DESIGN TOOL FOR OFFSHORE WIND FARM CLUSTERS

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Summary

The Design Tool for Offshore wind farm Clusters (DTOC) is a software tool to facilitate the optimised design of both, individual and clusters of offshore wind farms. DTOC is developed with the support of an EC funded FP7 project with contributions from science partners from the European Energy Research Alliance (EERA) and a number of industrial partners. The approach has been to develop a robust, efficient, easy to use and flexible tool, which integrates software relevant for planning offshore wind farms and wind farm clusters and supports the user with a clear optimization work flow.

The software includes wind farm wake models, energy yield models, inter-array and long cable and grid component models, grid code compliance and ancillary services models. The common score for evaluation in order to compare different layouts is levelized cost of energy (LCoE).

The integrated DTOC software is developed within the project using open interface standards and is now available as the commercial software product *Wind&Economy*.

1. Motivation

One of the most challenging tasks for wind farm developers is the optimization of offshore wind power plants. Large offshore wind farms and wind farm clusters, such as those in the German Bight or on the Dogger Bank, change the wind climate itself and make this optimization task even more demanding. During the process of wind farm optimization, hundreds of variations are considered and need to be managed, documented and benchmarked.

The new software tool, *Wind&Economy*, supports this challenging work with the seamlessly integrated modelling of wind climate, large scale and localized wind farm effects, electrical loss calculations and derivation of economic key figures. It has been developed around the EU-funded R&D project EERA-DTOC.

A clearly organized workflow supports the developer in the management of the set of all windfarm variations ever to be considered during the life time of your project. Using LCOE, the Levelized Cost of Energy, as a economic performance key indicator helps to benchmark different approaches and select the optimized design. In addition, the detailed knowledge of the uncertainties of energy production and LCOE support the management of financial risks.

Leading edge meteorological and wind farm models, taken together with a consideration of the uncertainty of energy production and the cost of energy, make results waterproof and bankable.

2. Wind Farm Scenarios

Having hundreds of variations of the wind farm layout is not rare during the optimization process of offshore wind farms. In order to support to handle these different configuration options as efficiently as possible, we have defined a workflow which organizes many different farm variants in a development tree.

For this purpose, Wind & Economy defines farm “scenarios” consisting of wind climate, turbine types, hub height, models used to calculate the energy production, electrical grid layout and economic parameters. These scenarios, organized in trees, help to keep track of the development process. Comparative reporting of the results from a number of scenarios supports selecting the right track towards an optimized wind farm.

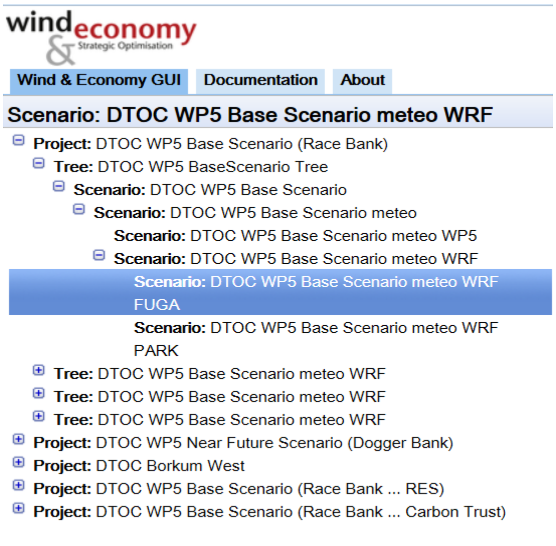

Figure 1: Organization of wind farm variants as scenarios. A scenario carries information about the wind farm configuration, wind climate, wind turbines, models and model parameters.

3. Wind resource

For most offshore applications, the wind resource for the target wind farm is non-uniform, and in most cases it is influenced significantly by existing or future wind farm installations.

Wind & Economy uses a specialized meso-scale model to calculate the long term wind climate in the area under consideration, with and without taking into account surrounding wind farms.

