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Wake Mitigation Strategies for Optimizing Wind Farm Power Production

Deepu Dilip and Fernando Porté-Agel
ENAC-IIE-WIRE, EPFL, Lausanne, Switzerland (deepu.dilip@epfl.ch, fernando.porte-agel@epfl.ch)

Although wind turbines are designed individually for optimum power production, they are often arranged into groups of closely spaced turbines in a wind farm rather than in isolation. Consequently, most turbines in a wind farm do not operate in unobstructed wind flows, but are affected by the wakes of turbines in front of them. Such wake interference significantly reduces the overall power generation from wind farms and hence, development of effective wake mitigation strategies is critical for improving wind farm efficiency. One approach towards this end is based on the notion that the operation of each turbine in a wind farm at its optimum efficiency might not lead to optimum power generation from the wind farm as a whole. This entails a down regulation of individual turbines from its optimum operating point, which can be achieved through different methods such as pitching the turbine blades, changing the turbine tip speed ratio or yawing of the turbine, to name a few.

In this study, large-eddy simulations of a two-turbine arrangement with the second turbine fully in the wake of the first are performed. Different wake mitigation techniques are applied to the upstream turbine, and the effects of these on its wake characteristics are investigated. Results for the combined power from the two turbines for each of these methods are compared to a baseline scenario where no wake mitigation strategies are employed. Analysis of the results shows the potential for improved power production from such wake control methods. It should be noted, however, that the magnitude of the improvement is strongly affected by the level of turbulence in the incoming atmospheric flow.