WakeBlaster simulates the waked flow in a wind farm using a specialised 3D CFD solver. The software has been developed by ProPlanEn in 2017 to meet performance requirements of the wind energy industry. ProPlanEn has validated the model with many years of wind speed measurements and production data from more than 15 wind farms.

WAKEBLASTER VALIDATION – LILLGRUND OFFSHORE WIND FARM

We present in this case study the validation of WakeBlaster against production data from one specific wind farm the Lillgrund offshore wind farm. The wind farm features include inter-turbine spacing of 3.3 D (diameters) on one symmetry axis and 4.3 D on the other.

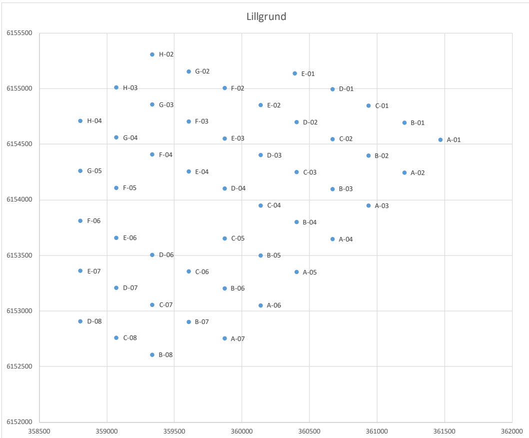

Figure 1: Lillgrund offshore wind farm layout, for details see [1-3]. The wind farm consists of 46 x SWT-2.3 wind turbines with 92.6 m diameter (D) and 65 m hub height.

Figure 2: Lillgrund offshore wind farm location in the Oresund between Copenhagen, Denmark and Malmo, Sweden. Distance to the nearest coast is around 6 km.

Note: We are presenting on the next pages flow cases for selected wind speeds and directions. The wake losses for these flow cases are not representative for the annual array losses of a wind farm.

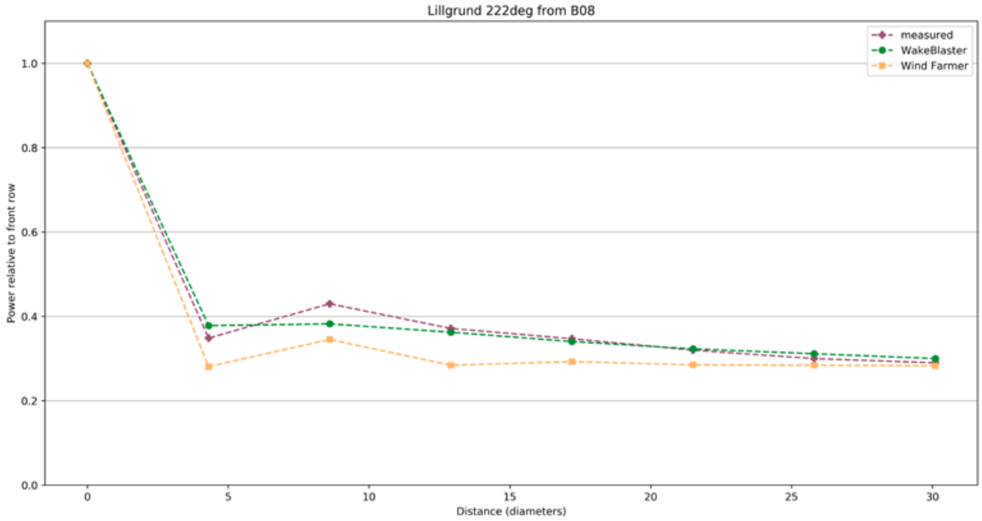

Figure 2: Development along a linear sequence of wind turbines at 3.3 D spacing [1]. The power deficit reaches an equilibrium with distance due to the induced turbulence. This effect is captured well by both the 2D model in WindFarmer and the new WakeBlaster 3D model.

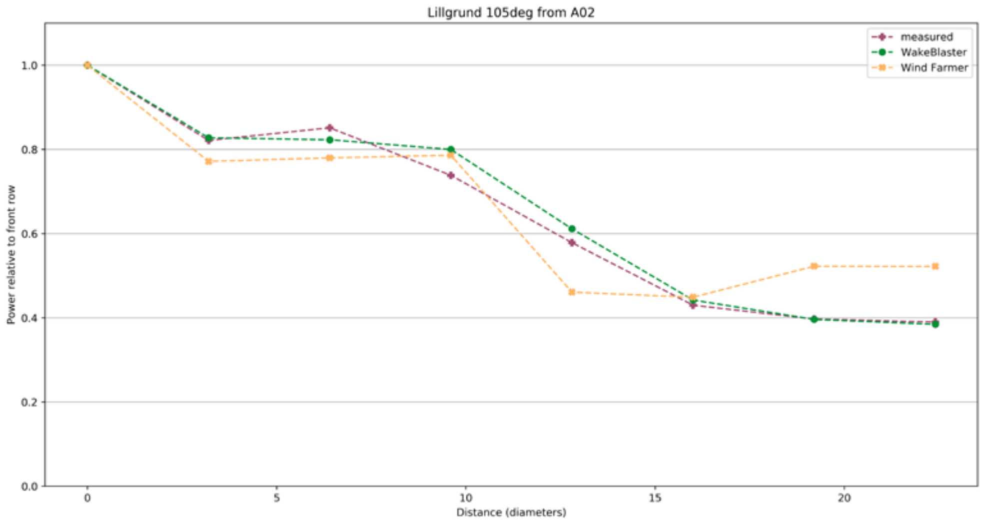

Figure 3: The figure shows for a wind direction of 105 degrees the relative power deficit for downstream turbines in the wind farm [1]. The turbines are alighted at 15 degrees relative to the wind direction such that they are partially waked. The 3D nature of the model allows WakeBlaster to accurately represents the merging of several overlapping non-co-axial wakes.

