A method for the optimization of the energy performance of an energy ship

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Abstract

Offshore wind energy technology has developed rapidly over the last decade [1]. It is expected to significantly
contribute to the further increase of renewable energy in 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 increase tremendously as the distance to
shore and the water depth increase. Thus, new technologies enabling harvesting the far offshore wind energy
resource are required. To tackle this challenge, mobile energy ship concepts have been proposed. [2] [3] [4] [5].

In those concepts, a ship is propelled using a wind propulsion system (e.g. traditional sails or Flettner rotor

). A water turbine is attached underneath the hull of the ship. The water turbine produces electricity. The
electricity is converted into chemical energy (e.g. hydrogen) for on-board energy storage. [4].

A model has been developed for the prediction of the energy performance of energy ships [4]. It shows that
a key parameter for the performance is the hull design. Therefore, the aim of this study is to optimize the hull
in order to maximize energy performance.

In this work, the ship configuration is as follows. The ship is a catamaran. The hulls are modelled as parabolic
Wigley hulls. The wind propulsion system consists of a set of 3 Flettner rotors of 5 m diameter and 30 m height.
The total mass of the ship is 460 t (which is expected to be the mass of a 1 to 2 MW energy ship taking into
account all the required equipments).

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The optimization objective is the electrical power produced by the water turbine for a true wind speed of 10 m/s and a true wind angle of 90 degrees. These wind conditions were selected because they are expected to be common wind conditions in the production area [7]. The optimization variables are the length, the width, the height of the floaters, and the separating distance of the floaters. The draft of the hull is constrained by the displacement of the ship (460 tonnes). The energy performance is obtained using an enhanced version of the model developed by Gilloteaux & Babarit [4] (the ship's wave resistance is calculated using a dedicated software instead of a heuristic equation). The optimization is performed using a NSGA II algorithm [8]. Results show that the performance can be increased in comparison to the initial design.

Wind Europe. The european offshore wind industry, key trends and statistics 2016. Technical report, Wind Europe, 2017.

Tsujimoto M. et. al. Optimum routing of a sailing wind farm. Journal of marine science and technology, 2009.

Pelz P.F., Holl M., Platzer M. Analytical method towards an optimal energetic and economical wind-energy converter. Energy, 2016.

Gilloteaux J.C., Babarit A. Preleminary desgin of a wind driven vessel dedicated to hydrogen production. In Proceedings of the ASME 2017 36th International Conference on Ocean, Offshore and Artic Engineering, 2017.

Babarit A., Gilloteaux J.C., Clodic G., Duchet M., Simoneau A., Platzer M.F. Techno-economic feasibility of fleets of far offshore hydrogen-producing wind energy converters. Hydrogen Energy, 2018.

Badalamenti C. ; Prince S. A. The effects of endplates on a rotating cylinder in crossflow. In 26th Applied aerodynamics conference, Honolulu, Hawaii, 2008.

Abd Jamil R. et. al. Comparison of the capacity factor of stationary wind turbinees and weather-routed energy ships in the far-offshore. Presentation in EERA DeepWind 2019, 16th Deep Sea Offshore Wind R&D conference, 2019.

Deb K. et. al. A fast and elitist multiobjective genetic algorithm : Nsga-ii. IEEE Transactions on evolutionary computation, 2002.

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