Task 25 Fact Sheet

VARIABILITY AND PREDICTABILITY OF LARGE-SCALE WIND POWER

Task 25

Design and Operation of Power Systems with

Wind power is generated by wind speeds that vary continually. This creates generation that is constantly fluctuating. The variations of wind power are smoothed as many wind turbines are aggregated in a power system. Aggregating many wind power plants will also improve the accuracy of forecasting output. Forecast accuracy is reasonable hours ahead, and will decrease for days ahead horizon. Forecast systems can also provide information about the uncertainty.

How much variability is there in wind power?

A single wind turbine can shut down from full power in seconds, and also start up during high winds very quickly. However, the aggregated output from hundreds or thousands of wind turbines in a power system area will be fluctuating more smoothly (Figure 1). The second and minute fluctuations will smooth out with increasing number of turbines. The hourly fluctuations will also diminish when the wind power plants are distributed over larger area of several hundred km^2.

The variability of large scale wind power depends on the variability of the wind resource, and how dispersed wind power plants are built in the area. Generally speaking, the hourly step changes from large-scale wind power are usually within ±10 % of the installed capacity – in larger areas even within ±5 %. This means that with 10 000 MW of wind power the changes are very rarely more than 500 MW or 1 000 MW in one hour. This should be compared with changes in electricity consumption. For a power system that has a peak load of 50 000 MW (Spain) consumption can change more than 3 000 MW in an hour.

Wind power changes in 15 minutes or 5 minutes are less than changes in one hour.

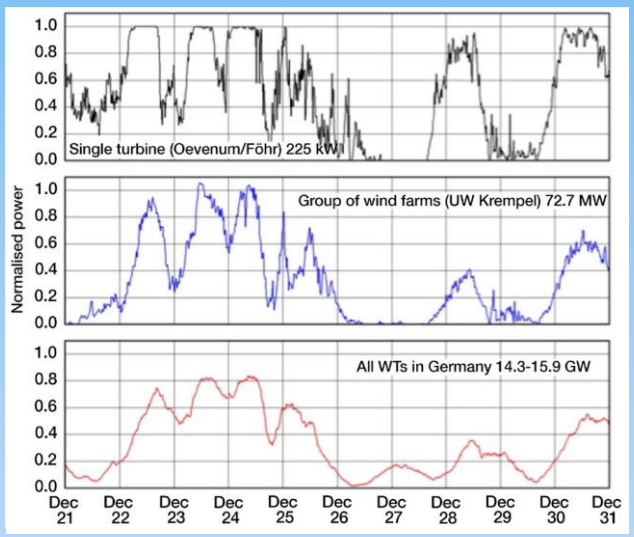

Figure 1. Aggregated generation from multiple wind power plants is a smoother curve than that of a single turbine. The minute and hour changes are smaller, and also the range will be reduced, not reaching full installed power from all turbines simultaneously (Source: Task 25 summary report, 2009).

How large can wind power ramps be?

In extreme situations, the change from one hour to another can be more than 20 % of installed wind power. The most extreme case is a storm, where wind speeds exceed 20-25 m/s and wind turbines shut down from full power to protect the structures. However, storm fronts usually take several hours to pass a region that covers several hundreds of kilometres. For large scale-wind power this will be seen as a decrease in total power output lasting for 2-6 hours. Storms this strong do not occur every year in all countries, but in storm prone areas there can be several storms in one year.

How accurately can wind power production be forecasted?

To predict wind for more than a few hours ahead, wind speed predictions from weather-prediction models are used. Wind energy forecasting has been developed since the 1990s and is still developing. The overall shape of wind generation can be predicted one day-ahead (Figure 2). Significant errors can still occur from time to time in both the output level and timing of wind generation – for example predicting that winds will start blowing at 10 am when they only start at noon. Wind forecast accuracy improves for shorter time horizons. There is a strong aggregation benefit for wind forecasting; aggregation of many wind power plants over a 500-km region reduces forecasting error by about half (Figure 3).

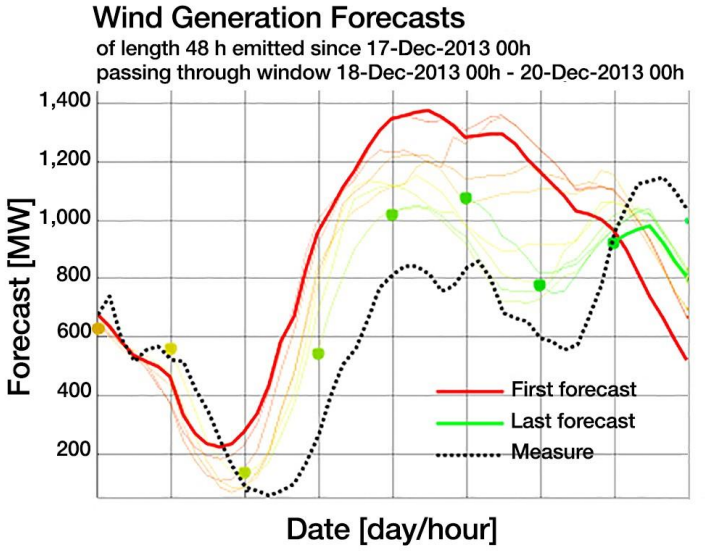

Figure 2. Short term forecasting of wind power generation, example showing how forecast accuracy improves with shorter forecast horizon. The first forecast 24 to 48 hours ahead in red, last forecast 6 to 30 hours ahead in green and measured power in black (Source: Hydro Quebec).

