Towards the Integrated Design of Floating Offshore Wind Turbines

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Global investment in floating wind energy is accelerating to meet 2050 decarbonization goals. Even if no more a young technology, floating wind turbines still demand tailored design methodologies to guide their development. To address this need, a systems engineering approach is crucial—one that optimizes the entire system rather than its individual components in isolation.

This research presents a study on the holistic design of floating wind turbines with the objective of minimizing the Levelized Cost of Energy (LCOE). The approach, therefore, is to design all the main components together from the very beginning, seeking the right balance among the different parts in terms of performance and cost, while at the same time using analysis and simulation tools required for the turbine's certification. The methodology builds upon a well-established, in-house wind turbine design suite originally developed for land-based turbines and validated across multiple research and industrial applications.

The design process is organized as a sequence of nested optimization loops. It begins with the co-design of the rotor's aerodynamic shape and the substructure, which includes the floating platform and catenary mooring lines. Subsequent stages involve model-based controller design and detailed structural sizing of the blade and tower, using load cases defined by certification standards. During this phase, the floating substructure is iteratively updated to account for mass variations within the system while ensuring compliance with ultimate limit constraints. Depending on the desired level of detail, the methodology employs models of varying fidelity—ranging from reduced-order static aero-hydro-structural models to fully coupled multi-body simulations for time-domain load assessments.

To illustrate the capabilities of this multidisciplinary, multi-level optimization approach, a reference multi-megawatt turbine originally designed for fixed-bottom installations has been adapted for a floating spar platform. The results indicate substantial redesign requirements across multiple subsystems. Notably, the rotor's aerodynamic characteristics and the structural configurations of the blade and tower show major deviations from the baseline model.

These results highlight the strong interdependencies among the components of floating wind turbines, underscoring the importance of a holistic design philosophy. Optimizing such systems requires simultaneous consideration of aerodynamics, hydrodynamics, structural behavior, and control strategies to achieve cost-effective and reliable performance.

The final presentation will detail the proposed integrated design methodology, discuss the optimized turbine configurations, and compare them against conventional fixed-bottom reference models, demonstrating the benefits and challenges of a system-level approach to floating wind turbine design.

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