



Spatial Deployment of offshore WIND Energy in Europe (WINDSPEED)

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Horizontal Key Actions

**“Specification of the GIS based
Decision Support System (DSS)”**

**WP 4
Report D4.1**

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Specification of the GIS based Decision Support System (DSS)

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Executive summary

This document describes the specification of the Decision Support System (DSS) developed within the WINDSPEED project. The DSS is designed to describe the potential to use offshore wind power on a spatial resolution. It shows the constraints of this potential may they be due to economic restrictions or due to the competition of other sea functions. The tool is designed to help policy makers to understand interrelations with other sea functions and to define their strategy for the use of offshore wind energy. It does provide the information needed for the planning of specific wind park installations.

The DSS is based on a Geographic Information System (GIS) which allows for a spatial analysis on an 5km x 5km resolution, combining different spatial and statistical information. It is driven by user defined input parameters as for example the definition of specific costs, framing conditions like exclusion areas or country selection. The DSS spatially combines data on windspeed, non-wind sea functions like nature conservation areas, shipping routes, oil and gas platforms etc. together with user defined data on costs of Offshore Wind Parks (OWP) to define suitable areas and resulting potentials for Offshore Wind Energy in the middle and southern North Sea. The analysis uses calculation rules for wind and non-wind sea functions defined by the project consortium. These calculation rules use input data (1) defined by the user, (2) provided by included input data (like windspeed, nature conservation areas, military zones etc.) and (3) provided by internal GIS-calculations (e.g. distance to shore)

The user can modify a set of input parameters to define her/his own scenarios for future wind energy usage. The Java-script-based dialogue box allows for intuitive and smooth modification of the parameters and for saving the settings into scenario file. The saved files can be loaded to the system for reruns and also can be shared with other users for comparison issues. The user-defined settings are transferred to the GIS software for the calculation. ArcGIS, a world-widely used GIS, is used as underlying GIS-software.

The input data provided by the project partner IMARES and Garrad Hassan was compiled and harmonized due to the different data sources, formats and details of information. Until the DSS is finalized, an update of input data is possible. Most of the data are free for use, only some of them are restrictive for user not belonging to the WINDSPEED consortium.

The provided results show maps of suitable areas for OWP containing information on different cost values (e.g. Net Annual Energy Production). The results are also provided in aggregated tables and reports for further usage like in the model ADMIRE-REBUS.

1. Introduction

The Decision Support System (DSS) is designed to describe the potential to use offshore wind power in the middle and southern North Sea on a spatial resolution of 5km x 5km. It shows the constraints of this potential may they be due to economic restrictions or due to the competition of other sea functions. The tool will be used for two major aspects. First of all it is the basis to establish a roadmap that will be developed within the scope of the WINDSPEED project. Secondly it is supposed to be used beyond the scope and timeframe of the project. This will be done by passing the tool to a limited number of stakeholders.

The tool is designed to help policy makers to understand interrelations with other sea functions and to define their strategy for the use of offshore wind energy. It does not provide the information needed for the planning of specific wind park installations.

The DSS is based on a Geographic Information System (GIS) which allows for a spatial analysis, combining different spatial and statistical information. The DSS is driven by user defined input parameters as for example the definition of specific costs, framing conditions like exclusion areas or general assumptions like maximum distance to shore.

In the following the specification of the DSS is described. As the development of the DSS is still in progress, some specification may change in the future to optimize the functionality of the DSS. Therefore, also this document is still in progress. It describes the status quo of the DSS for the date of delivery of this report.

2. General Features, Dialogue Box, Functionality and Structure of the DSS tool

2.1. General

The WINDSPEED project focusses on the area of the southern and middle North Sea. The area includes the territorial waters as well as the exclusive economic zones of Belgium, the Netherlands, Germany, Denmark, partially Norway and the UK. The exact boundaries of the area covered by the project are shown in figure 1. The red-marked area, divided into national exclusive economic zones, is the area to be analyzed. This area was discussed and defined by the WINDSPEED consortium taking into account issues like data availability, general suitability for Offshore Wind Parks, national and EU interests.

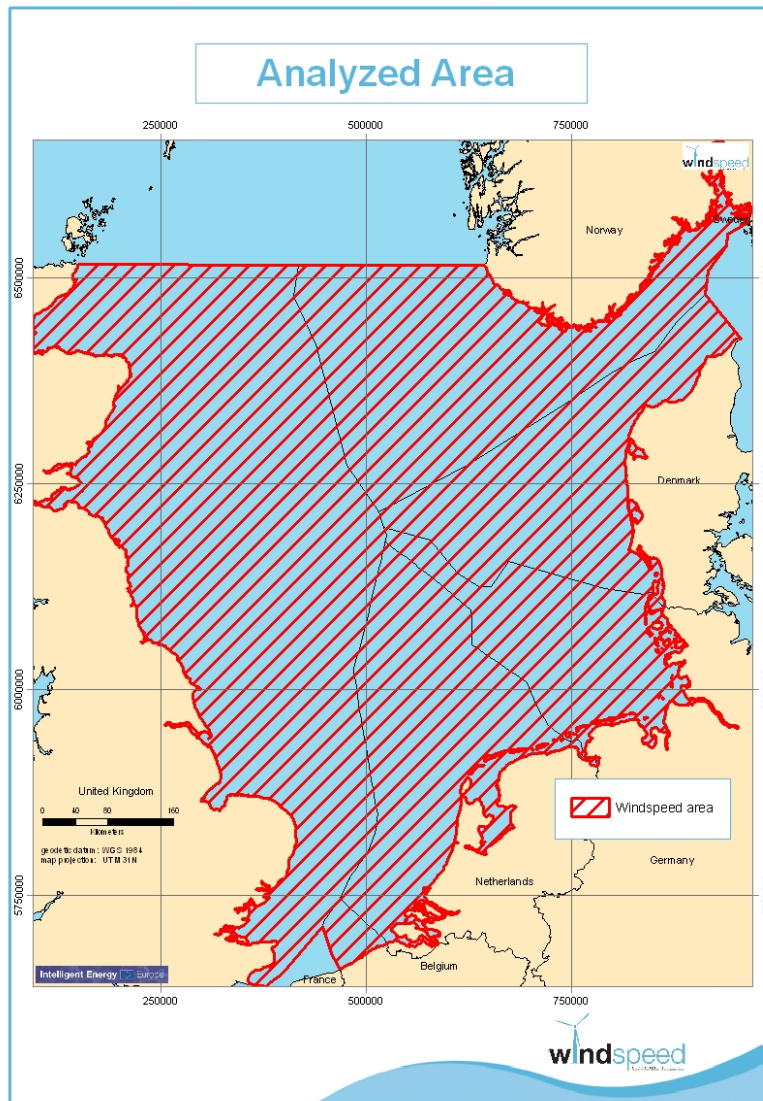


Figure 1: Area covered by the WINDSPEED project.

