Rotary waves: Butterfly device

Figure 1. Butterfly device in-situ

Summary description

This project was developed by Rotary Wave S.L. with financial support of CDTI and FEDER funds, from March 2015 to September 2016. The total amount funded was around 600.000€. The main objective of the Project was the validation in laboratory scale, and in a relevant environment, of a WEC prototype based on the new technology Butterfly Device.
The device was installed with a scale 1:4 in Pobla de Farnals (Valencia, Spain) and produced 7 kW in the highest wave range. A full-scale device is expected to produce between 500- 2000 kW.
The working principle of the device is based on the movement of the elements that comprise the device. As the waves passes through the device, the different elements will move and will serve to pressurized the internal fluid used for the Power Take Off (PTO). Differently to other hydraulic systems, this device uses water for the electricity conversion. Then, the pressurized fluid will travel to the coast, where the conversion will take place.
The hydraulic PTO system presents a number of advantages in terms of power, size and efficiencies and also for the lower environmental impacts, using fresh water as pressurized fluid and designing a specific pump configuration for reducing maintenance and operation costs.

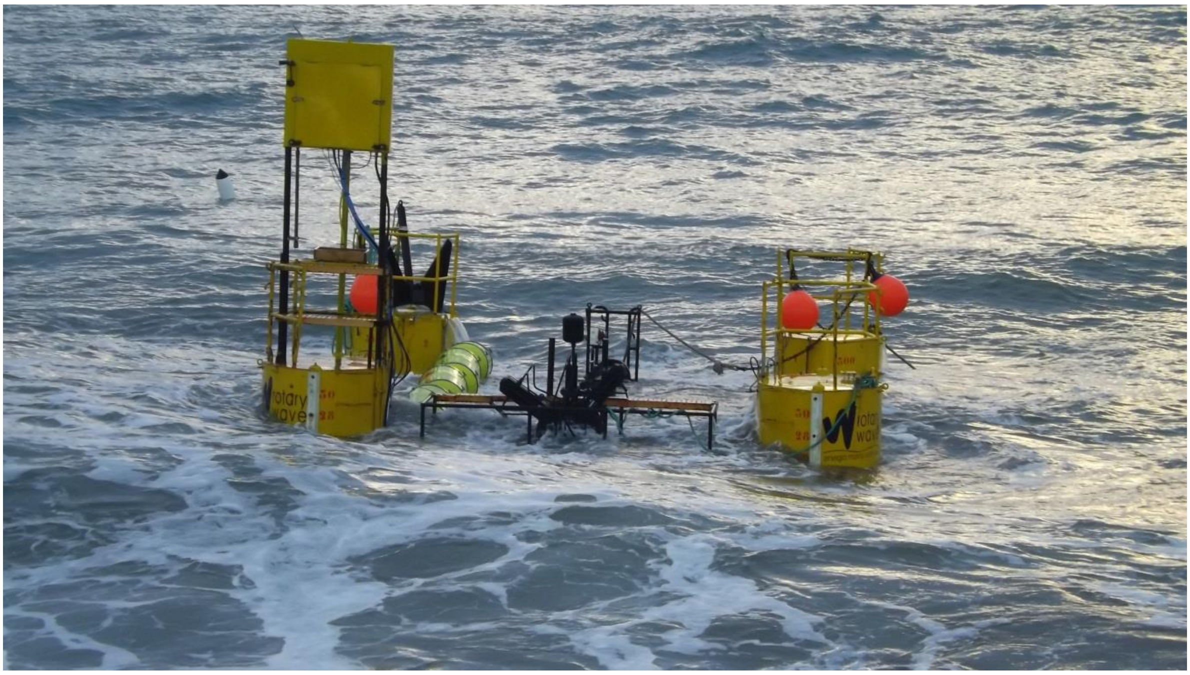


Figure 2. Butterfly device in-situ

Figure 3. Towing of the Butterfly device

Reason of interest for MAESTRALE

As the power take off (PTO) of the device is based on the movement of the different elements, which drives a pressurized fluid (water) that is pumped from the device (offshore) to the conversion facility (onshore), this fluid can be used for electricity conversion or other usages

such as water desalinization. This is very important in certain areas of the Mediterranean Coast, such as the Greek Islands, which not only are in need of electricity but also of water, as the resources are very limited. Therefore, the application of this kind of device in certain areas of Europe can be instrumental.

