PO.232

TotalControl

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

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Abstract

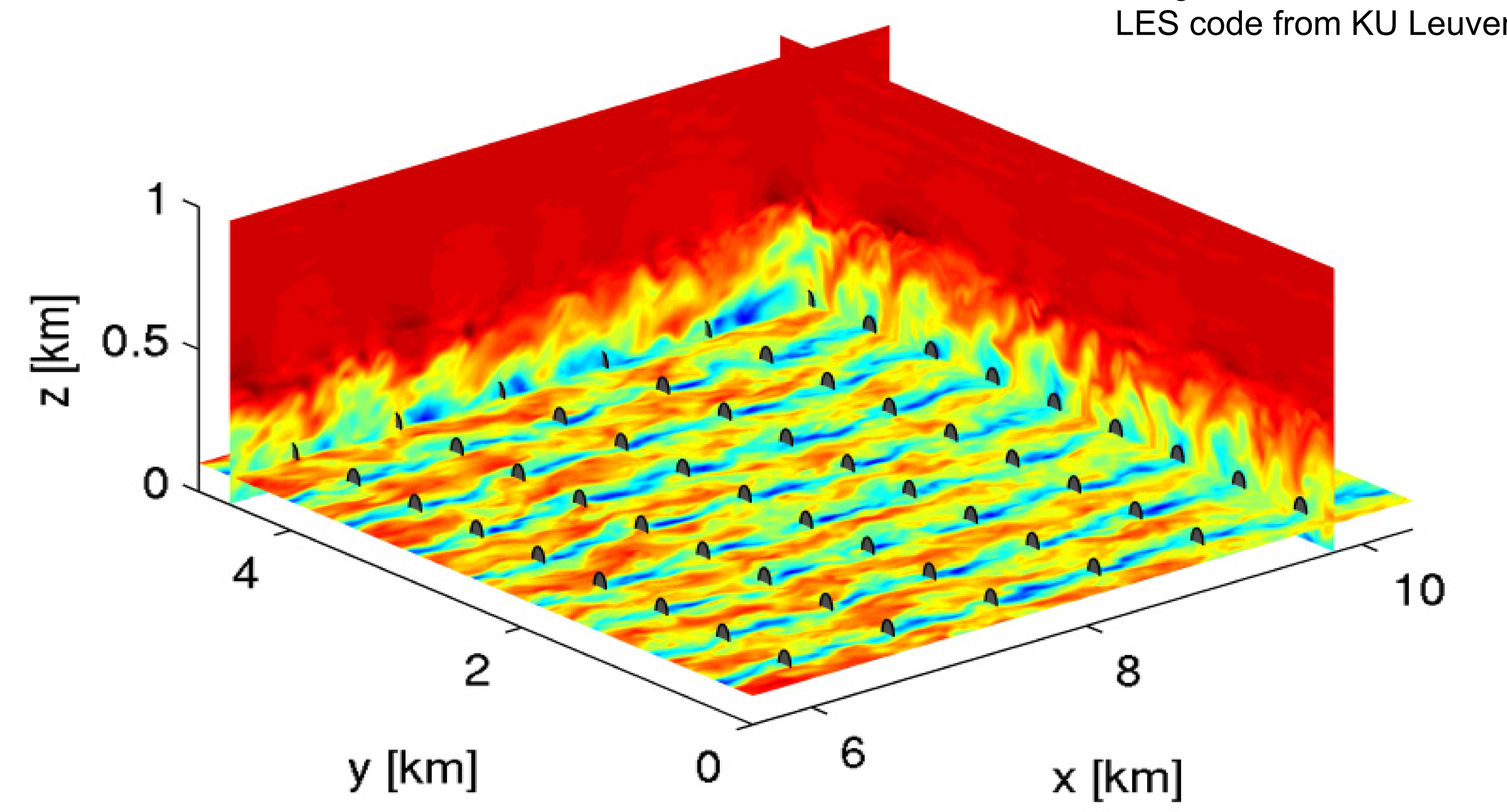
Current state of the art wind power plant (WPP) controllers operate wind turbines (WTs) independently as individual machines, thus dispatching the WTs' set points in an equal manner to all of them. To achieve optimal WPP control, three aspects need to be addressed:

- **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.

