Wind farm production estimates

In this paper, the Dynamic Wake Meandering (DWM) model is applied for simulation of wind farm production. In addition to the numerical simulations, measured data have been analyzed in order to provide the basis for a full-scale verification of the model performance.

The basic idea behind the DWM model is to model the instationary wind farm flow characteristics by considering wind turbine wakes as passive tracers continuously emitted from the wind farm turbines each with a downstream transport process dictated by large scale turbulent eddies (lateral and vertical transportation; i.e. meandering) and Taylor advection.

For the present purpose, the DWM model has been implemented in the aeroelastic code HAWC2 [1], and the performance of the resulting model complex is mainly verified by comparing simulated and measured loads for the Dutch off-shore Egmond aan Zee wind farm [2]. This farm consists of 36 Vestas V90 turbine located outside the coast of the Netherlands. The simulations in this paper were done with a modified version of HAWC2 only including aerodynamics and a rigid rotor in order to reduce the simulation time. With this code a 10min simulation takes approximately 1 minute on a 3GHz pc. The turbine controller is fully implemented.

Initially, production estimates of a single turbine under free and wake conditions, respectively, are compared for (undisturbed) mean wind speeds ranging from 3m/s to 25m/s. The undisturbed situation refers to a wind direction bin defined as 270° ±5°, whereas the wake situation refers to the wind direction bin 319° ±5°. In the latter case, the investigated turbine operated in the wake of 6 upstream turbines, with the mean wind direction being equal to the orientation of the wind turbine row.

The production of the entire wind farm has been investigated for a full polar (i.e. as function of mean inflow wind direction). This investigation relates to a mean wind speed bin defined as 8m/s±1m/s. The impact of ambient turbulence intensity and turbine inter spacing on the production of a wind turbine operating under full wake conditions is investigated. Four different turbine inter spacings, ranging between 3.8 and 10.4 rotor diameters, are analyzed for ambient turbulence intensities varying between 2% and 20%. This analysis is based on full scale production data from three other wind farms Wieringermeer [3], Horns Rev [4] and Nysted [5]. A very satisfactory agreement between experimental data and predictions is observed.

This paper finally includes additionally an analysis of the production impact caused by atmospheric stability effects. For this study, atmospheric stability conditions are defined in terms of the Monin-Obukhov length. Three different stability classes, including stable, neutral and unstable atmospheric stratification, have been investigated.

General information
State: Published
Organisations: Department of Wind Energy, Aeroelastic Design, Fluid Mechanics
Contributors: Larsen, T. J., Larsen, G. C., Aagaard Madsen, H., Hansen, K. S.
Number of pages: 8
Publication date: 2012

Host publication information
Title of host publication: Proceedings of EWEA 2012 - European Wind Energy Conference & Exhibition
Publisher: European Wind Energy Association (EWEA)
Electronic versions:
WIND_FARM_PRODUCTION_ESTIMATES.pdf