TotalControl Newsletter 2

The TotalControl project is in its third year, and the first results are ticking in. In particular, we will show those results:

- A novel quick but accurate model for the atmospheric boundary layer in presence of a large wind farm
- The reduction of electrical losses in the wind power plant by control of the reactive power of the individual turbines
- Cost models for the value of life extension through wind farm control
- The tests of two different control concepts at the 7MW test turbine at ORE Catapult

For more information on those and other topics, please come to the TotalControl workshop on December 10, see this announcement on our website (or rewatch it on the WindFarmControl YouTube channel).

December 2020

About TotalControl

The ambition of the TotalControl project is to develop the next generation of wind power plant (WPP) control tools, improving both WPP control itself and the collaboration between wind turbine (WT) and WPP control. To do this, TotalControl will use high-fidelity simulation and design environments that include detailed time resolved flow field modelling, nonlinear flexible multi-body representations of turbines, and detailed power grid models.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727680.

Website: www.totalcontrolproject.eu

A novel Three Layer Model for the Atmospheric Boundary Layer in presence of a wind farm

Large Eddy Simulations of the atmosphere are quite accurate, but very time consuming. For relevance in practical applications, it would be better to have a simple yet sufficiently accurate model of the atmospheric flow around a wind farm. On the background of their own LES tool SP-Wind, KU Leuven has developed such a model, partitioning the atmosphere vertically in a wind farm layer, where the wind turbine forces are felt directly, an upper layer, which is only indirectly affected by the wind farm, and above this, the free atmosphere. This model is called the Three Layer Model, and was recently both validated and coupled with a Gaussian wake model. Farm wakes compare favourably with the LES code, but require only seconds in contrast to hours or days for the LES calculations.

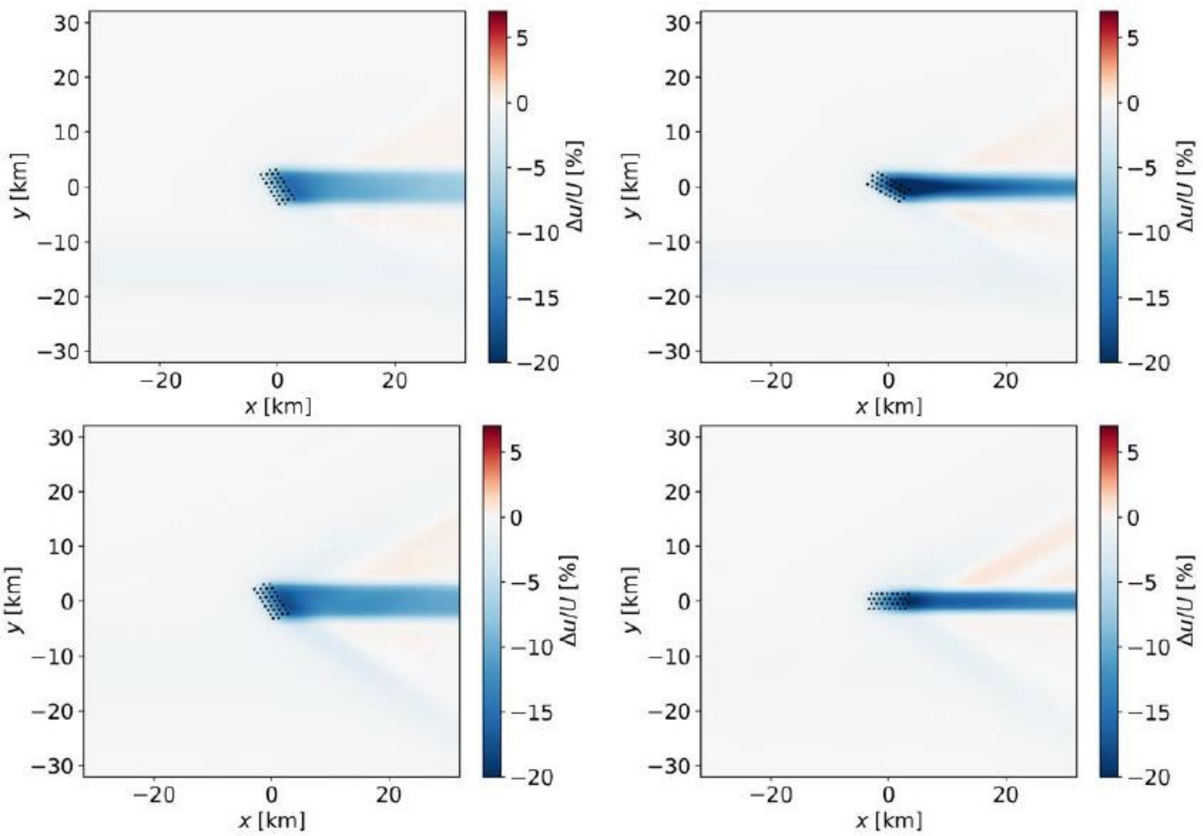

Figure 1: Velocity deficits from TLM, for different inflow conditions and farm orientations.

