**Case Study – Okeanós Pelamis Wave Farm**

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Okeanós: Pelamis wave energy farm Portugal Project Three P1-A Pelamis machines</th>
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<tbody>
<tr>
<td>Location</td>
<td>Aguçadoura/ Póvoa de Varzim, Northern Portugal</td>
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<tr>
<td>Installed capacity</td>
<td>3 * 750 kW = 2.25 MW; plans exist to extend to 30 devices (22.5 MW)</td>
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<tr>
<td>Technology Type</td>
<td>Pelamis: Floating articulated attenuator</td>
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<tr>
<td>Project Type/Phase</td>
<td>Commercial contract</td>
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<tr>
<td>Year</td>
<td>Construction of devices terminated in 2006, later assembly and partly testing by early 2008; installation summer 2008</td>
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**Project Description**

The Aguçadoura wave farm hosts three Pelamis devices and is the first undertaking worldwide as a commercial order of wave energy devices. The 8 M€ purchase of the three Pelamis P-1A machines of 750 kW each by the Portuguese project developer, Enersis, is expected to return the investment, due to the favourable feed-in tariff in Portugal. The agreement dates back to 2005, when Enersis and Ocean Power Delivery Ltd (now Pelamis Wave Power Ltd) signed the agreement of purchase. In July 2006 it was published by Decree-law authorising CEO (Companhia Energia Oceânica, S.A.) to install three machines offshore Aguçadora, Póvoa de Varzim.

The machines were entirely built in Scotland, in order to reduce technical and logistic risks during the manufacturing; Scottish suppliers had a proven prototype. The assembly took place in the Portuguese Peniche shipyard, after the devices were transported in segments to Portugal. The original deadline for deployment was 2006; however several technical issues and the weather delayed the process until summer 2008.

A previous test site of the 2 MW AWS (Archimedes Wave Swing) technology was used. Because of this the deployment site, the deployment license and grid connection, the subsea cable, and the parts of the conversion station on Aguçadoura beach could be re-used. The subsea cable connection and some other pre-installed offshore components were not expected, delaying the installation.

The Aguçadoura wave energy project in Portugal is supported by a specific feed-in tariff currently equivalent to approximately €0.23/kWh.

A letter of intent has been issued to order a further 30 Pelamis machines (for a total 20MW), subject to satisfactory performance of the initial project phase. It is not yet clear whether permission for this extension will be granted, due to some discontent with the exclusive character of the planned Portuguese wave energy pilot zone further south (offshore S. Pedro de Moel). For the Northern Portuguese Pelamis farm, only a substantial extension of 100 or more devices might be profitable; due to current legislation this will not be possible, because the government will grant wave-farm licenses exclusively for the pilot zone for several years, penalising any undertakings outside that zone.
Location of the Aguçadora Wave park (left; Google Earth). Constructions of the modules of power take off (top right) and three pelamis machines, 750 kW each (bottom right) in the harbour of Leixões, ready to be deployed (Pelamis wave Power).

The Technology

The Pelamis Wave Energy Converter is a semi-submerged, articulated structure consisting of four cylindrical steel sections linked by three hinged joints. The four sections move relative to each other and the hinges convert this motion by means of a controlled hydraulic power conversion system. Each hinge of the device contains its own hydraulic power take off composed of four hydraulic rams (in each power take off) that resist this movement, pumping high-pressure fluid via smoothing accumulators to hydraulic motors, which drive induction generators to produce electricity. Several devices can be connected together and linked to shore through a single sub-sea cable.

The machine is held in position by a mooring system of floats and weights that prevent the mooring cables from becoming taut. This maintains enough resistance to keep the Pelamis positioned but allows the machine to swing head on to oncoming waves.

The first full-scale pre-production Pelamis prototype was tested at the European Marine Energy Centre in Orkney. The design was independently verified by WS Atkins according to (DNV) offshore codes and standards.
Floating prototype, an artist's impression of a large-scale farm using the principle of the Pelamis device (Pelamis wave Power).

**Related projects**
The following projects have been proposed, but contracts have not yet been signed:

**Orcadian Wave Farm**: four Pelamis generators supplied by PWP to ScottishPower Renewables for installation at the European Marine Energy Centre (EMEC). In February 2007 the Scottish Executive announced a funding package for the Orcadian Wave Farm in excess of £4m and in September 2007 the Orcadian Wave Farm received final consent.

**Westwave project**: up to seven Pelamis generators installed at the Wave Hub facility supplied to E.ON UK & Ocean Prospect. In February 2006 Ocean Prospect secured exclusive access to one of the four Wave Hub’s berths for the connection of multiple Pelamis machines.
Project Partners

Pelamis Wave Power; Edinburgh, Scotland: technology development; manufacturer of the Pelamis Wave Energy Converter, which is an in-house product developed since the late 1990s. Starting with mathematical and experimental models with a small core team in Edinburgh, the company name was initially Ocean Power Delivery Ltd, which changed to Pelamis Wave Power in September 2007. Approximately 70 people are employed by the company, with a large number of engineers.

Enersis (CEO - Companhia de Energia Oceânica, S. A); Lisbon, Portugal: Project developer and ownership; Enersis has experience in developing and operating mini-hydropower projects and wind farms in Portugal, and was the first project developer to invest into a wave device, namely the 2MW AWS pilot plant in 2004. Since December 2005 Enersis has been a subsidiary of Australia’s investment bank Babcock & Brown. A Portuguese company, CEO-Companhia Energia Oceânica, S.A. was created under the Enersis group.

Cost and Financing

- 8 M€ for the supply and installation of three Pelamis devices. How these costs correspond to the total costs of the undertaking, has not been published.

- Largely private investment (Enersis-CEO) for capital return with favourable feed-in tariff (> 20 c€/kWh); national demonstration scheme grant of ca. 1.1 M€ awarded

- If predictions on power conversion efficiency and reliability are realised, revenue from electricity feed-in of 800k€ to 1.5 M€ may be expected. As an initial phase of a small series of technology, it is likely that maintenance expenses will be high; during the first years it is not realistic to rely on full temporal availability of the technology.

Further Information

Link to developer/company website