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EXPERIMENTAL ANALYSIS OF THE DYNAMIC RESPONSE AND CONTROL OF A FLOATING WIND TURBINE USING A HYBRID MODELLING APPROACH

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ABSTRACT

The experimental modelling of floating offshore wind turbines (FOWTs) at reduced scales is necessary to investigate strongly nonlinear problems, and validate simulation tools and concepts. To overcome scaling incompatibilities between hydrodynamic and aerodynamic loads in an ocean engineering wave tank, real-time hybrid-modelling methodologies have been developed over the last few years in various research facilities. In such methodologies, the aerodynamic loads are obtained by a dedicated numerical model and applied by a single or a set of actuators, in parallel to the wave tank experiment that provides the hydrodynamic loads and structure response, while data is exchanged between both domains.

We present here some results of SoftWind, a the software-in-the-loop (SIL) solution, which has been developed in Centrale Nantes (France) to study the coupled response of floating wind turbines.

A FOWT model, composed of the DTU 10 MW wind turbine mounted on a spar platform, was designed with an actuator at the top of the tower to model the aerodynamic loads on the rotor. These loads are calculated using the simulation tool OpenFAST and applied in real time by an electric ducted fan. A feedback controller ensures the accuracy of the force applied by this thruster. A particular focus is made on the calibration of this controller, to enhance its performance while avoiding the excitation of structural modes of the nacelle, which are not present on the full-scale wind turbine.

The OpenFAST tool can run Blade Element Momentum simulations of the turbine, including steady or turbulent wind fields, while the hydrodynamic and ocean engineering wave tank of Centrale Nantes can physically generate complex, long or short-crested, sea-states. The chosen FOWT can hence be tested in realistic environmental conditions.

This research device allowed to test innovative control laws for FOWTs and investigate the system's hydro-aero-elastic coupled response in various environmental conditions. It showed good performances and a satisfactory agreement with numerical simulations made with various numerical tools. The measured data provides a relevant database for the validation of coupled simulation tools for FOWTs, including higher-fidelity hydrodynamic models.