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Identifying space for offshore wind energy in the North Sea. Consequences of scenario calculations for interactions with other marine uses

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HIGHLIGHTS

- A new method for minimising effects of new Offshore Wind Energy on other uses.
- Calculation rules are based on density, economic or nature values of major marine activities.
- Most activities are concentrated near the coast and expected to increase.
- Increasing priority for OWE claims more and higher value area from other uses.
- Relocation and co-use of areas reduce negative consequences.

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ABSTRACT

The increasing demand for renewable energy drives the development of offshore wind energy (OWE) leading to competing claims with other human and nature related uses of the North Sea. This paper investigates possibilities to identify space for new OWE while minimising effects on other uses. An inventory is made of the major uses in the Central and Southern North Sea, including the expected development towards 2030. The spatial distribution of non-wind uses is determined as well as the possibilities for differentiation based on density, economic value or nature value and co-existence. These possibilities are translated into calculation rules quantifying the relative importance. These calculation rules have been incorporated in a Decision Support System (DSS) to analyse how the priority of OWE development could impact non-wind uses. In a low OWE priority scenario consequences for other use was found to be very limited, with fisheries and wildlife affected most. In a high OWE priority scenario a considerable amount of OWE may be developed with substantial claims on sand extraction and military use areas and a shift towards higher value categories for shipping and fisheries. Relocation and co-existence of uses are important means to reduce the impact of increased OWE development.

1. Introduction

In the Renewable Energy Directive the European Union has set a target of 20% renewable energy in the European energy supply by 2020 (EC, 2009a). This overall target has been broken down into a national binding RES target per Member State. As a result the Member States published National Renewable Energy Actions Plans (NREAPs), indicating the mix of RES technologies with which they expect to achieve their national 2020 targets, along with the supporting policy framework (Klessmann et al., 2011). Only few countries (Germany, Denmark, the Netherlands and the UK) formulated ambitions beyond 2020 (PBL, 2012; Ecofys, 2013). Wind energy including offshore wind farms is expected to contribute a major part. The Central and Southern North Sea is an attractive sea basin for large scale deployment of offshore wind energy (OWE) due to abundant and reliable wind resource, relatively shallow water depth and vicinity to developed electricity markets (Schillings et al., 2012).

At first glance, the North Sea wind resources seem abundant and could potentially fulfil a large share of the ambitious EU renewable energy target by 2020. At the same time, there are increasing pressures on this marine environment, especially near shore as new human activities are being introduced and current activities are expanding. The Central and Southern North Sea is one of the busiest seas in the world due to shipping, fisheries, sand and gravel extraction, military activities and offshore energy related activities such as the exploitation of oil and gas reserves including the laying of cables and pipelines.

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Large OWE projects are in preparation and countries surrounding the North Sea are, to some extent, speeding up planning activities in an attempt to identify viable locations for development The overall management of the North Sea basin is still fragmented, nationally focussed and rarely stream-lined in terms of timing. It is unlikely that a single plan will be produced for the North Sea in the near future. However cross-border cooperation on marine spatial planning and on the necessary electrical infrastructure (offshore grid) will play a key role to realise ambitious targets for OWE up to 2030 and beyond (EC, 2008, 2010; EWEA, 2011). Integrated plans are currently lacking and need to be developed including identification of the best places to develop OWE taking competing users into account (Veum et al., 2011; Cameron et al., 2012).

Opportunities for co-use of OWE with other uses at sea should receive more attention, especially given that wind parks densely installed with clusters of turbines are not regarded sustainable over large areas of deployment (Phillips et al., 2010). It is more realistic to consider that suitable areas foreseen for offshore wind electricity generation are only occupied for 30% by clusters of wind turbines, because regeneration lanes would be required to reduce wake effects (Jacquemin et al., 2009; Phillips et al., 2010). This will require more space for OWE but creates opportunities for co-use.

This paper has two aims.

1. Derive calculation rules for non-wind uses based on the spatial distribution of importance or value.
2. Evaluate the influence of the priority for OWE on the consequences for the non-wind uses at the North Sea.

