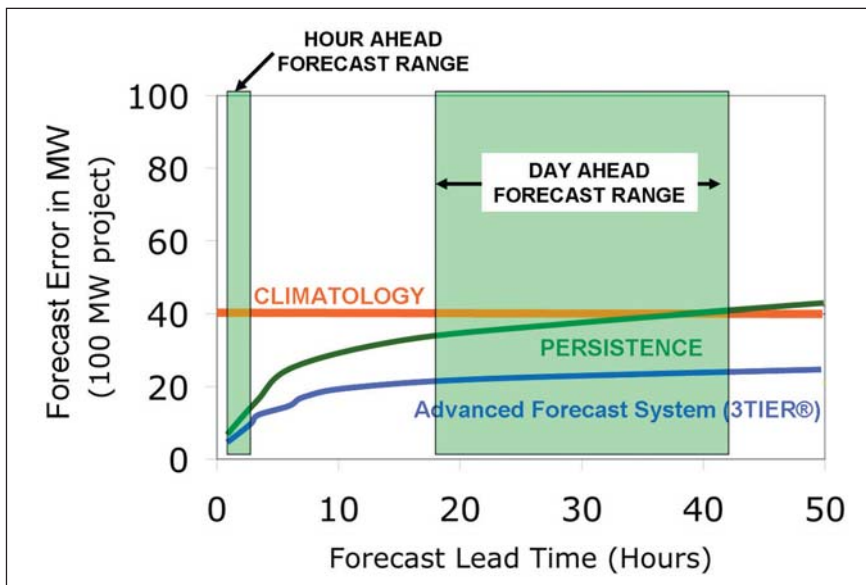


The Role and Importance Forecasting Plays for Wind Power Industry

By Jeff Lerner, Director of Forecasting and
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Figure 1: Forecast Error (MW) as a function of the forecast lead time (hours) for a wind power plant with 100 MW capacity. See text for explanation of climatology, persistence, and advanced forecast system.



Traditionally, electricity utilities and system operators are accustomed to understanding the supply side of load balancing with regards to the source of the energy, dispatchability and reserves, as well as the relative cost of producing electricity from non-renewable resources. With the recent and continued increase in penetration of wind power, the energy industry will need to adjust its thinking on how to integrate this intermittent power source into the electricity grid. This paper discusses how and why the wind power industry

currently requires forecasting to better position wind for continued growth and penetration into the global energy mix. Before the forecasting discussion can begin, it is equally important to note the critical need for proper coordination and cooperation in planning the distribution and size of wind projects and the electricity transmission grid from the municipal to international scale. This would undoubtedly involve unprecedented political will by decision makers, public support and education, and creative technological solutions.

The suitability of a particular location for the development of a wind energy project depends on a large number of factors. Site characteristics such as accessibility during construction and the distance to transmission and load may dictate whether a site is suitable for development. Clearly, for wind energy development, the meteorological conditions at the site are of the utmost importance, since wind acts as the fuel in wind energy projects. Even though this fuel is free, no amount of money can buy additional fuel once a project is built. Project siting is therefore the single most important, controllable factor in determining whether a wind energy project will be economically viable or not.

Since direct observations of wind speed are only made at a limited number of sites a comprehensive data set based on observations alone is impossible. Instead, computer models that simulate the dynamics of the atmosphere (numerical weather prediction models, NWP) can provide important spatial and high temporal information on the wind

resources at a site. Proper assessment techniques using NWP modeling can provide valuable information on the expected diurnal and seasonal load for a project as well as a long-term evaluation of the site's potential.

Understanding Forecast Error

A typical operational wind project will yield around 30% of the nameplate capacity over a year based on the wind potential. This is a gross estimate which assumes all turbines are always online and running at optimal efficiency. In actuality, several non-environmental factors exist that can diminish a project's output potential, many of which can be mitigated or efficiently dealt with.

Simply not having any forecast of the wind power is a gamble that proves costly over time. For example, the forecast error associated with not having any knowledge of the future wind power generation (unskilled forecast) will likely exceed 40% of the plant capacity when verified against actual output. Figure 1 illustrates the magnitude of the forecast error as a function of the forecast lead time for a hypothetical 100 MW wind project. In this figure, three different forecasting approaches show the reduction in error using different methodologies for wind power forecasting.

Climatology represents the error associated with using a constant value forecast that is calculated from the average power produced for that project based on actual or reconstructed historical data. A persistence forecast is taking the current power value and making that the constant power forecast

for the rest of the forecast period (e.g., 50 hours in Figure 1). A more advanced forecast system such as the 3TIER model is based upon the output of both statistical and NWP models that integrate project power or meteorological observations. Figure 1 illustrates that (1) the persistence forecast is not that bad, on average, particularly for the short-range period, (2) 3TIER's advanced forecast system has the least error and improves upon persistence, and (3) forecast error, in general, increases with lead time, eventually approaching climatology.

How Wind Power Forecasts Impact The Bottom Line

The financial implications of not having wind power forecasts can not be overstated. Imbalance charges imposed on energy providers that result from deviations in scheduled output will increase the project operating costs. Wind power forecasts can help to minimize these penalties, but will not

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completely eliminate them. Wind power forecasts can also reduce the significant opportunity costs of being too conservative in bidding output into a forward market, due to uncertainty of availability.

