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TRACK: TECHNICAL TOPIC: Wakes

A FAST PARAMETERIZED WAKE-MODEL FOR LARGE WIND FARMS

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The paper describes a model aimed at depicting quantitative details in the speed deficit of turbine wakes down through a large wind farm believed to be important for power production estimation.

Besides volume- and momentum conservation the model is based on parameterized rules for wake expansion and interaction with ground or water surface. The parameterization involves the dependence on turbine operating characteristics and the effect of wakes overlapping each other.

The wake model has been developed using available relevant wind farm data, and the paper will include model results for speed deficit profiles compared to selected wind farm data.

The performance of large modern wind farms depends on details in the pattern of individual turbine wakes and their evolution through a wind farm due to different interactions, details believed to be important for power production estimation but so far not sufficiently well treated in wind power engineering software.

With the model described in this paper we aim at depicting the quantitative details in the wake-induced speed deficit distribution throughout a large wind farm, including the impact from interaction of the individual turbine wake with other, downwind turbines and their wakes, and with the ground or water surface. In order to keep the model simple and computationally fast we have focused on the most important features in the wake behaviour.

The model is based on volume- and momentum conservation in suitable control volumes and the parameterization regards evolution rules, applying to the individual wakes, (1) for free wake expansion; (2) for wake interaction with a downwind turbine, (3) for interaction between 2 or more overlapping wakes; and (4) for wake interaction with ground or water surface.

For each of the evolution rules the parameterization allows for dependence on wind turbine operating characteristics such as instantaneous power production and thrust on the rotor. In addition, wake-wake interaction is taken into account by allowing e.g. the free-wake expansion rule to depend on overlapping with another wake, and the characteristics of that wake.

The wake model has been developed with the use of available, relevant data from large wind farms, including the Danish ?Horns Rev? and ?Nysted? off-shore wind farms. The paper will include comparisons of model predictions of the variation of wind speed over a wind farm with data from a selection of the applied wind farms. The comparisons will indicate the precision and degree of details that can be achieved with this kind of wind farm wake model.

Finally, the possibility of using this wake model to predict the recovery of the wind speed in the downwind area of a wind farm will be treated by model comparison with measured data.