GENERAL INFORMATION	
Type of Blue energy source	**Wave energy**
Type of energy output	**Electricity**
Type of project/plant	**Research project**
Status	**Decommissioned**
Location	***39.55N, -0.28 E*** ***Mediterranean Sea*** ***Valencia, Spain***
Involved actors	***The designer and owner of the patent is Rotary Waves and the WEC device was installed thanks to the funding granted by CDTI (Spanish public body that manages the European Funds for SMEs).***
Nominal power	***Considering a power range of the device of 0.5 MW, the total production would be 4380 MWh/year. This is fully dependent on the wave energy resource.***
Annual productivity	***Not available at this development stage.***
Size	***The project is focused on the development of the prototype so only a device was installed with the following dimensions: length 10 m and width 6 m (in a scale 1:4).***
Year	***March 2015 to September 2016.***
Implementation cost	***600 k € including the design costs for its development***
Payback period	***Not applicable for this project, but for any offshore project around a decade is foreseen.***
Key words	***Butterfly device, Wave activated body, Wave energy, Hydraulic PTO, Onshore Conversion***
Web link	**http://www.rotarywave.com/**

7.2.1 BACKGROUND

Energy policies framework

Integrated Maritime Policy
Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - An Integrated Maritime Policy for the European Union. The Integrated Maritime Policy seeks to provide a more coherent approach to maritime issues, with increased coordination between different policy area
Blue Growth
Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Blue Growth opportunities for marine and maritime sustainable growth. Blue Growth is the long term strategy to support sustainable growth in the marine and maritime sectors as a whole. Seas and oceans are drivers for the European economy and have great potential for innovation and growth. It is the maritime contribution to achieving the goals of the Europe 2020 strategy for smart, sustainable and inclusive growth.
Blue Energy
Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Blue Energy Action needed to deliver on the potential of ocean energy in European seas and oceans by 2020 and beyond. On 20 January 2014, the Commission set out an action plan to support the development of ocean energy, including that generated by waves, tidal power, thermal energy conversion and salinity gradient power in its communication entitled 'Blue Energy: Action needed to deliver on the potential of ocean energy in European seas and oceans by 2020 and beyond'.

Legal and administrative background

Recommendations
DNV-OSS-312 Offshore service specification: Certification of Tidal and Wave Energy Converters

EU Legislation
*** Regulation (EU) No 1255/2011 of the European Parliament and of the Council of 30 November 2011 establishing a Program to support the further development of an Integrated Maritime Policy**
*** Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. It seeks to contribute to ensuring biodiversity in the European Union by the conservation of natural habitats, and wild fauna and flora species.**

