On the Integration of green hydrogen production in multipurpose wave energy platforms

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***Abstract*—This work presents an integrated numerical modelling approach, developed in the Modelica language, for assessing green hydrogen production in a multipurpose offshore wave energy platform. The study focuses on the OctaPlat—a concrete hybrid platform composed of five oscillating water columns (OWCs)—evaluating only the wave energy conversion systems and their hydrogen integration. Hydrodynamic coefficients were obtained via WAMIT and served as inputs to a dynamic multiphysics model that couples the OWC array with an industrial-scale alkaline electrolyser, using the eCherry Modelica library. Twelve representative sea states from the North Atlantic wave climate, off the coast of Portugal, were simulated, each weighted by its annual occurrence probability to estimate annual hydrogen and oxygen yields. Key factors influencing the successful integration of green hydrogen production with offshore hybrid wind–wave systems are identified and discussed, ensuring that all relevant technical and operational requirements are addressed. Results demonstrate that the platform can produce approximately 305 t of green hydrogen per year under a scenario with no restriction on electrolyser capacity, with negligible difference compared to an idealised scenario of steady mean annual power supply from the OctaPlat, which is about 1.5 MW. Additional analyses assess the effect of electrolyser sizing, confirming that oversizing yields diminishing returns, while undersizing leads to underutilisation of available energy. This study provides the first dynamic simulation results of OWC systems integrated with green hydrogen production, offers new insights into the design and techno-economic optimisation of hybrid wave-hydrogen platforms, and demonstrates the viability of dynamic simulation tools for future power-to-X offshore project development.**

***Index Terms*—Oscillating water column; multipurpose platform; wind-wave hybrid systems; hydrogen integration; green hydrogen; Modelica.**

I. Introduction

ACHIEVING the decarbonisation goals outlined in the European Green Deal and the REPowerEU plan is dependent on accelerating the deployment of renewable energy sources and enabling the integration of the energy system with energy vectors. Offshore renewable energy plays a central role in this transition, with the European Commission setting a target of at least 60 GW of offshore wind by 2030 and 300 GW by 2050 [1]. However, as electricity generation is pushed farther offshore, the integration of variable resources such as wind and waves presents new challenges related to grid connectivity, energy storage, and infrastructure scalability, as described in Refs. [2] [3].

In recent years, wave energy has (re)gained increasing attention as a reliable and predictable source of renewable electricity. Unlike wind and solar, ocean waves offer a higher energy density and a temporal lag relative to wind patterns, which can help smooth overall renewable generation profiles when integrated with other sources. Despite significant technological progress and several demonstration projects, large-scale deployment of wave energy converters (WECs) remains limited due to challenges in device durability, conversion efficiency, and cost competitiveness [4].

Integrating green hydrogen production into offshore energy platforms is a promising solution. By converting electricity into hydrogen via water electrolysis, these platforms can store energy in molecular form, enabling decoupling from the grid and increasing operational flexibility [5]. It is within this evolving context that the present exploratory study focuses on the wave energy conversion subsystem of the OctaPlat platform, a concrete hybrid platform composed of five oscillating water columns (OWCs), leveraging its multi-chamber OWC configuration to assess the feasibility and dynamics of offshore green hydrogen production integration. Although the platform is designed to support both wind and wave technologies, the present analysis isolates the contribution of the wave energy to provide a clear understanding of its potential for green hydrogen generation. Integrating hydrogen production into OctaPlat could transform it into a self-contained energy hub, capable of producing green fuels directly at sea and potentially supplying hard-to-decarbonise sectors.

This work presents an integrated numerical modelling approach, developed in the Modelica language, to assess green hydrogen production in a multipurpose offshore wave energy platform. This is an exploratory feasibility study. This work is driven by the ambition of the Portuguese goals for offshore renewables, which have been translated into designated areas for offshore renewables, especially offshore wind [6]. Table I presents the offshore areas for future actions in Portugal.

The next sections describe the systems, the method-

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Digital Object Identifier:
https://doi.org/10.36688/ewtec-2025-1111