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WIND TURBINE WAKES

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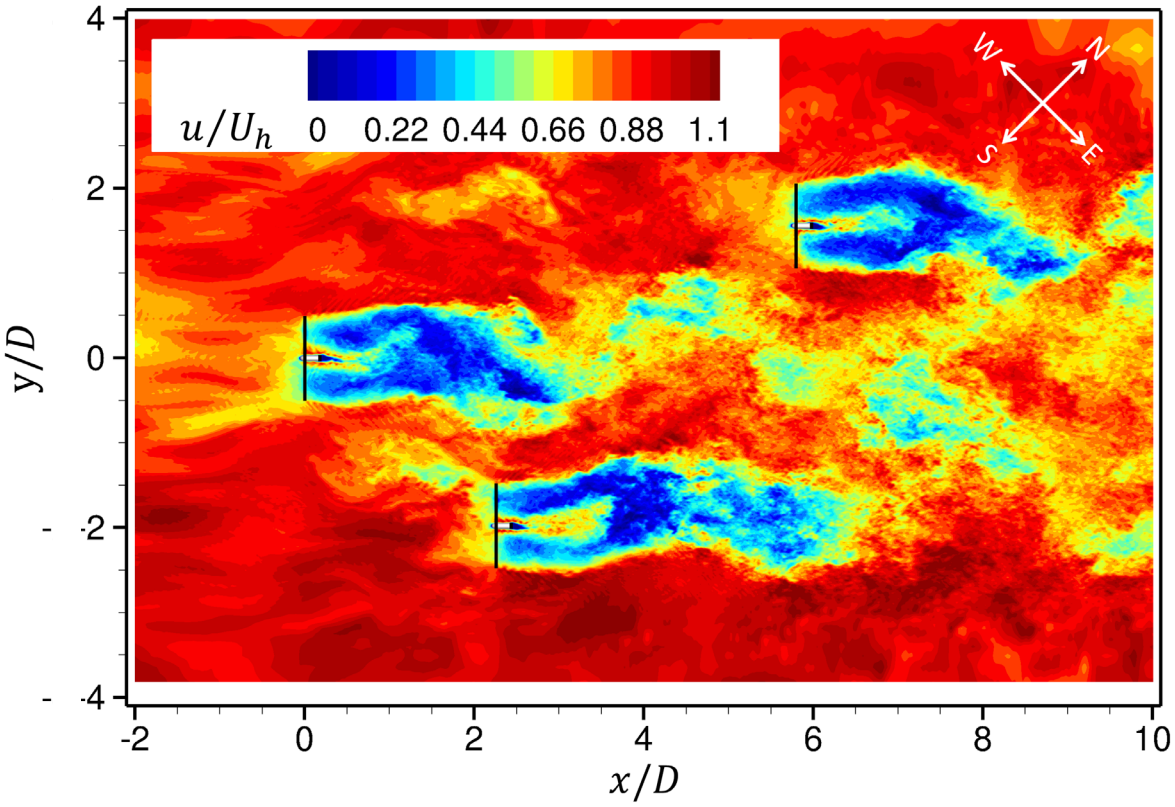
"Having access to powerful computing resources at Sandia allows our Wind Energy Technologies group to conduct innovative research that advances our goal of reducing the cost of wind energy."

– Chris Kelley

The total energy produced by a wind farm depends on the complex interaction of many wind turbines operating in proximity with the turbulent atmosphere. Sometimes, the unsteady forces associated with wind negatively influence power production, causing damage and increasing the cost of producing energy associated with wind power. Wakes and the motion of air generated by rotating blades need to be better understood. Predicting wakes and other wind forces could lead to more effective wind turbine designs and farm layouts, thereby reducing the cost of energy, allowing the United States to increase the installed capacity of wind energy.

The Wind Energy Technologies Department at Sandia has collaborated with the University of Minnesota to simulate the interaction of multiple wind turbines. By combining the validated, large-eddy simulation code with Sandia's HPC capability, this consortium has improved its ability to predict unsteady forces and the electrical power generated by an array of wind turbines. The array of wind turbines simulated were specifically those at the Sandia Scaled Wind Farm Testbed (SWiFT) site which aided the design of new wind turbine blades being manufactured as part of the National Rotor Testbed project with the Department of Energy.

Three specific areas of research were addressed with different simulation cases. First, researchers investigated the persistence of the wake for unique distributions of force along the wind turbine blades. Unique force distributions produced unique wake contours; however, turbulence removed any differences beyond 4 rotor diameters downstream. The next simulation investigated the effect of scale on wake persistence and showed that two wind turbines of the same design but different scales will produce different wakes. Finally, the simulations of the experimental SWiFT facility quantified the increased power and force fluctuations of downwind turbines. The research findings have already influenced the aerodynamic design of new wind turbine blades being designed at Sandia.



Velocity contour of a southwest wind for three wind turbines closely spaced.