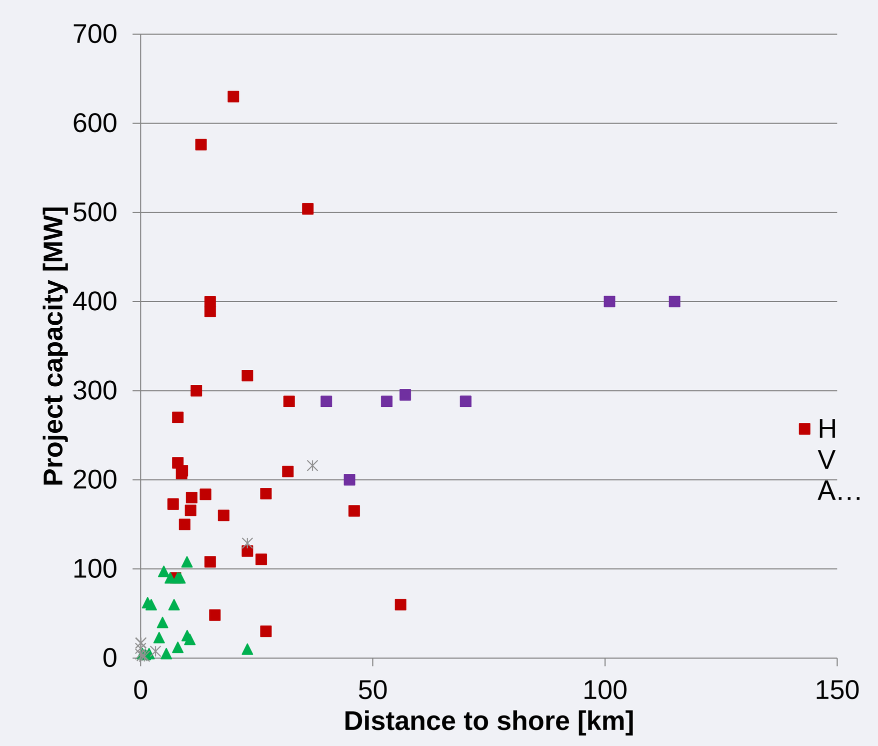
PO.ID 053

Power Frequency Optimisation for Offshore Wind Farms

Researchers'/Presenters' Names
DNV GL Energy - Advisory

DNV·GL

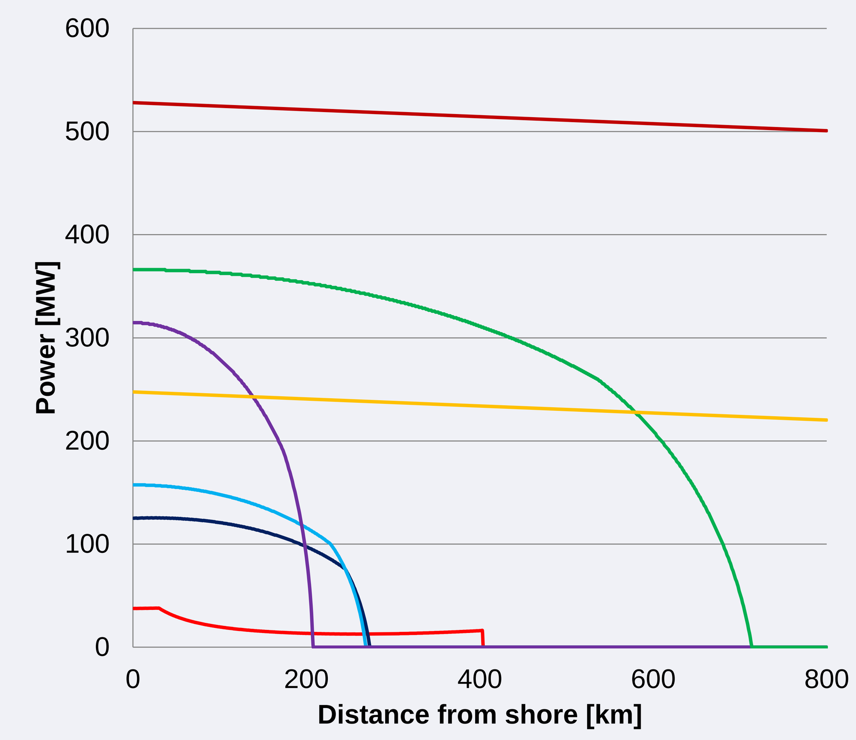
Abstract



The size of offshore wind farms and the distance at which they are located from shore are continuously increasing. Currently, the only way to export the generated energy to shore to the public utility grid is by submarine cable.

