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Experimental Study of Near Wake of Wind Turbines

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Abstract : Near wake development of a wind turbine affects the aerodynamic loads on the tower and the wind turbine. Design considerations of both isolated wind turbines and wind farms must include unsteady wake flow conditions under which the turbines must operate. The consequent aerodynamic loads could lead to over design of wind turbines and adversely affect the cost of wind turbines and, in turn, the cost of energy produced by wind turbines. Reducing the weight of turbine rotors is particularly desirable since larger wind turbine rotors can be utilized without significantly increasing the cost of the supporting structure. Larger rotor diameters produce larger swept areas and consequently greater energy production from the wind thereby reducing the levelized cost of wind energy. To understand the development and structure of the near tower wake of a wind turbine, an experimental study was conducted to describe the flow field of the near wake for both upwind and downwind turbines. The study was conducted under controlled environment of a wind tunnel using a scaled model of a turbine. The NREL 5 MW reference wind turbine was used as a baseline design and was modified as necessary to design and build upwind and downwind scaled wind turbine models. This paper presents the results of the wind tunnel study using turbine models to quantify the near wake of upwind and downwind wind turbine configurations for various lengths of tower-to-turbine spacing. The variations of mean velocity and turbulence are measured using a computer-controlled, traversing hot wire probe. Additionally, smoke flow visualizations were conducted to qualitatively study the wake. The results show a more rapid dissipation of the near wake for an upwind configuration. The results can readily be incorporated into low fidelity system level turbine simulation tools to more accurately account for the wake on the aerodynamic loads of a upwind and downwind turbines.

Keywords : hot wire anemometry, near wake, upwind and downwind turbine. Hot wire anemometry, near wake, upwind and downwind turbine
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