Local turbulence parameterization improves the Jensen wake model and its implementation for power optimization of an operating wind farm

In this paper, a new calculation procedure to improve the accuracy of the Jensen wake model for operating wind farms is proposed. In this procedure, the wake decay constant is updated locally at each wind turbine based on the turbulence intensity measurement provided by the nacelle anemometer. This procedure was tested against experimental data at the Sole du Moulin Vieux (SMV) onshore wind farm in France and the Horns Rev-I offshore wind farm in Denmark. Results indicate that the wake deficit at each wind turbine is described more accurately than when using the original model, reducing the error from 15% to 20% to approximately 5%. Furthermore, this new model properly calibrated for the SMV wind farm is then used for coordinated control purposes. Assuming an axial induction control strategy, and following a model predictive approach, new power settings leading to an increased overall power production of the farm are derived. Power gains found are on the order of 2.5% for a two-wind-turbine case with close spacing and 1% to 1.5% for a row of five wind turbines with a larger spacing. Finally, the uncertainty of the updated Jensen model is quantified considering the model inputs. When checked against the predicted power gain, the uncertainty of the model estimations is seen to be excessive, reaching approximately 4%, which indicates the difficulty of field observations for such a gain. Nevertheless, the optimized settings are to be implemented during a field test campaign at SMV wind farm in the scope of the national project SMARTOOLE.