Renewable energy by harnessing waves – NW Atlantic

1. Policy Objective & Theme

- ADAPTATION TO RISK: Integrating coherent strategies covering the risk-dimension (prevention to response) into planning and investment
- SUSTAINABLE ECONOMIC GROWTH: Developing Europe's regional seas sustainably

2. Key Approaches

- Ecosystems based approach
- Technical

3. Experiences that can be exchanged

Countries wishing to make use of installations to generate electricity from wave energy can see the approach being adopted in Portugal and the UK.

4. Overview of the case

A wave energy converter that is contributing electricity input into the national Grid of the UK and Portugal is described.

5. Context and Objectives

a) Context

Offshore wave energy has the potential to be one of the most environmentally benign forms of electricity generation with a minimal visual impact from the shore. Wave energy is essentially stored, concentrated wind energy, the waves being created by the progressive transfer of energy from the wind as it blows over the surface of the water. Wave energy could play a major part in the world’s efforts to combat climate change, potentially displacing 1 - 2 billion tonnes of CO2 per annum from conventional fossil fuel generating sources. Such installations would also provide many employment opportunities in construction, operations and maintenance. As an indigenous resource that will never run out, wave power would provide the NW Atlantic with security of supply e.g. the wave energy around the British Isles is equivalent to three times current UK electricity demand. Moreover, it is technically possible to convert a sizeable fraction of this wave energy to electricity – the technically and economically recoverable resource has been estimated to be 50-90TWh of electricity per year or 15-25% of current UK demand. The western sea-board of Europe, facing the Atlantic, also offers an enormous number of potential sites off the coast of Ireland, France, Spain and Portugal all being highly energetic.

b) Objectives

To contribute to reaching the European Renewable Energy Roadmap target of a binding 20% of the overall share of renewable energy in 2020 for the EU.

6. Implementation of the ICZM Approach (i.e. management, tools, resources)

a) Management

Pelamis Wave Power Ltd, an Edinburgh-based company, is the manufacturer of the Pelamis Wave Energy Converter producing renewable electricity from ocean waves.

b) ICZM tools

The Pelamis Wave Energy Converter is a semi-submerged, articulated structure composed of cylindrical sections linked by hinged joints. The wave-induced motion of these joints is resisted by hydraulic rams, which pump high-pressure fluid through hydraulic motors via smoothing accumulators. The hydraulic motors drive electrical generators to produce electricity. Power from all the joints is fed down a single umbilical cable to a junction on the sea bed. Several devices can be connected together and linked to shore through a single seabed cable. Current production machines are 180m long and 4m in diameter with 4 power conversion modules per machine. Each machine is rated at 750kW. The energy produced is dependent upon the conditions of the installation site. Depending on the wave resource, machines will on average produce 25-40% of the full rated output over the course of a year. Each machine can provide sufficient power to meet the annual electricity demand of approximately 500 homes. It was first installed at EMEC in the Orkney Islands in 2004 following a series of sea trials in the North Sea.

In 2006, the prototype was upgraded to the same specification as the production machines now being manufactured. The machine then completed a further extensive phase of testing, meeting a large number of critical test objectives. Each machine requires its own individual mooring spread consisting of the main moorings and a restraint line. The main moorings consist of a number of anchors connected to a central point. The restrain line is a simple single anchor and mooring line configuration. There is scope for neighbouring mooring spreads to share anchor points, depending on the anchoring techniques employed at the site. The Pelamis mooring spread has been designed to minimise its footprint area allowing the highest concentration of MW capacity to seabed space and reducing infrastructure costs. On a typical site, up to 30MW of generating capacity could be installed within 1km2. A power export cable is required to take the power from site to shore. Once the machines have been installed on site, operation of them is done by remote control from land.

The Orcadian Wave Farm, 2km off the west coast of the Orkney mainland, consists of 4 x 750kW generators utilising the existing electrical sub-sea cables, substation and grid connection. The three x 750kW multiple units making up the Aguçadoura wave farm (5km off the Atlantic coastline of northern Portugal) constitute both the world’s first, multi-unit wave farm (2.25 MW) and also the first commercial order for wave energy converters. This project in Portugal is supported by a specific feed-in tariff currently equivalent to approximately €0.23/kWh. There are plans to expand the initial project by 20 MW in a larger scheme. A 30MW offshore ‘wavefarm’ would consist of 40 machines occupying a square kilometre providing sufficient power for over 20,000 homes.

7. Cost and resources

In February 2007, the Scottish Executive announced a funding package for the Orcadian Wave Farm in excess of £4m. The World Energy Council has estimated the market potential for wave energy to be in excess of 2,000TWh/year, representing a capital expenditure of more than £500 billion. This is broadly equivalent to the existing deployed markets for nuclear and hydro-electric power.

8. Effectiveness (i.e. were the foreseen goals/objectives of the work reached?)

The prototype was the world’s first commercial scale wave energy converter to generate electricity to a national grid, in the UK. In Portugal, too, the three units are also exporting power into the local grid. A Pelamis machine operating in a good wave resource (40kW/m annual average wave energy level) will have an energy payback period of less than 20 months with a life cycle emission of ca. 25g/kWhr. Under these conditions, it would offset the production of ca. 2,000 tonnes of CO_2 from a conventional combined cycle gas power station each year.

9. Success and Fail factors

The key to development of these markets are 'market enablement mechanisms' of feed-in tariffs that typically provide solar and wind installations with support of 8-15c/kWh and 30-50c/kWh respectively. Wave energy has lower 'opening' costs than wind did 25-30 years ago, lower current costs than solar and the potential to become one of our least cost generating options over time, providing that deployment into the market allows continued cost reductions through the process of learning by doing. As such a number of countries now have, or are planning to have, specific mechanisms to support the development of wave energy, these include: Scotland, the UK, Portugal, Spain, France, and Ireland. Costs are expected to significantly fall with continued deployment into the market. Unlike a ship, where marine growth causes drag and therefore increased fuel costs, wave energy systems are stationary and any increased drag due to marine growth is negligible. This means that the installation is largely tolerant of growth and that harmful anti-foulants are not required over the entire submerged structure.

10. Unforeseen outcomes

The longer term impacts are not known. However, modelling has shown that wave farms will have a negligible downstream effect on the coastal environment. Offshore wave energy is considered to be one of the most environmentally benign forms of electricity generation although the mooring components and their installation may cause disturbance to local species during installation. Installations will most likely attract fish shoals and, through providing shelter from fishing activities, the populations of indigenous fish species could increase. With particular reference to marine mammals and noise, wave energy produces noise of ca. 70-80dB at 1m. in air, but the coupling to water is poor. They have been designed to have a minimal footprint (for example chains, ropes and anchors). The visual impact is also minimal since machines are ballasted to lie approximately 50% submerged therefore there is only around 2m of structure visible above the waterline. They are also currently fitted with flashing yellow lights (one flash every 5 seconds) on the front and rear of the machines. These lights are visible at 2 nautical miles at night time. Nonetheless, depending upon the regulatory regime, they should be subject to an Environmental Impact Assessment (EIA). Decommissioning of the mooring system is a relatively simple process

11. Prepared by

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12. Verified by

It has not been possible to verify this case.

13. Sources

- Pelamis wave power (undated) Pelamis, Edinburgh
- Why Marine? (2006) BWEA
- www.bwea.com/marine
- www.pelamiswave.com

NW Atlantic-Pelamis wave power (445.83 KB)

NW Atlantic-Why marine (3.19 MB)