Coupled Gaussian wake-merging model, Deliverable D1.8 of the TotalControl project. 9 p., 2020

Reduction of electrical losses by up to 6% by control of reactive power

In a wind farm like Lillgrund (48 turbines, 110MW in total), the electrical losses between the turbines and the transformer station during one high-wind day were 1.3% of the total energy produced. Through optimised control of the reactive power and voltage settings in the individual turbines, up to 6% of those losses could be avoided in a simulation. For a medium-wind and low-wind day, the savings were lower, as the attainable loss reduction scales with the actual power. Overall, 6.2% of total losses can be reduced which can amount to 6 GWh over lifetime of the wind farm (assumed 25 years).

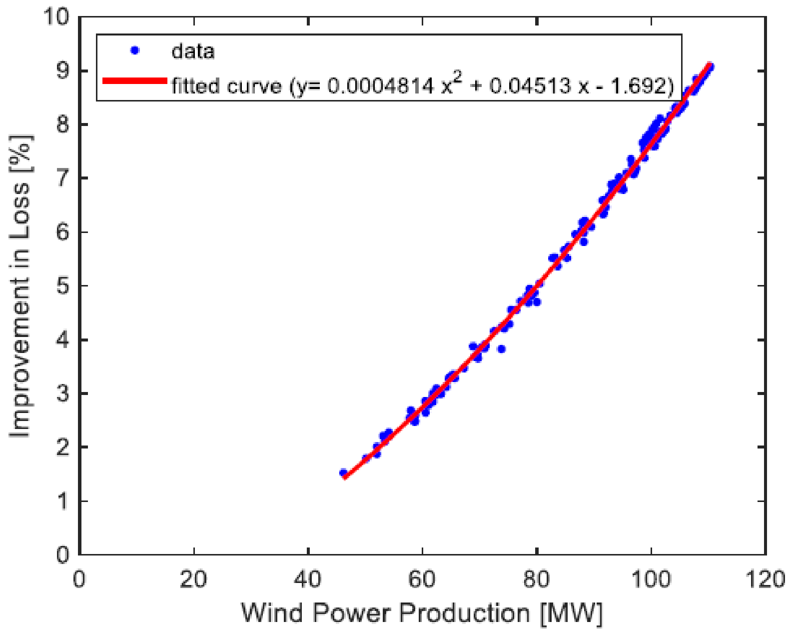

Figure 2: Improvement in active power loss against power production during a high-wind day.

Optimization of reactive power dispatch, Deliverable D2.4 of the TotalControl project. 22 p., 2019

Cost models for the value of lifetime extension through WFC

There is a large potential for O&M cost reduction by using advanced control strategies that reduce the loads and increase the lifetime of the components. A collection of techniques used for the estimation of the remaining lifetime is found in this report. The TotalControl project detailed the potential lifetime impact on wind farms on a per-component basis, as different components degrade by different mechanisms. The result is an Excel based tool that computes the O&M cost and energy production of a wind farm using wake turbulence and wake deficit computations along with the damage equivalent loads and power production. Further work can use this tool to balance the benefits in reduced O&M cost from lowered fatigue with the effects on energy production and wind farm ancillary services. This means that the models presented in this deliverable report can be used in TotalControl to optimize WT and WPP control strategies.

