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A decision support system for assessing offshore wind energy potential in the North Sea

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HIGHLIGHTS

- Decision Support System (DSS) to identify offshore wind energy (OWE) potential in the North Sea.
- Spatial analysis of existing sea use functions and offshore wind energy potential.
- Input parameters of DSS depend on the level of OWE spatial priority assumed by the user.
- DSS performs the required calculations and provides results in form of maps and statistics.
- DSS available after registration at www.windspeed.eu.

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ABSTRACT

Offshore wind energy (OWE) in the North Sea has the potential to meet large share of Europe's future electricity demand. To deploy offshore wind parks in a rational way, the overall OWE potential has to be realistically determined. This has to be done on an international, cross-border level and by taking into account the existing man-made and nature-related uses of the North Sea. As spatial conflicts will arise between existing uses and the new OWE uses, a Decision Support System (DSS) based on a Geographic Information System (GIS) was developed. Based on data of existing sea uses and calculation rules for spatial prioritisation analysis, the DSS helps in identifying areas that are (1) generally suitable for offshore wind power, (2) strictly excluded or (3) negotiable with respect to other existing sea uses. The combination of this conflict analysis together with cost assumptions for offshore wind farms and their expected electricity yield leads to identification of favourable areas for OWE deployment in the North Sea. This approach helps to reduce the conflict between offshore wind deployment and existing sea uses in the North Sea for future planning. The results can assist decision makers in developing transnational roadmaps for OWE.

1. Introduction

In 2007 the European Commission proposed new actions against climate change resulting in the widely noted energy and climate change package and its 20-20-20 goals. With the recent publication of the Renewables Directive, the binding target to supply 20% of total EU energy consumption from renewable energy sources by 2020 was agreed upon (European Commission, 2009). Currently, National Renewable Energy Action Plans (NREAPs) to meet these goals have been developed by each member state.

Within this context offshore wind energy (OWE) in the North Sea has the potential to meet a large share of Europe's future electricity demand. There are several reasons for this, two of them are mentioned here. Firstly, there are generally higher and more consistent wind speeds over sea than over land which results in potentially higher full load hours for offshore turbines (EWEA, 2009) and second, the North Sea is relatively shallow – about 40% of its area has a sea depth lower of less than 50 m – which reduces the costs of offshore wind farms.

On the other hand, significant portions of the North Sea are already used by traditional non-wind functions such as shipping,

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military activities, nature conservation areas and others. This can, in effect, create competition for space between the comparatively new sea user 'offshore wind energy' and existing users of the sea.

In addition to NREAPs – which include national offshore wind energy projections in 2020 – the European Commission has an interest in understanding the overall potential for offshore wind energy in the North Sea. Such knowledge can be used in developing a coordinated roadmap for the deployment of OWE and to define framing conditions for letting this deployment happen in an appropriate and reasonable way. There are a number of reasons why offshore wind deployment should take place within a transnational context rather than a national context. In terms of transmission/grid related issues, an transnational offshore grid can offer benefits for electricity market integration and cross-border exchange capacities compared to connecting wind parks to national onshore connection points. Additionally, why should a single area with promising conditions for OWE but lying at the border of two countries be developed as separately with national wind parks and not as a cross-border wind park nor take advantage of the possibilities for common infrastructure? Additionally, there are a number of cross-border sea uses in the North Sea such as shipping, fisheries, cables, pipelines and – although currently typically implemented nationally – nature conservation. A coordinated and cooperative approach to the planning of OWE development with respect to such sea uses may make it easier to maximise social benefits from the allocation of space in the North Sea while minimising possible impacts to nature values; potentially offering opportunities for finding additional space for OWE deployment. Furthermore, large scale OWE will affect not only national energy supply mixes but will also influence the operation and deployment of other renewable and conventional energies in neighbouring countries.