The increase in capacity and distance from shore is pushing theoretical limits of conventional 50 Hz AC technology to transmit the generated energy. In the German sector of the North Sea, this has led the grid operator to opt for an HVDC solution instead.

HVDC maximally utilizes a cable's real power transmission capacity at the expense of an onshore and an offshore converter stations. The realization of the offshore converter station is challenging and recent setbacks have led to a significant increase in the perceived risk.



The constraints on AC cable capacity are inversely correlated to the applied power frequency. The frequency of 16.7 Hz, which has long used in the European railway sector, has thus been suggested in the technical literature [1] for use in offshore wind farms' export and array systems.

Low-frequency transmission extends the range of conventional AC technology, and obviates the need for offshore converter stations. Moreover, generally lower frequencies result in lower losses but larger transformers.

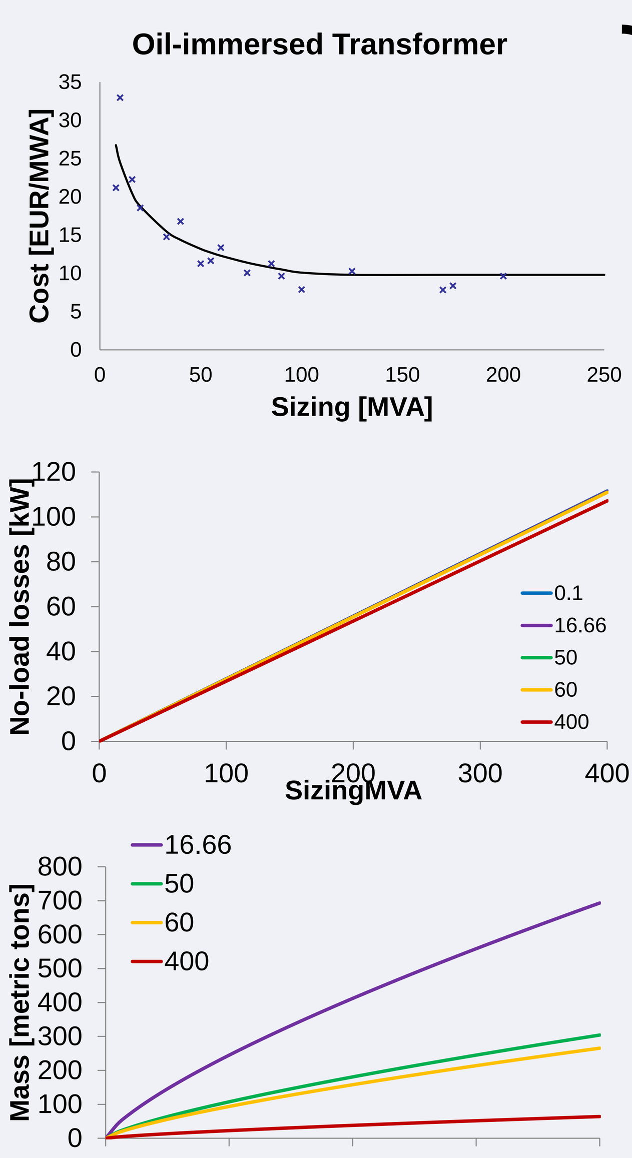
The suggestion of 16.7 Hz is one of convenience, since a standardized supply chain exists around it. A change in frequency affects all electrical and some structural components, and thus the cost, of a wind farm. This work aims to determine which frequency minimizes the lifetimes cost of energy of an offshore wind farm.

