Title of Diploma Thesis

Hydrodynamic Interaction Effects and Performance of a Co-located Offshore Wind and Wave Farm

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ABSTRACT

Renewable energy has been used in the recent years, in order to overcome many environmental issues and the lack of fossil fuels as well as in order to satisfy growing energy demands. Offshore wind and wave energy present two abundant marine renewable energy sources. Contrary to the offshore wind energy sector, characterized nowadays by proven technological maturity, the wave energy sector has to overcome many barriers for achieving technological readiness and, thus, ensuring commercialization. The combined deployment of Wave Energy Converters (WECs) with Offshore Wind Turbines (OWTs) through the formation of co-located offshore wind and wave farms, may contribute to the efficient handling of these barriers, offering at the same time multiple benefits (e.g. reduction of costs, increased energy yield, etc). Within such a farm, hydrodynamic interactions between the WECs and the OWTs' support structures occur, affecting both the WECs' performance as well as the OWTs' hydrodynamic loadings. Therefore, these interactions should be adequately considered and examined towards an efficient assessment of the wind-wave farm's performance.

Motivated by this, in the present thesis, the hydrodynamic interaction effects and the performance (hydrodynamic behavior and absorbed power) of a co-located wind-wave farm are numerically investigated by applying an appropriate numerical model (WAMIT). The farm consists of 4 bottom-mounted OWTs with monopile support structure of large diameter and 13 free floating cylindrical WECs. Each WEC is assumed to absorb power through a linear power taking off mechanism, actuated from each WEC's heave motion. The analysis is implemented in the frequency domain (boundary integral equation method) under the action of head and oblique, regular and irregular (including shoaling phenomena) waves. Focus is given on the effect of the WECs' configuration and of the wave direction on the hydrodynamic interactions and the farm's performance. Constructive/destructive interactions in terms of the WECs' absorbed power are quantified using an appropriate interaction factor. Furthermore, the hydrodynamic interactions' effect on the OWTs' hydrodynamic forces is examined by introducing a relevant coefficient (force on an OWT within the farm divided by the force applied on an isolated OWT). Finally, the OWTs' hydrodynamic loadings and the WECs' absorbed power are compared with results obtained considering the absence of WECs and OWTs respectively.

The results illustrate that the WECs' configuration in combination with the wave direction, affect significantly the farm's performance, the existence of constructive/destructive interactions, in terms of the WECs' absorbed power, as well as the OWTs' hydrodynamic forces. Moreover, the WECs' existence may lead to smaller forces on the monopiles, while the OWTs seem not to have a significant effect on the WECs' power efficiency.

Keywords: Co-located wind-wave farm, Hydrodynamic interactions, Absorbed power, Wave farm configuration, Wave direction.