



## Experimental verification of a real-time power curve for downregulated offshore wind power plants

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Wind farm scale experiments with wakes under downregulation have been initiated in Horns Rev wind farm in the frame of the PossPOW project (see [posspow.dtu.dk](http://posspow.dtu.dk)). The experiments will be compared with the results of the calibrated GCLarsen wake model for real-time which is used not only to obtain real-time power curve but also to estimate the available power in wind farm level. Available (or Possible) Power is the power that a down-regulated (or curtailed) turbine or a wind power plant would produce if it were to operate in normal operational conditions and it is becoming more of particular interest due to increasing number of curtailment periods. Currently, the Transmission System Operators (TSOs) have no real way to determine exactly the available power of a down-regulated wind farm and the PossPOW project is addressing that need.

What makes available power calculation interesting at the wind farm level is the change in the wake characteristics for different operational states. Even though the single turbine level available power is easily estimated, the sum of those signals from all turbines in a wind farm overestimates the power since the wake losses significantly decrease during curtailment. In order to calculate that effect, the turbine wind speed is estimated real-time from the produced power, the pitch angle and the rotor speed using a proximate  $C_p$  curve. A real-time wake estimation of normal operation is then performed and advected to the next downstream turbine, and so on until the entire wind farm is calculated.

The estimation of the rotor effective wind speed, the parameterization of the GCLarsen wake model for real-time use (i.e. 1-sec data from Horns Rev and Thanet) and the details of the advection are the topic can be found in Göcmen et al. [1] Here we plan to describe the experiments using the Horns Rev wind farm and hopefully present the first validation results.

Assuming similarity of the wind speeds between neighbouring rows of turbines, the power produced by the second turbines in the line can be compared when some of the front row turbines are down-regulated. To get a good signal, a trigger mechanism is employed which assures that the experiment is only started if the wind is blowing directly down the line of turbines, and in a strength which is below rated power. The design of the experiments is finalized and the triggers have been introduced to the controller – they will run during the first quarter of 2015.

A verified algorithm could be employed by manufacturers and operators world-wide, both for the determination of compensation payments during mandated down-regulation as well as for the exact determination of reserve power for use in ancillary services markets.

[1] T. Göcmen Bozkurt, G. Giebel, P. Rethore, M. Mirzaei, N. Poulsen, Effective wind speed estimation and real-time wake model re-calibration for down-regulated turbines, in: Wind Integration Workshop 2014.