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Modelling and Design of Off-Shore Floating Platform for High Altitude Wind Energy Converters

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Wind turbines represent one of the cheapest and well-known types of renewable energy generators. Given the huge availability of windy offshore locations, in the last years there has been a growing interest towards offshore wind farms. Existing offshore turbines are usually deployed in shallow waters and are fixed on the seabed, nonetheless a few prototypes of floating wind turbines exist. The high cost is still a limiting factor to the commercial development of floating wind turbines.
High Altitude Wind Energy Converters (HAWECs) represent a promising new technology that aims at providing low cost renewable energy by exploiting high altitude winds. It has been predicted that an HAWEC can be up to two orders of magnitude lighter than a conventional wind turbine featuring the same rated power. However, HAWECs require a large amount of airspace, they present safety issues, and they might also face the so called Not-In-My-BackYard (NIMBY) effect.
The installation of HAWECs in marine offshore locations makes it possible to get around safety and NIMBY issues. Among the possible marine layouts, a particular case of interest is the one that considers a HAWEC system installed on a slack-moored floating platform, which can be installed in deep waters that are the cheapest and the most abundantly available.
Thanks to their lightweight and the favourable loading conditions, floating offshore HAWECs can be potentially much cheaper to deploy than offshore traditional turbines. In particular the dimension of the floating platform that is required to sustain the HAWEC structure can have relatively small mass and encumbrance. In order to properly address the problem of design and verification of a deep water offshore HAWEC installation, we developed a simplified model which couples the hydrodynamics of the floating platform, the aerodynamics of the airborne system and the electromechanics of the power unit.
This paper provides a first insight into the hydrodynamics of a full scale floating HAWEC. Two different kinds of platform are considered. The first is the so called "flat" platform, and the second is the so called "funnel" platform. The flat platform is basically a flat-bottomed barge, while the funnel platform is composed by two parts: a large upper part that holds the HAWEC, and a lower ballasted part aimed at lowering the centre of gravity, improving the overall stability and reducing the pitch and roll wave-induced motions. The funnel layout is specifically designed for HAWEC applications and analysed here for the first time. For both platforms the hydrodynamic coefficients and the time response to incoming waves are provided. The effect of the platform motion on the kite control is also analysed. As a result, a numerical methodology is provided to compare different types of platform. Finally, a roadmap to a full scale offshore HAWEC is proposed, starting from a theoretical analysis, through simulations, small scale wave-tank experiments and full scale prototype.