Boulder Fluid and Thermal Sciences Seminar Series

Tuesday, August 30, 2016
3:30pm-4:30pm (refreshments at 3:15pm)
Bechtel Collaboratory in the Discovery Learning Center (DLC)
University of Colorado, Boulder

Nonsteady Forcing of the Wind Turbine Drivetrain by the Passage of Daytime Atmospheric Turbulence Eddies Analyzed by Combining Field and Computational Data

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Levelized Cost of Energy (LCOE) is determined both by the power generated by the individual wind turbines within the wind farm (LCOE denominator) and by the costs required to replace failed components within the assumed 20-year life of a wind farm (LCOE numerator). In this study we focus on the strongest nonsteady loadings that underlie drivetrain component failures, with particular focus on the main bearing, a principle failure point in current utility scale wind farms. We integrate data and analysis from two data types to arrive at interesting and potentially important conclusions. The first data type is a field campaign carried out by GE in 2008 with a unique GE 1.5 MW wind turbine that was specially instrumented at three locations on the outer 30% of a blade. At each location a leading edge 5-hole pitot probe collected the time-resolved velocity vector while a trailing edge pitot rake collected component velocity in the boundary layer on the suction and pressure sides relative to the rotating blade. A met tower 250 m upstream of the wind turbine collected time-resolved velocity and temperature. Combined with meteorological data at a nearby airfield, it was possible to estimate, with reasonable certainty, the stability state of the afternoon daytime atmospheric boundary layer (ABL). An equivalent ABL was generated with high-fidelity large-eddy simulation (LES). In a separate LES, the equivalent ABL forced an equivalent GE 1.5 MW wind turbine rotor modeled using an advanced actuator line blade model (ALM). The load and velocity field outputs from this LES-ALM provided the second data type analyzed. We find important consistency in nonsteady response characteristics between the field GE wind turbine data in a true daytime ABL and the modeled GE wind turbine in the simulated ABL. I shall discuss these characteristics in context with the combined discovery of four significant time scales that characterize wind turbine response to daytime atmospheric turbulence.

Please note that this presentation will be a repeat (with minor modifications/additions) of a presentation given at the NREL National Wind Technology Center on 11 July 2016.