leanwind

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

Holistic supply chain optimisation model

Work Package 5 - Deliverable number 5.7

Lead Beneficiary: University of Portsmouth
Due date: 31 July 2016
Delivery date: 2 August 2016
Dissemination level: CO (Confidential)

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

Disclaimer

The content of the publication herein is the sole responsibility of the authors and does not necessarily represent the views of the European Commission or its services.

While the information contained in the documents is believed to be accurate, the authors(s) or any other participant in the LEANWIND consortium make no warranty of any kind with regard to this material including, but not limited to the implied warranties of merchantability and fitness for a particular purpose.

Neither the LEANWIND Consortium nor any of its members, their officers, employees or agents shall be responsible or liable in negligence or otherwise howsoever in respect of any inaccuracy or omission herein.

Without derogating from the generality of the foregoing neither the LEANWIND Consortium nor any of its members, their officers, employees or agents shall be liable for any direct or indirect or consequential loss or damage caused by or arising from any information advice or inaccuracy or omission herein.

Document Information

Version	Date	Description			
			Prepared by	Reviewed by	Approved by
V1	01.07.2016	UOPHEC	Chandra Irawan	Iver B. Sperstad Katie Lynch	
V2	25.07.2016	UOPHEC	Chandra Irawan	Iver B. Sperstad Katie Lynch	Jan Arthur Norbeck
V3	01.08.2016	UOPHEC	Chandra Irawan	Iver B. Sperstad Katie Lynch	Jan Arthur Norbeck

Author(s) information :	
Name	Organisation
Chandra Irawan	UOPHEC
Dylan Jones	UOPHEC
Xiang Song	UOPHEC
Graham Wall	UOPHEC
Negar Akbari	UHULL
Elin E. Halvorsen-Weare	MRTK
Thomas Van Lanschot	UEDIN
Cormac Gebruers	CIT_NMCI
Thanos Pappas	NTUA
Mar Rodríguez	VGSC

Acknowledgements/Contributions:	
Name	Organisation
Iver Bakken Sperstad	SINTEF
Katie Lynch	UCC
Jan Arthur Norbeck	MARINTEK

Definitions

O&M	operation & maintenance
OWF	offshore wind farm
PortLay	port layout model for installation phase at port segment
PortIns	port choice model for installation phase at port segment
PTPIns	prior to port segment model for installation phase
VMIns	port to site segment model for installation phase
PortOM	port choice model for O&M phase at port segment
PTPOM	prior to port segment model for O&M phase
VMOM	port to site segment model for O&M phase
PortDis	port choice model for decommissioning phase at port segment
IntDis	integrated decommissioning model
GIS	geographic information system
MILP	mixed integer linear programming
MCDM	multi-criteria decision-making
AHP	analytical hierarchy process
ANP	analytical network process
ELECTRE	elimination and choice expressing reality
PROMETHEE	preference ranking organisation method for enrichment evaluation
MODM	multi-objective decision-making
MADM	multi-attribute decision-making
CR	consistency ratio
VNS	variable neighbourhood search
SBSBPP	single bin size bin packing problem
LIVO	LEANWIND Installation Vessel Optimizer
CTV	crew transfer vessel
HLV	heavy lift vessel
GUI	graphical user interface
NP	non-deterministic polynomial-time
DSS	decision support system

Executive Summary

This report details the Holistic supply chain optimisation model (the LEANWIND project deliverable 5.7), which is the final deliverable of LEANWIND Task 5.5. A set of modular optimisation algorithms, together with a GIS supply chain visualiser from the substance of this deliverable. These can be used separately, or in conjunction, to provide solutions to a wide range of offshore wind supply chain configuration problems.

The report presents holistic supply chain optimisation models for offshore wind farm in a 2-dimensional mapping. The first dimension is that of the life cycle of the offshore wind farm where a three phase model consisting of the installation (or construction phase), operation & maintenance (O&M) phase, and a decommissioning (dismantling) phase is used. The second dimension is that of the geographical segment of the supply chain, which can be divided into three phases. The first phase consists of all the activities that take place prior to the parts arriving at the support port (in the installation or O&M phases) or upon leaving the support port (in the decommissioning phase). For the installation and O&M phases it can consist of manufacture, transportation by multiple transportation modes (including sea-borne transportation of parts from port to port), storage, and part-assembly. In the decommissioning phase it can be thought of as movement of parts from the support port onto their recycling or landfill sites. This segment of the supply chain is termed “prior to port” in this report. The second segment is the decisions taking at or concerning the support port itself. This has been included as a separate supply chain segment due to the importance and distinct nature of these decisions. These include the evaluation and choice of port(s) for each life cycle phase and the optimal layout and usage of the port itself. This life cycle phase is termed “at port” in this report. The third supply chain segment is the movement of the wind turbine parts from the offshore wind port to the site itself (or vice versa for the decommissioning phase). This is normally entails sea-borne transport, sometimes with specialised vessels that need to be optimally scheduled due to their high charter costs. This supply chain segment is referred to as the “port to site” segment in this report. This offshore wind farm life cycle and supply chain classification leads to nine distinct sub-classes relating to life cycle – supply chain segment pairings. Each of these requires quantitative model(s) to be built to optimise the decisions made if a holistic optimisation of the offshore wind farm supply chain is to be achieved.

In this report, the description of supply chain optimisation in an offshore wind farm is provided in Chapter 2. In this Chapter, a brief explanation of a set of technical models proposed for the installation, operation and maintenance, and decommissioning phases is given along with the description on how models are used together to produce holistic solutions. Chapter 3 presents a set of optimisation models for the installation phase of an offshore wind farm. First, a model of transport to coastal bases is described where the main objective of the model is to obtain the optimal flows of components from suppliers to coastal (port) bases. Thereafter, two models of ports and coastal bases are presented. The first model aims to identify the most suitable ports for the installation phase of the offshore wind farm whereas the second one is to generate the layout of an installation port to minimise the transportation cost of the main components of an offshore wind turbine within the port. Finally, a model of transport from coastal to offshore site is given where a decision support system for the logistic system is developed. A set of optimisation models in the O&M phase of an offshore wind farm is presented in Chapter 4. The first model deals with finding the optimal location for warehouses that support operation and maintenance in an offshore wind farm. Then, a model that aims to identify the most suitable ports for

the O&M phase is presented. A model for decision support for the logistic system from coastal base to offshore wind farm is finally presented where the model focuses on the resource management problem, i.e. the strategic vessel fleet size and mix problem. Chapter 5 describes optimisation models proposed for the decommissioning phase of an offshore wind farm. A model for determining the most suitable ports to dismantle the offshore turbines is first given followed by an optimisation model for scheduling the decommissioning of an offshore wind farm. Chapter 6 presents a set of solutions generated by the proposed models described in Chapters 3 – 5. A LEANWIND wind farm site project (West Gabbard) is used as case study. Geographic Information System is also used to visualize the solutions produced by the models. The analysis on the solutions along with commentary on coordination and integration with other Work Packages in the LEANWIND project will also be presented in the last section of this chapter. In the last chapter, conclusions of this report are presented.