WindSpeed Decision Support System (DSS), a planning instrument to reduce conflicts between offshore wind parks and environmental concerns.

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Abstract

Offshore wind power has the potential to fulfill a large share of Europe's future electricity needs. However, offshore wind farms can have both negative and positive ecological effects on the marine environment. Unless adequately and timely addressed, environmental concerns and other uses of the sea could hamper a large scale development of offshore wind energy. A GIS-based Decision Support System developed within the EU-project WindSpeed can help to define a realistic potential for offshore wind energy by taking into account environmental concerns as well as other relevant sea use functions, and their interactions. Based on the application of a DSS tool, options to reduce the conflict between offshore wind deployment and environmental aspects are addressed.

Introduction

Offshore wind power has the potential to fulfill a large share of Europe's future electricity needs. However, offshore wind farms can have both negative and positive ecological effects on the marine environment. If these effects are not adequately and timely addressed, environmental concerns as well as other uses of the sea could hamper a large scale development of offshore wind energy. A GIS-based Decision Support System (DSS) developed within the EU-funded project WindSpeed can help to define a realistic potential for offshore wind energy taking into account ecological issues and other relevant sea use functions, and their interactions.

The WindSpeed project is currently assessing the spatial opportunities and constraints for offshore wind in the Central and Southern North Sea, and aims to develop a Roadmap to the deployment of offshore wind energy up to 2030. The GIS-based DSS tool can produce overlaying maps to give a spatial representation of offshore wind energy potentials in relation to environmental aspects and non-wind seas functions. Spatial data on nature conservation areas, bird migration routes[1], spawning areas or benthos occurrence as well as information on military areas, shipping routes, etc. are used for the analysis. The tool can facilitate the quantification of trade-offs between electricity generation costs from offshore wind and constraints due to nature conservation and non-wind sea functions. In a spatial planning context, this tool can provide a sound foundation for decision making by policy makers in terms of understanding the potential conflicts and in prioritising and allocating space to the deployment of offshore wind the Central and Southern North Sea.

[1] Data regarding bird population and migration routes are not yet included in the DSS tool.

In this paper, the applicability of the DSS tool[2] as a spatial planning instrument will be demonstrated by a case study focused on nature conservation issues. The problem of finding optimal locations for offshore wind parks is thereby assessed by considering both environmental and ecological aspects. Calculation rules are developed and applied within the tool and the outcome in terms of suitable areas for OWP is assessed.

Methodology

A three-stepped methodology is applied. The first step includes identifying, collecting and collating existing relevant data. Secondly, these datasets are combined in a DSS tool together with calculation rules, which are used to allocate space to OWP development and non-wind sea use functions. Thirdly, location specific Levelized Production Costs (LPC) of wind offshore energy are calculated. LPC is used to indicate the area which is most suitable for OWP. LPC takes into account costs such as capital expenditure when constructing a wind farm as well as operational costs in combination with the number of megawatts of electricity that will be generated.

1. Identify, collect and collate existing data

Within the WindSpeed project several datasets for calculating wind offshore costs and potentials as well as non-wind sea use functions have been collected and harmonised for the DSS tool. The datasets currently incorporated into the WindSpeed DSS tool are listed in table 1. The offshore wind parameters and non-wind sea use functions taken into account in this paper are highlighted in bold. The parameters listed in the left column are used when calculating LPC. E.g. wind speed determines energy productions; sea depth and wave height influence what foundation structures are required and thus influence capital expenditure; distance to port plays a role in determining operational costs.

Table 1: Used input dataset within the WINDSPEED DSS tool.

WIND / COST	**NON-WIND**
Planned / Existing OWP	Nature Conservation Areas
Designated OWP zones	Fishery / Fish / Spawning Areas
Wind speed at 90m	Benthos
Sea Depth	Military Use
Spring Tidal Amplitude	Shipping Routes/Density
Storm Surge	Platforms
Wave Height	Pipelines
Drilling Requirement	Cables
Grid Connection Points	Sand Extraction / Dredging
Staging Ports	

For nature aspects the following information has been used:

a) Nature Conservation Areas which are based on RAMSAR Convention, Bird Directive and Habitat Directive and Natura2000 sites. [1]

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[2] An online interface of the DSS will be available soon at www.windspeed.eu.

b) Benthos: based on a combination of benthic habitat maps for Germany, the Netherlands and Belgium, and extrapolated to the UK, Norway and Denmark by incorporating information on water depth and sediment composition. [1]
c) Fish: Species Richness: based on results for several years from the regular BTS and IBTS surveys. [1 and 2]

This information is illustrated in the following maps (see figure 1):

