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Coupling the Actuator Line and Finite Element Methods to Model Fluid Structure Interaction of a Commercial Wind Turbine in the Atmosphere JAVIER MOTTA[1], PANKAJ JHA[2], ROBERT CAMPBELL[3], SVEN SCHMITZ[4], JAMES BRASSEUR[5], Pennsylvania State University — Wind turbine blades deform in response to unsteady loadings from atmospheric turbulence, causing changes in local angle-of-attack and blade loadings. This interaction is modeled by a fluid-structure interaction (FSI) solver that combines a finite element (FE) solver with an actuator line method (ALM) model for aerodynamic blade loads and vorticity shedding developed by Jha, et al. (2013). The FSI solver is embedded within an OpenFOAM large-eddy simulation (LES) solver for daytime atmospheric boundary layer (ABL). The flow and structure solvers are tightly coupled to ensure convergence of blade deformation and its impact on the flow field. The structural deformations are computed using a modal summation approach, where the required modal matrix and resonant frequencies are extracted using Abaqus. The ALM and FE algorithms are being optimized to provide a reasonable balance between accuracy of prediction and computation time, particularly due to the sub-iterations required for blade deformation convergence. We also aim to present an analysis of the coupling between blade loading and deformation on the NREL 5MW turbine operating in the ABL. Supported by the DOE.

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