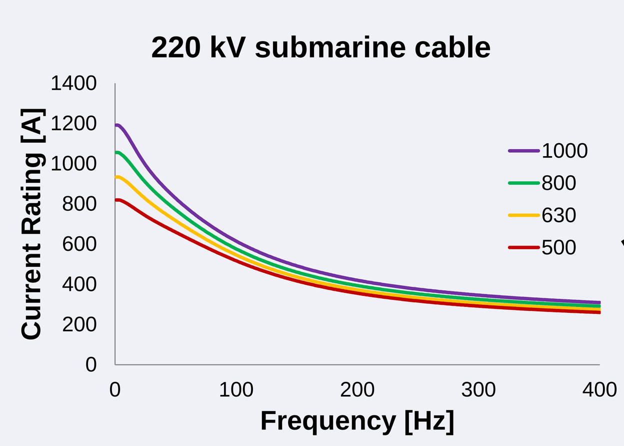
Objectives

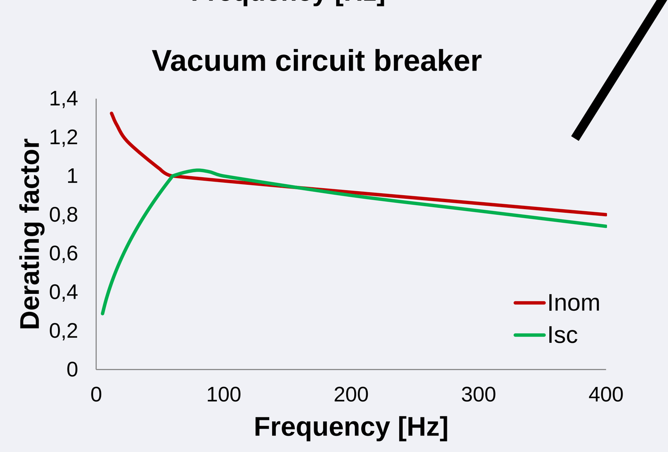
The development of offshore wind energy started by adapting onshore wind technology to be able to cope with the offshore conditions. By now, manufacturers have designed turbines specifically for this purpose, yet the power system is still designed using the same principles that are used for onshore utility applications.

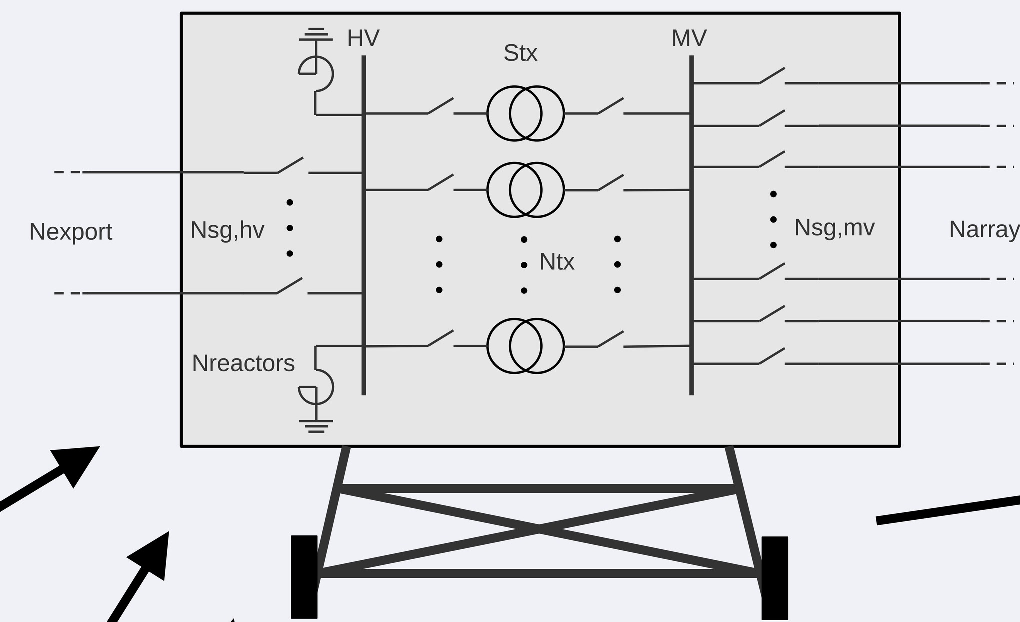
DNV GL Energy advocates a paradigm change in design approach by regarding a wind farm as a system rather than as the sum of individually optimized components and aims to understand how technological changes, such as a change in the key system parameter i.e. power frequency, affects the wind farm's lifetime costs.

