Field trials validate wind turbine wake steering impact at scale

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NREL's experimental design for the wake steering field campaign incorporated lidar measurements of atmospheric conditions. Credit: Andrew Scholbrock, NREL

If every turn of the wheel is a revolution, then every sweep of a wind turbine blade is an opportunity. That's how researchers at the National Renewable Energy Laboratory (NREL) view the potential for wind plant operators to increase energy capture using plant-level controls. By steering individual turbine wakes away from downstream turbines, existing facilities can achieve annual energy production gains of 1 percent–2 percent depending on the plant size and design.

With funding from the Department of Energy, NREL developed the FLOw Redirection and Induction in Steady State (FLORIS) model to help wind plant operators optimize turbine interactions. This open-source software allows users to design controllers that can choose the best yaw angles for turbine operation under different conditions.

Over the past few years, NREL researchers have conducted several small-scale campaigns to validate FLORIS predictions. One- and two-turbine studies at NREL's National Wind Technology Center in Boulder, Colorado, and the Scaled Wind Farm Technology (SWiFT) facility in Lubbock, Texas, contributed to FLORIS updates. Another single-turbine experiment at a commercial offshore facility provided additional insights into optimal configurations.

"There is no shortage of interest in applying this approach," said NREL Senior Engineer Paul Fleming, who leads the laboratory's wind farm control research. "But before we can see controls adopted at scale, the industry needs to see field trials that are conducted in realistic environments."

To fill this gap, Fleming and colleagues recently designed a study to bring increased clarity to wind plant control research. The team incorporated a range of sensing equipment—including a ground-based lidar, meteorological tower, and two sodars—at subsection of the Peetz Wind Energy Center during the 3-month-long field study.

"Our experimental setup used specific instrumentation to gather additional data points, which greatly increased our ability to analyze the accuracy of simulated predictions," Fleming said.

NREL has now released a fourth-generation FLORIS software, which has accuracy and usability improvements. This version includes an additional representation of flow physics that incorporates advances in the understanding of wake steering aerodynamics. NREL software engineers also introduced a modular approach that enables features to be added quickly and a redesigned interface that gives researchers more control over simulations.

Fleming and colleagues have published Part 1 of their findings from the field trials in the journal *Wind Energy Science*. The authors identified several areas for improvement, such as dynamic controller design refinements, time filtering, and uncertainty quantification. However, they report that the controller successfully increased energy capture at downstream turbines in accordance with FLORIS predictions.

"Given that a 2 percent gain at a typical 300-megawatt (MW) wind plant could represent $1 million per year in additional profits, it's no surprise that the industry is expressing widespread interest in implementing optimized controls," Fleming said.

More information: Paul Fleming et al. Initial results from a field campaign of wake steering applied at a commercial wind farm – Part 1, *Wind Energy Science* (2019). DOI: 10.5194/wes-4-273-2019

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