The DSS tool will be designed as an expert tool based on the ArcGIS¹ software that today is established as one of the leading software in the field of geographic information systems. To be able to use the DSS tool an ArcView licence (Version 9.3 or higher) will be necessary. The user interface is based on Javascript (ExtJS) and Active X-Objects which allows for the intuitive definition and modification of required parameters by the user. The defined parameters are transferred to the geoprocessor of the GIS-Software that calculate the results.

The DSS tool itself will be placed as a toolbox in the ArcGIS environment. As the method of toolboxes, where all available functions and methods are stored, is already applied to the programme ArcGIS, this approach seems to be most feasible for the further use and dissemination of the DSS tool. Figure 2 shows a screenshot of the ArcGIS environment. Within the ArcToolbox, the software provides functions needed for spatial analysis. The WINDSPEED toolbox containing the DSS tool is added to this ArcToolbox architecture.

¹ A product developed by ESRI: <http://www.esri.com/>

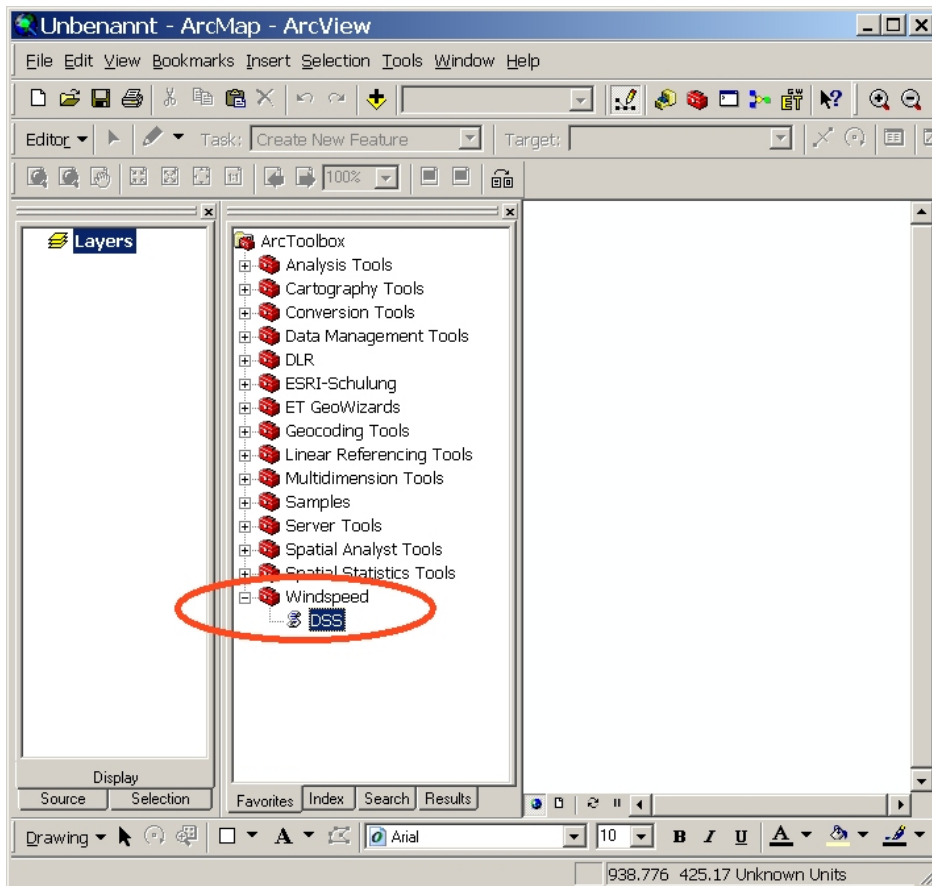


Figure 2: Example of the implementation of the WINDSPEED DSS tool (starting script) within the ArcGIS environment.

The DSS tool will consist of a variety of functions that generate maps that can be used for assisting analysis and decision exercises. These functions may be either standard function of the GIS such as “DISTANCE”, “BUFFER” or “EXTRACT” or they will be programmed especially for the needs of the project, e.g. cost functions like the calculation of “NET ANNUAL ENERGY PRODCUTION”.

The ArcGIS geoprocessor will be adressed via Python-scripting (a freely available dynamic object-oriented programming language) to work with the provided GIS-functions more flexible and to achieve the desired results. For the DSS a new Python-based script-programme is developed which is implemented in the ArcGIS toolbox environment.

2.2. Processing structure and functionality

The tool will be used within the WINDSPEED project to develop a roadmap for the expansion of offshore wind parks. Additionally the tool will be made available for interested stakeholders.

The DSS-tool with it functions and underlying data will be merged in a comprehensive File Geodatabase. This File Geodatabase can be disseminated to interested stakeholders. An ArcView license (9.3 or higher) is required to use the DSS-tool.

The processing structure of the DSS tool is shown in figure 3. The DSS tool starts with a dialogue box which provides the user all information about the input data. The user can change all parameters shown in the dialogue box which are then used for further processing. The first processing step is to take into account non-wind sea functions. Using different exclusion criteria as defined by IMARES (D3.3) these input data are used to define suitable areas for Offshore Windparks. These suitable areas are used to calculate the potential for Offshore Wind Energy. Therefore, several wind energy functions are calculated which result in final maps as suitable area, potential cost etc.