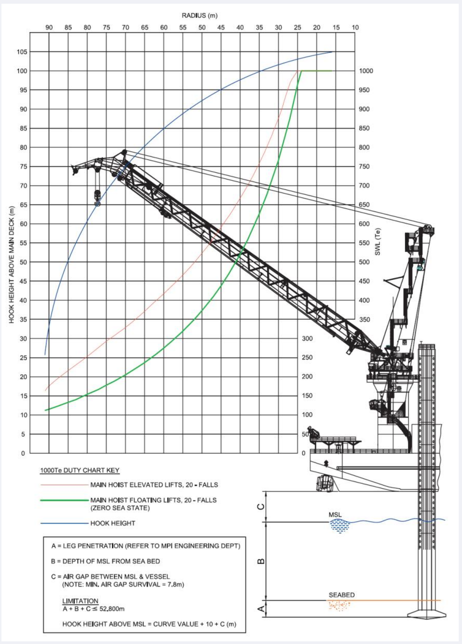
Methods

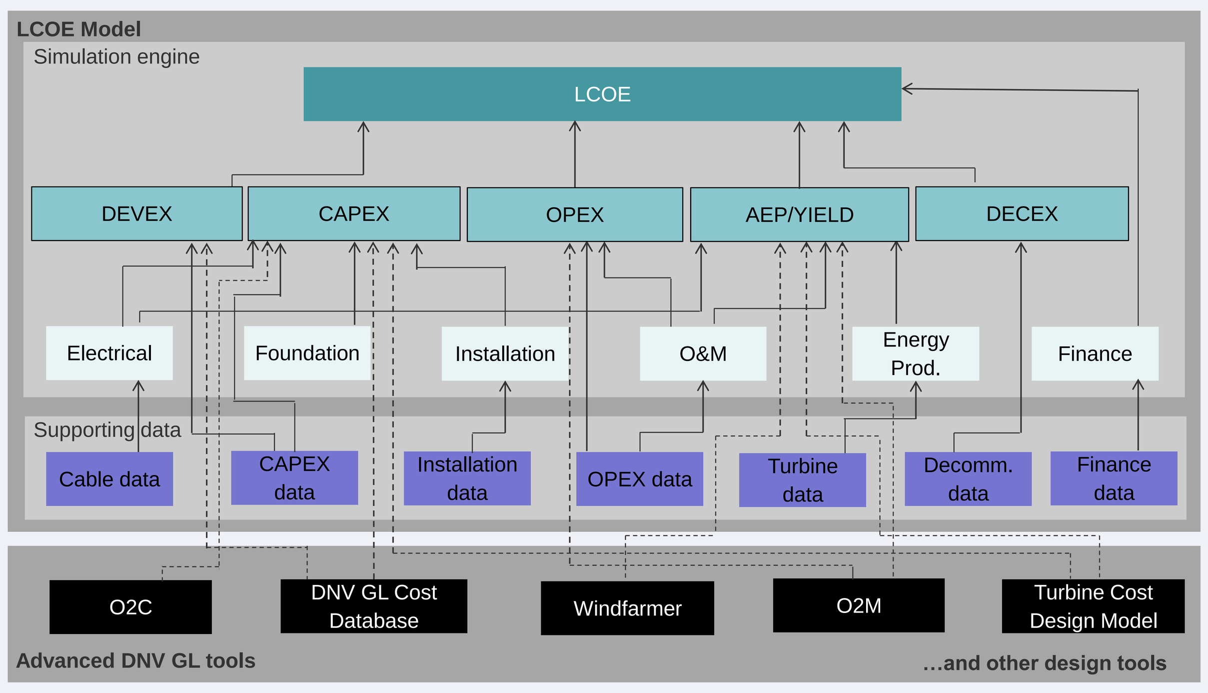




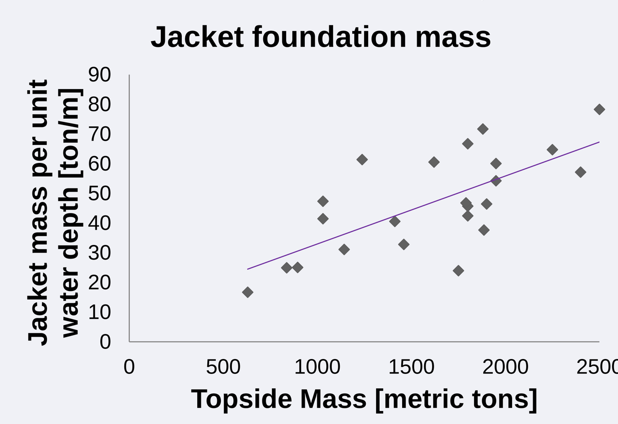


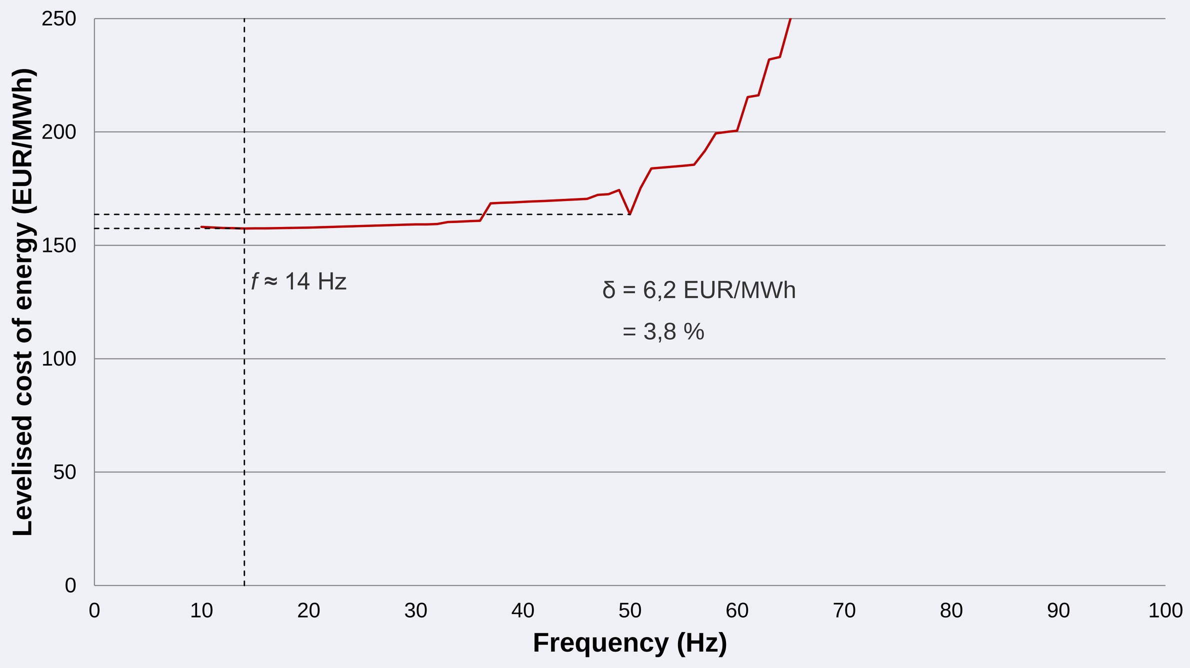




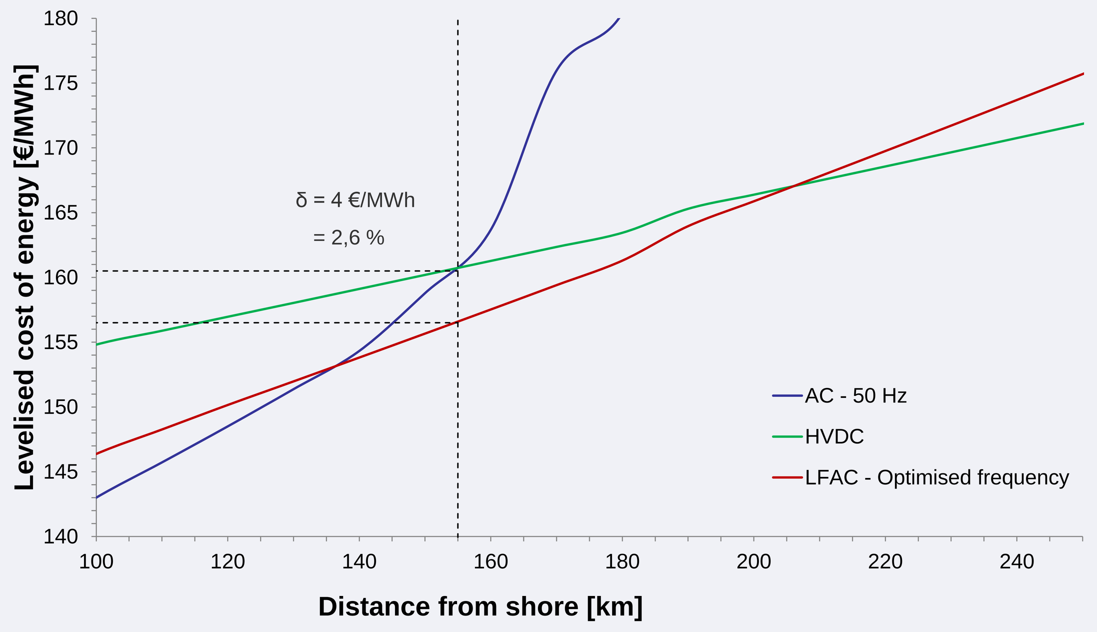


A frequency sensitivity study with respect to cost, weight and efficiency for all major wind farm components was carried out to determine change in CAPEX, OPEX and yield as function of frequency. The DNV GL Cost of Energy Model was