Possible Power Estimation of Down-Regulated Offshore Wind Power Plants.

The penetration of offshore wind power is continuously increasing in the Northern European grids. To assure safety in the operation of the power system, wind power plants are required to provide ancillary services, including reserve power attained through down-regulating the wind farm from its maximum possible power. Currently, there is neither a standardised regulation by the TSOs nor a verified approach regarding the wind farm scale available power estimation. Here we describe an industrially applicable, validated method for the real-time estimation of the possible power of an offshore wind power plant. The developed procedure, the PossPOW algorithm, can also be used in the wind farm control as it yields a real-time wind farm power curve. The modern wind turbines have a possible power signal at the turbine level and the current state of the art is to aggregate those signals to achieve the wind farm scale production capacity. However, the summation of these individual signals is simply an over-estimation for the wind power plant, due to reduced wake losses during curtailment. The determination of the possible power with the PossPOW algorithm works as follows: firstly the second-wise upstream wind speed is estimated, since it is not affected by any wake. Then the upstream wind is introduced into the wake model, adjusted for the same time resolution, to simulate the power losses that would occur during nominal operation. The PossPOW algorithm uses only 1 Hz turbine data as inputs, namely power, pitch angle, and rotational speed. The method is validated in Horns Rev-I, Lillgrund and Thanet offshore wind farms, together with NREL 5MW simulations. The reduced wake is replaced by the wake model which estimates the velocity deficit for nominal operation. An evaluation of the existing wake models show that the suitable models are tuned for 10-min averaged data. Therefore, the Larsen wake model is re-calibrated for real-time using Thanet data, validated in Horns Rev-I and then implemented in farm scale considering the local turbulence, time delay and meandering. The validation of the algorithm is performed using experiments in Horns Rev-I where two of the upstream turbines are curtailed. The PossPOW algorithm is compared to the current practice and shown to perform significantly better, according to the error scores stipulated in the Danish grid code.

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