IEA Wind Task 36

Forecasting for Wind Power

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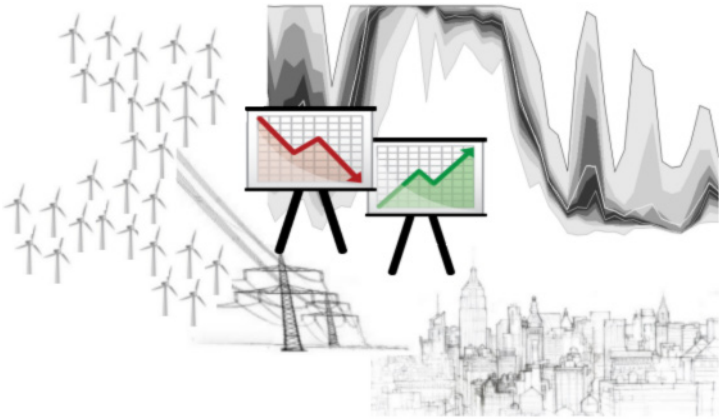
Understanding Uncertainty: the difficult move from a deterministic to a probabilistic world



Challenge

Uncertainty forecasts are filling a gap of information missing in deterministic approaches and are gradually moving into the control rooms and trading floors. Nevertheless, there are a number of barriers in the industrial adaptation of uncertainty forecasts that have their root in a lack of understanding of the methodologies and their respective applicability.

There is a complication level that needs to be overcome in order for industry to move forward. The effectiveness of forecasts in reducing the variability management costs of power generation from wind and solar plant is largely dependent upon the ability to effectively choose and use forecast information in the grid management decision-making process. This process is becoming more complex with higher penetration levels and the possibilities to engage large amounts of information to generate forecasts.

Solution

The Work Package 3 team of the IEA Wind Task 36 has been picking up a number of the loose ends of integration and application issues and discussed them in a number of conferences and published recommendations and use cases in a number of conference papers. Allpublications and a number of workshops and webinars are available through the tasks webpage.

Additionally, a peer reviewed journal publication was published in autumn 2017 in the Open Access Journal Energies (see reference section). This was a direct response to the results from a survey carried out in 2016, which revealed a significant gap between available products on the market and lack of knowledge and documentation in how to apply, decide and make efficient use of probabilistic forecasts by end-users.

Background

Understanding the benefits and the pitfalls when employing probabilistic forecasts requires objective documentation that is scientifically sound, practical and understandable for power engineers as well as scientists and managers.

For this reason, the IEA task 36 is dedicated to translate academic knowledge into understanding how industry applications have to be setup and how to increase the acceptance of uncertainty in the forecasting processes by providing objective information about existing methods and how to deal with uncertainty. This includes the three W's ("what, when and which") regarding methods to be applied to typical or specific challenges and to publish freely accessible objective information for the industry and interested individuals through the website **(ieawindforecasting.dk**) and open access publi-cations.

In summary, the IEA Wind task 36 has been dedicated to fill part of that gap of under-standing when probabilistic forecasts and uncertainty information are helpful or required and how to implement or design a forecasting system for that purpose. The task has set focus on examples of applications in all documentation for the industry to also provide examples of applications in order to demonstrate The applicability, benefits and limi-tations, as well as to enhance the understanding and further development of applications for industrial use.

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Definitions and Methods

The IEA Wind task 36 has been compiling a number of definition of uncertainty and the corresponding methodologies that provide forecast uncertainty. The main characteristics of uncertainty forecasting are:

1) forecast error spread
2) confidence interval
3) forecast uncertainty
4) forecast interval

While the **forecast error spread** is defined as the historically observed deviation of a forecast to its corresponding observation at a specific time, one of the common misunderstandings is that a **confidence interval** is showing the uncertainty of a forecast. This is not the case. By adding and subtracting for example one standard deviation to the deterministic forecast of wind speed and converting it to wind power, such intervals represent a measure of the deviation to climatology and do not represent current or geographically distributed uncertainty.

The **forecast uncertainty** on the other hand is defined as a possible range of forecast values in the future. In meteorology this range is defined by the uncertainty of the atmospheric development in the future and represented in ensemble forecasts by applying perturbations to initial and boundary conditions and/or expressing model physics differences.

When represented as **forecast intervals** the so-determined uncertainty band represents forecast uncertainty containing the respective probability of the real value being contained in the range of forecasted values, which will only be observed in the future.

