Experimental investigation of a novel wave energy floating platform for hybrid wind-wave applications: The OctaPlat

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Abstract—**Hybrid offshore renewable energy systems might become part of the solution to reduce energy production costs offshore, and this work presents advances of a new hybrid offshore platform. The main objective of this study is to experimentally characterise and assess the energy conversion performance of the novel OctaPlat platform, a multi-oscillating water column (OWC) wave energy converter. A physical model based on the OctaPlat concept was built at a 1:100 scale. Due to infrastructure constraints, only three of the five oscillating water columns were included. The experimental campaign comprised free decay tests and tests under both regular and irregular wave conditions. Different power take-off systems for OWCs (impulse air turbines) were approximated through small orifices. Parameters such as RAO, dimensionless pressure, and the capture width ratio (CWR) were determined and analysed to understand the model performance under different conditions. Results under regular waves show that the different orifice plates considerably affect the CWR and the peaks' frequencies of its maximum values. Under irregular wave conditions at full scale, peak pneumatic power varied with wave height and orifice size. The peak of power production was estimated between 1.6 MW and 3.8 MW for 2.5 m and 3.4 m of significant wave heights, respectively. These results confirm the platform's feasibility for megawatt-scale wave energy conversion, supporting a key claim of this technology. The experimental results were compared with the numerical ones in terms of CWR. Good agreement was found between both, with a coefficient of determination (R^2) of about 0.94, and the relative difference between them was always less than 20%, except for a few peak deviations.**

Index Terms—**Wave Energy Converter; Oscillating Water Column; Wave Energy; Wave Flume; Experimental Testing; OctaPlat; hybrid wind-wave systems**

I. INTRODUCTION

FOSSIL fuels have had an important presence in people's lives, but their combustion is a major source of greenhouse gas (GHG) emissions, contributing significantly to climate change [1]. In 2023 alone, energy-related CO_2 emissions increased by 1.1%, adding 410 million tonnes of CO_2 to the atmosphere [2]. Although the rate of growth of emissions has slowed, it has not yet peaked, emphasising the urgency of transitioning to cleaner energy sources. The Paris Agreement aims to limit global temperature rise to 1.5ºC above pre-industrial levels, requiring rapid reductions in GHG emissions and achieving net zero emissions (NZE) by 2050.

According to the IEA, the annual renewable capacity additions reached 507 GW in 2023, increasing almost 50% compared to 2022, with solar photovoltaic (PV) alone accounting for 75% of the additions [3]. Although the renewable energy capacity is increasing, it falls short on the goal to triple from renewable sources by 2030, with regard to NZE target for 2050 [3]. Bearing in mind the difficulty of achieving these targets, offshore renewable energy can be part of the solution.

Hybrid offshore energy systems, particularly those combining wind and wave technologies, are emerging as promising solutions to enhance the efficiency and reliability of renewable energy production. These systems leverage the complementary nature of wind and wave resources, which often coexist in marine environments, to improve energy yield and grid stability [4], [5]. Wave energy converters (WECs) offer greater predictability compared to other offshore renewable sources, making them valuable additions to wind farms. Hybrid systems can be categorized based on their connectivity and integration level—co-located, hybrid, and island systems [6]—each offering different advantages in terms of infrastructure sharing and energy optimization.

Recent studies have focused mostly on bottom-fixed hybrid configurations, integrating wave energy devices like oscillating water columns (OWCs) into offshore wind turbine substructures [7]–[9]. For example, Pérez-Collazo et al. [7] conceived and studied systems such as OWC-monopile and oscillating body-monopile, demonstrating technical feasibility and potential for energy cogeneration. However, these designs also introduce increased structural loads, requiring further engineering solutions to ensure long-term viability [8]. As offshore installations move into deeper waters, floating hybrid systems may become more relevant, though their economic competitiveness remains a challenge. Continued innovation in wave energy integration is essential to reduce costs and unlock the full potential of hybrid offshore renewable energy systems.

In this work, a novel offshore platform concept (OctaPlat) was studied experimentally. It is a multi-OWC wave energy conversion system. The main objective of

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