Based on the risk tolerance of the forecast user, prediction intervals can be incorporated into the decision making process for scheduling power

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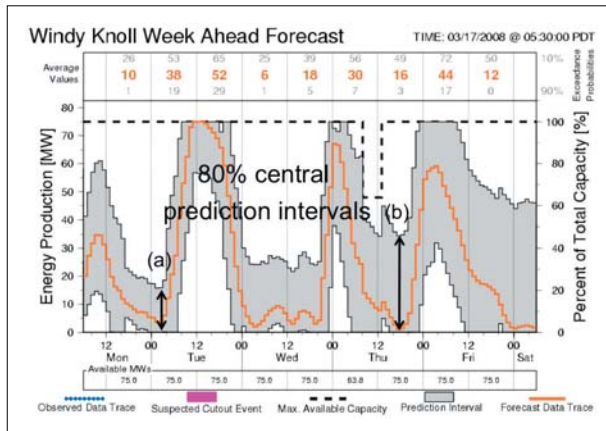
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Figure 2: Week ahead forecast for wind project with 75 MW capacity. The grey shaded area is between the 90% and 10% exceedance probability values. The thick black dashed line is the wind project scheduled capacity. The orange line represents the P50 or value where the forecast has an equal probability of exceeding or being less than.



production. The gray shading bounded by black lines in Figure 2 visually illustrates the concept of a prediction interval. The prediction interval encompasses the range of values where the hourly-averaged observation falls in a given percentage of the

In Figure 2, forecast power values (thick orange line) display different prediction intervals in time: the 21-hour forecast at Tuesday 0300 prediction interval (labeled “(a)”) spans about 15% project capacity whereas by forecast hour 84 (Thursday 1800, labeled “(b)”), the interval range is over 40% capacity. A sharp prediction interval conveys more forecast certainty and could result in less conservatism and lower opportunity costs concerning an energy bid. In general, as the wind power forecast becomes less certain for a longer term forecast, the width of the prediction interval increases. The key message of Figure 2 is the importance of accurately interpreting the expected forecast errors and using this information in decision making processes such as energy scheduling and electricity trading, where wind power can affect price fluctuations.

So, what does obtaining forecast information mean in terms of cost savings to a trader, grid operator, or perhaps a wind tower maintenance scheduler? By employing advanced forecast information, the realized cost savings accumulate over periods of time when compared to using a non-skillful approach such as persistence or climatology. In Figure 3, the accumulated savings, in MWh, is summed over a 30-day period. In this example for a 100 MW capacity wind project, this equates to over 2000 MWh savings by simply using the forecast at face value. Assuming a wholesale price of \$0.05/KWh, a monthly savings of \$100,000 is realized from using a skilled forecast instead of persistence!

Volatile electricity prices and load imbalances frequently result in wind energy curtailments in several regions of the country where the electricity transmission infrastructure has not been updated to manage the influx of energy from a variable energy source like wind. However, the frequency and length of curtailments often has to do with underutilizing the information contained within a wind energy forecast. Knowing in advance when expected surges in cheap and clean wind energy production will occur could allow for grid operators to reduce costs through the power-down of more expensive natural gas-fired plants. Region-wide wind power forecasts are becoming increasingly available through forecast service providers, thus removing much of the uncertainty associated with electricity bottlenecks. Another added benefit of regional wind power forecasts is the reduction of the overall forecast error as individual wind project forecast errors tend to cancel each other.

Another area where forecasting can be applied to save costs is when operators need to schedule wind project maintenance and construction. Wind projects often require that turbines be taken down during the

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time, in this case 80%. The size of the prediction interval is determined by the historical forecast errors, which are a function of the forecast hour and the value of the forecasted power and wind speed (Meade and Islam 19952).

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Table 1: Current and future challenges to forecasting wind power.

commissioning of new turbines. This can take hours to weeks depending in part on the weather. Precipitation, high winds and extreme temperatures need to be avoided for obvious reasons. Without accurate forecasting information, the chances of idling a mobilized work crew and necessary equipment (such as large cranes) increases. The associated costs can exceed \$10,000 per day. By not taking advantage of the right weather conditions for construction, operations, and maintenance, overall project costs increase as deadlines are not met, plant generation is diminished, and resultant production revenues from Green Tags or Production Tax Credits are lost.

The Forecast for Wind Power Forecasting

Utility scale wind power forecasting is in its second decade and has seen great improvements with regard to quality, timeliness, and delivery of the forecast product. However, there are clear challenges facing the wind power industry and the science behind the forecasts (see Table 1). In the future, short-term wind power forecasts will benefit from longer historical forecast records and additional observations. Additionally, utilization of NWP model ensemble forecasts has enormous potential in reducing error that isn't currently being exploited for the short- to long-range forecast. In short, it is imperative that government, academia and industry continue to work in tandem towards more accurate weather forecasts that will benefit the renewable energy industry.

It has been shown that forecasts of wind power are closer to actual wind power production when utilizing a more advanced forecast product that utilizes state-of-the-art Numerical Weather Prediction models. Statistical methods (such as Artificial Intelligence models) incorporate project power and nearby observations for more accurate short-range forecasts than what could be obtained from persistence alone. The implications of the value of the forecast are: reduced imbalance charges and penalties, competi-

tive knowledge advantage in real time and day ahead energy market trading, and more efficient project construction, operations, and maintenance planning. Accurate wind power forecasts are also important in reducing the occurrence or length of curtailments (which translate to cost savings), improved worker safety, and mitigating physical impacts of extreme weather on wind power systems. ■

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Figure 3: The forecast advantage expressed in percent of full capacity for a 100 MW wind energy project. The solid black line is the cumulative advantage (MWh), the gray shading is the standard deviation of the forecast (%), and the pink bar is the forecast advantage (%) of using an advanced forecast system over that of using a baseline hourly persistence forecast over a 30-day period.