The major applications of forecast uncertainty in the power industry are today based on three main methods, processes and procedures and can be summarized to: (see also figure on right side):

1) Statistical methods of probabilistic forecasts
2) Statistically-based ensemble scenarios
3) Physically based ensemble forecasts

The first type of methods "**Statistical methods of probabilistic forecasts**" are based on statistical processing of past (historic) data in order to derive a probability density function of the possible forecasting spread. The advantage of such methods are that they are computationally extremely cheap and simple to apply. The disadvantage is that There is no physical dependency on the forward results, the spread is based on past climatology. Typically, statistical learning algorithms (e.g., neural networks, machine learning) are used to fit historical time series of weather parameters from a NWP model to their corresponding power generation data. From the fitting process, a PDF can be derived and used forward in time.

The second type of methods "**Statistically-based scenarios**" produce statistically-based scenarios that are a result of statistical generation of scenarios from the probability distributions produced by statistical models based on the copula theory. The difference and disadvantage of the statistical scenarios is that they only capture the spatial variability of the forecast, but not the temporal variability. Outliers that indicate extreme events, require specific analysis, long time series and at least one event in that series to be able to detect the possibility of such an event.

The third type of methodologies, the "**physically based ensembles**" are a set of NWP forecasts produced by perturbing the initial or boundary conditions (e.g. with "Breeding", "Singluar vector", "Kalman Filters") and/or model physics perturbation, the result from different parameterization schemes of one NWP model ("multi-scheme" approach) or complete different NWP models ("multi model" approach), converted in a subsequent phase into power with a curve fitting method. The NWP ensemble is configured to represent the physical uncertainty of the weather ahead of time rather than uncertainty as a function of past experience.

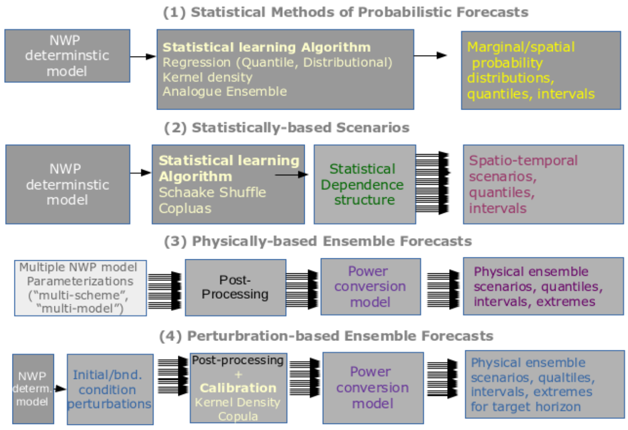

Figure: Schemata of the different methodologies to generate uncertainty forecasts for the power industry.

Further reading

Open access publications on ieawindforecasting.dk

S. E. Haupt, M. Garcia Casado, M. Davidson, J. Dobschinski, P. Du, M. Lange, T. Miller, C. Möhrlen, A. Motley, R. Pestana, J.W. Zack: The Use of Probabilistic Forecasts in Theory and Practice, IEEE Power and Energy Magazine, submitted for Nov.-Dec 2019 volume.

Würth, I.; Valldecabres, L.; Simon, E.; Möhrlen, C.; Uzunoğlu, B.; Gilbert, C.; Giebel, G.; Schlipf, D.; Kaifel, A.: Minute-Scale Forecasting of Wind Power—Results from the Collaborative Workshop of IEA Wind Task 32 and 36. *Energies* 2019, *12*, 712. Open Access: https://www.mdpi.com/1996-1073/12/4/712

Bessa, R.J.; Möhrlen, C.; Fundel, V.; Siefert, M.; Browell, J.; Haglund El Gaidi, S.; Hodge, B.-M.; Cali, U.; Kariniotakis, G.: Towards Improved Understanding of the Applicability of Uncertainty Forecasts in the Electric Power Industry. *Energies* 2017, 10, 1402, doi:10.3390/en10091402. Open Access: http://www.mdpi.com/1996-1073/10/9/1402/pdf

J. Dobschinski, R. Bessa, P. Du, K. Geisler, S.-E. Haupt, M. Lange, C. Möhrlen, D. Nakafuji, M. d.l.T. Rodriguez: Uncertainty Forecasting in a Nutshell: Prediction Models Designed to Prevent Significant Errors, IEEE Power and Energy Magazine, vol. 15, no. 6, pp. 40-49, Nov.-Dec. 2017. doi: 10.1109/ MPE.2017.2729100.

For more information, contact:
Dr. Corinna Möhrlen
WP3 Co-Lead
com@weprog.com
Tel +45 4692 2907

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The **IEA Wind Technology Collaboration Programme** supports the work of 38 independent, international groups of experts that enable governments and industries from around the world to lead programmes and projects on a wide range of energy technologies and related issues.
IEA Wind Task 36 connects 250 experts from academia, forecast vendors and end users to improve the accuracy and value of wind power forecasts.