A new lightweight wave canceling semi-submersible design
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Abstract

Floating Offshore Wind Turbine (FOWT) platforms are still large and expensive structures, which require further innovation for the technology to be competitive.

A new, integrated design approach has been implemented at the University of Stuttgart for the design of a semi-submersible FOWT platform. The findings from this approach have been used for the concept design of a more cost-efficient and sustainable layout.

The potential for cost reduction is based on two major innovations: The first is a hull shape design which cancels the first order wave forces, yielding a favorable load response of the entire FOWT. The second is a lightweight cable structure, connecting the columns of the semi-submersible platform.

First coupled simulations show tower-base loads at comparable levels to onshore turbines. The concept is sought to be further developed in a collaborative project with the aim of demonstrating its feasibility.

Objectives

A new generation of FOWT platforms shall be developed, featuring a:
1. Lightweight structural design
2. Minimal sensitivity to wind and wave forces
3. Modular and scalable layout

Methods

The favorable “counter-phase pitch-response”-behavior illustrated on the right could be found through an integrated design optimization using a low-order coupled dynamic model (SLOW).

- Parameterized structural dimensioning
- Parameterized panel code
- Estimation of hydrodynamic viscous drag
- Low-order coupled simulation (DLC 1.2)
- Automated controller design

Results

Ocean waves excite floating wind turbines, usually leading to power overshoots and increased structural loads. The response behavior found in this work is such that the waves force the entire FOWT to oscillate about a point near the hub and the fore-af motion of the rotor is almost unaffected by the waves.

This yields a stable power production and tower-base bending moment fatigue damage only slightly above the one of an equivalent land-based turbine.

The behavior was reported for TLPS in [6] through an adjusted layout of the tendons. For the semi-sub, the behavior results from an optimal hull shape yielding Froude-Krylov wave pressures, which force a positive surge motion and at the same time a negative pitching (counter-phase pitch response) [5].

The proposed design features the indicated behavior. It is a modular design of a central column and outer columns, held in place by radial struts. A cable structure, instead of a truss structure allows to save material through a separation of stress components: While the radial struts take up compressive stresses, the cables take up the tensile stresses.

Conclusions

The proposed design combines an innovative cable structure for a semi-submersible FOWT platform with a new method for the hull shape design. A FOWT system, which operates optimally even in harsh wave conditions can be an innovation yielding competitive FOWT designs of the future.

As next steps, the design components shall be designed in a collaborative research project, followed by wave tank tests and a demonstration unit.

counter-phase pitch response to waves

References