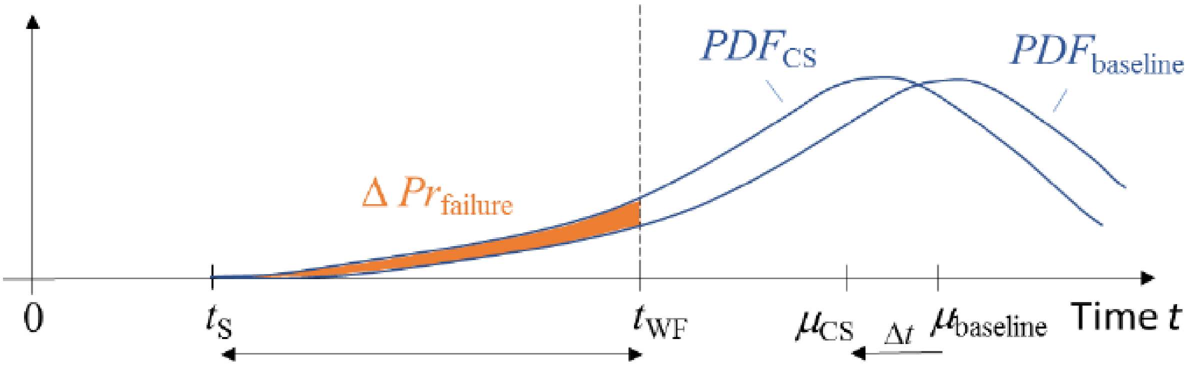

Figure 3: Changed failure probability due to changed operational strategy.

[Cost Model for fatigue degradation and O&M](), Deliverable D2.1 of the TotalControl project. 76 p., 2018
[SCADA-based condition monitoring and fatigue estimation](), Deliverable D2.2 of the TotalControl project. 31 p., 2019

Reduction of tower base loads using lidar assisted control and individual pitch control

Field tests on ORE Catapult's 7MW turbine at Levenmouth will include two load reducing technologies: LiDAR-assisted control and individual pitch control. The LiDAR installation and a snapshot scan of a wake can be seen in Figures 4 and 5. Simulations have shown that LiDAR-assisted control can reduce tower base bending moments by 7 - 9% in above-rated wind speeds as shown in Figure 6.

Figure 4: DTU SpinnerLidar installed on the Levenmouth turbine nacelle roof in Scotland, measuring the rotor inflow conditions.
Photo by Elliot Simon.

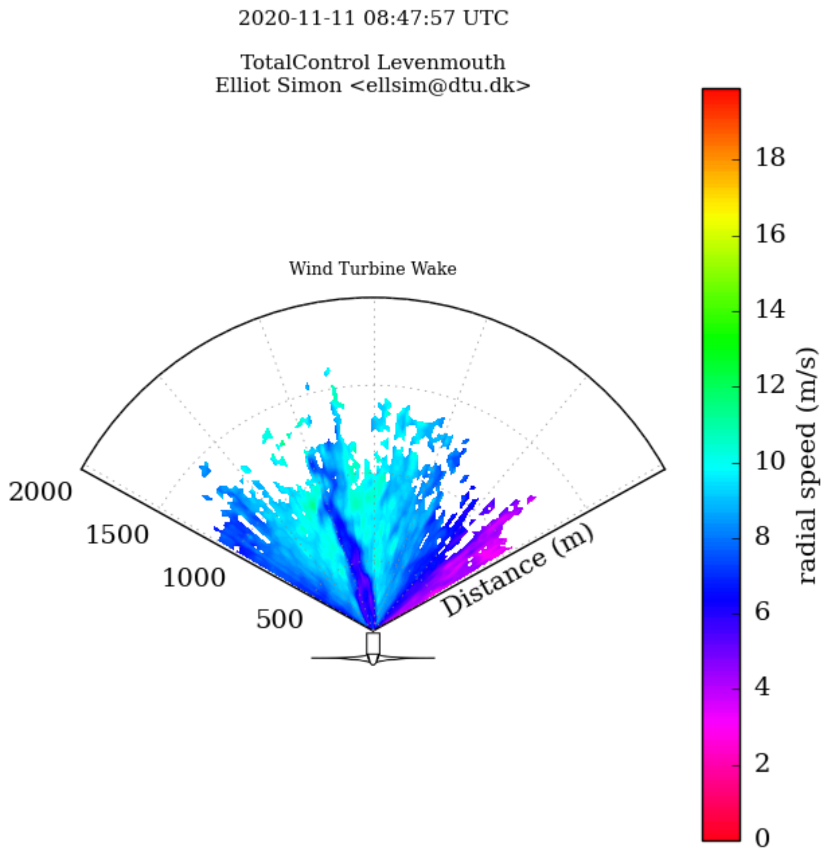

Figure 5: Single lidar scan of the LDT wake during a 20 degree yaw misalignment test. Created by Elliot Simon.