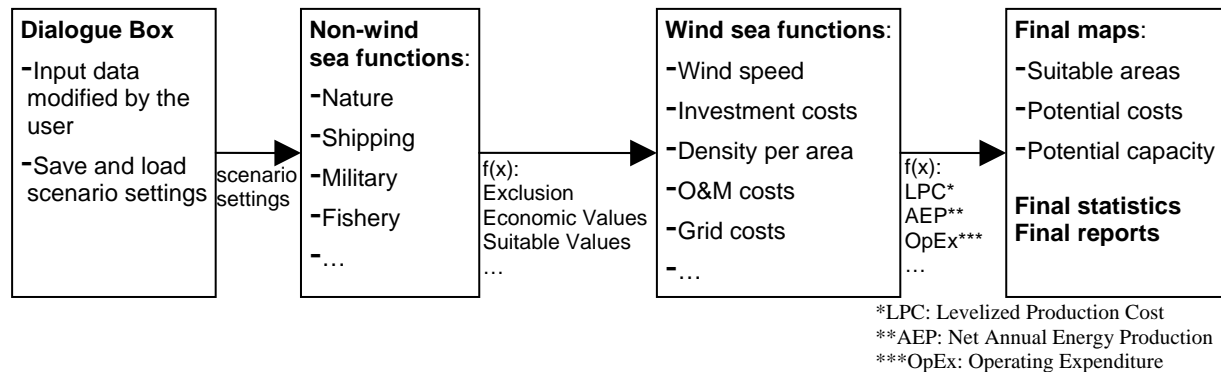


Figure 3: Overview structure of the DSS tool

The applied functions describing the interrelations of various parameters are defined mainly by the project partners IMARES and Garrad Hassan. The outcome of this work are functions applied to the DSS tool that can not be changed in its further use. Some parameters/variables within those functions, however, are changeable for the user of the tool. The user is given a range of options to choose from. This may seem advisable as certain assumptions would not produce any feasible results from a scientific or practical point of view. Also it may occur that some assumptions would create a failure within the tool as different maps and there respective functions are brought together in a final map. Therefore, the dialogue box provides a default value and a value range for some parameters.

The dialogue box allows the user to define and modify different input parameters. Before running the tool with the defined parameters, the user has to save these settings within a scenario file. To run a scenario, the desired scenario file has to be selected. The saved files can be loaded to the system for reruns and also can be shared with other users for comparison issues.

During the calculation process, many spatial and statistical data are combined and analyzed. To do this in an appropriate way, three different databases are needed:

1. Input database: All required input data are stored in this geodatabase. E.g. data on windspeed, sea depth, military zones, platforms etc.. All data are compiled and harmonized by the WINDSPEED consortium and are implemented within the DSS. The input database may be updated during the project phase if newer or better data are available.
2. Process database: During the calculation process, many intermediate calculation steps are performed. The results of these steps are input data for further processing steps. All intermediate data are temporary stored within the process geodatabase. This database is generated automatically.

3. Output database: The results calculated by each module are stored in the output geodatabase. The stored data are used for creating the final maps and statistics. This database is generated automatically.

If new settings are defined by the user, the DSS will check whether existing intermediate data can be used for the new model run. As each intermediate data file includes information on the used settings, this allows for optimizing reruns or new runs. Not each of the intermediate data has to be recalculated.

The structure of the DSS and its functionality to store user-defined settings to a scenario file allows to reproduce model runs and allows to share defined settings with different users. Also a transfer of the DSS to a web-based interface is possible to publish the tool to a wider community.

2.3. Dialogue Box / User Interface

Starting the DSS by doubleclicking in the WINDSPEED DSS tool (see figure 2), the user interface/dialogue box appears (see figure 4). A short description is given in a header text. Additional help is provided by pressing the <Show Help> button. Several tabs contain the settings requested by the DSS. These settings have default values but can be changed by the user. Some of the settings are general, some of them are country-specific. The user can change settings in pre-defined ranges. All settings can be saved to a so-called scenario-file. The user can save as many scenarios as she/he likes. These scenario-files contain all information for running the DSS and allow to save settings and also to easily provide the settings to other users for comparison issues or reruns. The user only have to load the specific scenario into the DSS. After the user has pressed the <OK> button of the dialogue box, the selected scenario file is sent to the Python-script. This script runs the geoprocessor of ArcGIS to calculate all functions and to produce the intermediate and final maps.

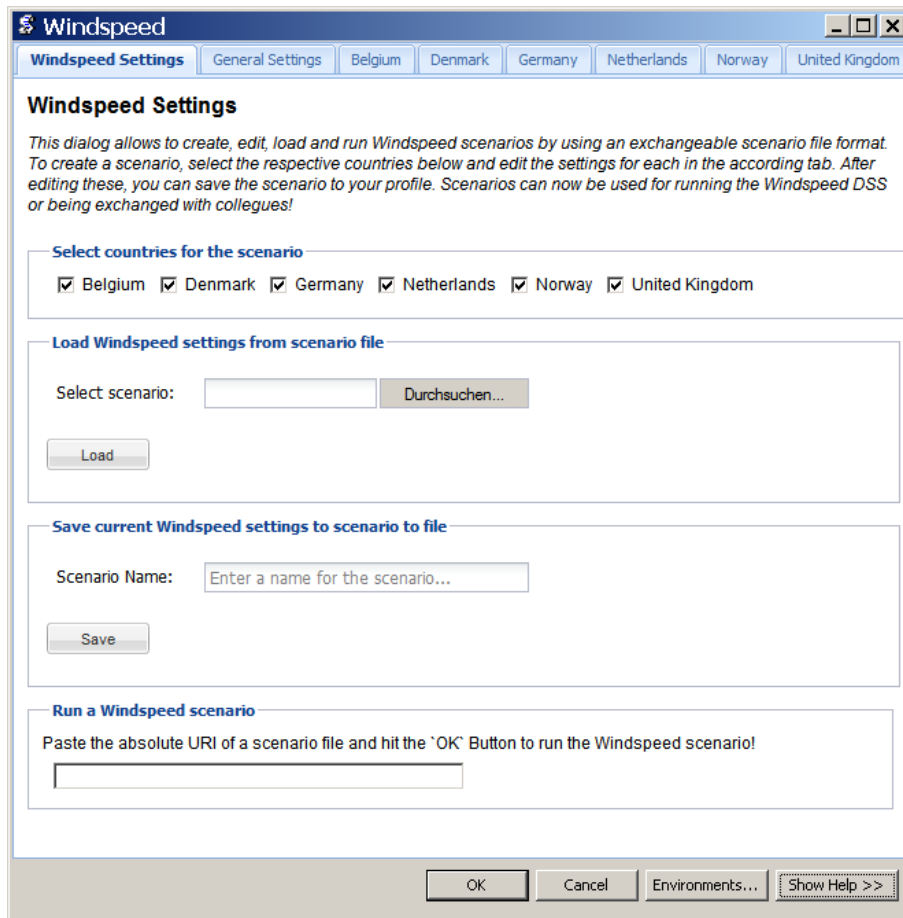


Figure 4: WINDSPEED opening dialogue box.

The tab <General Settings> contains input parameters for several functions. In the example shown in figure 5 the module <CostsCalculation> defines the settings for the cost calculation. Several parameters can be modified by the user. Further modules will be <GridConnection> and <WindparkSettings>. As an example, the user can modify the installed density from the default value 2 to a value within the range 1-3 (red-marked ellipse). The minimum and maximum values are shown by pressing the <Min> and <Max> buttons. If the value given by the user is out of range, an error message occurs.

