The Uses of Probabilistic Forecasts in Operating a High-Renewables Grid

A BRIEF FROM ESIG

As levels of solar and wind generation rise and the power system becomes more sensitive to weather, it becomes increasingly important to understand how those generation sources vary with atmospheric conditions. Our ability to forecast the weather and the power produced by solar and wind is important for the efficient and economical operation of the electricity system.

Nearly all operators of grid systems with high shares of renewables use weather-dependent generation forecasts, typically a single "best" forecast known as a deterministic forecast. However, because the atmosphere is inherently complex, forecasts of power production from wind and solar contain a degree of uncertainty. A probabilistic forecast can be useful in such cases, examining several different possible scenarios and calculating the likelihood of each. When system operators have information about the probability of different weather/renewables outcomes, they are able to make decisions based on a "most likely" outcome and also to prepare for less likely, but still possible, scenarios. Probabilistic forecasts can be used to coordinate the power system's resources and market mechanisms, using them in a manner that is efficient and robust for both the expected scenario and the range of possible alternative scenarios.

Since varying degrees of uncertainty are present in various elements of the overall operation of the grid—including load, the dynamic capacity of transmission lines, and unscheduled outages of traditional power plants and transmission infrastructure—a probabilistic approach can assist with the management of the entire system.

Predicting Grid Congestion

Probabilistic forecasting can be used to improve the management of grid congestion, such as can occur at points in the transmission and distribution systems where voltage steps up or down. In the German power system, for example, most renewable generators are connected at lower voltage levels, making it important to forecast the power flow through substations that connect different grid levels (referred to as vertical grid load). Grid operators in Germany currently calculate congestion forecasts for a specific voltage level using deterministic forecasts of generation and loads; therefore, the resulting load flow forecasts and grid reliability measures do not incorporate uncertainty information regarding the wind and solar generation. German transmission system operators plan to begin using probabilistic forecasts as an input for grid congestion calculations to more efficiently prepare for congestion (figure 1).

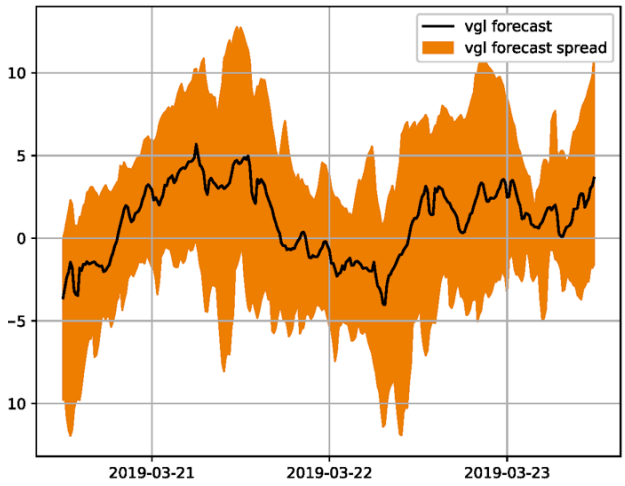

Figure 1. Forecast of vertical grid load (solid black line) for one substation between the transmission and distribution grids, with the orange band indicating possible outcomes with a lower probability. Negative values refer to transport to lower voltage grid, positive values to higher voltage grid.

Fine-Tuning the Coordination of Generating Units

Probabilistic forecasts can also be used to more robustly plan for sufficient power generation capacity at times when it is needed. The Southwest Power Pool (SPP), for example, uses probabilistic forecasts to identify time frames during which it may be more difficult to accurately forecast load and renewable generation, helping the system operator to take steps to maintain reliable operations during those periods under the logical range of possible scenarios. SPP also assesses possible errors in the wind forecast during one-, four-, and eight-hour horizons across multiple days, evaluating available wind capacity during each of the horizons for sufficiency. One element of ensuring sufficient generation is SPP staff's monitoring of the impacts of potential forecast errors through real-time studies that assume different levels of forecast errors.

