Turbine-Turbine Interaction and Performance Detailed

A next-generation modeling capability assesses wind turbine array fluid dynamics and aero-elastic simulations

Characterizing and optimizing overall performance of wind plants composed of large numbers of multi-megawatt turbines requires a new generation of modeling capability to assess individual turbine performance as well as detailed turbine-turbine and turbine-atmosphere interactions. Scientists at the National Renewable Energy Laboratory (NREL) are coupling physical models of the atmosphere and wind conditions with turbine models covering the range of scales important for wind plant dynamics to help address questions surrounding wind plant underperformance, component reliability issues, and climate impacts of large-scale wind deployment.

The computational and modeling challenges include the sheer size of the domains and the range of scales, from sub-meter-scale phenomena to tens of kilometers. Coupling large, extant community models originally developed for different scales with conservation and fidelity is another significant challenge, requiring careful code performance comparison and validation using idealized and ultimately real-world scenarios. The new model will require many thousands of hours of supercomputing time on NREL's 180 TFLOP supercomputer, RedMesa, but it will help scientists better understand the impacts that upwind turbines have on turbines in their wake and give greater insight into overall wind plant performance.

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References: NWTC: Pat Moriarty (PI), Matt Churchfield, Sang Lee, Julie Lundquist; CSC: John Michalakes, Avi Purkayastha, Michael Sprague, Kenny Gruchalla

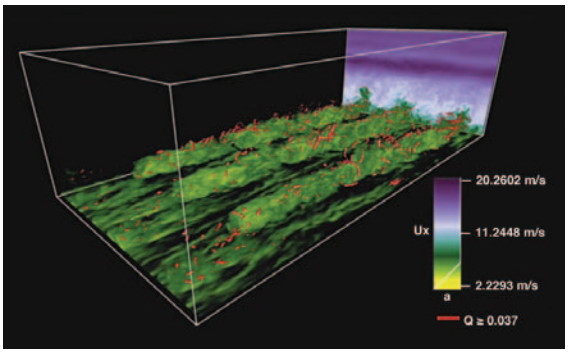

Figure 1: *Actuator line models of nine wind turbines reacting to and generating wake turbulence within Computational Fluid Dynamics (CFD) simulation of atmospheric boundary layer. NREL's research helps understand the impacts that upstream turbines have on turbines located in their wake, a key question regarding wind farm underperformance. Simulation: Matt Churchfield and Luis Martinez. Visualization: Kenny Gruchalla.*

Key Research Results

Achievement

NREL researchers are coupling physical models of wind turbine fluid dynamics and aero-elastic simulations at scales ranging from less than a meter to tens of kilometers. The large-scale simulations will be run on RedMesa, NREL's 180 TFLOP supercomputer.

Key Result

The work is generating several models, including actuator line models of several wind turbines both reacting to and generating turbulence. NREL's research helps understand the impacts upstream turbines have on turbines located in their wake, a key question regarding wind plant underperformance and reliability.

Potential Impact

This work creates a better understanding of wind plant performance and insight into the dynamics of wind at scales important for wind plants—from wind turbines to mesoscale. This research will help determine optimal layout and operational strategies for future wind plants.

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NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

NREL/FS-2C00-51423 • May 2011

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