Quick Facts

Using a high-performance computing system, NREL scientists and engineers are developing innovative software tools to simulate the behavior of both individual wind turbines and multi-turbine configurations in a variety of atmospheric environments.

NREL researchers have completed the first-ever high-fidelity simulations of a fully operational wind farm, Lillgrund, off the coast of southern Sweden.

Wind plant developers can use NREL's analysis to create improved layouts and controls for wind farms, thus enhancing wind farm efficiency and helping to extend the life of wind turbines. The research could also help the development of offshore wind farms.

Working together through the International Energy Agency, NREL and the Centro Nacional de Energías Renovables (CENER) in Spain are leading an international collaboration to gather data from operating wind farms and benchmark existing simulation tools. The data from the interagency study will provide valuable insights into the operation and optimization of these large wind turbines.

This research will lead to better design standards and tools for both wind turbines and entire wind farms. This will help to reduce the levelized cost of wind energy, making wind power more competitive with other sources of electricity.

NREL Studies Wind Farm Aerodynamics to Improve Siting

NREL researchers are using advanced remote sensing instruments and high-performance computing to understand atmospheric turbulence and turbine wake behavior—a key to improving wind turbine design and siting within wind farms. As turbines and wind farms grow in size, they create bigger wakes and present more complex challenges to wind turbine and wind farm designers and operators.

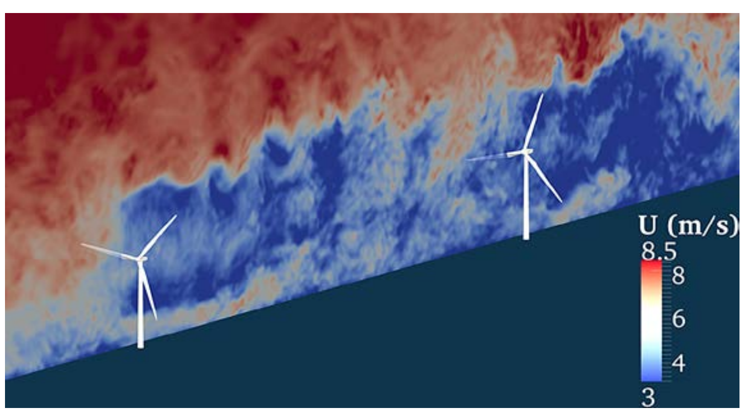
NREL researchers have confirmed through both observation and simulation that the influence of the atmosphere and wakes is more complex than the way it is represented in computer models used by the industry today. For example, fluctuations in air and ground temperature throughout the day can affect wind turbine wakes, so it's important to study these temperature fluctuations in detail and understand how to minimize their impacts.

To gain new insights into wind turbine wakes, NREL joined together with the National Oceanic and Atmospheric Administration (NOAA), the University of Colorado at Boulder, and Lawrence Livermore National Laboratory to fund a comprehensive study that began in 2011. A multi-organizational team of experts used precise instruments to create a detailed picture of the atmosphere surrounding large turbines. Among these instruments was the high-resolution Doppler LIDAR—a laser-based system that stands for "light detection and ranging"—used for the first time to produce a three-dimensional portrait of atmospheric activity in the wake of a multi-megawatt wind turbine.

NREL's work has shown that the atmosphere contains large-scale turbulence structures that propagate through the wind turbines and wind farms and influence wake motion. Over the course of a day, the wind plant performance and turbine fatigue loading changes dramatically as the atmosphere goes through its diurnal cycle.

NREL researchers have also developed high-performance computing tools that can simulate the airflow through a wind farm and the individual turbine response with those farms. In the past, these types of high-performance simulations have not typically been available.

Ultimately, the better understanding through observation and simulation is inserted into industrial models—such as NREL's Dynamic Wake Meandering model—that will be used by those with more limited computing resources. These new models and the knowledge gained from studying wind turbine wakes is expected to lead to improved turbine design standards, increased productivity in large wind farms, and a lower cost of energy from wind power.



The wake from a wind turbine can affect other downstream turbines in a wind farm, as shown in this computer model image. Cooler colors represent slower wind speeds.

Illustration by Kenny Gruchala and Matt Churchfield, NREL

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