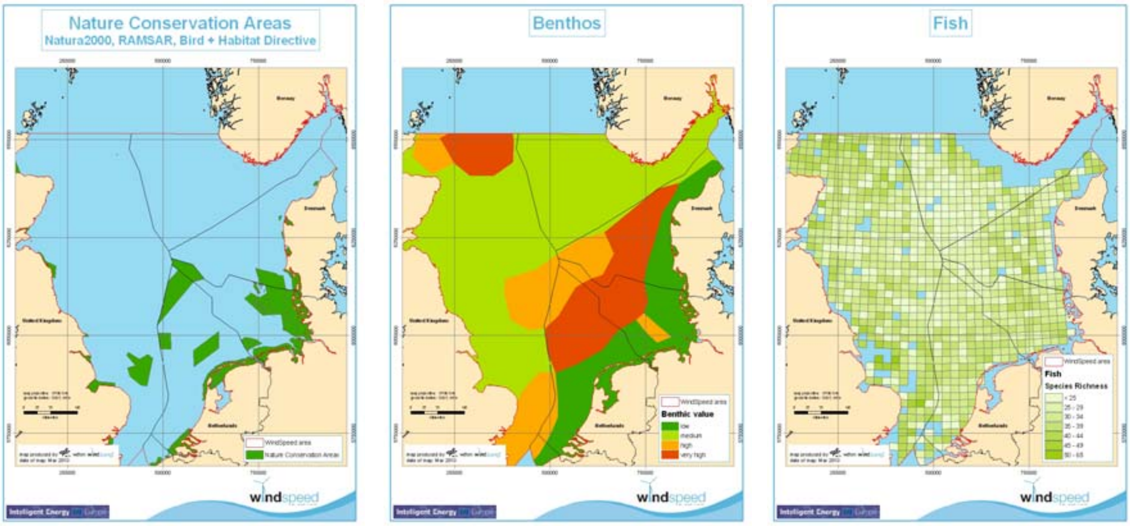

Figure 1: Information on nature aspects used for the presented analysis.

2. Combine all available data and apply calculation rules

The calculation rules with respect to nature and ecology aspects applied in this case study are chosen as follows:

- Nature Conservation Areas: ‘No go’ for OWP
- Benthos: low, medium and high: ‘Go’; very high: ‘Negotiable’
- Fish species richness: ‘No go’ for areas with highest fish biodiversity (>40 species) to preserve, ‘Negotiable (but widely available)’ for areas with 30-40 species, and ‘Go’ for the remainder.

The rationale behind these calculation rules is as follows. Marine Nature Conservation Areas (NCA) are mostly designated as part of the Natura2000-network, which is based on the EU Birds Directive (79/409/EEC) and Habitats Directive (92/43/EEC). These directives stipulate that OWP can be developed within NCA, however, the developer must show that the activity will not harm the conservation goals set out for the area. The first calculation rule above reflects a precautionary principle, which implies that if scientific knowledge is presently insufficient to conclusively build a case in favour of OWP, development should not occur inside a NCA. Only after sufficient knowledge has been gathered by monitoring development around OWP, will OWP development have the option of moving into NCA. It seems likely that the future options for developing OWP within NCA will depend on the conservation goals. As an example birds could remain a candidate for a problematic combination with wind turbines. Please observe that this calculation rule does not entail a full exclusion of OWP inside NCA. Also the other calculation rules on natural values allow for limited development of OWP in their respective prime locations. Alternatively, a less strict calculation rule could be applied to allow for OWP to be built with an extensive monitoring system in order to gain further knowledge on the impacts of OWP.

With respect to benthos and fish, the calculation rules are such that they steer OWP development away from locations where these natural values are known to be best developed. In this way the DSS aims to conserve what is present. In the case that OWP are shown to be beneficial to the benthos and/or fish, the gain will be made in poorer areas. Access for fishing vessels to OWP is expected to be limited, with some gear types being allowed and others fully excluded. From this decrease in fishing pressure inside an OWP a beneficial effect could arise with increased benthic biodiversity and fish standing stocks. For fish this would be limited to demersal species which remain within the area for long periods, although it is worth mentioning that pelagic fish species are not likely to benefit much. These species will only remain inside an OWP for short time periods.

3. Calculate of Levelized Production Cost.

Based on cost assumptions for a wind farm size of 600 MW, Levelized Production Costs (LPC) are calculated for each 5x5km² grid cell. The LPC is calculated as following:

$$LPC = \frac{FCR \times CapEx + OpEx}{AEP} \quad \text{(eq. 1),}$$

where

- LPC: Levelized Production Cost (€/MWh)
- CapEx : Initial Capital Expenditure for the wind farm (€)
- FCR: Fixed Charge Rate (%)
- OpEx: Operating Expenditure (€/annum)
- AEP: Net Annual Energy Production (MWh/annum)

More information on the calculation of location specific values for CapEx, OpEx and the chosen value for FCR can be found in [4]. The methodology used for the assessment of location specific input data relevant for the calculation of LPC, for example wind speed, can be found in [5].

