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Logistic Efficiencies And Naval architecture for Wind Installations with Novel Developments

Project acronym: **LEANWIND**
Grant agreement nº 614020
Collaborative project
Start date: 01st December 2013
Duration: 4 years

Mathematical optimisation models and methods for transport systems
Work Package 5 – Deliverable number 5.6

Lead Beneficiary: MRTK
Due date: 28 February 2016
Delivery date: 22 February 2016
Dissemination level: Confidential (CO)

This project has received funding from the European Union's Seventh Programme for research, technological development and demonstration under grant agreement No. 614020.

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Document Information

Version	Date	Description			
1.0	19/02/16	LEANWIND Deliverable number 5.6			
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Definitions

Acronym	Description
CAA	Civil Aviation Authority
CAPEX	Capital Expenditure
CPU	Central Processing Unit
CTV	Crew Transfer Vessel
DP	Dynamically positioned
DSS	Decision support system
GBF	Gravity based foundations
GUI	Graphical user interface
HSE	Health and Safety Executive
HLV	Heavy Lift Vessel
ILT	Internal Lifting Tool
JUP	Jack-up Platforms
LIVO	LEANWIND Installation Vessel Optimizer
O&M	Operation and maintenance
OPEX	Operating Expense
PSV	Platform Supply Vessel
ROV	Remotely Operated Vehicle
SPIV	Self-propelled installation vessel
SOV	Service operation vessel
TIV	Turbine Installation Vessel

Executive Summary

This report is part of the LEANWIND project deliverable 5.6 (D5.6), related to LEANWIND task 5.4. The focus of D5.6 is on the logistic challenges for the maritime transportation chain of the offshore wind industry, i.e. the challenges related to transportation from port and out to the offshore wind farm site. In addition to this report, D5.6 consists of:

- A decision support system (DSS) prototype for the installation phase logistic resource management problem
- A decision support system prototype for the operation and maintenance (O&M) phase logistic resource management problem

In this report, we consider the installation, O&M and decommissioning phases for offshore wind farm projects. For the installation and O&M phases, mathematical optimisation models are proposed and implemented in decision support system prototypes that can be used to determine the optimal mix of resources and their deployment. For the decommissioning phase, this report contains a summary of the internal LEANWIND report for the logistic challenges, related to the maritime transportation part of the supply chain. A mathematical optimisation model for the supply chain for decommissioning of offshore wind farms (not only considering maritime transportation) is developed in LEANWIND task 5.5, and will be described in LEANWIND deliverable 5.7.

The resource management problems that are studied relate to choosing the best mix of vessels and corresponding infrastructure, e.g. ports and offshore bases, for both the installation and the O&M phases. To make this decision, we also need to consider the optimal deployment of the resources. Hence, for the installation phase prototype both optimal resources and the corresponding installation schedule will be output. For the O&M phase prototype, the output will consist of optimal resources and their deployment, i.e. which maintenance activities that will be executed by what resources and when. Both prototypes estimate the total cost (CAPEX and OPEX) of the obtained solutions.

A literature survey shows that there only exist a few studies of the logistic challenges related to the maritime supply chain for the installation phase. These mainly consider the installation scheduling problem, hence no studies were found that explicitly study the resource management problem. This report proposes two versions of a pattern-based mathematical model formulation where patterns define which installation activities the vessel resources may execute during the proposed planning horizon. Objectives include minimizing the total cost of the installation process from onshore port to offshore wind farm site, and minimizing the total time of the process. These have both been implemented in the decision support system prototype. A computational study illustrates how the model can be used to provide decision support with respect to which vessel resources and installation port that are preferred for one of the LEANWIND offshore wind farm sites (Case 1 – West Gabbard).

For the O&M phase there exist some studies that consider the resource management problem, and also several studies that involve simulation models for evaluating best O&M strategies and overall O&M costs. However, there are few studies that involve the use of mathematical models and optimisation techniques, where some of these have developed by LEANWIND partners. LEANWIND partner MARINTEK has in a previous research project

developed a mathematical model for the resource management problem. This report presents a heuristic optimisation method for the problem based on this previous work. The heuristic method does not guarantee an overall optimal solution, but will, within reasonable computational time, provide a local optimum. The method has the advantage over the previously proposed methods that it can be used to solve larger problems in more detail.

The heuristic method for the O&M phase has been implemented in a decision support system prototype, and a computational study shows how it can be used to find which vessel resources, O&M ports, and O&M offshore bases that are most promising when the objective is to minimize total cost. Costs include vessel time charter rates, costs of ports, bases, the deployment of the vessels and downtime costs.

The decision support systems for the installation and O&M phases can, in addition to propose an optimal combination of vessel resources and corresponding infrastructure, be used for, e.g., the following types of analysis:

- Setting competitive time charter rates of vessels
- Analyse the willingness to pay for vessels/helicopters with different characteristics, e.g. higher operational wave height limits, higher transit speed
- Analyse the willingness to pay for offshore station concepts, e.g. mother vessel concepts
- Indicate which installation/O&M strategies/activities that are most promising
- Calculate potential cost savings of fewer turbine failures, e.g. to justify investment in more expensive and more robust wind turbines or condition monitoring systems

The study of the decommissioning phase shows that there are some inconsistencies in the proposed approaches for the necessary logistic activities. One example being the assumption that the decommissioning process will be a reversal of the installation process. Little is known about the strategies for decommissioning of offshore wind farms as there currently is a lack of experience with such processes. Recommendations are to learn from future re-powering and decommissioning activities, and to explore viable options, some new ones being proposed in this report, when decommissioning activities are to be executed.