Offshore & Dredging Engineering

Technische Universiteit Delft

Design of a Feeder System for Offshore Wind Turbine Installation with an SSCV

With increasing demand for renewable energy, the offshore wind industry is ever growing. Wind turbine generators (WTGs) proceed to grow in numbers and in size, wind farms are located further offshore, in deeper waters, poorer soil conditions or in areas prone to earthquakes. These changes make it increasingly difficult to find capable and affordable jack-up vessels for transport and installation of WTGs. Installing with Thialf, one of Heerema's semisubmersible crane vessels (SSCVs), would mitigate most of the problems jack-ups have today and is thus regarded promising. However, Thialf is expensive and has a low sailing velocity. To optimize its installation up-time it will stay offshore for the project duration. A feeder system is required to supply it with WTG components, which are readily available at the marshalling yard. The objective of this research is to determine the critical activities in a feeder system for installation of WTGs with an SSCV, and to improve them so Heerema can make a competitive entrance to the WTG installation market.

Turbine manufacturers demand that WTG towers are positioned vertically at all times. A qualitative assessment for all components points to transport and offloading of the turbine towers to be critical activities. A comparative motion response analysis between a barge and a heavy transport vessel (HTV) shows that during transport, both solutions perform well in sea states higher than the intended installation sea state, thus making them suitable for the task. As offloading demands stricter limits than transport, vessel motions for that activity are too severe. The natural frequency of the vessel-tower system increases with each removed turbine, moving into governing wave frequency ranges for North Sea conditions. This phenomenon shows for both vessel types, from which it is concluded that a supply vessel will be selected based on project specific parameters, rather than motion response.

During preliminary developments within Heerema, tipping of the tower when its sea fastening is released and large swinging motions of the tower after lift-off were main problems found during offloading, to which improvements are necessary. Three concept solutions are assessed: one an alteration of the existing, single tower lift solution, two others making use of the SSCV's cranes with high capacity by respectively lifting a frame with 4 towers and two frames with 8 towers. For each concept, response limits are defined at relevant locations in the system. In-house software is used to determine the RAOs, from which the heading with the highest operability is computed. The offloading and installation activity sequence for wind farms of 48 and 96 turbines are defined, followed by a weather downtime assessment.

First simulations show waiting on weather (WoW) is governed by crew transfer from a crew supply vessel to the barge for mooring operations. This can be improved by using a crew basket, motion compensated gangway or HTV. Simulations with revised limits show that using a frame with 4 towers results in significantly lower WoW days and shortest net project times, making it the most promising concept. Shorter lifting exposure and reducing motion amplification by means of a low frequency system are drivers for the decrease in weather downtime. With a lower total project duration, costs are reduced substantially.

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