferences in Herning (2016 and 2017) and Hedensted (2018).



Another channel of communication was the website, see section 1.5.1. Additional information was a list of publications, a list of partners and a news section.

Finally, the Task [YouTube channel](#) (see below for a screenshot) was used to transmit most meetings live (though non-public) and to keep videos of the workshops in full length available. A series of Webinars throughout November 2018 presented the major results of the Task.



1.5.8 Final workshop at Risø

In December 2018, the finalisation of the first EUDP support project was celebrated with a workshop just for the Danish participants. A full day of presentations and discussions concluded phase 1, and initiated phase II.

1.6 Utilization of project results

The main project results have been described in the previsous sections. In summary, it can be seen that the funding of the participation in the task has led to a number of important developments in the wind power forecasting community under the coordination and collaboration of Danish participants. Without funding this would not have been possible.

Participation at conferences with the preparation of oral as

well as written publications, journal publications, as well as recommended practices are deliverables that have a massive impact on the wind power forecasting community and that has attracted a lot of experts in the field to join the task. Collaborations with other tasks has also lead to a visible impact with a workshop as well as a journal publication.
A set of 4 webinars have been broadcasted and are available at the Tasks YouTube channel and get gradually more visitors as the word spreads.

1.7 Project conclusion and perspective

The conclusion of the project is that all results from the first phase of the Task have a fingerprint from Danish participation. The group has been invited to lead sessions at workshops and are collaborating the IEC standards group in order to plan standards for the wind power forecasting community. The Danish participants are highly motivated through the funding to participate in the development of such standards and thereby put Denmark in the position to impact the future of wind power forecasting. There are also planned a number of IEA Recommended Practices along the use of probabilistic forecasting technologies as well as data format standardisation with Danish participation in the lead.
This is a great achievement and perspective for the next phase of IEA Wind Task 36.

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Recommended Practices

IEA Recommended Practice on Forecast Solution Selection

The Recommended Practice is composed of three parts:

- Part 1: Forecast Solution Selection Process
- Part 2: Design and Execution of Benchmarks and Trials
- Part 3: Evaluation of Forecasts and Forecast Solutions

The documents can be accessed online here: http://ieawindforecasting.dk/news.