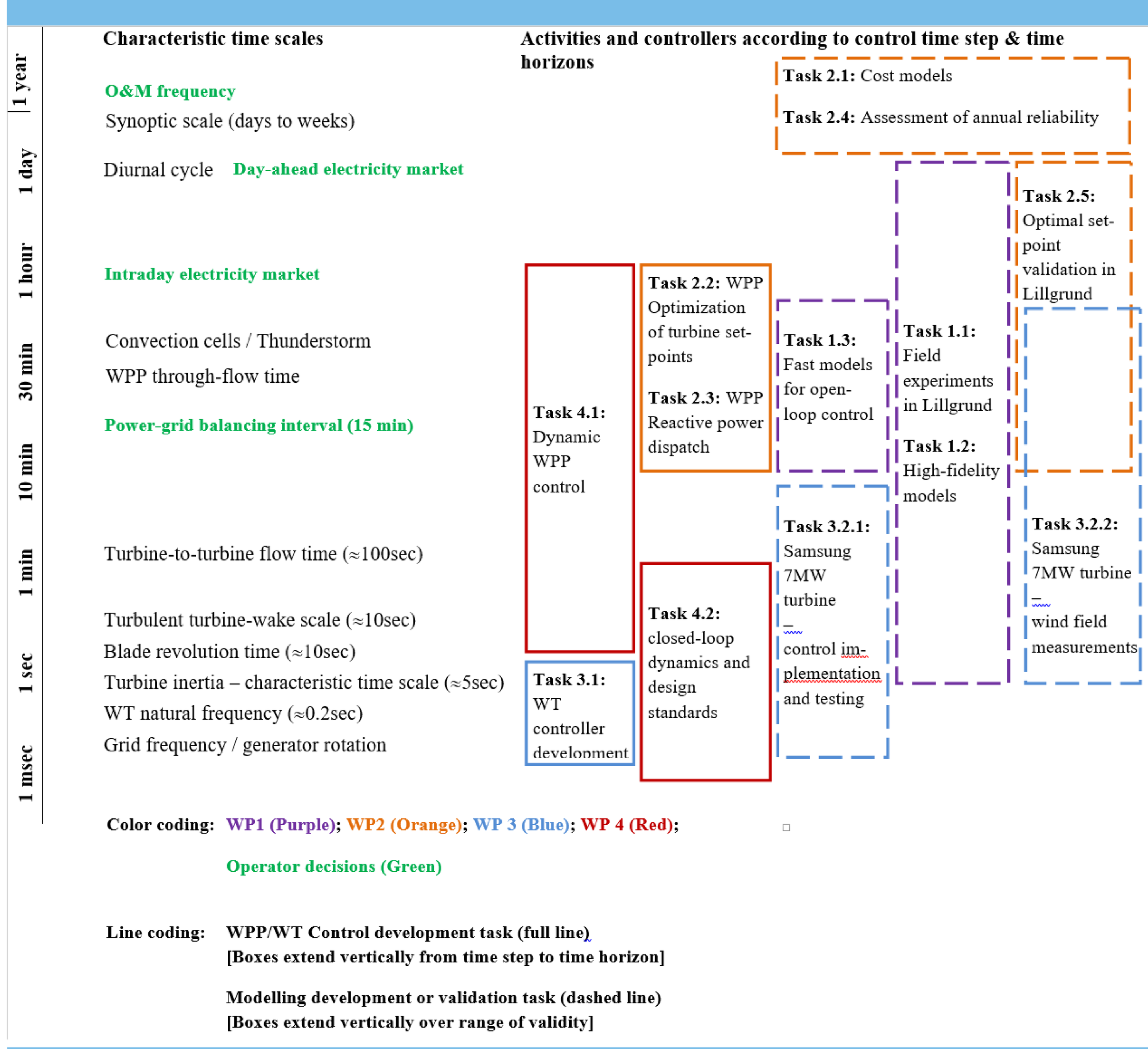
The goal of TotalControl is to move the WPP controller design philosophy from *individual* optimization of WT operation to a *coordinated* optimization of the overall WPP performance. The TotalControl project aims to achieve this by developing and validating advanced *integrated* WPP/WT control schemes conditioned on grid demandsand 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.