Links with spatial planning instrument

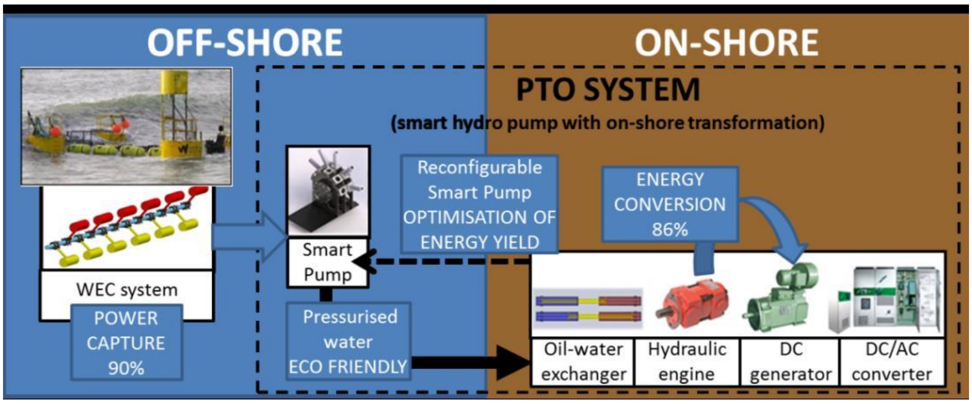
Maritime Spatial Planning
Directive 2014/89/EU of the European Parliament and of the Council of 23 July 2014 establishing a framework for maritime spatial planning
Competition for maritime space – for renewable energy equipment, aquaculture and other uses – has highlighted the need to manage our waters more coherently. Maritime spatial planning (MSP) works across borders and sectors to ensure human activities at sea take place in an efficient, safe and sustainable way. That is why the European Parliament and the Council have adopted legislation to create a common framework for maritime spatial planning in Europe.

This case study is a research project so just a device was deployed for its development, and therefore not a significant impact was found on the maritime spatial planning. If a full plant is installed, the definition of the deployment area must be agreed with the key players of the Mediterranean Sea, e.g. tranport companies, main sea routes; so as to reduce the impact on other sectors.

7.2.2 TECHNOLOGICAL ISSUES

Applied technology

The wave energy converter used was the BUTTERFLY system developed by ROTARY WAVE, which has the configuration of an attenuator, i.e. a slender structure with dimensions larger than the wavelength of the waves, and oriented parallel to the wave propagation direction. The buoys that comprise the technology move with the waves and this movement is what leads to the generation of electricity.



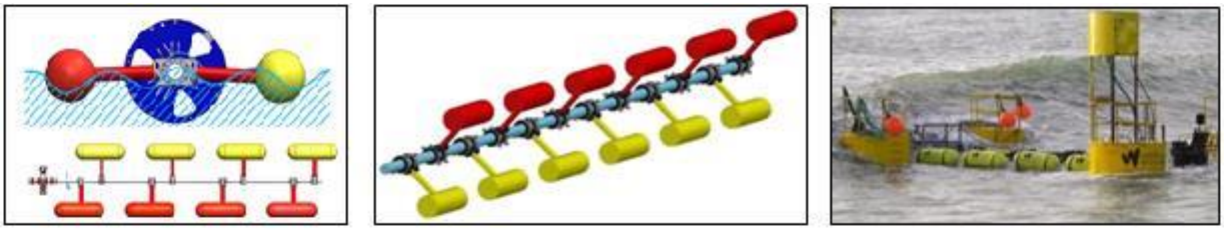


Figure 4. Information on the working principles of the Butterfly device

Innovation aspects

The main advantages of this technology are:
(i) Conversion onshore --> less cost of the infrastructure such as submarine cable, which is one of the most expensive elements of a wave farm (approx 1 M € / km deployed)
(ii) Low visual impact as it is deployed offshore --> the structure has a very low freeboard so it will not be visible from distances larger than 3 km.
(iii) Hydraulic PTO driven with water, which reduces the risks to the environment in case of failure (Typically oil is employed)
(iv) Capacity of absorbing waves from 0.5 m to 5 m, which facilitates its deployment under any kind of wave conditions.
(v) Easy to be built and uses recyclable materials -- ecofriendly technology
(vi) Reduced impact on the marine environment, as it is a floating structure, the risks of collision and so on it is very low.

Figure 5. Butterfly device in port

Quantitative information

The prototype deployed in a scale 1:4 had the following dimensions: 10 m length, 6 m width and 4 m draft.

Background information

One of the main advantages of this device is the wide range of environmental conditions that can produce energy, from 0.5 by up to 5 m. However, if the device is installed in areas with conditions higher than 5 m, the survibality of the device can be compromised. On this sense, an area for installation like the Mediterranean Sea is the perfect environment for its deployment. Wind and currents are not critical for the location, unless in areas characterized by large currents that could cause the failure of the mooring system.
In any case, the higher the wave energy resource, the greater the electricity produced. On this sense, mean annual values of wave energy resource larger than 10 kW/m should be aimed for the deployment of wave farms so as to guarantee their economic viability.