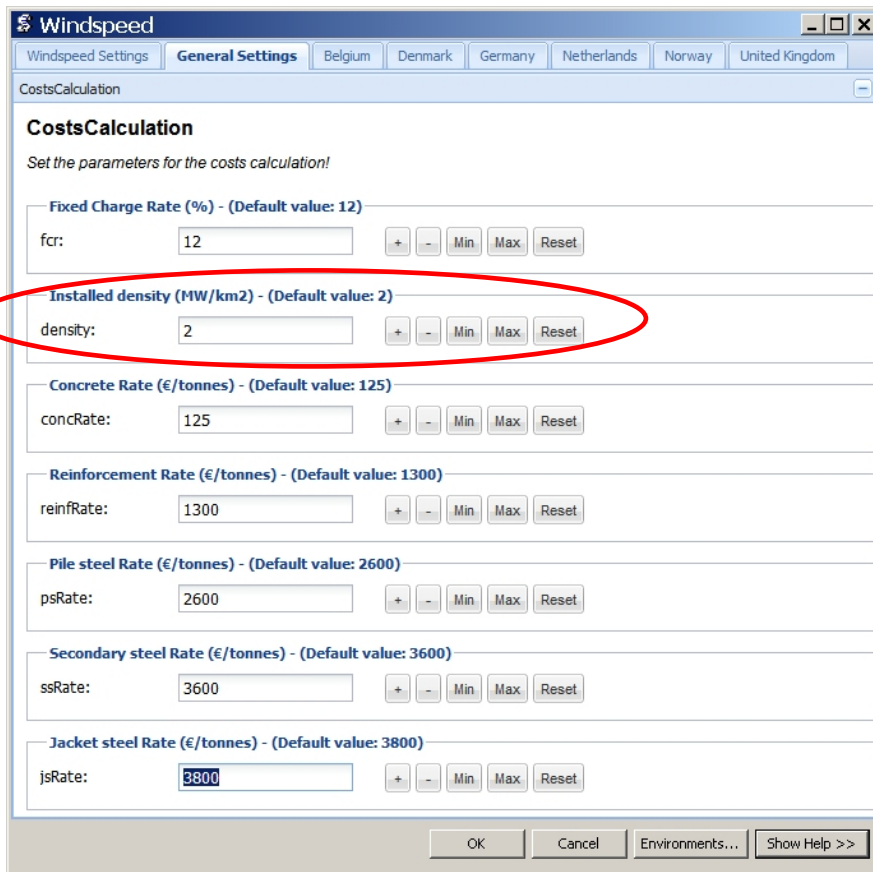


Figure 5: WINDSPEED dialog box <General Settings>

The country specific tabs allow to modify parameters for each country individually. Figure 6 shows Belgium as an example. Several modules are listed for each country, here exemplary <DistanceToShore>, <AeraByDepth>, <Shipping>, <Military Zone>, <Platforms>, <CablesAndPipelines>, <NatureConservationAreas>.

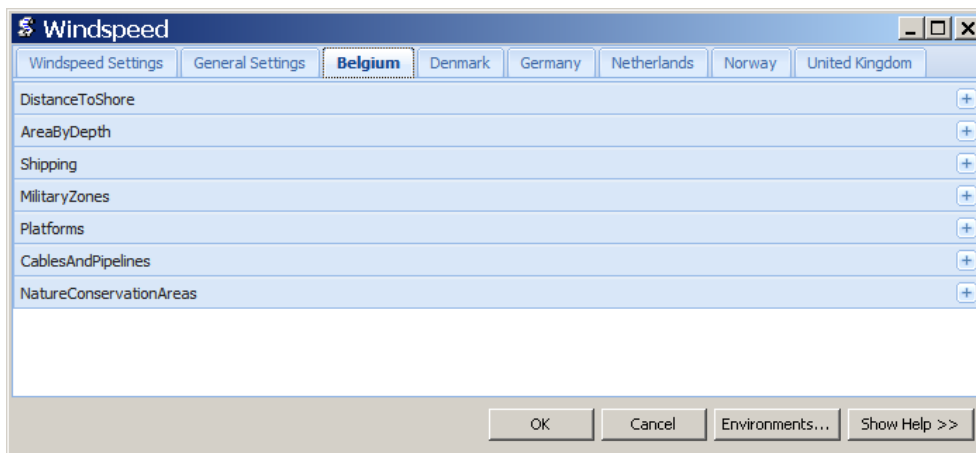


Figure 6: WINDSPEED dialog box <Country Specific Settings>, Belgium as example

Clicking on the module <DistanceToShore>, the parameters minimum and maximum distance to shore for defining suitable areas for Offshore Windparks can be defined by the user as shown in figure 7.

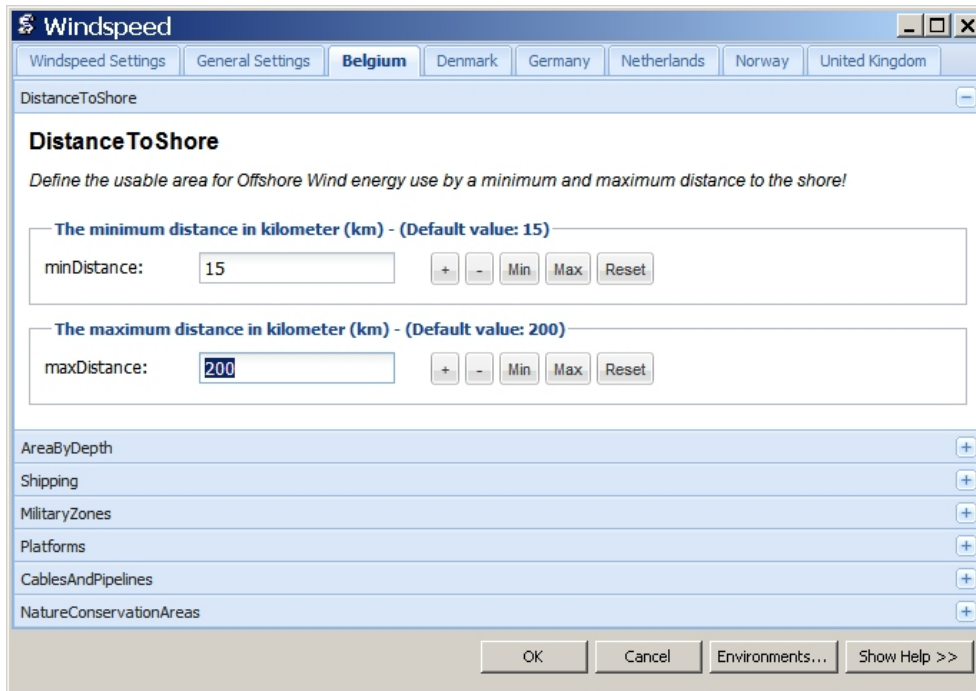


Figure 7: WINDSPEED dialogue box <Country Specific Settings> with module example DistanceToShore

All other modules have the a similar structure and functionality for defining input parameters. After the definition of all parameters, the user has to save these settings to a scenario file. To run the DSS, a scenario file has to be chosen. The DSS needs a scenario file as input.

