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MARELAB: THE LAB OF THE MEDITERRANEAN SEA FOR MARINE RENEWABLE ENERGY

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ABSTRACT

This work aims to describe the testing capabilities of the Mediterranean Marine Renewable Energy Laboratory for mid-to-full scale devices. As an illustrative example, it presents various experimental campaigns conducted in recent years on a hybrid breakwater – wave energy converter and a floating wind turbine.

KEYWORDS: Sea laboratory, field test, marine renewables, breakwater – wave energy converter, floating wind turbines

1 INTRODUCTION

The Mediterranean region is experiencing an increasing interest in marine renewable energy (MRE), particularly in the floating wind turbine sector. This sector has emerged as a promising solution to address the unique challenges of the region, i.e., deep waters, seismic activity, and stringent environmental regulations.

In 2019, the Italian government funded a groundbreaking research project led by the National Research Council (CNR) to develop an innovative concept of multi-modular floating structures (Lugni et al., 2022). As a result of this project, a collaborative effort between CNR and the University of Campania "Luigi Vanvitelli" led to the establishment of the first Italian lab dedicated to MRE in the Mediterranean Sea, off the coast of Naples harbor, known as the Marine Renewable Energy Lab (MaRELab). This partnership aims to leverage expertise in various aspects of "blue" engineering, drawing from experience in environmental, coastal, and naval fields. This field laboratory holds particular significance due to its capacity to assess the energy and structural performance of medium - full scale innovative devices in a relevant environment. This is crucial given that the local Mediterranean meteo-climatic conditions differ significantly from those typically encountered in oceans or northern seas. Consequently, the lab becomes an optimal solution to implement a de-risking strategy for stakeholders in the MRE sector. A detailed analysis of the historical wave series and wind-wave-current forecasting (Contestabile et al., 2022), allowed for the identification of suitable time windows that fit the needs of the scaled prototype tested. Similarly, environmental and biological analysis, enabled the exploration of novel sustainable solutions for the MRE (Colaleo et al., 2021; Rezaei et al., 2023).

2 THE LABORATORY

MaRELab is strategically situated in the Gulf of Naples, Italy, within the Middle Tyrrhenian Sea. It marks a natural progression from the facilities established in 2015 to house the OBREC (Overtopping Breakwater for wave Energy Conversion) prototype (Contestabile et al., 2020). The selection of this site was driven by logistical considerations, along with environmental factors. The prevalence of calm sea states during the summer season and the narrow directional sector of the wave climate were key determinants.

The 25-meter water depth at the breakwater's toe effectively prevents breaking conditions, even during the period from November to March when extreme waves are common. These features prove advantageous for meeting the field monitoring requirements of both wind and wave energy devices. Successful monitoring activities necessitate calm conditions for safe installation and instrument maintenance. The nearshore wave power density was measured at 1.84 kW/m, and the average

annual wind energy flux at a height of 10 meters has been estimated at 31.52 W/m².

3 EXPERIMENTAL TESTING

Testing at MaRELab has been ongoing since 2015, focusing on the evaluation of hydraulic and energetic performances of the full-scale OBREC device (Figure 1). This device, designed to harness the wave overtopping phenomenon, efficiently captures and converts wave energy into usable electrical energy. Positioned on the conventional rubble mound breakwater, it utilizes a single reservoir to collect overtopping water above sea level. The subsequent flow is then directed towards low head turbines, generating electricity by leveraging the head difference between the water in the reservoir and the mean sea level.

Within the research project mentioned in the introduction, MaRELab has emerged as the testing site for an intermediate-scale floating wind turbine prototype (Figure 1), developed through a collaborative effort between CNR and Saipem. Specifically, from April to October 2021, a 1:7 scale model of a pendulum-type floating foundation was tested (Delahaye et al., 2019). The primary objective of this program was to assess the dynamic behavior of the floating wind turbine under various conditions. Subsequently, a second campaign unfolded from May to November 2023, building upon the insights gained during the initial testing. The introduced experimental setup underscores the crucial role of MaRELab in testing offshore floating structures for marine renewable energy, spanning both medium and full scales.

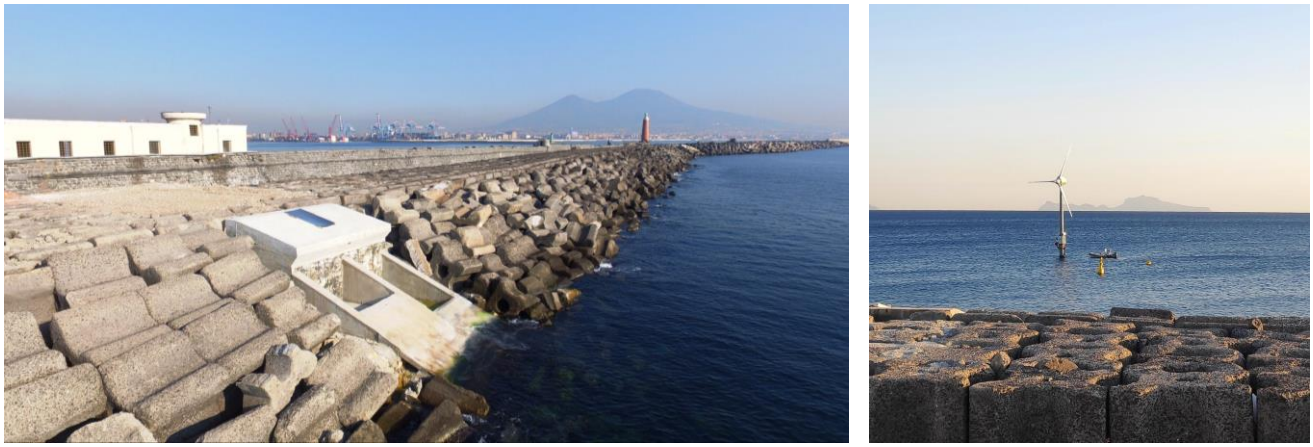

Figure 1. Frontal view of the OBREC device (left) and view from the laboratory of the floating wind turbine (right).

4 CONCLUSIONS

The establishment of MaRELab, with its unique focus on the Mediterranean's specific challenges, has proven instrumental in advancing marine renewable energy research. The successful testing of a floating wind turbine prototype and an overtopping breakwater demonstrates the lab's capability to assess innovative devices in a relevant environment. The insights gained from the experiments pave the way for further advancements in offshore floating structures for marine renewable energy, positioning MaRELab as a crucial resource for stakeholders seeking to mitigate risks in the sector.

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