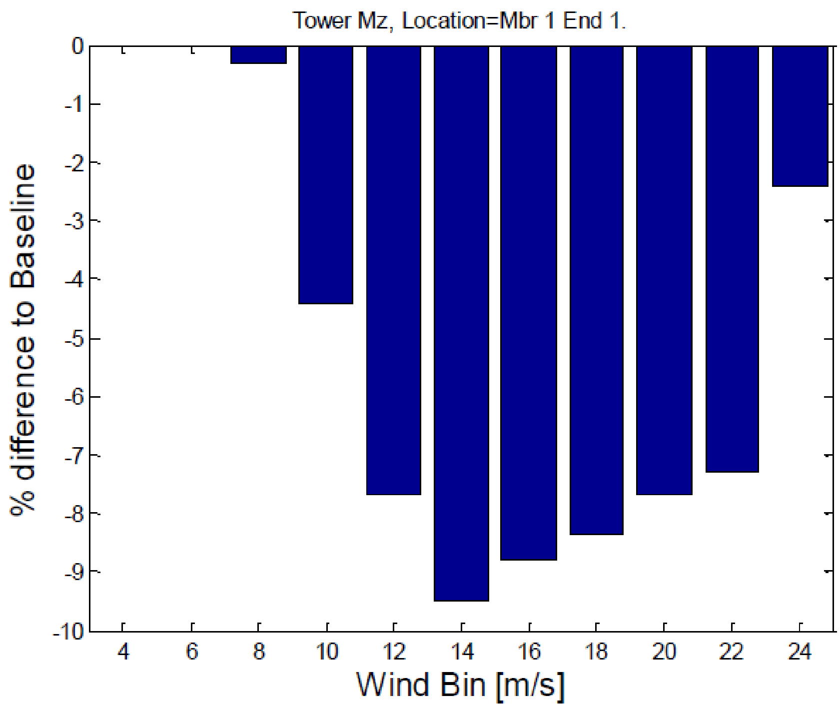

Figure 6: Damage Equivalent Load - average Reduction in Tower Base fore-aft moment (m=4) from LiDAR assisted control.

Individual pitch control is already implemented on the Levenmouth turbine, using blade root strain gauges. However, these can be replaced by potentially cheaper and more reliable strain gauges located at the tower top. Simulations have demonstrated that the achieved load reductions should be very similar, as shown in Figure 7.

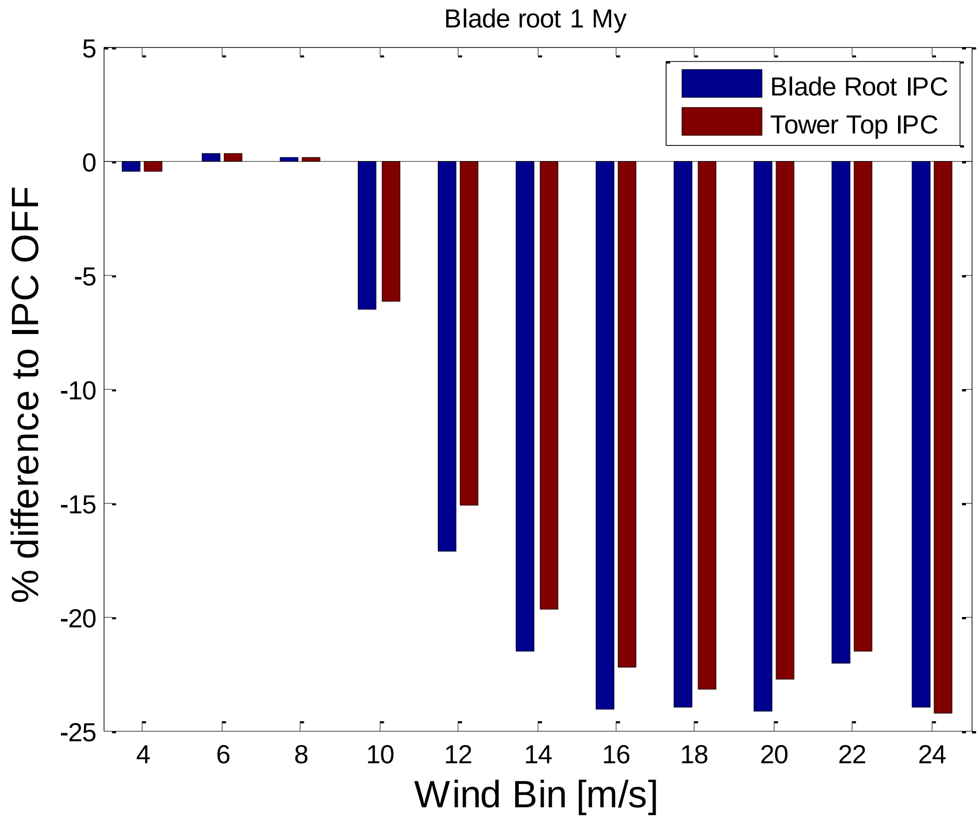

Figure 7: Damage Equivalent Load - average Reduction in blade 1 root My DEL (m=10) using blade root or tower top strain gauges.