Group 19 - Design of a floating offshore airborne wind energy system (AWES) farm

The main challenges in the growing offshore wind energy market are that conventional bottom-fixed turbines cannot be used in deeper water and that the shallower locations are starting to get occupied. Floating foundations have to be used in deeper water where currently there is little competition from conventional turbines. Here lies an opportunity for a novel innovation such as airborne wind energy. The airborne wind energy concept has considerable advantages compared to conventional wind turbines, mainly in the way that the operating altitude can be varied to harvest the best wind speed and to decrease wake losses in a farm. Also, airborne wind systems are much easier to implement on a floating foundation due to the low centre of mass. Furthermore, a lesser amount of and more sustainable materials can be used compared to conventional wind turbines. These advantages are significant, but the main challenge to overcome is the levelised cost of energy (LCoE), which has to be similar to or less than that of conventional turbines to compete in the energy market.

Mission Objective

The objective of this Design Synthesis Exercise was: To design a floating large-scale wind farm in deep water, using Airborne Wind Energy Systems, that is cost-competitive, largely recyclable and uses twice less material than conventional wind turbines, with ten students in ten weeks.

System Design

There is currently no AWES in operation larger than 100 kW, thus the first step to designing a 1 GW farm is to design a larger-scale single system. After an extensive trade-off, the team converged on a rigid wing fly-gen concept with a semi-submersible floating foundation. This airborne concept produces power in the air by using onboard generators, essentially acting as a flying wind turbine, and transfers this energy through a conducting tether to the ground system. The main reasons for this choice are the reduced lifetime material use compared to the soft wing concept, and the easier launch and landing compared to a ground-generation rigid wing concept. For the seaborne element, the semi-submersible was chosen because of its ease of transportation and installation. Utilising relations from different aspects of the concept, a calculation tool was developed. Which yielded initial parameters through iterative design methods. The final design is a 1 MW rigid wing fly-gen system, which uses 8 onboard turbines to generate the power and uses a vertical take-off and landing method. For this design, a range for the LCoE from 49.5 to 69 €/MWh has been estimated. This design is more sustainable than conventional wind turbines since 90% of the materials that are used are recyclable, 95% of the components are removable at the end of life and the system only uses 40% of the mass of a conventional turbine. For the final week, the team will expand on the LCoE calculations to increase the certainty of this value. Additionally, the team will make technical drawings and graphical renderings of the design. Finally, a plan of next steps that are required to reach an operational airborne wind energy farm shall be developed.