Advanced integrated control of large-scale wind power plants and wind turbines

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Reducing operating costs
Enhancing WPP capability
Maximizing the yield

Current state of the art wind power plant (WPP) controllers operate wind turbines (WTs) independently as individual machines, thus dispatching the WTs’ set points in an equal manner to all of them. To achieve optimal WPP control, three aspects need to be addressed:

- Maximizing the yield (power production) balanced against turbine mechanical loading and electricity price
- Enhancing WPP capability to provide ancillary services (primary, secondary, and tertiary reserves), and
- Reducing operating costs (i.e., reduced fatigue load degradation of WTs and O&M requirement) over the lifetime of the WPP.

The goal of TotalControl is to move the WPP controller design philosophy from individual optimization of WT operation to a coordinated optimization of the overall WPP performance. The TotalControl project aims to achieve this by developing and validating advanced integrated WPP/WT control schemes conditioned on grid demands and wind turbine fatigue damage limits. For developing and testing of the different WPP controllers, a range of high-fidelity and medium-fidelity simulation models are used. These models are already available in the consortium, but will be thoroughly validated against full-scale measurements in the Lillgrund WPP. Due to the complexity and multi-scale nature of WPP flow dynamics, the high-fidelity CFD-based models are very expensive in simulation time, e.g., requiring supercomputing, and therefore not well suited as control design models.

Wind farm control time scales

TotalControl is built on a hierarchy of controllers, each reacting at different time scales and control time steps. At the slowest control level the WPP is quasi-statically adapting its WT active and reactive power set points and WT yaw angles, adapting to slowly changing environmental conditions and market elements. A second control level is the WT controller, accepting power set points from the quasi-steady control levels. Finally, a fast WPP controller is considered which responds dynamically to faster events (turbulent gusts, requests for ancillary services, etc.) and uses feedback from the WTs. This controller uses model-predictive control for prediction of dynamic wake behavior and impacts on turbine loads. The dynamic WPP controller also contains a direct control level related to the WPP internal power grid.

Lillgrund tests

Vattenfalls Lillgrund wind farm, where a full-scale test will be run, monitored with two synchronized lidars.

Levenmouth tests

ORE Catapult’s Samsung 7MW prototype turbine at Levenmouth, to be used for turbine control trials.

References

www.TotalControlProject.eu

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