Using objective analysis and dual-Doppler synthesis to document wind turbine inflow and wake flow; flow fields upstream, downstream and within wind farms; power deficits; and enhanced turbulence

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Technology description

Wind Farm Turbine Wake and Flow Field Analysis With Dual Doppler

Wind turbines not only produce power, they produce wakes (like those in water) in the atmosphere downstream from each turbine. The wakes can damage other turbines and decrease the efficiency of the wind farm.

A Ka-band mobile research dual-Doppler radar system developed by the Texas Tech Wind Science and Engineering Research Center allows wind farm operators and developers to measure turbine wakes, turbulence, and air flow fields created by wind turbine operation. This advancement will help to lower the cost of wind energy through optimized wind turbine/farm performance and enhanced reliability.

Understanding the structure and evolution of turbine wakes allows wind farm engineers to plan wind farms and estimate wind turbine efficiency.

Knowing the impact of turbine wakes allows wind farm developers to space turbines appropriately and helps control infrastructure costs. It also allows engineers to predict a large wind park's expected total power output.

Controlling the impact of turbine wake will help to lower the cost of wind energy by improving wind turbine/farm performance and enhancing its reliability as a power source. It may also be possible to build smart wind farms by integrating remotely sensed flow fields into turbine and wind farm controls.

Dual-Doppler Radar Provides Complete Flow Field Analysis

Texas Tech's mobile dual-Doppler radar system has been field tested and is able to provide a complete two-dimensional flow field analysis, document flow field disturbances that impact wind turbine response, estimate available power, and track areas of increased turbulence. Current technologies, like single-location light detection and ranging (LIDAR) or radar alone, are not able to provide such comprehensive analysis.

Compared to line-of-site analysis efforts and predictive based models, the radar technique has significant advantages, including the ability to fully define the horizontal flow field (e.g. wind direction perturbations) throughout an entire wind farm with high spatial resolution (tens of meters).

Wind Energy Research, Wind Farm Design

Created by Texas Tech University in 2010, the National Wind Resource Center (NWRC) aims to be the research and development arm of the rapidly growing wind energy industry.
The center's goals are to:
-Lead the industry, state and nation to achieve the Department of Energy’ s goal of 20 percent wind energy integration by 2030
-Enhance research collaboration and technology development by meeting the research and development needs of industry
-Expedite phased construction of research wind farms and related facilities to aid in prototype development on a variety of research initiatives
-Recruit world-class researchers with expertise in the wind sector
-Position the U.S. as the world’ s leader in wind energy research and development
-Enhance the state’ s capacity for job creation in the wind energy sector by developing the best-in-class training methods for the emerging workforce

Application area

-Wind farm operation
-Wind farm development
-Instrument development
-Wind turbine manufacture
-Wind resource assessment
-Documenting wind turbine wakes for different manufacturers
-Enhanced power performance testing (i.e. more comprehensive documentation of inflow conditions relative to turbine power generation)
-Enhancing wind farm turbine layout (existing commercial codes are based on assumptions which this technology can validate in full scale)
-Site-specific resource assessment (defining localized wind flow prior to or after turbine deployment)
-Future applications could include:
Wind turbine and wind farm performance optimization including the development of “smart” wind farms based on integrating the generated flow and power fields into turbine and wind farm controls
Mitigation of turbine loads through anticipatory control based on the remotely sensed flow and turbulence fields

Advantages

-Faster, more comprehensive profiling of wind wake effects
-Documenting the upstream, downstream and modulated flow fields around a wind farm
-Lower cost for more information than existing technologies

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