

## D7.9 Guidance and Recommended Methods for Hybrid/HIL-based FOWT Experimental Testing

Model testing is an important step in the design process of floating offshore wind turbines and is used for global and partial system verification and characterisation, validation of numerical models, and estimation of extreme loads and responses.

Model testing in hydrodynamic facilities with focus on hydrodynamics only can be used for component testing, marine operations, and partial system identification where simplifications have to be assessed carefully. Model tests in wind tunnels have traditionally been used for understanding complex aerodynamic phenomena at the wind turbine level like dynamic stall and 3D rotational effects, but also at a larger scale like the wake interference for wind turbines operating in array configurations typical of wind farms or for the development of advanced control logics at the level of the wind farms.

For global system verification, validation of numerical codes, system characterisation and estimation of extreme loads and responses, it is advised to model the FOWT as closely as possible. Due to the challenges related to generation of high-quality wind and waves, scaling incompatibility and model construction limitations, the real-time hybrid or HIL<sup>1</sup> approach for performing true-to-scale model testing with FOWT is appealing and can be used in a wind tunnel or an ocean basin.

The main advantages of performing HIL model tests in a wind tunnel over full physical model tests in an ocean basin is the increased control over the wind field. HIL model test in a wind tunnel can be used in open-loop (i.e. forced motion) for calibration and validation of aerodynamic models, and in closed-loop mode (measured aerodynamic loads are used as input to the numerical model) for preliminary tuning of the wind turbine controller if performed before ocean basin tests. Advanced tuning of the wind turbine controller can be performed if the numerical model for simulating the platform dynamics has been calibrated previously.

Real-Time Hybrid Model tests in an Ocean Basin enables testing of FOWT. The limitations of classical physical tests due to scaling issues, model construction, and wind generation are removed allowing to test with a true-to-scale model, under realistic environmental conditions (irregular waves with turbulent wind). Real-Time Hybrid Model tests of FOWT in an ocean basin can be used for final system verification, which requires modelling of the complete system, as well as system development such as controller tuning. Validated numerical models for the calculation of the aerodynamic loads are required. Additionally, the tests can be used for calibration of hydrodynamic models.

The following procedure is recommended when performing real-time hybrid/HIL model tests with a FOWT. First, perform HIL wind tunnel tests for the validation of the aerodynamic model that will be used in the ocean basin tests. Perform then Real-Time Hybrid Model tests in an Ocean Basin for calibration of the platform and hydrodynamic model as well as for final verification.

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<sup>1</sup> The terms HIL testing, as used by Politecnico di Milano, and Real-Time Hybrid Model testing, as used by SINTEF Ocean, refer to the same testing method coupling experiments and simulations in real-time.