3. Input data

Input data are structured in wind-energy related data/functions and non-wind-energy data/functions. The input data that will be fed into the tool will be provided by various project partners (IMARES, Garrad Hassan and SINTEF). The data as well as its intended use will be discussed at national stakeholder workshops. A detailed description of the input data is provided within the deliverables D2.2, D2.4, D3.1, D3.2 and D3.3

The following chapters give a short assumption on the input data and calculation rules. The translation of the defined calculation rules into the DSS are described in D4.2 more detailed.

3.1. Inventory of wind potential and related infrastructure

The goal of the inventory of wind potentials and related infrastructure is a map that displays the costs of the use of offshore wind per kWh and area. This map will be generated within the DSS tool. Cost related data are provided by the partner Garrad Hassan. In the following, an overview of the used wind-energy related data is given.

Capacity per area

In the DSS the available area for potential wind installations will be assessed. In order to be able to apply the installed capacity to this area, a relation has to be defined, e.g. 2 MW/skm. This definition on its own might not be enough though as an offshore installation may only be built at a certain size. Therefore a minimum and maybe even a maximum capacity need to be defined per offshore wind park (e.g. 200-300MW). This will have the effect that certain areas may be generally available for offshore wind installations but are too small for the minimum size of the wind park. If only one size of wind park will be defined, the available area that can be used will have to be a multiple of the defined size. (see also D2.2 for more details)

Investment costs

The assumptions concerning investment costs will be based on recent experiences with wind offshore projects in the North Sea. A differentiation between investment costs for the wind turbine and their foundation will be applied. Regarding the costs of wind turbines an average value will be defined. For the foundation a number of technological options will be taken into consideration with average investment costs accounted for each technology.

As the project looks at a period up until 2030, assumptions regarding the development of investment costs are made. These assumptions are given by progress ratios and are based on technological learning curves as described in D2.2. Within the calculation of costs, there are further information needed like distance to ports, spring tidal amplitude, storm surge and wave heights. (see also D2.2 for more details)

Wind speed

To reach the target of a map that displays the costs per kWh, wind speed is a very important variable. As the wind speed varies between different heights, an average hub height will be defined and used as a fixed assumption in the DSS tool. At the moment the windspeed at a

height of 90 m is implemented in the DSS. The wind speed data is available on a spatial resolution of 5km x 5km. (see also D2.2 for more details)

Grid infrastructure

The grid infrastructure that needs to be established for the use of offshore wind is a crucial aspect when it comes to the costs related to it. The DSS tool will cover the costs regarding the connection of the wind parks to defined connection points on shore with a simple approach. It will not tackle the question of costs associated to the expansion of the onshore distribution to the areas of consumption. Our proposal could be to define a certain amount of connection points. A function to search for the areas that would be connected to each defined connection point could be applied to the model. This way the model would choose the nearest / cheapest option for connection and could calculate the costs related to the length of needed connection line. This is still work in process and has to be further discussed. (see also D2.4 for more details)

Distance to shore

Another issue that belongs to the inventory of wind potentials are possible exclusion zones in connection to the distance to shore. A function will be implemented that describes a minimum and maximum distance to shore feasible for the use of wind power. As the existing requirements vary from country to country the variables used will be differentiated for each country. This also implies the possibility for the user to individually change the criterions for each country.

Area by depth

The DSS also takes into account the sea depth. This is done in two ways. On the one hand, the user can define a maximum sea depth where OWP can be built. All deeper areas are excluded. On the other hand, the sea depth influences the installation costs of an OWP. Therefore, this information is included in the cost functions which can not be modified by the user.

3.2. Inventory of other sea functions and identification of interactions

The inventory of other sea functions should include all sea functions that interfere with the use of offshore wind energy. The interactions between these other sea functions and offshore wind installations can be either positive or negative and will be provided by IMARES. In the following, an overview of the used non-wind-energy related data is given.

Shipping routes / Shipping density

Shipping routes can generally be defined as exclusion areas for offshore wind installations. This is especially the case for official international shipping routes. Outside those international routes however a more refined assessment will be aimed for in taking shipping density data into consideration. The way this will be done in the DSS tool is to define the

lowest shipping density that leads to an exclusion area. If needed an additional buffer zone can be applied in the model. The definition of the lowest shipping density as well as the buffer zone will be defined as variable input data. Also the option to make shipping routes more compact / smaller can be chosen by the user.

Oil and gas extraction

Oil and gas extraction sites are another issue that competes with the use of offshore wind energy. At the same time wind installations might have a positive influence on offshore extraction sites as they can provide the electricity supply.

The existing as well as the planned sites for oil and gas extractions will be treated as exclusion zones for wind offshore installations including a buffer zone if necessary. At the same time there is the possibility to implement a positive link between extraction sites and wind installations in the DSS tool. This can be thought of if a country has a very narrow definition for the maximum distance to shore that offshore wind plants should have.

Again the development over time is important as oil and gas extractions are an important economic factor. As mentioned in the last paragraph the existing as well as the planned extractions sites should be taken into consideration. The reason for this is again the lifespan of wind installations. Another issue that has to be considered though is the possibility that extraction sites might be closed down and the area might become available for wind installations.

Areas with fishery activities

Fishery is another economic activity that needs to be taken into consideration while assessing the potential for offshore wind energy use. Other than most usages of the sea that are a matter of national concern, fishery activities are under the responsibility of the Directorate-General for Maritime Affairs and Fisheries of the EU. Due to this fact a differentiation between countries will not be applied to the DSS tool.

A map of areas for fishery activities will be added to the DSS tool. Like sediment extraction an economic trade-off will be necessary to take the effects of wind installations on fishery activities into consideration. As long as wind offshore installations have a negative influence on fishery activities they might have a positive influence on the fish stock and the benthos. All these issues have to be taken into account and will be added to the DSS tool in a suitable way. This is still work in process and has to be further discussed.

