Study gathers comprehensive wind info to improve renewable energy

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Pacific Northwest National Laboratory scientists are researching how radar weather instruments can help improve predictions on when and how strongly winds will blow. They're testing the instruments from a working wind farm in southeastern Washington State. Credit: PNNL

Meteorological equipment typically used to monitor storms could help power grid operators know when to expect winds that will send turbine blades spinning, as well as help them avoid the sudden stress that spinning turbines could put on the electrical grid.

"We know that the wind will blow, but the real challenge is to know when and how much," said atmospheric scientist Larry Berg. "This project takes an interesting approach –adapting an established technology for a new use – to find a reliable way to measure winds and improve wind power forecasts."

Berg and Rob Newsom, both researchers at the Department of Energy's Pacific Northwest National Laboratory, are using a variety of meteorological equipment to measure winds high up into the air – about 350 feet, the average height of turbine hubs – and get a better reading on how winds behave up there.

Wind measurements are typically made much lower – at about 30 feet high – for weather monitoring purposes. Wind power companies do measure winds higher up, but that information is usually kept proprietary. PNNL's findings will be available to all online.

The study's findings could also provide more accurate wind predictions because of its field location – a working wind farm. The equipment is being erected on and near a radio tower near the 300-megawatt Stateline Wind Energy Center, a wind power project that runs along the eastern Washington-Oregon border. Any wind power company could use the study's findings to improve how sites are chosen for wind farms and how those farms are operated.

The equipment started collecting measurements in November. Berg and Newsom will continue gathering measurements for about nine months, or through this summer. The period will allow the researchers to draw a more complete and accurate picture of how wind behaves at turbine height. The period represents the windiest months for the area.

"The goal here is to help everyone – not just one group – better understand wind's behavior and ultimately improve our use of it as a renewable power source," Newsom said.

Cool tools

But first researchers need to document wind behavior. To do that, they're employing a handful of sophisticated meteorological tools.

One key instrument is the National Weather Service's NEXRAD Doppler radar weather station in Pendleton, Ore., about 19 miles south of Stateline. The station emits short pulses of radio waves that bounce back when they strike water droplets and other particles in the air. A national network of these stations is routinely used by television meteorologists to show clouds and precipitation in familiar, colorful digital maps. For this study, computers will analyze the returned signals to determine how the wind varies in the area around the radar, including the wind farm.

The team is also installing equipment specifically designed to measure wind speed and direction: a radar wind profiler. Like NEXRAD, the profiler sends out radio waves that are bounced back when it hits variations in moisture or temperature. But while NEXRAD scans the entire sky with its one rotating radar beam, the profiler sends three radar beams up into the sky. The profiler being used is part of the DOE's Atmospheric Radiation Measurement Climate Research Facility.

Another tool they're using is Doppler sodar, which uses sound instead of radio waves. A regular sequence of high-pitched beeps is sent into the sky and, like radar, will be reflected from variations in moisture and temperature. That information will help researchers measure winds that are at lower heights in the sky than the profiler can measure.

Finally, the researchers will install ultrasonic anemometers on the radio tower. The anemometer holds six tiny microphones, and measures the time it takes for sound pulses to travel from one microphone to another. Beyond measuring speed, the anemometer also helps determine wind direction. Combined, all this equipment will help researchers gain a more comprehensive understanding of how wind behaves at the turbine level of a working wind farm.

Improving renewable energy

Data collected during this study will be used to evaluate the performance of computer models of the atmosphere near the operating wind farm. These computer models are routinely used to provide weather forecasts of wind conditions hours and even days into the future. This information can help wind farms operate more efficiently and lets them better integrate the power they produce into the electric grid. These models are known to have relatively large errors in forecasting the severity and times of strong winds, including gusts during thunderstorms as fronts pass through an area. Even relatively small errors in wind speed predictions can lead to large errors in the predicted power outputs of wind farms.

When that happens, grid operators have to accommodate the influx of power, often by diverting or turning off other power sources. In the Pacific Northwest, that can mean spilling river water over hydroelectric dams instead of sending the water through the dams' power-producing turbines. Sometimes those diversions are needed on a moment's notice, when the grid becomes overwhelmed by unexpected windy weather. If such gusts could be reliably predicted ahead of time, power operators could make adequate plans beforehand. And when the wind stops blowing unexpectedly, the grid can experience a quick need for power.

Wind power companies could also use improved predictions to more wisely choose their wind farm sites. These companies invest heavily in understanding the wind characteristics of their sites before breaking ground, but forecasting turbine-level winds is still an evolving field.

As a result, two industrial partners are collaborating with Newsom and Berg on their research. 3TIER of Seattle, Wash., and WindLogics of St. Paul, Minn., both help wind power developers identify and evaluate potential locations for wind farms. They're serving as consultants and have provided input on what kind of data would be most helpful when examining wind sites.

If the NEXRAD wind data is verified by the data collected through the other meteorological equipment, the next step in this research would be to plug the NEXRAD data into a working weather model. The model could then be used to better predict future wind behavior. Using the data in a weather model is outside the scope of Berg and Newsom's current research, but they hope to be able to do so in the future.

Field work for the study began this month and will continue for about nine months. This study is funded by the DOE's Office of Energy Efficiency and Renewable Energy's Wind and Water Power Program and the Office of Science Atmospheric Radiation Measurement Facility.

Provided by Pacific Northwest National Laboratory