PO. ID 154

Automated grid connection design process for offshore wind farm clusters

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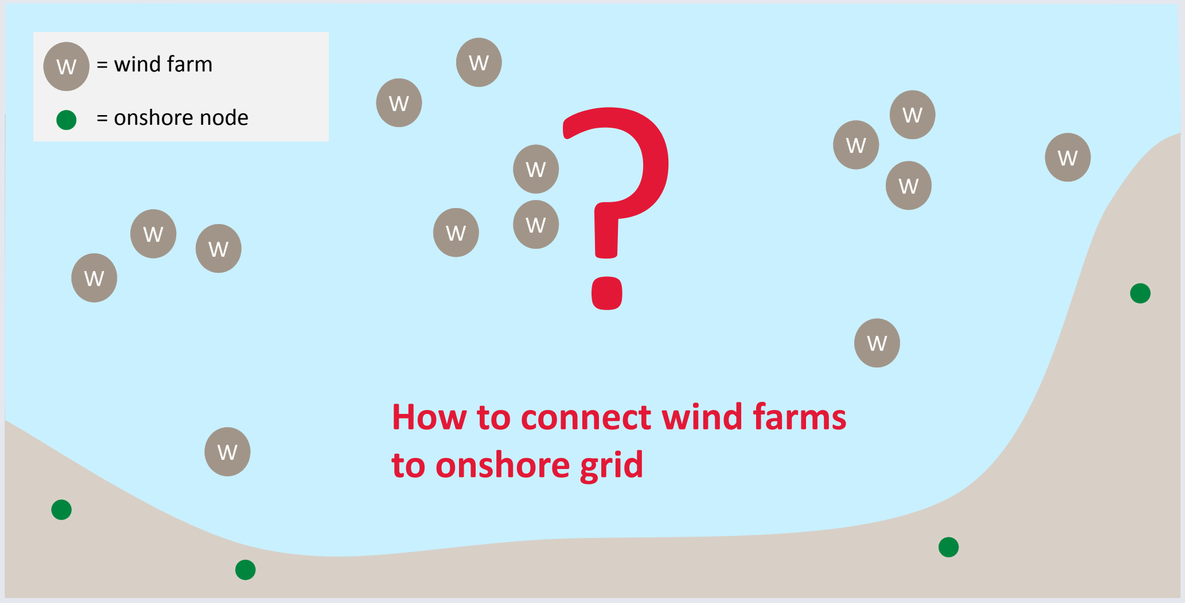
Abstract

The use of the Net-Op planning tool for offshore wind farm clustering and grid connection is demonstrated on a case study inspired by Dogger Bank.

Two modelling approaches for demand, generation and prices are outlined and compared for this case study. Both approaches result in the same optimal offshore grid and clustering of wind farms, taking into account variability of the wind and demand/prices.



Objectives

The ultimate objective is to realise grid connection solutions for offshore wind farm clusters that are beneficial from a socio-economic point of view.

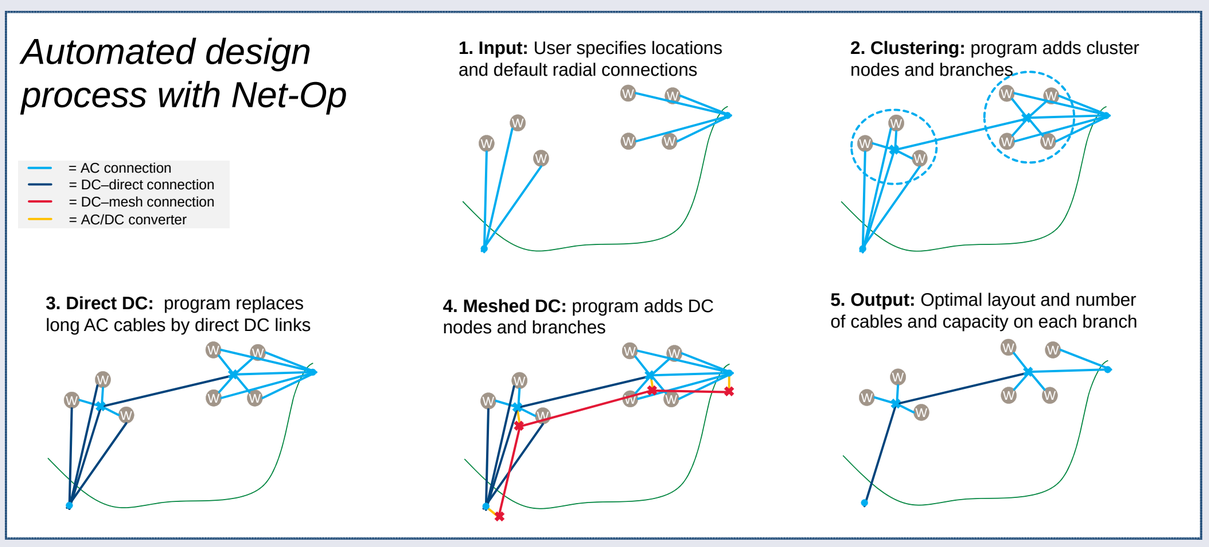
- Provide design assistance for early stage planning with minimal need for input data
- Take into account the variability in wind power, power prices and power demand
- Take into account offshore grid's potential dual purpose of wind power transmission and inter-area power trade

Methods

Net-Op is a planning tool for offshore grid design, wind farm clustering and optimised grid connection. The tool is suitable for high level, strategic planning of clustering and grid connection of future offshore wind farms that are planned in the proximity of each other. Formally, it performs an optimisation in terms of a mixed integer linear programming problem. The output is the optimal offshore grid layout.

