Challenge 2.5

Floating wind farms

Park-level control	Long-term	Medium priority

Description and scope

The plant supervisory controller can influence the operation of each individual wind turbine. Typically this takes the form of power set-point commands, although it is also possible to envision a more intrusive plant controller that dictates things like the target rotor speed or yaw angle.

The primary objective of the plant controller is to provide grid support functions, making the wind turbines act collectively, from the grid's perspective, as a virtual power plant.

By optimally coordinating the operation of the wind turbines, it is also possible to marginally increase production, or to reduce detrimental effects like wake turbulence. These secondary control objectives are difficult to attain because the expected effects are small, and the signals must propagate through the noisy, turbulent atmospheric boundary layer. A lack of suitable experimental facilities between the wind tunnel scale (plants with 10 cm-scale turbines) and full scale (plants with 100 m-scale turbines) hinders the development of novel plant control algorithms.

Floating wind turbines present special challenges for a plant controller. For example, if all the turbines are given a power command simultaneously, then, due to the low-frequency platform modes, this will tend to set them all in synchronous motion, which could result in unwanted power fluctuations.

Recommended research actions

- Develop holistic models of large-scale floating wind power plants that can be used in the design and simulation of plant control algorithms.
- Increase influence of accumulated turbine control actions on the atmospheric boundary layer, in particular how perturbations to the flow propagate downstream through large plants.
- Develop reduced-order models capable of predicting these effects in real-time.
- Develop optimal control algorithms that can detect changes in the flow conditions, such as wake turbulence, and adapt the operation of the turbines accordingly.
- Investigate and compare benefits and limitations of possible system architectures, including model-based, adaptive, and data-driven/machine-learning.
- Quantify the potential benefits of additional sensor data like lidars, as well as short-term wind forecasts.

Milestones

- Demonstration of a wind turbine as a wind speed observer, and reconstruct an estimate of the atmospheric flow from these observations. This could provide the capability to anticipate and react optimally to changing weather conditions, like the passage of weather fronts.
- Research on wind plant control would benefit from an experimental facility, representing a large wind power plant (>50 turbines) at a small scale (1 to 10 m diameter rotors), where different control algorithms could be tested and demonstrated.