Assessment tools & methods

As this was a research project that was installed for a year, it was not necessary to conduct such studies. However, the potential impacts on the environment brought about by the device were considered and mitigated, as will be described in the following section.

Environmental & Landscape impacts

In order to reduce the risks of the failure of the PTO, a hydraulic system driven with water was developed. Typically, oil is used in these cases; however the risks associated are larger. In this case, water was employed without losing any power, as it was overcome with the employ of a complex system of pumps. Regarding the visual impact or the impact on the environment, it must be noticed that this system is deployed offshore and therefore the visibility is very limited from large distances, especially considering the low freeboard of the device.

Socio-economic impacts

There is a clear positive effect on the socioeconomics of the area, not only derived from the device construction and posterior O&M tasks; but also in the different uses that could be given to the device. The pumped water could be used to generate electricity but also employed for water desalinization. Furthermore, the synergetic application of wave farms is an aspect that is paying the attention of the research lines currently. The use of wave farms in conjunction with aquaculture and wind energy could enhance the viability of these projects. Another relevant positive effect is the coast protection induced by the wave farm: a reduction of wave height is found in the lee of the devices, which could in turn reduce the erosion on the adjacent beaches.

7.2.3 IMPLEMENTATION ISSUES

Implementation cost

The funds granted by CDTI were 600 k € for the installation of a prototype in a scale 1:4, but part of it was devoted to the WEC development and design.

Financial sources

This project was funded by a Spanish public body (CDTI), in a specific call for SMEs. The company that developed the patent (Rotary Waves), in conjunction with other companies leaders in their sectors (TYPSA, Marin, WAVEC) have submitted new proposal to reach a higher level of maturation of the technology in the Horizon 2020 calls (funded by the EU).

Problems and obstacles

When it comes to the deployment of any type of WEC, one of the main issues is the survivability of the device. In the case of the Mediterranean Sea this issue is less critical but cannot be overlooked. This project was installed for a year, but for a typical service life (aprox 25 years), the environmental design conditions will be much more energetic and therefore ensure the integrity of the structure would be more complicated. For overcoming this shortcoming, the design of a strategy that can withstand the loads generated during an extreme event is instrumental for these projects. This is typically relative to the position of the elements, which can be adjusted in order to reduce the loads. For instance, wind turbines remain in an idle position during extreme events so as to avoid the global failure.

Success factors

The success of this case study lied in the relatively close distance between the WEC and the coast, which allowed the mitigation of the losses when transferring the pressurized fluid from the device to the conversion point on the coast. It is under investigation how to optimize this, and therefore improve the capability of the device to be installed in deeper water depths, in which the wave energy resource will be larger and therefore its viability will be enhanced.

Transferability in the MAESTRALE area

The device was already deployed in the Mediterranean Sea (Valencia), so it goes without saying that any area of this coast would constitute a prime location for their operation. However, there are areas where its functionality can be optimized. For instance, in the islands where the water resource is limited, the benefits of the installation of these devices would be twofold: on the one hand to produce electricity and on the other hand to desalinize water. Desalinization plants just require pressurized water, and that is what is driven from the movement of the WEC to the conversion point. On this sense, part of this fluid could be used for electricity conversion, and the other part for water desalinization. Furthermore, this is a very typical situation is some parts of Europe, such as the Greek Islands.
Regarding the resource or the features of the area, no significant differences are expected to be found along the coast. However, it is clear that the greater the waves, the greater the resource and therefore the greater the electricity produced. Thus, this type of devices should not be deployed in areas very sheltered, where the wave height does not exceed 1 m.

Notes/Comments

1) **https://www.youtube.com/watch?v=RyD_mEbKGZ0**