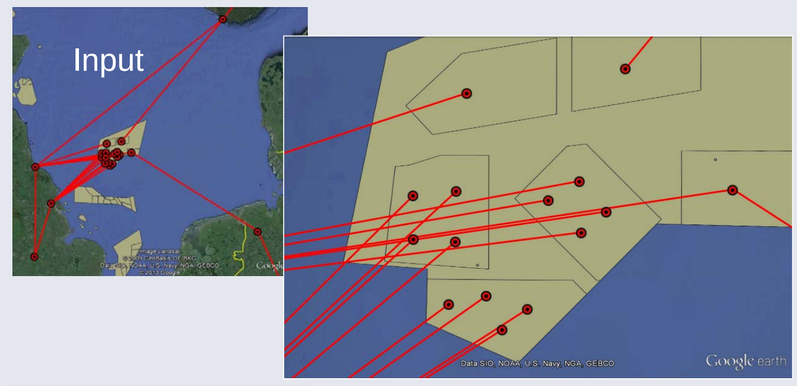
Two alternative modelling approaches are compared

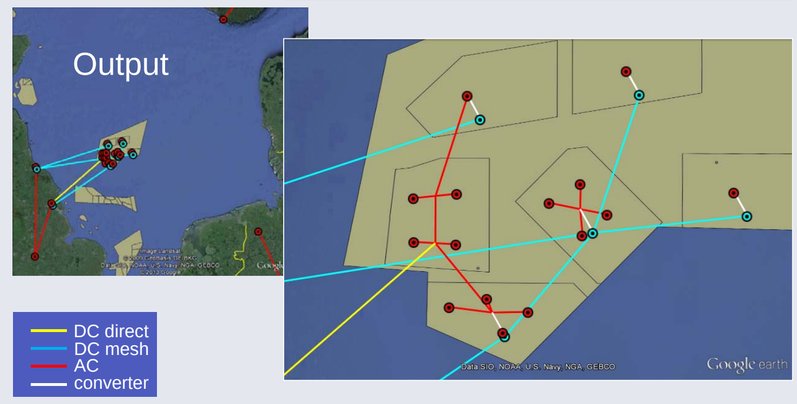
- Price driven: Single onshore generator per price area with generation cost equal to the electricity spot price (time series input). Demand is relevant only in curtailment situations.
- Demand driven: A representative portfolio of onshore generators and time series input for demand per price area. In this case, demand and wind power availability determines which generators should produce, and therefore the overall cost of generation.



Results

- No significant difference between price-driven and demand-driven modelling approaches
- No connections to NO or DE
- Both direct DC and meshed DC grid
- Wind farms interconnected via both offshore AC grid and meshed DC grid
- Results are sensitive to assumed cost figures





Conclusions

Net-Op is a planning tool for offshore grid design, wind farm clustering and optimised grid connection. The tool is suitable for high level, strategic planning of clustering and grid connection of future offshore wind farms that are planned in the proximity of each other.

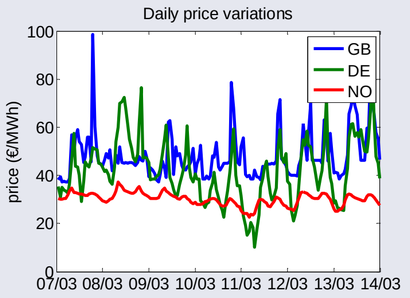
Assumptions

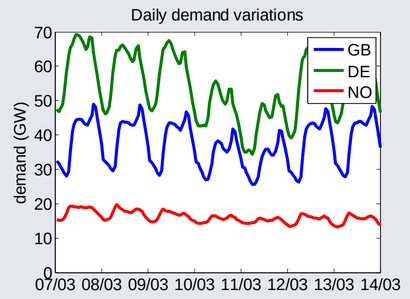
Case: Dogger Bank 6000 MW wind farm cluster
- 4 × 300 MW substations in Creyke Beck A, B and Teeside A
- 1200 MW acummulated power at Teeside B,C and D.
- Potential connections to GB (Creyke Beck and Teeside), DE and NO

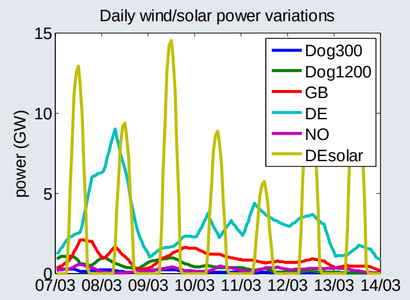
Time series (2012)
- Wind and solar power, estimated from Reanalysis weather data
- Electricity prices (Elexon, EEX, Nordpool)
- Power demand (ENTSO-E)

Fixed values
- Generation capacity 2012 (ENTSO-E)
- Generation cost per type 2010 (OffshoreGrid project)
- Electrical infrastructure costs (Windspeed project)
- Constraints: cable capacity, converter capacity

Optimisation problem
- Mixed integer linear programming (linear cost function)
- Latin hypercube sample (N=30) of operating states







References

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2. H. G. Svendsen, Planning Tool for Clustering and Optimised Grid Connection of Offshore Wind Farms, *Energy Procedia* **35** (2013) 297–30, DOI: 10.1016/j.egypro.2013.07.182.

Acknowledgements

Norwegian Research Centre for Offshore Wind Technology (**NOWITECH**, www.nowitech.no)

EU FP7 grant agreement 282797 (**EERA-DTOC**, www.eera-dtoc.eu).