Pipelines and cables

The area needed for pipelines and cables is clearly an exclusion zone. However, taking the diameter of a pipeline into consideration this might not have such a strong influence on offshore wind installations. The existing pipelines in the North Sea have a diameter below 50 inches (1.27 m). As the distance between offshore wind installations is usually between 600 and 900 m a combination of offshore wind installations with pipelines can be done even by including a buffer zone. This buffer zone will have to take maintenance issues as well as negative effects for example during the ramming of the foundation pylons into consideration.

Military activities

Areas in the North Sea are used for different military purposes. As wind installations have different effects on different usages, a differentiation of these areas does seem to be advisable. There are three different approaches that could be chosen for areas with defence activities.

One is to exclude the existing areas as they are. This is quite likely to be the approach chosen for munitions dumping areas. Another one is to shift defence activity areas if they have better conditions for the use of wind energy than others. This could be thought of for exercise areas. The last approach would be to define a certain share of an area for defence activity open for wind installations. This will probably have to be done under certain requirements regarding distance between plants or parks etc. This can be thought of for marine exercise but not for air force training areas. For air force training areas buffer zones in which wind installations are not allowed might even be advisable. Again possible developments of the defence activities areas have to be taken into consideration. This is still work in process and has to be further discussed.

Sediment extraction

Sediment extraction is part of the economical use of natural resources in the North Sea. The areas for its exploitation need to be taken into consideration in the DSS tool. As the extraction of sediment does have a negative influence on the stability of offshore wind foundations, these two usages are incompatible with each other. Therefore areas defined for sediment extractions will be regarded as exclusion zones.

The development over time also needs to be taken into consideration. As sediment extraction is restricted to areas with certain conditions, a trade-off with wind energy use has to be defined for these areas. This can be done by either setting one usage prior to the other or by comparing the economic gains for an economy. The second approach can only be chosen if enough information on the economic value of both goods is available. As this might go beyond the scope of the project, the first approach might be chosen. A possibility would be to set a certain percentage for the use of offshore wind energy in areas suitable for sediment extraction. This figure would be implemented as variable.

Nature conservation

Nature conservation is an important issue that has to be taken into consideration when looking at the use of offshore wind energy. As nature is not an economically valuable good, it tends to be neglected. To ensure biodiversity within the EU a network of 26,000 protected areas representing more than 20 % of total EU territory have been defined and set up in the Natura 2000 network. Some areas within the North Sea are part of this network and should be considered as the EU intended to. As the EU only gives guidelines on the use of Natura 2000 areas, different approaches are taken in the North Sea countries. The Netherlands and Germany for example considers Natura 2000 areas as exclusion zones for the use of offshore wind energy. Great Britain on the other hand sees offshore wind installations to be a good match for Natura 2000 areas.

As mentioned before the DSS tool can take any interrelation that needs to be added into consideration as long as it can be described in a mathematical equation. Therefore more detailed approaches can be thought of. First of all a differentiation between various species could be done to assess the influence wind installations would have on each one. Regarding birds for example the tool could differentiate between the influence on breeding areas and on migratory routes. For example certain species of breeding birds might have a certain range in which they collect their food. If some area within this range would be used for offshore wind installations than the distance they would have to fly in order to have an equivalent area available for food collection would have to increase. The maximum acceptable increase of way could be defined and processed in the DSS-tool. For migratory routes an increase of distance might not be suitable. Instead a distance that needs to be additionally covered per

wind turbine might be defined. A maximum can be applied to this approach as well. These approaches can also be combined with exclusion zones, for example if an area has specific features necessary for a bird species that could not be exchanged for some other area. Similar approaches regarding different fish species or benthos can be taken into consideration as well. This is still work in process and has to be further discussed.

4. Processing chain

The complete processing chain within the DSS is divided in four major steps:

- Step 1: Definition of scenario settings using the dialogue box
- Step 2: Calculation of general suitable areas with respect to non-economic sea functions
- Step 3: Calculation of costs of OWPs
- Step 4: Compilation and visualization of final maps, statistics and reports

The user can not interactively modify a single processing step but she/he can modify the parameters in the dialogue box before the complete processing chain starts. In the following the four processing steps are described in an overview. A detailed description can be found in D4.2. The overview of the processing chain and its steps is shown in figure 8.

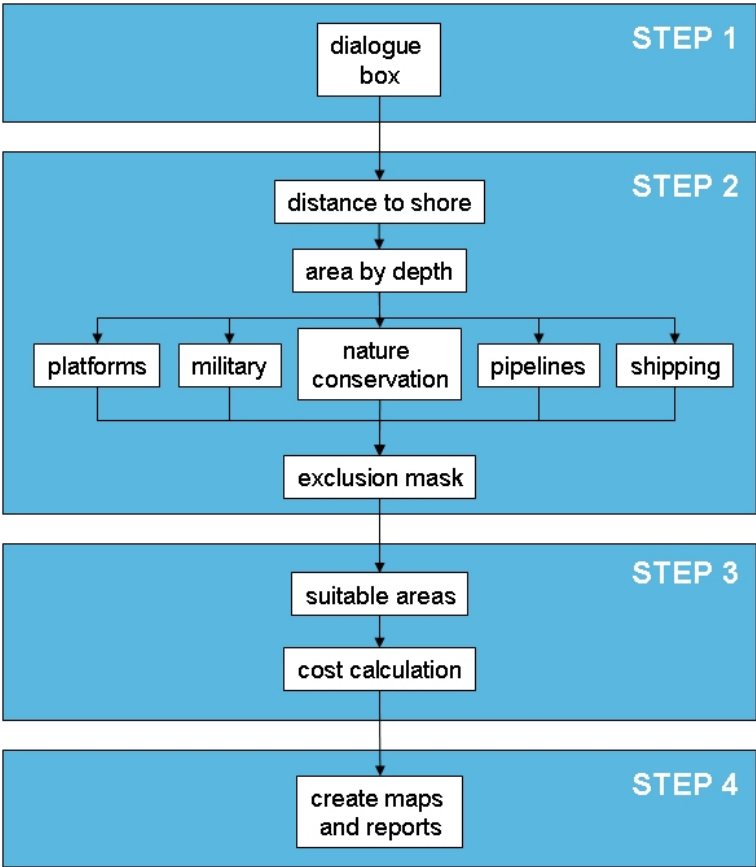


Figure 8: Processing chain and its four steps within the DSS

4.1. Step 1 – Definition of scenario settings using the dialogue box

As described in detail in chapter 2.3, the dialogue box compiles all user defined settings to a scenario file. This scenario file contains all parameters needed for the complete DSS processing chain.

4.2. Step 2 – Calculation of general suitable areas (non-economic sea functions)

Step 2 starts the ArcGIS Geoprocessor using Python scripting. All parameters provided by the scenario file are available for the processing.

