Investigation of the capacity factor of wind turbines and weather-routed energy ships when deployed in the far-offshore

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Abstract

To reach the target of limiting global warming to 2◦ C between now and 2100, it is essential to continue the development of renewable energies. In this respect, offshore wind energy capacity is expected to contribute significantly to the global energy production in the future. However, even with floating wind turbines, only a fraction of the global offshore wind energy potential can be harvested because grid-connection, moorings, installation and maintenance costs increased tremendously as the distance to shore and the water depth increase. Thus, new technologies enabling the harvesting of the far offshore wind energy resource are required.

To tackle this challenge, energy ship concepts have been proposed [2, 3, 4]. In these concepts, electricity is produced by a water turbine attached underneath the hull of a ship propelled by the wind using sails. It includes an on-board Power-to-Liquid production plant for energy storage [5]. The ships route schedules are dynamically optimized considering weather forecast for maximizing energy production.

The aim of this study is to investigate the capacity factors of energy ships harvesting wind power in the far-offshore and compare them to that of hypothetical stationary floating wind turbines deployed in the far-offshore.Note that it is assumed that the rated velocity of the energy ships is similar to that of current offshore wind turbines which allows the capacity factors of those two technologies to be compared.

The methodology is as follows. The design of the ship was developed using an in-house Velocity and Power Performance Program (VPPP) developed at LHEEA [4]. Velocity and power production polar plots of the ship were used as input into a modified version of the weather-routing software QtVlm. This software was then used for capacity factor optimization. 90m altitude wind data extrapolated from 10m altitude wind data analysis was extracted from the ERA Interim dataset provided by European Centre for Medium-Range Weather Forecasts (ECMWF). Three years data are considered (2015, 2016, and 2017). For the wind turbines, the power curve of the NREL 5MW wind turbine was used. Results show that capacity factors over 80% can be achieved in some locations. Detailed power performance results will be presented for both wind power conversion systems as function of the deployment area.

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