Multi-fidelity flow modelling

Image source: SP Wind, a LES code from KU Leuven.



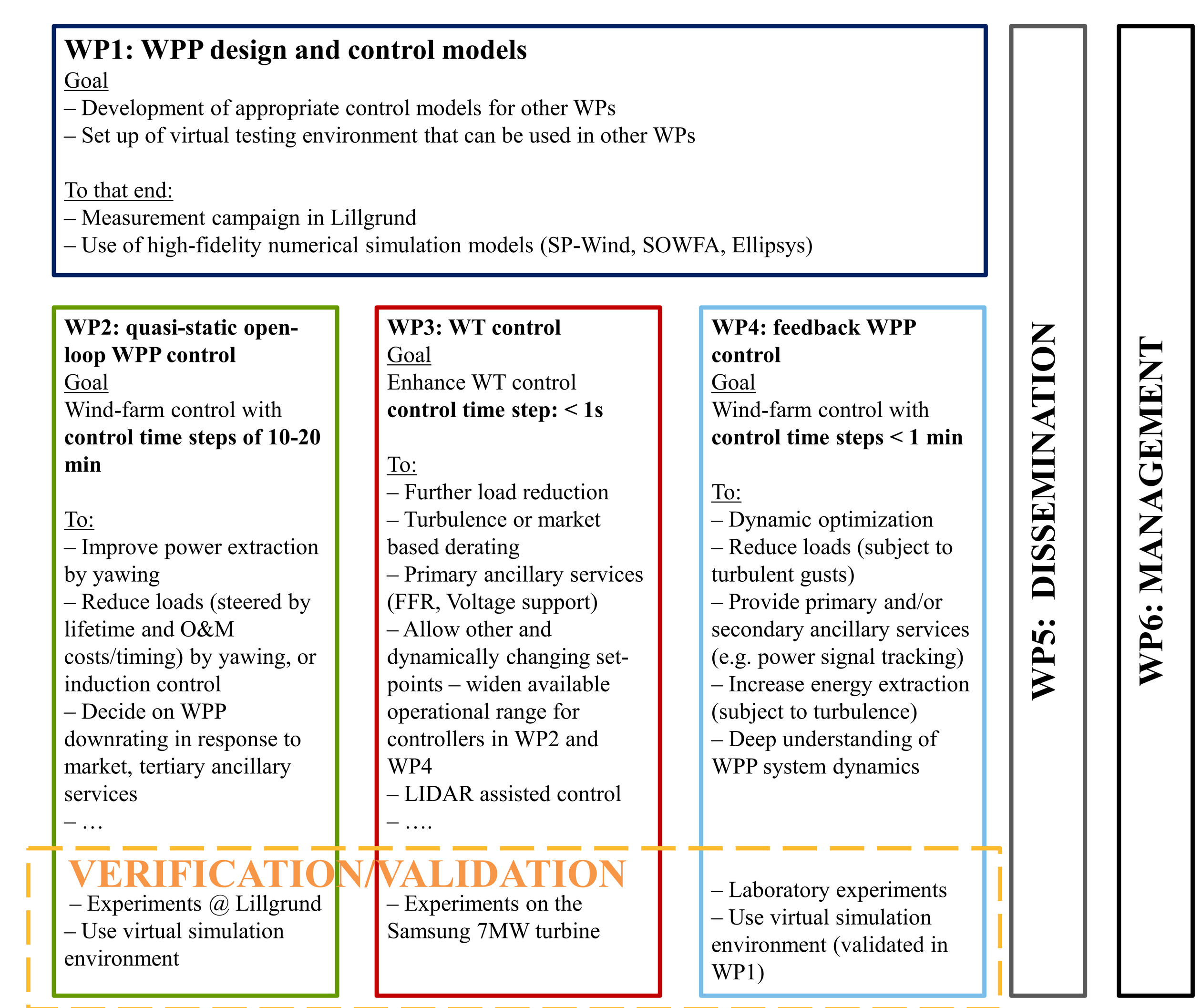
Wind farm control time scales



Project set-up

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.