In terms of programming methodology it is recommended to reduce the amount of data that are used for calculation. This increases the calculation speed. Therefore, step 2 will identify all areas that are not suitable for OWPs due to the user-defined parameters. Some sea-functions clearly define the possible suitability. E.g. if the user defines a minimum distance to shore, the DSS will exclude all areas nearer to shore than the minimum value. Other sea-functions are not that clear. E.g. nature conservation areas can be strictly excluded, but in some countries there is also the possibility to open some of the nature conservation areas for OWP in some extent. Therefore, the DSS provides the option to define country-specific nature conservation areas to be used for offshore wind energy. The user can define a percentage of the area that is suitable. The DSS defines the area by taking into account the selected strategy. E.g. the user can define that the subarea (the user defined percentage of the complete nature conservation area) with the highest wind speed should be taken into account. Another strategy could be to select the area with the lowest cost. For this, the costs have to be calculated for the complete nature conservation areas. After this, the suitable area out of the nature conservation is selected automatically by the DSS.

Following non-economic sea functions are used for step 2 to compile a final exclusion mask:

- Distance to shore
- Area by depth (maximum of sea depth)
- Shipping routes/ shipping density
- Oil and gas extraction
- Cables and pipelines
- Military activities
- Sediment extraction
- Nature conservation

The exact calculation rules, how these non-wind sea functions are taken into account by the DSS, are described in detail in D4.2.

The result of step 2 is an exclusion map that will be used by the DSS to define the remaining suitable areas out of the complete WINDSPEED area. This remaining area is transferred to the next processing steps.

4.3. Step 3 – Calculation of costs of OWPs

Taking the map of step 2 as basis, for each area economic parameters are calculated. In figure 9 an example suitable area is shown. The red marked area in the German EEZ was selected by minimum and maximum parameters of distance to shore and maximum parameters of sea depths. Within the red marked area, the regular 5km x 5km grid is noticeable. The cost calculation is performed for each single 5km x 5km grid cell as most of the cost-related input data are provided in this spatial resolution.

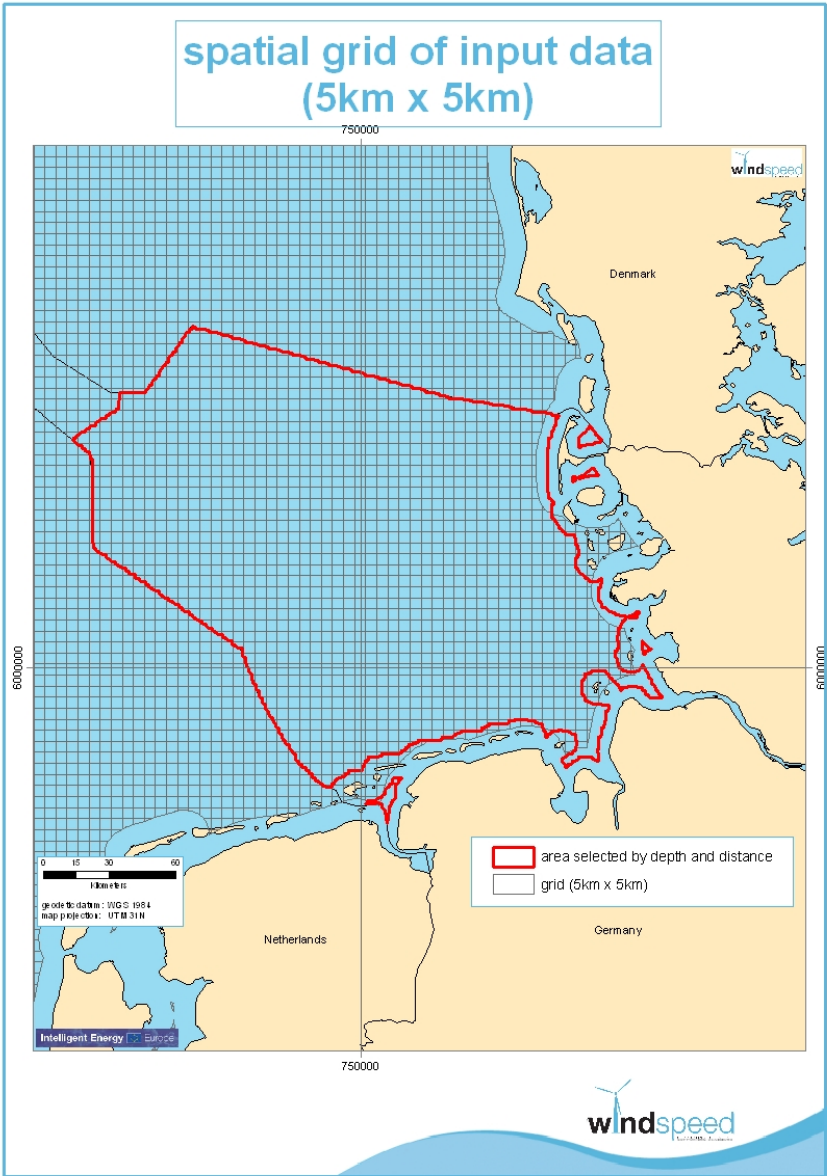


Figure 9: Spatial grid of input data as base grid for all cost calculation.

For each grid cell the cost parameters as listed in table 1 are calculated. The detailed cost functions developed by the project partner Garrad Hassan is described in detail in D2.2.

Acronym	Parameter	Unit
LPC	Levelized Production Cost	€/MWh
CapEx	Initial Capital Expenditure for project	€
FCR	Fixed Charge Ratio	%
OpEX	Operating Expenditure	€/a
AEP	Net Annual Energy Production	MWh/a

Table 1: Used parameters for the cost calculation

The Levelized Production Cost (LPC) is used in the DSS to compare the overall economics of different zones in the North Sea.

4.4. Step 4 – Visualization of final results

The final results, e.g. the information on the Levelized Production Cost (LPC), can be visualized in different ways. The main outputs of the DSS are digital maps showing the suitable zones/areas and the resulting cost parameters. These maps are in GIS-ArcView format and can therefore be used for further analysis. Within the DSS, the calculated data/layers are compiled to resulting maps. For publishing issues, all maps can be converted to image-format like jpg or tif. Another output format is Geo-pdf which allows for choosing different layers for visualization within Adobe Acrobat. Additionally, a statistical report will be created containing most relevant input and output parameters for each country and region.