Results

By combining all data and applying the calculation rules in this case study, three categories can be identified: 1) areas that are restricted by nature conservation constraints and by high fish species richness, 2) negotiable areas having less fish species richness and very high benthos values, and 3) remaining areas that are generally suitable for OWP. The calculations rules applied in this example would suggest around 1/5 of the area to be 'out-of-bounds' (no-go) for OWP development due to environmental restrictions. The remaining area would be roughly divided between (1) non conflict areas and (2) areas where some degree of conflict between environmental concerns and OWP would arise. A significant portion of the negotiable areas are areas with relatively low LPC for OWP, and are therefore subject to a closer look at trade-offs and negotiation.

A significant portion of the no-go areas due to strict application of nature conservation rules can also be found in areas close to shore where LPC is relatively low. This is especially the case for Belgium, Germany and the Netherlands. The DSS tool could be used to look further into the potentials for developing OWP in prime locations, i.e. locations with relatively low LPC, under less stringent calculation rules for nature conservation.

The figure 2 below shows all negotiable as well as suitable areas together with their corresponding Levelized Production Costs for OWP.

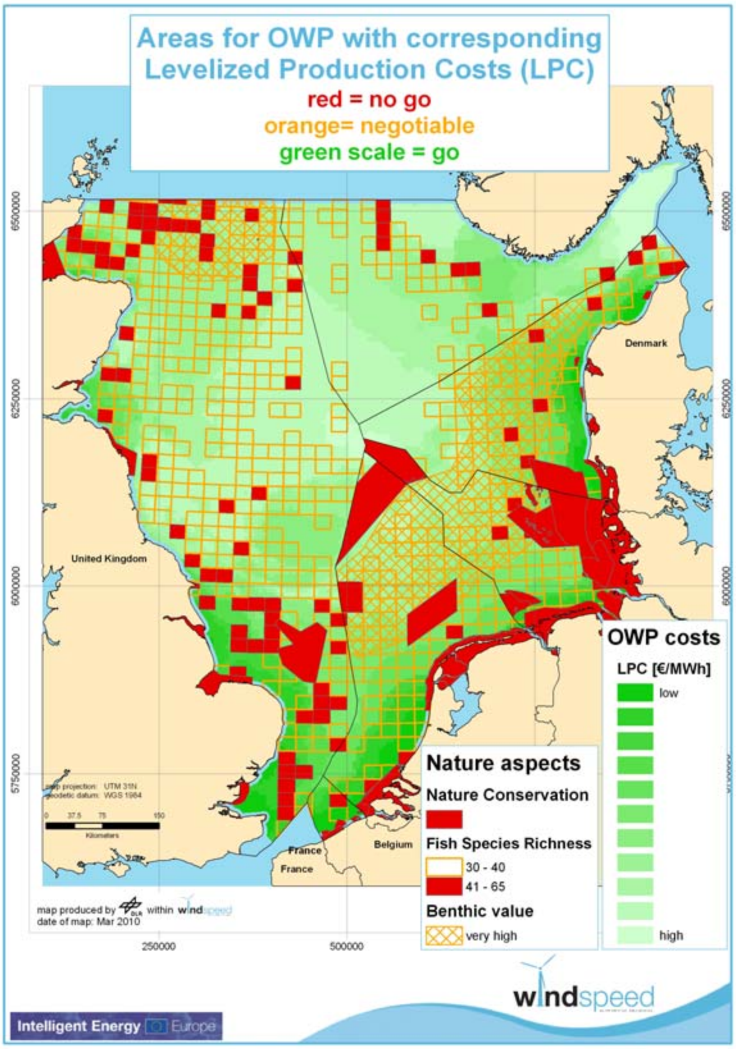

Figure 2: Levelized Production Costs (LPC) for suitable areas analyzed by using presented method.

Conclusions

When addressing only environmental aspects (i.e. not taking into account non-wind sea use activities, such as shipping and offshore oil and gas production), the calculations rules applied in this example would suggest around 1/5 of the area to be 'out-of-bounds' (no-go) for OWP development. The remaining area would be roughly divided between (1) non conflict areas and (2) areas where some degree of conflict between environmental concerns and OWP would arise, and therefore subject to a closer look at trade-offs and negotiation.

WindSpeed DSS calculation rules for nature conservation areas and natural values (Benthos and Fish) can be modified to reflect different values and priorities, and do not necessarily exclude any area 100% from the use of OWP. They merely distinguish between more or less suitable areas for OWP development.

References

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