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Original article

Resource Sharing in the Logistics of the Offshore Wind Farm Installation Process based on a Simulation Study

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Abstract

This present contribution examines by means of a discrete event and agent-based simulation the potential of a joint use of resources in the installation phase of offshore wind energy. To this end, wind farm projects to be installed simultaneously are being examined, the impact of weather restrictions on the processes of loading, transport and installation are also taken into consideration, and both the wind farm specific resource allocation and the approach of a resource pool or resource sharing, respectively, are being implemented. This study is motivated by the large number of wind farms that will be installed in the future and by the potential savings that might be realized through resource sharing. While, so far, the main driver of the resource sharing approach has been the end consumer market, it has been applied in more and more areas, even in relatively conservative industries such as logistics. After the presentation of the backgrounds and of the underlying methodology, and the description of the prior art in this context, the network of the offshore wind energy installation phase will be described. This is the basis for the subsequent determination of the savings potential of a shared resource utilization, which is determined by the performance indicators such as the total installation time and degree of utilization of the resources. The results of the simulation show that weather restrictions have a significant effect on the installation times and the usage times of the resources as well as on their degree of utilization. In addition, the resource sharing approach, has been identified to have significant savings potential for the offshore wind energy installation.

Keywords: Resource sharing, offshore wind energy, installation phase, logistics, simulation

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1. Introduction

This contribution examines the benefits of the resource sharing approach for the installation-logistics of offshore wind energy (OWE). To this end, the introduction first of all describes the status of OWE in Germany. Furthermore, the subject matter of resource sharing will be introduced and first considerations regarding the implementation in the OWE installation logistics will be made. This first chapter concludes with the description of the research approach the present contribution is based on. A presentation of previous scientific studies in the area of planning and control of OWE installations as well as in the area of resource sharing in logistics is presented in chapter 2. Chapter 3 specifies the area of application in more detail and further describes the logistics network of the OWE installation phase. The key aspects of this contribution are presented in chapter 4. The benefits of resource sharing in installation-logistics are examined by means of an agent-based simulation. For this purpose, the structure of the simulation will be explained, the scenarios, parameters, variables, restrictions and performance indicators will be described and, finally, the simulation of the results will be presented. This contribution concludes with a discussion of the results as well as with an outlook on the subject matter for subsequent research (chapter 5).

1.1 Offshore wind energy and its logistics

In the context of the German energy transition, OWE is a key technology (Federal Ministry for Economic Affairs and Energy 2015, Hau 2014). The reason for this is the high potential availability of wind, which results in a high number of full load hours and the good power plant characteristics of OWE (Burton et al., Hau 2014). Due to the planned exit from nuclear energy in Germany, OWE, as a form of energy generation that is able to provide a base load, is an important component of the future energy mix. Both, the specific challenges of OWE and the competition with conventional and other renewable energy sources, lead to a need for optimization and the lowering of costs in all areas of the value chain in this young industry (Federal Ministry for Economic Affairs and Energy 2015).

Along the entire value chain, logistics is what connects the different OWE players. The most important challenge of OWE logistics is the need to manage dynamic influences, especially the weather conditions and sea state. Thus, a standardization of procedures, equipment and turbine components as well as the creation of logistical processes in accordance with the OWE framework conditions is necessary (Schweizer et al. 2014). Since logistics serve as a connecting element, this requires that the optimization of logistics is considered as a cross-system matter (Beinke et al. 2015). In the context of the OWE installation phase, this does not only include considering the supply chain of one offshore wind farm (OWF) but also taking into account all the OWFs that are to be installed at the same time. Thus, a consideration that extends across different supply chains and projects is necessary due to the supply chain structure of an OWF as well as its project-based nature.

1.2 Resource sharing and its framework conditions in offshore wind energy installation logistics

The subject of the shared use of resources (hereinafter referred to as resource sharing) is described as a virtually unlimited use of resources with negligibly low transaction costs and an increase in resource efficiency (Schönberger et al. 2014). The resource allocation aims at a distribution of the limited resources that is as effective and efficient as possible.

For logistics, resource sharing means new opportunities and challenges. According to Schönberger et al. (2014) and Freitag et al. (2016), the reason for this that performance is no longer based on the possession of resources but on their use. Therefore, due to the high level of standardization of the processes and the logistic objects, in the area of logistics, no competitive advantage can be achieved t exclusively through use of resources.

A transfer of the approach to a specific industry requires defining the potential object of resource sharing. In the context of the logistics of the OWE installation phase, the said object is the means of transport, the storage and port areas as well as the equipment for the installation (Beinke et al. 2015). Due to the fact that the involved stakeholders vary from wind farm project to wind farm project and that, at the same time, are involved simultaneously in different projects, there are always points where the individual supply chains overlaps. Since the number of deployed resources is limited, that leads to a need for a parallel use of publicly provided resources at the same value chain level. Due to the high charter rate of the installation vessels (IV) and the resulting need for a fast and uninterrupted loading and unloading of the vessels,