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D7.8 Required numerical model fidelity and critical design load cases in various design phases

The design of floaters for offshore wind turbines usually follows three steps: Conceptual design, basic design, and detailed design. Within basic design, state-of-the-art models such as FAST, Bladed and HAWC2 are used to calculate time domain loads under various design load cases. Simplified models, however, may be valuable in the conceptual design phase, where fast answers for response levels and load levels may affect the design at an early stage. The purpose of D7.8 is to answer two questions:

- How can you obtain accurate results from simplified models for different load cases?
- For which load cases is it sufficient to apply the simplified models?

This is investigated through comparison of the simplified model QuLAF and the state-of-the-art model FAST for the OO-Star Wind Floater Semi 10MW floater-turbine configuration of LIFES50+. A review of simulation requirements and critical environmental conditions is provided.

Next, the two models are presented and the limitations of QuLAF are discussed. These are (A) an underprediction of the wave excitation force at large sea states; (B) an underprediction of the wind-induced response around rated wind speed; (C) an over-predicted aerodynamic damping for the tower mode motion and (D) restriction to planar motion. All the limitations are linked to approximations applied for achieving the substantial model speed up relative to the state-of-the-art model.

A comparative study based on the planar version of DLC 1.2, 1.3, 1.6, 2.1 and 6.1 is next presented.

- The FLS (fatigue) analysis shows that the simplified model is very good at estimating the damage-equivalent bending moment at the tower base, but has problems with the nacelle acceleration. The large under-prediction in the nacelle acceleration is likely due to an over-prediction of the aerodynamic damping of the nacelle motion.
- For the ULS analysis, under-prediction of the nacelle acceleration is also found. The largest tower base bending moments are generally over-predicted. It is observed though, that while stronger wind leads to an over-prediction, stronger waves lead to an under-prediction. Thus in DLC 1.6 where the largest load was obtained at 10.3 m/s a perfect match between the two models is found.
- Regarding the platform ULS motions, the largest surge responses are achieved in DLC1.3 and DLC1.6 with a 3% over-prediction and 11% under-prediction, respectively. The largest heave motions are generally very well matched by the two models and achieves highest values in the ESS (Extreme Sea State) cases. Lastly, the ultimate pitch responses are obtained in DLC1.3 and DLC1.6 both at rated conditions and within 4% deviation.

Despite the discussed limitations, QuLAF is found to be a quite accurate load and response prediction tool for aligned wind-wave load cases, especially for tower bending moments, heave and pitch motions. Although a full design load evaluation with a state-of-the-art model must be carried out for the final design, the present results shows the potential of QuLAF model application in the preliminary design phase to predict loads at an early stage, explore design variations and enable optimization within floater design for offshore wind turbines.