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ScienceDirect

Energy Procedia 94 (2016) 249 – 260

Energy Procedia

13th Deep Sea Offshore Wind R&D Conference, EERA DeepWind'2016, 20-22 January 2016, Trondheim, Norway

Probabilistic assessment of floating wind turbine access by catamaran vessel

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Abstract

In this work, it is evaluated the accessibility of a floating platform, by means of a catamaran vessel equipped with a fender. The two bodies are modelled as a constrained multi-body system in the frequency domain. Transfer functions are calculated for the motions and forces of the system. Access is possible when no slip conditions occur at the fender, and when the relative rotations between the two bodies are within certain tolerance limits. Four response variables are defined to impose such conditions. In a short-term sea state the extreme maximum crest height of these variables is computed, assuming that response crest heights follow a Rayleigh distribution. Each of the extreme values is compared to a specific threshold, to determine whether access is possible or not. Accessibility is calculated for a sample platform located off the coast of Scotland using hindcast data for the period 1980-2013. Average accessibility resulted to be 23.7%. A strong seasonality is ascertained, together with a large variation of accessibility, due to the variability of wave climate.

Peer-review under responsibility of SINTEF Energi AS

Keywords: floating wind turbines; offshore accessibility; catamaran landing; walk-to-work;

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Peer-review under responsibility of SINTEF Energi AS
doi:10.1016/j.egypro.2016.09.233

1. Introduction

1.1. Offshore wind market evolution

At the end of June 2015, the offshore wind capacity installed in European waters surpassed 10 GW [1], confirming the growing trend of the previous years. The majority of the farms is located in the North Sea, where high wind speeds and a large shallow water continental shelf boosted the installation of turbines over fixed foundations. Nevertheless, in recent years the interest of offshore and energy industries towards floating wind turbines has significantly grown. These systems allow to harness energy far offshore, where wind tends to be more sustained and less turbulent, also in deep waters which are not economically exploitable by conventional fixed turbines [2]. Few full-scale prototypes have been installed and performed well during different operating conditions, encouraging the respective developers to planning the first floating wind farms [3][4][5]. These technologies may unfold a vast potential market: 66% of the North Sea itself has a water depth between 50 m and 220 m and many other regions with high power demand present similar characteristics (Mediterranean Sea, Atlantic Sea, US Pacific coast, Japan).

1.2. The availability challenge

The availability of a wind turbine is defined as the percentage of time it is able to generate electricity. In order to reach high values of availability, downtimes need to be shortened and, when possible, prevented. This is achieved through inspection and maintenance (either preventive or corrective), activities are known to affect significantly the final cost of energy (up to 25%, [6]). Costs and risks are expected to be higher for floating wind turbines, due to the short experience with real-scale systems and the added complexity brought by the platform motion [7]. For inspection and light repair, access to offshore wind turbines is usually guaranteed by means of catamarans equipped with fender or larger vessels mounting a motion-compensated gangway. In both cases, technicians walk directly from the vessel to a ladder mounted on the wind turbine structure. A number of guidelines exist to ensure that these activities would take place within certain safety limits [8]–[10]. Appropriate modelling tools are also necessary, in order to optimize maintenance strategies and identify limiting sea states for which access is possible.

1.3. Motivation

The aim of this work is to evaluate numerically the accessibility of a floating wind turbine by means of a catamaran vessel, in a walk-to-work configuration. Motivation for this effort comes mainly from the following points:

- The offshore wind energy trends and the potential market for floating turbines.
- The high costs and risks associated with operation and maintenance of offshore wind farms.
- The lack of modelling tools for walk-to-work access of floating platforms.

Previous studies, both numerical and experimental [11], [12], dealt only with fixed wind turbines and cannot be applied to the analysis of floating systems.

2. Methodology

Catamaran Crew Transfer Vessels (CTVs) are used to transfer small groups of technicians for inspection and light maintenance purposes. As it approaches the wind turbine, the catamaran docks on a boat landing structure and pushes on it through a bow-mounted fender, which absorbs the energy of the impact and provides friction to impede vertical motion. Workers access the wind turbine stepping over from the vessel and holding on a ladder. Access is possible when no-slip conditions occur at the fender, which acts as a joint from the kinematic point of view.