

Combining a spar type floating offshore wind turbine with a current turbine

With the shift towards a more sustainable energy society, the increase in the electricity produced by renewable energy sources is steadily rising. However the cost of renewable energy sources still remains high compared to the traditional fossil fuel based energy sources. With the total worldwide energy demand also rising, combining renewable energy sources helps to reduce the cost through a shared infrastructure and increase in energy production. This thesis investigates the feasibility of a combination of floating offshore wind and marine current energy. As a basis the Hywind spar type floating offshore wind turbine is used. This 5 MW system is combined with a 1 MW marine current turbine. The characteristics of the current turbine will be examined with the program Aerodyn and the blades are designed with the program Harp_opt. As a cost reduction, the effect of scaling down the weight of the mooring system in combination with reversing the direction of the thrust of the current turbine is also investigated.

The program ANSYS AQWA is used to investigate the dynamic behavior of the combined system. The thrust forces of the wind and current turbines are calculated via an external python server and added to the simulation in AQWA. The structure is modeled in a rigid body approximation, assuming no structural deformations. The behavior of the combined system is investigated in 3 operational and 1 survival load case. The operational load cases represent the environmental conditions of the cut-in, rated and cut-out wind speed of the wind turbine. In the fourth load case the system is subjected to survival conditions and the direction of the thrust of the current turbine is reversed. The environmental conditions are simulated with a steady wind velocity and the sea state is modeled using the JONSWAP wave spectrum. In all 4 load cases the system is subjected to a strong current.

By using a levelized cost of energy prediction model, a first estimation of the levelized cost of energy of the combined system is obtained. Adding a current turbine to the Hywind spar increases the cost of the initial investments and operational cost of the system, but also increases the total energy generation. Compared to the original Hywind spar, adding a current turbine to the system lowers the levelized cost of energy from 149.4 €/MWh to 142.3 €/MWh. Scaling down the weight of the mooring system lowers the levelized cost of energy to 141.9 €/MWh.

From the results of the simulations it is found that using the current turbine during survival conditions has a positive effect on the motions and maximum tension in the lines. It is concluded that by using the thrust of the turbine the weight of the mooring system could be scaled down, but the effect on the levelized cost of energy is minimal and doesn't justify the increased risk of failure.

Student
J.P. Haaker
19-04-2018

Sponsor
Jumbo Maritime

Thesis committee
Prof.dr.ir. A.P. van 't Veer, TUD
Ir. J. den Haan, TUD
Dr.Ir. H. Polinder, TUD
Ir. K. van der Heiden, Jumbo