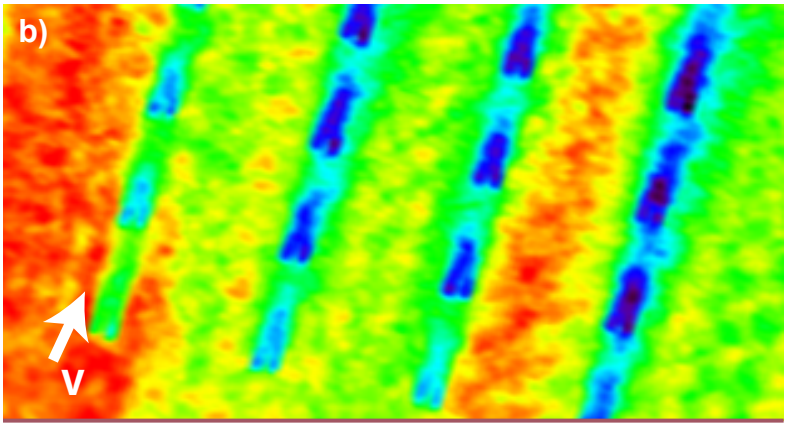
Success Story: Siemens Energy, Inc.

Computation-Based Wind Forecasting to Optimize Wind Power Production

The use of wind power, widely seen as the renewable with the best chance of competing with fossil fuel power stations in the near term, is expanding rapidly worldwide. The United States Department of Energy calculates that wind power could provide as much as one-fifth of America's electricity needs by 2030, up from about one percent in 2009. Essential to maximizing power production from wind turbines is computation-based wind forecasting. Accurate predictions would enable wind farm operators and owners to know, hours or days ahead of time, how wind conditions will affect power generation. These predictions help design tall wind turbines able to withstand high-turbulence environments and reduce the risk of wind-power investments. LLNL's high-performance computing, which can handle data-intensive problems at multiple scales and in the presence of uncertainty, can help industry and governments achieve their wind-power production goals.

Photo: Horns Rev, Denmark, owned by Vattenfall. Photographer Christian Steiness

Turbine wakes in an offshore wind farm made visible by condensation (a). Impacts of these wakes, including velocity deficits and increased turbulence stress loading, can be simulated using HPC (b). Such simulations can assist turbine design and array layout, as well as providing operational guidelines to increase energy capture and reduce component fatigue.



As part of its renewable energy portfolio, LLNL, under an agreement with Siemens Energy, Inc., has created high-resolution atmospheric modeling capabilities to improve the efficiency of individual wind turbines and entire wind farms, including both site design and operation. LLNL has developed simulation and prediction capabilities at a variety of scales, from mesoscale weather prediction to turbulence-resolving large-eddy simulations. This capability involves combining complex atmospheric turbulence models; large databases of wind park performance, topography, and sea-surface temperature; and sophisticated statistical and numerical techniques.

By taking into account both large-scale wind processes and small-scale terrain and turbine wake effects, LLNL and Siemens Energy, Inc. in partnership, have produced forecasting and simulation capabilities to help the wind-power industry optimize power production, making wind power cost-effective enough to compete with fossil-fuel power.

LLNL's partnership with Siemens Energy, Inc. is aligned with its growing wind energy program, focusing on high-resolution simulation, probabilistic forecasting, uncertainty quantification, and high-fidelity observations. These efforts are increasing understanding of basic atmospheric science related to wind power production, and providing enhanced simulation and forecasts tools.

Leveraging LLNL's high-performance computational capabilities, these improved models incorporate the uncertainties inherent in climate and weather prediction and account for smaller-scale wake effects in large arrays. LLNL is also coordinating field observations with multiple partners (including the National Renewable Energy Laboratory) to better understand complex flows in wind farms and to validate computer models. The advanced simulation and prediction tools emerging from these efforts have the potential to significantly improve wind farm planning and operations, ultimately lowering the cost of wind-generated electricity.