Vessel motion prediction near a monopile offshore wind turbine

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Offshore wind energy is regarded as key renewable energy source to help global energy transition. There has been a sustained growth in the industry where the biggest annual new installation capacity, 6.1 GW, was recorded in 2019 [1]. Within 6.1 GW of global new installed power capacity, 370 MW came from Belgium which also set up Belgium's national record [2]. Although offshore wind industry is moving in the right direction, both globally and specifically in Belgium, there are some aspects in the current practice that can be optimized to reduce energy cost. The current research project will enhance personnel access operability analysis where the industry can expect 0.6% energy cost reduction opportunity from the crew transfer operation improvement [3]. In order to do that, interaction between vessel and waves near a wind turbine needs to be correctly assessed, e.g. by using proper numerical simulations. Further, numerical simulations are employed to define thresholds for marine operations, depending on meteo-marine conditions [4].

This specific research will focus on the crew transfer operation from a Crew Transfer Vessel (CTV) to a monopile wind turbine and investigate several numerical strategies for wave-structure interaction analysis near the monopile to reduce uncertainty in weather-window estimation. Monopiles are the most common wind turbine foundations in the industry, taking 81% of all installed wind turbines [2]. This topic has been investigated by some researchers. Wu [5] delivered an operability analysis of a CTV to a wind turbine where the friction force between the CTV and the structure was accounted for in frequency domain analysis assuming a transparent structure (*i.e.* same wave field with or without wind turbine under potential-flow assumption). Further, Konig *et al.* [6] accounted for both the friction between the CTV and the monopile and the diffraction of the wave field around monopile but without considering a boundary condition on the free surface in potential-flow theory. They found that, compared to the experiment, the heave and pitch motions were underestimated in short wave cases because the free surface boundary condition was neglected [6]. Thus, the complex nature of the wave field around monopile should be captured correctly in numerical simulations of a vessel near a wind turbine. Navier-Stokes (NS) simulations have demonstrated to be able to capture wave dynamics around a monopile [7]. However, the computational cost of a NS simulation is significantly higher than the cost of a potential-flow simulation.

This research, which is planned for the next 4 years, will investigate the possibilities of combining potential-flow and NS theory for the vessel-monopile interaction. Three numerical strategies are defined in the research: potential-flow in frequency domain, NS simulation, and combination of those two. These three approaches will be validated and contrasted to experimental results. Operability analysis will also be checked at the end of the research to assess the sensitivity of different numerical methods as a basis for weather window estimations.

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