Today there are also forecast systems that provide additional information about the forecast uncertainty. (Figure 4). These forecasts are also able to warn of extreme forecast errors that impact power system stability

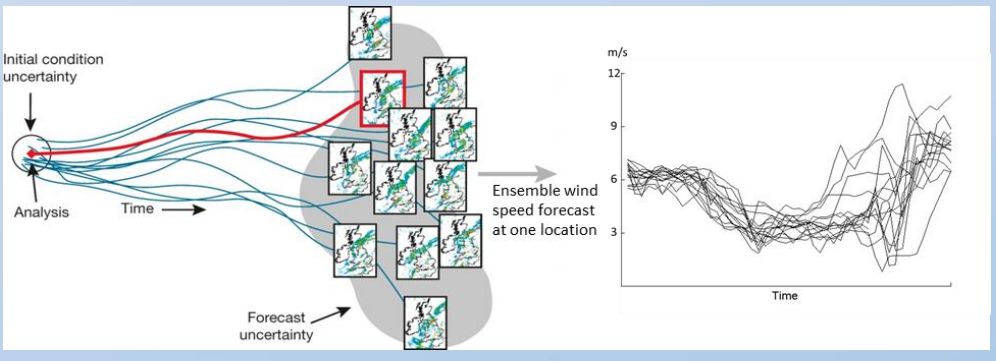

Figure 4. Illustration of a generation of an ensemble weather forecast based on varied initial conditions (left, based on Bauer et al., 2015).

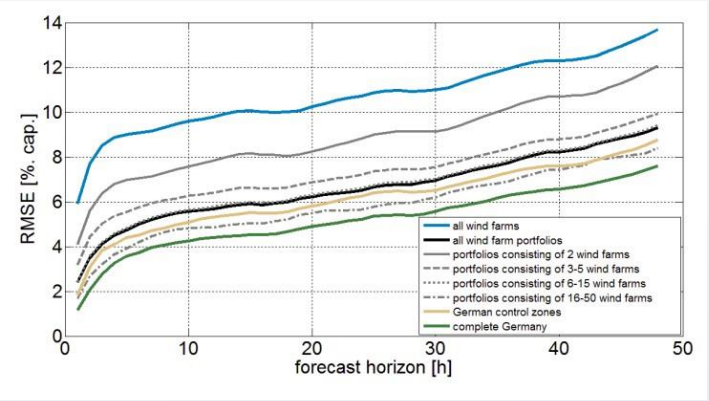

Figure 3. Example of aggregation benefit of forecast errors of wind energy. The average error is increasing as the time horizon to forecast is increasing. When wind power plants from larger area are aggregated the errors are less, in all time horizons. Blue curve represents an average for a single wind power plant, green curve the aggregation of whole of Germany, and the curves in between different portfolios of wind power plants. (Source: Dobschinski, 2014.)

Associated publications

Dobschinski, J., ***How good is my forecast? Comparability of wind power forecast errors****, Proceedings of the 13th International Workshop on Large-Scale Integration of Wind Power into Power Systems as well as on Transmission Networks for Offshore Wind Power Plants, November 2014, Berlin, 2014*

Holttinen, H., Kiviluoma, J., Estanqueiro, A., Gómez-Lázaro, E., Rawn, B., Dobschinski, J., Meibom, P., Lannoye, E., Aigner, T., Wan, Y.H., Milligan, M., 2011. ***Variability of load and net load in case of large scale distributed wind power****. Proceedings of WIW2011, October, 2011, Aarhus, Denmark.*

Holttinen, H. (Ed.). (2016) ***Design and operation of power systems with large amounts of wind power. Final summary report, IEA WIND Task 25, Phase three 2012– 2014.***

Bauer et al., **The quiet revolution of numerical weather prediction,** Nature 525, 47-55 (2015)

See our website at
https://community.ieawind.org/task25

IEA Wind Task 36 Wind Power Forecasting
www.ieawindforecasting.dk/

More information

This Fact Sheet draws from the work of IEA Wind Task 25: a research collaboration among 18 countries. The vision is to provide information to facilitate the highest economically feasible wind energy penetration within electricity power systems worldwide. IEA Wind Task 25 works on analysing and further developing the methodology to assess the impact of wind power on power systems.

See also:
Storage Needs and Wind Power
Capacity Value of Wind Power
Balancing Power Systems with Wind Power
Wind Integration Issues