As an example result, the Net Annual Energy Production (AEP) in [GWh/a] is shown in figure 10. The AEP is calculated per km². As the base information (windspeed at 90m in m/s) for the calculation is based on the 5km x 5km grid, the AEP is given for each grid cell or subset of grid cell (e.g. if an exclusion area reduces one grid size). The GIS calculates the corresponding AEP for each pixel (grid) size. The blue-coloured areas are suitable areas for OWP containing the AEP-values. Grey-marked areas are non-suitable / excluded areas (e.g. pipelines with buffer, platforms with buffer, nature conservation areas, military zones etc.). Table 2 gives the sum of the AEP given for each country. As shown for the AEP, all calculated and analyzed parameters will be visualized in maps and will be provided in text/tabular format.

This example calculation is based on specific input parameter defined in the dialogue box (see figure 5). These defined parameter will also be provided in text format for documentation purposes.

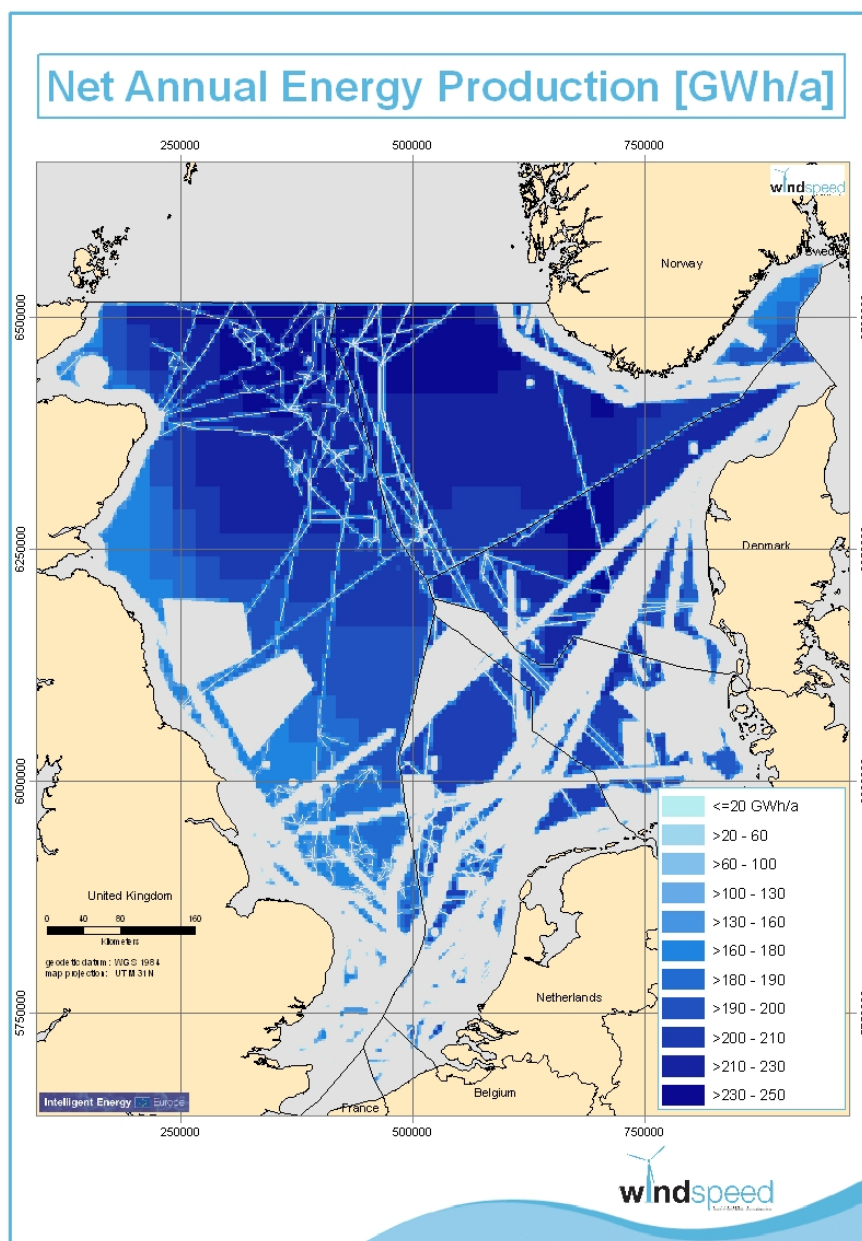


Figure 10: Example of calculated Net Annual Energy Production (AEP) in [GWh/a] for each (blue-coloured) grid cell. Grey-coloured area is not suitable for OWP with respect to the user-defined scenario settings.

Country	AEP [TWh/a]
BE	1.6
DE	80.4
DK	261.3
NL	15.2
NO	597.8
UK	1050.4

Table 2: Sum of Net Annual Energy Production (AEP) in [TWh/a] for each country based on an example run of the DSS, corresponding map is shown in figure 10.

5. Constraints of the DSS tool

The most important constraint of the DSS-tool is most likely to be the availability of data. This may be due to various reasons. The data required might not exist or only for a certain area covered by the project. The owners of data may not be willing to share the data with the project. The data may even be of high confidentiality and therefore not available. Also it might occur that the project partners may be advised not to hand the original data to any third person. Therefore, certain functions used in the tool may be available for the project itself but not to the use beyond the projects scope.

Also the actuality is an important issue. Within the project, the used data will be checked for updates until the final version of the DSS is completed. After that time, no update is planned so far.

Another constraint is the spatial resolution of the available data. The map with the lowest resolution does set the standard for the overall analysis. Therefore the data has to be chosen with caution. For the cost calculation, the spatial resolution is 5km x 5km, for exclusion data, the spatial resolution can be higher (e.g. 1km² for bathymetry)

Processing time is another issue that needs to be addressed. Depending on the complexity and amount of interdependencies that need to be taken into consideration the processing time of the DSS tool might be quite long (up to hours or even days). This might not be a problem for the use within the WINDSPEED project. However, it might not meet the requirements for the use of other stakeholders. This issue needs to be discussed at the stakeholder workshops as there might be a trade off between processing time and level of detail.

Another aspect is the acceptance of the DSS-tool. The discussion of spatial planning for offshore wind is at very different stages in the countries covered by the project. In countries with a very in depth level of discussion (e.g. Germany) the results of the WINDSPEED project may be not as detailed compared to the national tools. In other countries where the discussion has not even properly started yet, the tool may go beyond the needs of the stakeholders. It has to be kept in mind that the target of this tool is to foster the international discussion and to possibly identify synergies that can be gained in an international collaboration.

All this shows that the cooperation with stakeholders is crucial for the outcome of this project as well as the relevance of the DSS-tool.

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