These model calculations give an immediate insight into

- variations of the wind resource over the wind farm area
- energy lost by wake effects from surrounding wind farms
- particular effects from large wind farm installations, including how they influence their own wind resource

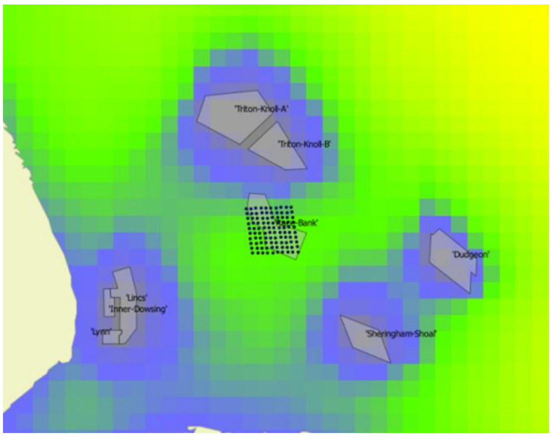

Figure 2: Wind resource with influence of neighboring wind farms in a wind farm cluster. Calculations with the WRF model.

4. Wake interaction in offshore wind farms

Today we know that wake effects in offshore wind farms are much more pronounced and long lasting than in onshore installations. To gain accurate modelling results, we have integrated the wind farm and wake model, FUGA, into the modelling platform. FUGA is optimized for offshore applications and, in particular, is able to model long distance wakes as they occur within and downstream from large offshore wind farm installations.

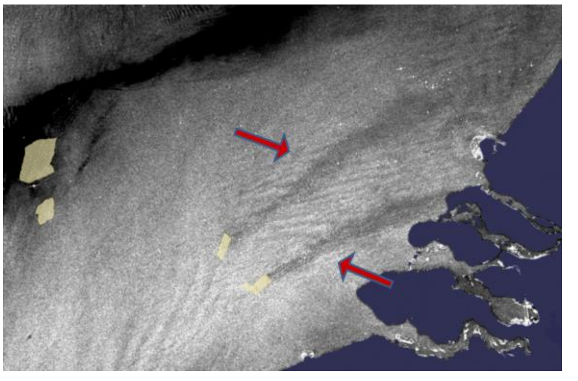

Figure 3: Far distance wakes from two offshore wind farms in the North Sea. Radar picture of wind speed.

5. GIS Integration Offshore Wind Farm

Many tasks which must be performed in order to optimize offshore wind farms are well supported by Geographical Information Systems, GIS. To benefit from this approach, we have included an open source GIS, the QGIS software, into the Wind & Economy workflow as one possible frontend.

By using this approach, the following tasks are supported:

- edit turbine layout
- visualize local and large-scale wind resources and energy production
- edit turbine types and other parameters
- optimize the cable layout
- calculate electrical losses
- select grid connection options
- consider environmental protection areas
- include additional information such as maps of water depth, exclusion areas, shipping lanes and others into your planning work.

6. Economic Modelling and Risk Management Support

For all offshore applications, there are two main key performance indicators: the return on investment and the uncertainty of these profits.

For each wind farm variant, *Wind&Economy* provides the user with the LCOE, the Levelized Cost of Energy. On this basis, he or she may decide whether additional investments, e. g. in a higher hub height, lead to a sufficient increase in energy production and are thus economically feasible.

By integrating wind resource calculations, wind farm modelling, economic modelling and uncertainty calculations into a single tool, the uncertainty of production and LCOE for each wind farm variant can be estimated. An uncertainty module takes into account the uncertainty of the expected energy production and the prices of wind farm components, finally resulting in so-called POEs (probability of exceedance) for different financial risk levels.

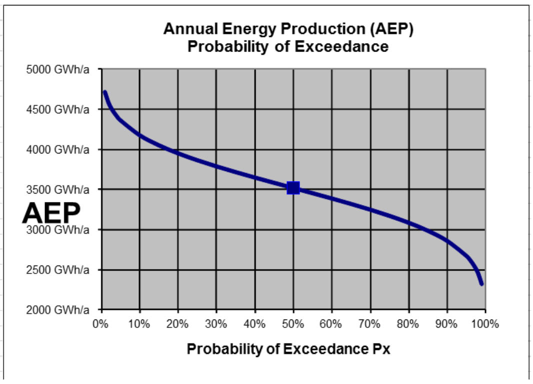

Figure 4: POE and annual energy production for an example wind farm.