The WINDSPEED (*SP*atial *D*eployment of offshore *WIND E*nergy in *E*urope) project – funded by the Intelligent Energy Europe (IEE) programme – examines the potential for OWE deployment in the Central and Southern North Sea with regards to competing non-wind sea use functions. The final deliverable of the WINDSPEED project is a roadmap for the deployment of OWE in this sea basin up to 2030 that identifies realistic but ambitious targets with corresponding policy recommendations. Specifically the project analyses the OWE potential in the relevant portion of the North Sea for the countries Belgium, Denmark, Germany, Norway, the Netherlands and United Kingdom by taking into account several constraints:

(1) spatial constraints: finding space for the deployment of OWE with respect to existing sea use functions; (2) first order economic constraints: assessing the economic OWE potential with regards to other renewable energies, conventional generation sources and supply-chain restrictions; and (3) grid – or second order economic – constraints: assessing the OWE potential under different grid development assumptions.

In this paper, the method of the Decision Support System (DSS) developed and used within the WINDSPEED project to assess the impact of differing spatial constraints on OWE potential – the first level of potential described above – and its example application are presented. Several key aspects for performing this spatial analysis had to be taken into account:

- An international approach: all relevant input data and all results have to be available for all countries.
- Variation of input parameters: to reflect different scenario or framing conditions, the analysis should allow for a wide range of input parameters that relate to spatial interactions between existing sea use functions and OWE as well as costs.
- Country specific variation of input parameters: although the aim of the analysis is the assessment of the overall potential for the whole North Sea, each country may have national restrictions, guidelines and development preferences, which should be taken into account in the analysis.
- Cost assumptions that are valid for the whole analysed area as well as for each country to provide comparable relative costs.
- The output of the analysis should provide information relevant to the development of a roadmap for the deployment of offshore wind energy in the North Sea.
- User friendly access via the internet to choose input parameters and assumptions for user-specific scenarios.

One approach to identify the OWE potential in the North Sea is to perform a spatial analysis that identifies areas that: (1) *are* suitable (2) *are not* suitable and (3) *may be* suitable for OWE if existing constraints could be relaxed.

Such a spatial analysis can be conducted by a DSS using Geographic Information Systems (GIS). DSS are tools that "enhance the process and/or outcomes of decision making" and "provide knowledge and/or knowledge processing capability" (Holsapple, 2008). These two general descriptions of a DSS allow a rather wide field for further definitions. While the latter description often gets reduced to the pure meaning of a "precise knowledge of what is where", the "potential for high resolution spatial modelling and its use as policy-support instrument" has only now been discovered by a growing group of people.

2. Related work

A wide variety of DSS exist, ranging from general information systems like the Continental Shelf Information System (CONTIS) of the German Federal Maritime and Hydrographic Agency (BSH, 2011) to software products for detailed planning of offshore wind parks. Therefore a search for DSS applications developed for the domain of offshore wind energy examines various approaches.

An overview of systems used in the wind energy sector was assembled by the EU-project POWER (Pushing Offshore Wind Energy Regions) (Pahlke, 2007; see Table 1). The project concludes that "Decision Support Systems are rarely used in the offshore wind energy field", an observation that corresponds with the authors' investigations that examined mostly scientific approaches and educational prototypes, finding that many of these are linked to onshore activities (Wanderer, 2009). Pahlke (2007) likewise notes, that most spatial DSS "are specific to onshore developments and only parts of those systems may be transferred to the offshore sector".

Pahlke (2007) also reports somewhat contradictory results from a questionnaire conducted within the POWER project, wherein 40% of participants affirmed the current use of DSS for offshore wind energy developments related to the North Sea. However, he explains this discrepancy through (1) a high return of answers by participants developing a DSS themselves, and (2) the mistake of misleadingly naming classical software tools (for example Microsoft Excel) or standard GIS software as DSS tools.

Wanderer (2009) concludes that there is no commercially available or generally applied state-of-the-art DSS tool for OWE. Furthermore he notes that systems dealing with the wider context of Marine Spatial Planning (MSP) are very rare. Additionally many tools cover only a limited area—none of them consider such a large extent of the North Sea.

Based on this conclusion a DSS was developed within the WINDSPEED project to analyse cross-border potentials for OWE in the North Sea with regard to various spatial constraints and OWE deployment assumptions.