EMS Annual Meeting Abstracts
Vol. 20, EMS2023-287, 2023, updated on 20 May 2024
https://doi.org/10.5194/ems2023-287
EMS Annual Meeting 2023

Aspects of wind power forecasting over the Finnish wind fleet considered as a single wind farm

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The share of wind energy sources in Finland was reasonably expanded over last years. It is foreseen that wind power generation will exceed 30 % of the total electricity production in Finland by 2030. The growing share of wind resources, however, brings more variability to the electricity grid raising the risk of imbalances between electricity production and consumption. The larger wind share also has stronger impact on electricity prices in Finland that are set daily at the Nordic energy trading stock Nordpool. To estimate wind power generation for coming days a probabilistic wind power forecasting system has been developed at the Finnish Meteorological Institute (FMI).

The system is based on the Meteorological Ensemble Prediction System (MEPS) HARMONIE, running operationally by the group of Nordic countries under MetCoOp cooperation project. Information on wind farms is provided by the Finnish Wind Power Association (FWPA). FWPA data essentially enables wind calculations for every Wind Turbine (WT) location. MEPS-based wind speed is interpolated to the WT hub heights at their locations and further corrected by applying a wake propagation model. The key advantages of the method are 1) the method exempts from the necessity of calculating wake interaction between adjacent wind farms, 2) wind direction variations within large-scale wind farms are considered.

The method requires both power curve and thrust coefficient (C_T) curve of installed WT models for calculating respectively power and wake-related losses. Power curves for new WT models are typically not available in open databases, whereas C_T curves are generally not available for most installed WT models. A statistical solution was developed at FMI to approximate both power and C_T curves. The method well approximates power and C_T curves of most of the models installed by 2022. New WT models of 4 MW or larger capacity are often equipped with a system that reduces power generation at wind speeds exceeding c.a. 15-18 m/s towards cut-off to prevent abrupt shutdown of the rotor. This feature of WTs was addressed in approximating both power and C_T curves, with preliminary results demonstrating reasonable improvement, specifically for C_T curves.

The FMI power forecasting system is somewhat struggling to properly include all new WT installations, because of the rapidly expanding installed capacity in Finland. Correction of the forecast is done using data on actual aggregated power generation and installed capacity provided by Fingrid, the Finnish Transmission System Operator. The overall agreement between forecasted and actual wind power production is satisfactory. However, a detailed analysis reveals some

seasonal and diurnal behavior, which can be approximated as a function of month, day's hour and forecast lead time. Power losses associated with downtime and icing can be accounted for by applying short-range correction.