7. R&D Project EERA-DTOC

The Wind & Economy software is a spin-off of the EU funded R&D project DTOC, the Design Tool for Offshore Wind Farm Cluster. This project, initiated and led by the European Energy Research Alliance (EERA), brings models from leading edge research together with the practical needs and experiences of high-impact industry partners.

In the framework of this R&D project, tools and software where not only integrated, but also benchmarked against satellite and sea based measuring campaigns.

References

www.wind-and-economy.com

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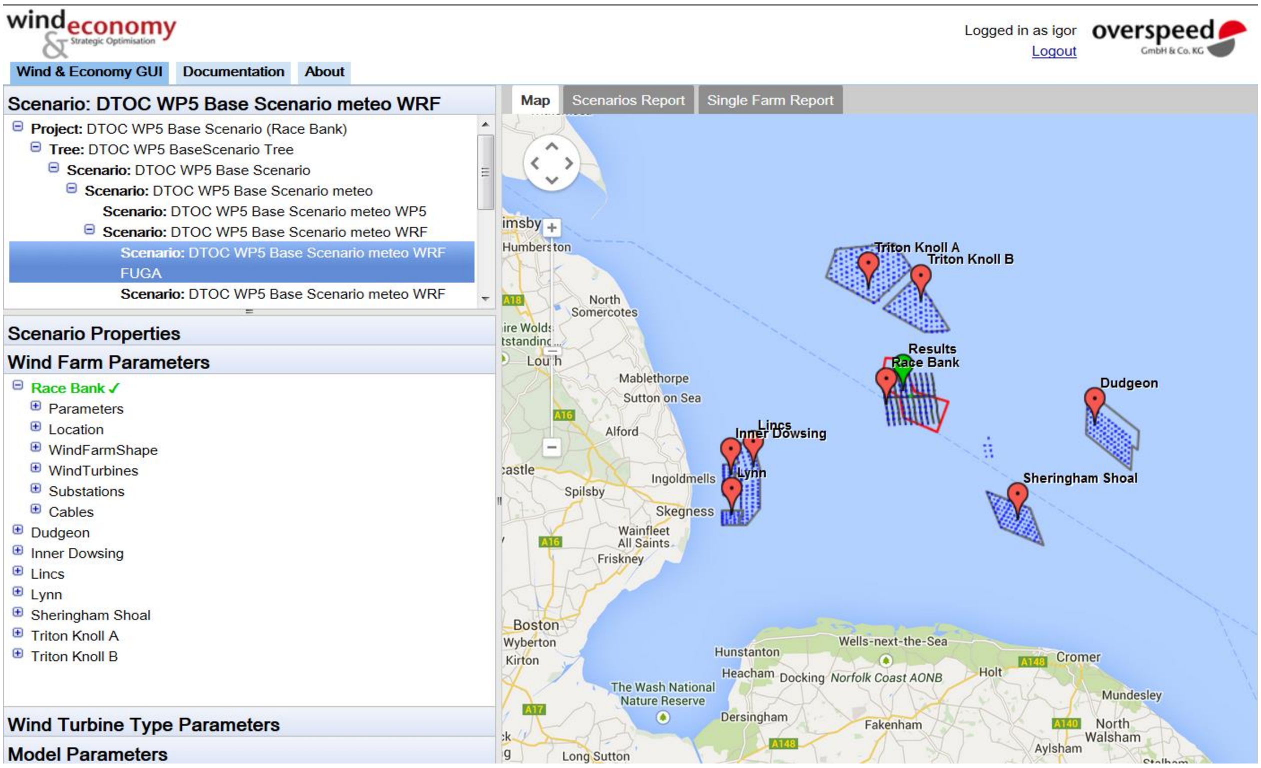

Figure 5: Web-based user interface of the commercial tool Wind&Economy*, a spin-off from the R&D projekt EERA-DTOC.*