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Managing Extreme Conditions

Probabilistic forecasting for wind is particularly valuable when wind generation may experience large departures from the forecast. When these low-probability, high-impact events are predicted within the distribution of the probabilistic forecast, system operators are better able to mitigate the effects of unexpectedly high or low wind levels on grid reliability. The Electric Reliability Council of Texas (ERCOT) uses a probabilistic forecast updated every 15 minutes to alert system operators when large increases or decreases in wind generation are projected during the next six hours (figure 2). Probabilistic forecasts can also be used in situations where wind generation is meeting or exceeding local demand in order to determine the likelihood of wind speeds reaching such high levels that multiple wind plants shut down—an event that would have significant impacts on the grid. The Irish system operators, EirGrid and the System Operator for Northern Ireland (SONI), also use a high-speed shut down warning system. A forecast of the probability of a high-speed shut down event enables the system operator to verify system reliability and allocate reserves well ahead of time in order to minimize costs.

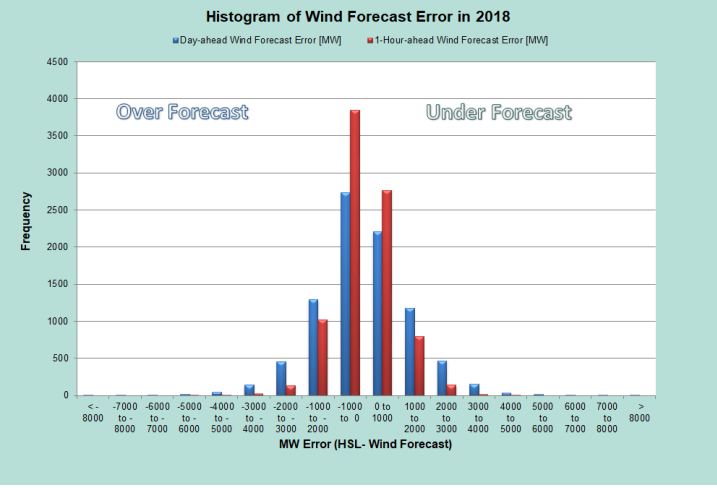

Figure 2. System-wide wind generation forecast error at ERCOT in 2018.

Calculating Reserve Generating Capacity

With rising levels of renewables and increasing flexibility from loads and other weather-sensitive resources, probabilistic forecasts can help system operators coordinate all resources to achieve grid reliability as economically as possible. Probabilistic forecasts can help to calculate overall reserve requirements, taking into account potential variability and uncertainty in load, wind generation, and outages of thermal units, and provide estimates of the resources that are necessary to meet demand. Probabilistic forecasts are also being used to design market products that appropriately compensate resources for the value of their flexibility—their ability to rapidly respond to keep the system balanced and therefore reliable.

Looking Ahead

Probabilistic forecasts show promise as a tool to better forecast and manage the variability and uncertainty of power systems. Ongoing efforts are needed for case studies, documentation, standards, and guidelines for how the industry can use the value of such forecasts. The International Energy Agency collaboration activity on wind energy forecasting (Wind Task 36) includes work to facilitate the use of probabilistic forecasts and uncertainty information for operation and management of power systems with substantial variable generation for operation, trading, and balancing in power markets. The collaboration will develop best practice guidelines for the implementation, measurement, and quantification of the value of probabilistic forecasts based on experience from experts around the globe. Decisionmaking processes that leverage forecast uncertainty information can provide near-term opportunities for using higher levels of wind and solar energy and getting additional value from the power system as a whole.

Adapted from Sue Ellen Haupt, Mayte Garcia Casado, Michael Davidson, Jan Dobschinski, Pengwei Du, Matthias Lange, Timothy Miller, Corinna Möhrlen, Amber Motley, Rui Pestana, and John Zack, "The Use of Probabilistic Forecasts: Applying Them in Theory and Practice," IEEE Power and Energy Magazine November-December 2019. Guest editor, Charlie Smith, ESIG. DOI: 10.1109/MPE.2019.2932639.

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