In order to achieve these aims the following steps have been taken:

1. Investigate the spatial distribution of non-wind uses in the North Sea and the possibilities for differentiation based on importance or value.
2. Determine the possibilities to identify space for OWE development without large effects on the importance or value of other uses and reduction of negative interactions between different uses when relocation occurs.
3. Translate these possibilities into calculation rules.
4. Build a Decision Support System (DSS) implementing these calculation rules and combining them with a set of calculation rules for OWE development.
5. Use the DSS to calculate results for scenarios differing in priority for OWE development.

In this article the focus is on the interactions between all non-wind uses and the spatial consequences for them. This article is complementary to Schillings et al. (2012) who focussed on the methodology of the DSS and the consequences for OWE. Both papers are part of the EU-funded project WINDSPEED (Spatial Deployment of offshore WIND Energy in Europe) (www.windspeed.eu) which focussed on the Central and Southern North Sea covering approx. 75% of the North Sea, including the whole EEZ of Belgium and the Netherlands and part of the EEZ of Germany, Denmark, Norway and the United Kingdom.

2. Methodology

A systematic approach has been followed to arrive at calculation rules and scenarios for the major sea use functions (see Fig. 1). First, an inventory was made of the most important non-wind sea uses present in the Central and Southern North Sea, including expected future development of these sea use functions towards the target years 2020 and 2030. Second, a study was performed on the interactions between OWE and other sea use, as well as interactions between the different non-wind sea uses. Third, calculations rules and appropriate scenario settings were derived that match the legal requirements and the most important economic and ecological targets. The calculation rules were tailored to the possibilities offered by the available datasets and the desired functionality of the DSS. Also included in the DSS are rules for OWE to calculate costs for different fundament layout, for investments and operation and maintenance. The inputs for the DSS are geographical datasets that were collected, created or collated from different sources as specified in Appendix Table A.1 (non-wind sea uses) and Appendix Table A.2 (offshore wind energy). The output is a data-rich geographical dataset, detailing both input values and calculated results for each polygon (area/patch). Fourth, consequences of a low and a high OWE priority scenario for non-wind uses were calculated.

It should be realised that not all potentially available space is equally suitable for OWE development due to other factors like the levelised production costs (wind speed, sea depth, distance from shore, grid infrastructure). These factors are dealt with by Baldock and Jacquemin (2009), Jacquemin et al. (2009), Korpås and Van Dyken (2009), Schillings et al. (2012) and Veum et al. (2011) and have been included as part of the DSS. The scenarios presented here have been described in depth by Cameron et al. (2011) and have been constrained further by taking into account economical limits posed by the market for renewable energy as well as technical limits of the uptake capacity of onshore high voltage electricity lines. These so-called first and second order economic constraints and the methods used to calculate them are also described in Cameron et al. (2011). In the present paper only the main calculation rule as applied to Offshore Wind Energy (OWE) is described. This calculation rule is based on Levelized Production Cost (LPC) which is a measure to compare the overall economics of different areas of the North Sea (Jacquemin et al., 2009). A simplified approach using a fixed charge rate (FCR) is used to annualize the initial capital expenditure for the OWE project.

The LPC is traditionally calculated using:

$$LPC = \frac{FCR \times (CapEx) + OpEx}{AEP \times Avai \times Elec},$$

where: LPC = levelized production cost (€/MW h), CapEx = initial capital expenditure for the OWE project (€), FCR = fixed charge rate (%), OpEx = operating expenditure (€/annum), AEP = net annual energy production (MW h/annum), Avai = the average availability for all installed capacity, Elec = the electrical losses for all installed capacity.

On top of the spatial potential for developing offshore wind energy, the output from the DSS, two types of economical restraints on OWE development have been applied to arrive at a realistic estimate of capacity for OWE deployment in the North Sea by 2013 (Cameron et al., 2011). Going from a potential where only spatial constraints are considered to a realistic economic potential is necessary because not all the spatial potential is truly available for OWE development. Some limitations arise from grid and transmission constraints, others from the available and competing generation capacities from other sources (both conventional and renewable). Also other bottlenecks such as the availability of vessels, harbour facilities as well as that of production facilities for turbines and foundations are considered. In this process models such as RESolve-E, COMPETES and Net-Op have been used. Further information can be found in Cameron et al. (2011).

2.1. Current and future use

An inventory was made of non-wind uses present in the Central and Southern North Sea, including expected future development of these uses towards the target years 2020 and 2030.