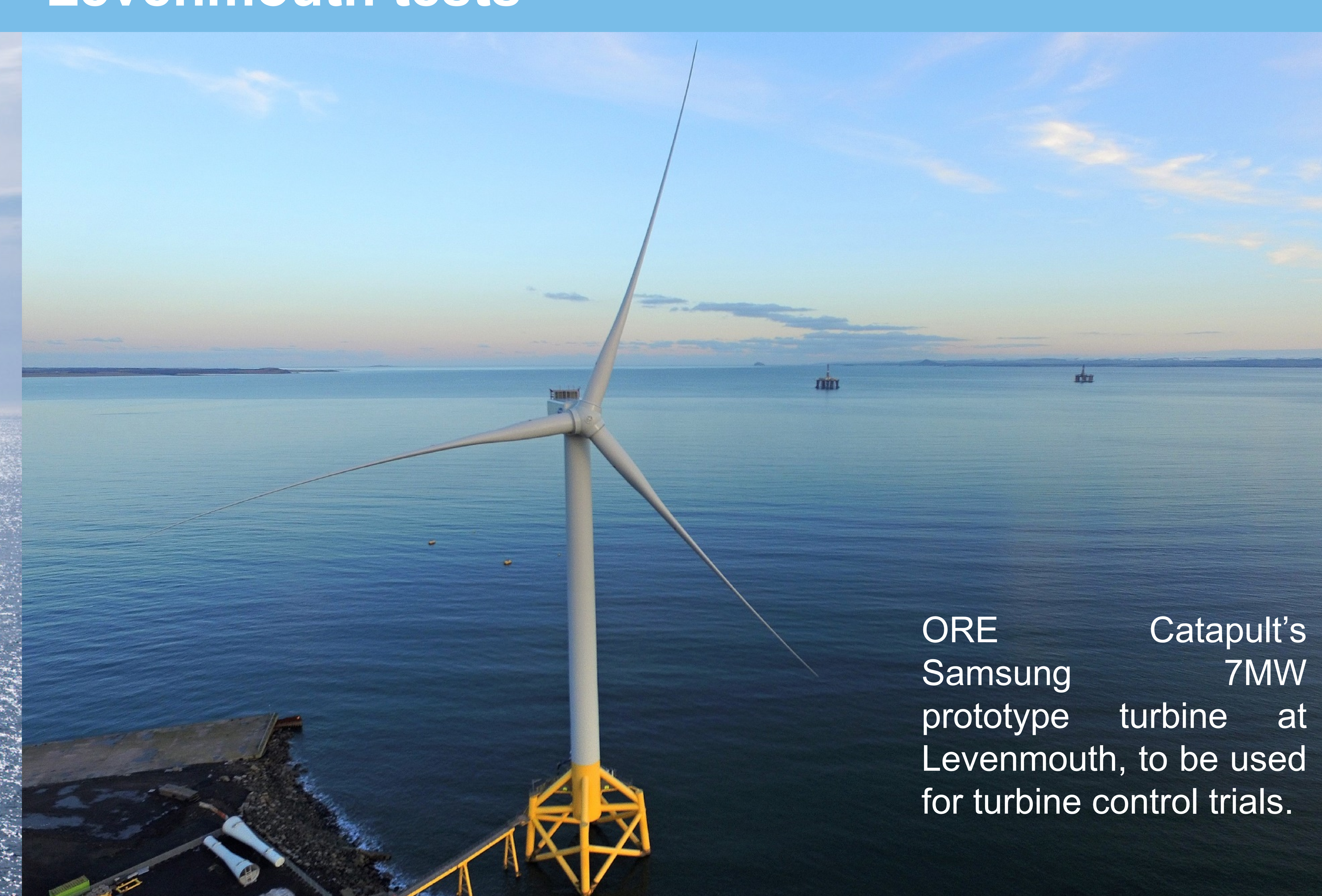


Lillgrund tests

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

Lillgrund image © www.siemens.com/press, Lidar scan pattern from Windscanner.eu.

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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Meet us at B1.EG 313 (DTU), B4.EG 330 (DNV GL), B1.OG 308 (ORE Catapult), B6 470 (Siemens Gamesa), or B6 339 (Vattenfall)!

Please also see poster 233 (the Concert project).