adapted accordingly and used to find the frequency that minimizes the wind farms lifetime costs.

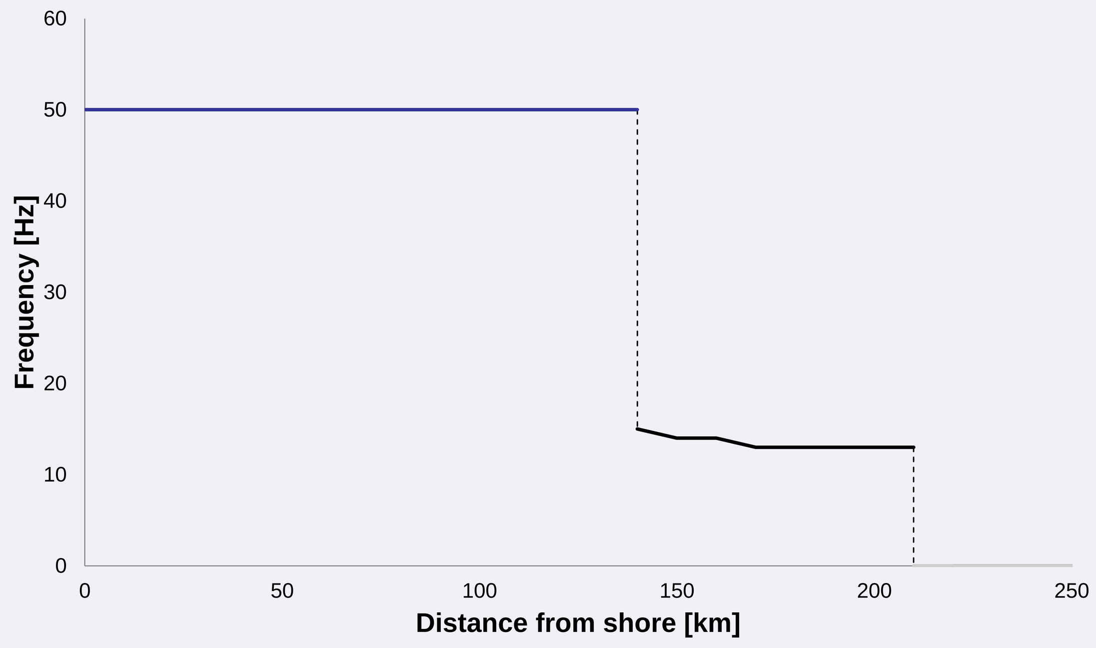




Conclusions



A change in power frequency can have a substantial impact on the levelized cost of offshore wind energy. The use of low-frequency transmission in the range 10 - 20 Hz provides an economically advantageous alternative to 50 Hz AC and HVDC solutions for mid-range/long export distances. Taking all frequency sensitivities into account, an optimal frequency with respect to cost can be found. The standardized power frequency of 16.7 Hz is marginally close to the optimal frequency and is thus a sensible choice to reduce the development and qualification costs.



References

1. Fischer W, Braun R, Erlich I. Low Frequency High Voltage Offshore Grid for Transmission of Renewable Power. 3rd IEEE PES Innovative Smart Grid Technologies Europe, Berlin, 2012