Development of Wave Energy Technology Exploitation in Portugal in the International Context

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R&D in wave energy conversion started in:

- Japan: late 1940s (Yoshio Masuda, navigation buoys, . . .)
- Europe (UK, Norway) and USA: about 1973
- Portugal: about 1977
  - Instituto Superior Técnico: 1977
  - LNETI (presently LNEG): 1983
  - Wave Energy Centre (WavEC): 2003
  - Kymaner: 2005
<table>
<thead>
<tr>
<th>Countries</th>
<th>No. of projects</th>
<th>% Total projects</th>
<th>% Projects coordinated</th>
</tr>
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<td>UK</td>
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<td>73.3%</td>
<td>40.0%</td>
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<td>Portugal</td>
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<td>57.3%</td>
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<td>Ireland</td>
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<td>25.3%</td>
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<th>Organization (10+)</th>
<th>Country</th>
<th>No of projects</th>
<th>No of coordinations</th>
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<td>University of Edinburgh</td>
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Unlike for wind, there is a wide variety of technologies for wave energy conversion.

Since the beginning, most of the R&D effort in Portugal has been devoted to the Oscillating Water Column (OWC) with an air turbine, a major class of wave energy converter.
The Oscillating Water Column (OWC)

• is possibly the simplest and most reliable type of wave energy converter
• and is the most extensively studied and tested.
The **OWC plant on Pico Island, Azores**, developed mostly in Portugal (with funding from the EC), operated between 1999 and 2017, with the **original air turbine and 400 kW electrical generator**, longer than any other wave energy converter worldwide.
In the last few years, the technology development effort in Portugal (mostly at IST) focussed on:

- **Floating OWC converters for offshore deployment.**

- **New types of air turbines for OWCs (with Kymaner).**

- **Niche market applications of OWCs converters:**
  - Wave powered oceanographic buoy.
  - Wave powered docking station for autonomous underwater vehicles (AUVs) (recent).
  - Wave powered platforms for aquaculture support (with WavEC) (recent).
Floating OWC converters for offshore deployment

OWC spar-buoy

Wave tank NAREC, UK

Bay of Biscay, Spain

Nazaré, Portugal

Wave tank Plymouth, UK
Floating OWC converters for offshore deployment

**U-Gen**, rocking floater with interior OWC

Wave tank: IFREMER, Brest, France.
Floating OWCs for low power applications

- Wave powered oceanographic buoy.
- Wave powered docking station for autonomous underwater vehicles (AUVs).

Turbine rotor
Development of special air turbines for OWC converters

Self-rectifying air turbine of axial-flow impulse type. Sea tests in Galway Bay, Ireland (European project CORES)

Aerodynamic design: IST
Mechanical design and supply: KYMANER
Development of special air turbines for OWC converters

Testing of twin-rotor self-rectifying air turbine at IST, 2017
European project: WETFEET
Development of special air turbines for OWC converters

Testing of biradial self-rectifying air turbine at IST, 2017
European project: OPERA

High-speed valve

Aerodynamic design: IST
Mechanical design and supply: KYMANER
Development of special air turbines for OWC converters

Installation of biradial turbine at OWC-breakwater, Mutriku, Basque Country, Northern Spain, 2017. European project: OPERA
• In Portugal, R&D in wave energy (and marine renewables) is almost totally funded by European projects.

• Scarce coordination between the Portuguese research institutions and groups.

• In the waves, the interest in exploiting the results from Portuguese R&D is mostly from foreign companies (Spain, Ireland, Denmark, UK), not Portuguese companies (possibly as a result of some unsuccessful demonstration projects?).
• **Needs in I&D:**
  
  o More involvement of Portuguese companies in R&D, and especially **demonstration projects**.
  
  o **Better coordination** between research institutions and groups.
  
  o Exploitation of **niche markets** (multi-use platforms, integration into coastal and harbour protection structures, specific equipment,...).
  
  o Reinforcement of **testing infra-structures** with international utilization (pilot zone, oceanic tank, test rigs for specific equipment).
Thank you for your attention