SoDAR Takes Assessment To New Heights

By measuring the frequency and time delay of chirp echoes, SoDAR can measure the wind speed and direction at heights up to 200 meters.

BY SUSAN GIORDANO

The world of wind assessment is looking up, literally. As commercial wind turbines grow taller – commonly 80 meters and climbing – wind prospectors need accurate measurements from higher elevations. Wind prospectors and developers have reason to be upbeat, as improvements to sound detection and ranging (SoDAR) technology show promise for assessing wind resources at today's turbine heights accurately and economically.

Wind energy success is all about location, and selecting the right site is essential to cost-effective wind generation. Several factors are critical for selecting a site for a successful utility-scale wind project, but the most important is a good wind resource at the site.

Site selection typically begins with wind prospecting. At the earliest stage, wind data may come from publicly available maps and databases of historical climate data. Such data sources provide only a rough estimate of the average annual wind at a proposed site.

Computer models of wind flow over terrain have improved dramatically in the last several years. Such models can supplement and refine both historical data and site-specific measurements.

Ultimately, there is no substitute for real data recorded over a sufficient period of time (typically a year or more) directly at the proposed site. To minimize economic risk, this data must be measured as close as possible to the rotor of the proposed turbines.

The conventional method of measuring the wind at a site is to use wind sensors mounted on a met mast or tower, recorded by a data logger. A typical configuration consists of a 60-meter (m) tower with anemometers at 40 m, 50 m and 60 m, and wind vanes at the top levels. Duplicate anemometers at each height provide for valid data even when one sensor is shadowed by the tower, and also serve as backup against sensor failure.

A temperature sensor can provide information on air density. Barometric pressure is the other component of air density, but many developers rely on the assumption of a mean air pressure based on site altitude instead.

Remote communications is a virtual must, whether via cellular modem or satellite. Receiving the data daily gives wind prospectors a chance to identify sensor, power or logger issues. Gaps in data can be minimized by identifying and fixing problems right away, which helps to provide the steady stream of information needed to assess seasonal variations and the overall quality of the resource over time.

With most current turbine hub heights being at least 80 m high, conventional wind speed measurement systems only directly measure the lowest portion of the area swept by a turbine's blades. This means that predictions of wind speed and energy have to be based on extrapolations. These can be relatively simple vertical extrapolations (based on the 1/7 power law) or involve complex computer models.

Improvements in SoDAR technology are allowing assessment specialists to measure wind speeds reliably at and above the highest turbine hub height.

SoDAR was invented in the early 1960s, predating the development of weather radar. While the latter technology is superior for measuring the upper atmosphere, SoDAR is ideally suited for measuring the lower boundary layer below the sweep of radar and above the ground.

As the name suggests, SoDAR employs sound rather than radio waves for measurement. SoDAR systems

measure the wind by sending up focused sonic beams in succession, producing an audible "chirp" through the air and then listening for the return signal, echoing off turbulence in the atmosphere for a short period of time. By precisely measuring the frequency and time delay of the chirp's echo, SoDAR measures the wind speed and direction at various heights up to 200 m. If no unwanted sounds interfere, the measurement of wind speed is accurate, based on conceptually straightforward trigonometry.

Most commercial SoDAR systems are composed of an array of speakers and a flared acoustic enclosure, and stand from 3 feet to 10 feet tall. SoDAR systems are relatively compact, and all maintenance is performed at ground level. In addition, SoDAR's reach for wind speed measurement easily exceeds the requirements for current industry wind turbine hub heights. The equipment cost for most systems, hundreds of which have been deployed, is in the range of $40,000-$80,000.

Many correlation studies between conventional measuring equipment and SoDAR have been undertaken. In "A Look Back on Two Decades of Doppler SoDAR Comparison Studies," Gennaro Crescenti summarized a number of studies and found an average correlation coefficient of .92 between SoDAR and anemometers on a -1 to +1 scale. Improvements in technology over and since the study period suggest that current SoDAR systems may offer a higher correlation.

Although prospectors are using SoDAR selectively to profile their sites, existing designs have multiple limitations for long-term wind assessment, including:

- current offerings are not suited for remote operation, making frequent site visits necessary;
- many models cannot withstand harsh weather;
- systems deliver wind data in formats that require expert interpretation;
- readings must be analyzed to filter out unwanted sound reflections;
- systems cannot operate unattended for prolonged periods of time due to power supply constraints; and
- some systems do not support remote data transfer, again requiring site visits.

In response to the need for affordable, accurate assessments at turbine heights, companies are working on enhancements to remote sensing technologies by developing SoDAR systems that overcome many of the current limitations. Products currently in beta testing are made of all-weather materials, have newly designed acoustics, low power consumption, and satellite communications for long-term, unattended use. As these and other innovations are developed, prospects are looking up for SoDAR to provide reliable, long-term remote measurements that meet a wide variety of assessment needs. WP

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