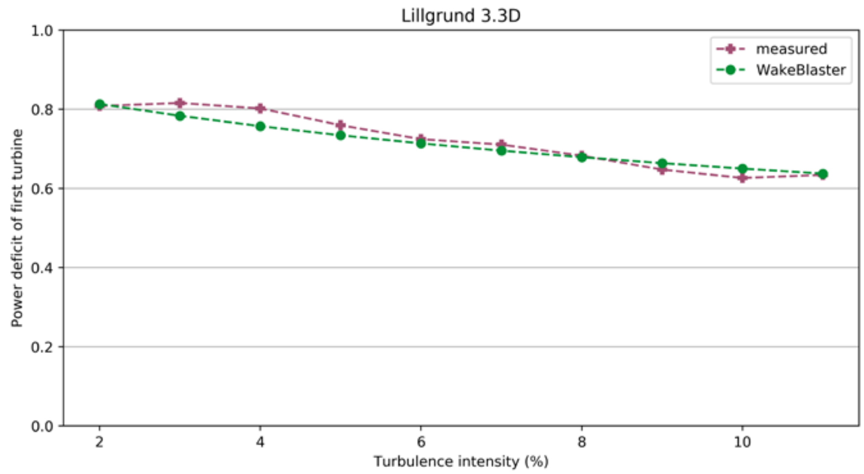

Figure 4: WakeBlaster model and observations [1] of the maximum power deficit downstream of a single wake as function of ambient turbulence intensity. WakeBlaster reacts to changes to in turbulence intensity and ambient wind shear, driven by atmospheric stability.

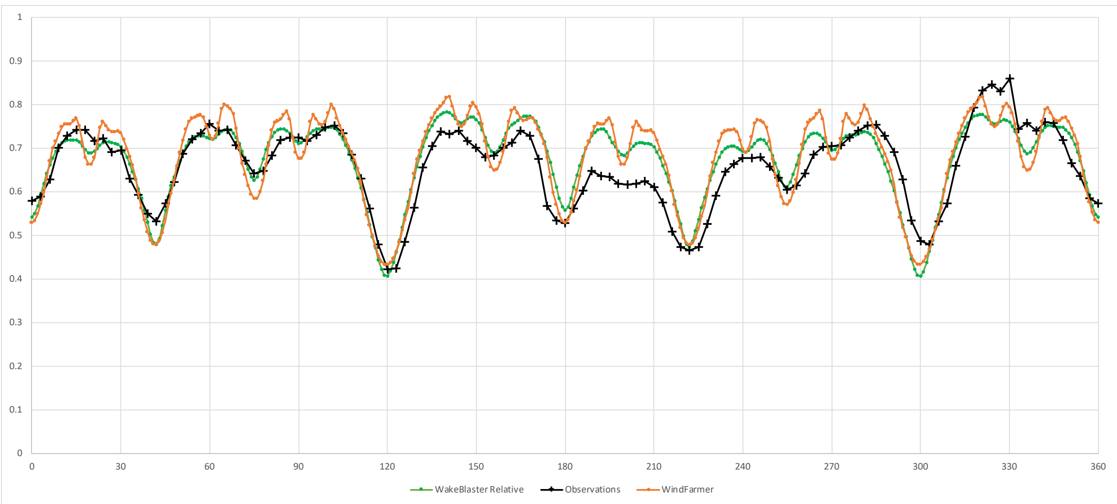

Figure: Lillgrund 360 degrees wind farm performance, data from [1]. Comparing WindFarmer and WakeBlaster predicted wake losses for a wind speed of 8 m/s and 5 degrees resolution. Both models show a good representation of the wind farm wakes. The 3D model WakeBlaster shows excellent results for the important direction sectors with partially overlapping wakes.

[1] Patrick Moriarty et al. IEA-TASK 31 Wakebench: Towards a protocol for wind farm flow model evaluation. Part 2 wind farm wake models. The science of Making Torque from Wind 2014, Journal of Physics: Conference Series 524 (2014), doi:10.1088/1742-6596/524/1/012185.

[2] Charlotte Bay Hasager et al. EERA DTOC (Design Tools for Offshore wind farm Clusters) final summary report, D7.20, European Research Alliance (EERA), 2015

[3] Jan Ake Dahlberg, Assessment of the Lillgrund Wind Farm: Power Performance Wake Effects, Vattenfall Vindkraft AB, 6_1 LG Pilot Report, Sept. 2009

Acknowledgements: The WakeBlaster development was co-funded by the UK's innovation agency, Innovate UK. The Lillgrund wind farm was evaluated as part of IEA Task 31 Wakebench.