Wind into power, from ANEMOS to SafeWind

Georges Kariniotakis

Wind into power

Large-scale integration…

Nowadays, European countries like Germany, Spain and Denmark already have a significant share of wind generation in their electricity generation mix. In parallel, the large-scale integration of wind power is also taking place at a rapid pace in other European countries. The European Wind Energy Association (EWEA) foresees 230,000MW of wind capacity installed by 2020 (of which 40,000MW will be off-shore) able to produce 600TWh per year and to cover 14-18% of EU electricity demand.

Due to the variable nature of the wind resource, this large-scale integration of wind power causes several difficulties in the operation and management of a power system. Forecasts of wind conditions and related power generation from a few hours to a few days ahead are paramount for various management tasks related to the integration of wind generation in power systems (eg. quantification of reserves, economic dispatch of wind generation within a broader generation portfolio, or the design of optimal trading strategies). A major concern expressed by end-users is related to the accuracy of wind power predictions, whose level is highly variable and too low, on average, according to their expectations. Especially, the prediction error may reach a high level in case of fronts or wind speeds near cut-off speed (high wind speed where the wind turbines have to be stopped for protection against damage). In addition, if one considers the problem of the spatio-temporal correlation of prediction errors, an extreme case would translate to a very high correlation of prediction errors for a large number of wind farms in a region, the prediction errors then adding up and leading to a highly significant and very costly imbalance to be faced by the system operator.

> ‘Forecasts of wind conditions and related power generation from a few hours to a few days ahead are paramount for various management tasks related to the integration of wind generation in power systems…’

In the past 15 years, considerable research has been carried out in the field of wind power forecasting, leading to several operational tools. The main modelling approaches in the state of the art include physical, statistical and combined models. The role of meteorology is important as weather forecasting models provide numerical predictions that are used as input to the models. The art of wind power forecasting models lies in combining such weather forecasts together with measurements to provide a prediction of the power output of a wind farm for the next minutes, hours or days. The performance depends on the input information, the spatial resolution of the weather forecasts, and the complexity of the terrain where the wind farm is located. Typical performances today range between 10-15% for 24 hours ahead and for single wind farms. When it comes to a regional or national scale, performances improve significantly thanks to the spatial smoothing effect due to the geographical dispersion of the wind farms.

Although several operational tools exist today and are used by end-users, research remains very important for improving the performance of the models, the uncertainty estimations, and also the capacity of the models to predict challenging or extreme situations such as rapid changes of wind power. Research in wind power forecasting is thus recognised as a priority for the next few years for reaching the objectives mentioned above regarding large-scale integration.

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From ANEMOS to SafeWind

A success story of European research…

In 2002, a group of 24 partners launched the four year ANEMOS R&D project on short-term wind power forecasting. This project, financed in part by the European Commission under the 5th Framework Programme, had as an objective to develop advanced models for forecasting the wind production in the next hours or days, and at the level of a wind farm or at regional or national scale. Several physical, statistical or combined models were developed. Emphasis was given on predictions for off-shore wind farms, as well as for wind farms located on complex terrain. The consortium was composed by research organisations, universities, meteorological institutes, and industrial partners such as power system operators, wind farm developers and software developers. The project permitted to develop an advanced software platform, ANEMOS, which integrated the various models developed by the partners. During the project, this platform was installed at various end-users in order to be evaluated, including EIRGRID, the system operator of Ireland, SONI, the system operator of Northern Ireland/UK, EDF in France, PPC-Crete in Greece, Dong in Denmark, EWE in Germany, and Acciona and IDAE in Spain.

By the end of 2006, the System and Market Operator of Australia AEMO (ex NEMMCO) launched an international call for a prediction system for all wind farms participating in the Australian market. This project (ANEMOS@OZ) was won by the ANEMOS consortium (a sub-group of six partners). The ANEMOS platform was adapted for the Australian conditions and was installed in Australia in September 2008. Since then, it operates online with very good performances in terms of accuracy and reliability of service. It provides predictions for five minutes ahead up to two years, which are used directly by the various tools of AEMO for managing the power system and the Australian energy market.

Consortium SafeWind at the kick-off meeting of the project

ANEMOS.plus: Increase the value of wind forecasting for power system operators

The ANEMOS.plus demonstration project was launched in 2008 as a follow-up of ANEMOS (6th Framework Programme). This project aims at the optimal management of electricity grids with large-scale wind power generation. For this purpose, the project develops new intelligent management tools for addressing the variability of wind power. Emphasis is given on the integration of wind power forecasts and related uncertainty in power system key management functions (ie. reserves estimation, congestion management, scheduling, coordination of wind with storage). The project demonstrates the applicability of such tools at an operational level, both for managing wind penetration and for trading wind generation in electricity markets.

SafeWind: Improve wind predictability in extreme situations

The integration of wind generation into power systems is affected by uncertainties in forecasting the expected power output of wind farms. Mis-estimating of meteorological conditions or large forecasting errors (phase errors, near cut-off speeds, etc.) are very costly for infrastructures (ie. unexpected loads on turbines) and reduce the value of wind energy for end-users.

The state of the art in wind power forecasting focused so far on the 'usual' operating conditions, rather than on extreme events. Thus, the current wind forecasting technology presents several bottlenecks. End-users urge for dedicated approaches to reduce large prediction errors or predict extremes at local scale (gusts, shears) up to a European scale, as extremes and forecast errors may propagate. Similar concerns arise from the fields of external conditions and resource assessment, where the aim is to minimise project failure.

Under this context, the four year R&D project SafeWind was launched in 2008 (7th Framework Programme). The aim of SafeWind is to substantially improve wind power predictability in challenging or extreme situations, and at different temporal and spatial scales. Going beyond this, wind predictability is considered as a system design parameter linked to the resource assessment phase, where the aim is to take optimal decisions for the installation of a new wind farm.

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