EMS Annual Meeting Abstracts
Vol. 11, EMS2014-124, 2014
14th EMS / 10th ECAC

How do uncertainties of numerical weather forecasts propagate into power predictions for offshore wind farms?

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With the expansion of the renewable energy the requirements for power market, grid and energy supply are changing. More and more the generation of European energy is decentralized and highly variable since especially solar and wind energy potential are varying strongly with time. Against the background of 150GW of expected offshore wind capacity in Europe in 2030 it becomes more and more important to be able to predict precisely the potential producible energy of the next hours and days to ensure a stable energy supply. To be able to predict the power output of offshore wind farms, accurate weather forecasts especially of the wind speed and wind direction are necessary.

Therefore, hindcasts with the Weather Research and Forecasting (WRF) model of selected weather conditions have been validated against FINO1 met mast data to determine uncertainties of the simulations. The selected time periods of 2011 and 2012 represent weather pattern with low and high wind speeds for westerly wind directions. The comparisons showed that WRF underestimates high wind speeds and is not able to reproduce the turbulence intensity measured at FINO1.

Furthermore, power generation has been predicted with the Ainslie approach implemented in the engineering wake model FLaP (Wind Farm Layout Program) for measurements as well as for the hindcasts to determine how the uncertainties of the simulations propagate into the prediction of power. Hence, results for both inputs (hindcasts and measurements) have been compared to measured power at the northern part of the wind farm Alpha Ventus in the German North Sea. Differences of some meters per second for the wind speed and up to 50 degrees in wind direction can lead to instantaneous power prediction errors of several MW and to accumulated prediction errors of hundreds of MW for a 24-hour hindcast.