Case Study – Wave Dragon Milford Haven Project

Project Name	Milford Haven Wave Dragon Pre-Commercial Demonstrator
Location	Milford Haven, offshore Wales
Installed capacity	4-7MW
Technology Type	Wave Dragon – floating overtopping device
Project Type/Phase	Large-scale prototype
Year	2009 (planned)

Project Description

The Milford Haven Wave Dragon Pre-Commercial Demonstrator is a floating slack moored wave energy converter with a rated capacity of 7MW. The demonstrator device will be located 2 - 3 miles off the southwest Wales coast, off St Ann's Head, northwest of Milford Haven, on an area of approximately 0.25 km^2. The deployment of the 7 MW Wave Dragon device is the largest undertaking of wave energy deployment to date, and consists of one single device. Unlike other wave energy converters, the Wave Dragon can be scaled up with relative ease compared to multi-MW devices.

The first objective of the project is to prove the feasibility of installing and grid connecting the device at commercial scale, with the intention of undertaking tests and verifying performance for a period of up to five years. The intention would then be to commercialise the development of multiple devices to be deployed further offshore as part of a wave farm or array.

The second objective of the project is to generate clean electricity from a renewable source of energy. The device is intended to be tested for three to five years, and then removed and the site decommissioned. This demonstrator project has been linked to a further development of a 77MW wave energy farm in the Celtic Sea following the successful demonstrator testing.

The demonstration project is being supported by the Welsh Assembly under the Objective 1 initiative and the Welsh Development Agency (WDA) has been supporting the efforts of the project over the last few years. The Welsh Demonstrator project will also host an EC research and development project funded under the Framework Programme 6. Wave Dragon Wales Ltd is backed by KP Renewables Plc who is providing the required co-funding to deliver the project.

Wave Dragon is the offshore wave energy technology that has endured one of the most extensive consecutive testing periods: "A 1:4.5 scale prototype launched in 2003 was the world's first offshore grid-connected wave energy conversion device. Deployed off the coast of Denmark at Nissum Bredning, this test unit has accumulated over 20,000 hours of experience supplying electricity to domestic homes" (*www.wavedragon.net*)

Timetable:
Announced in April 2007 (www.wavedragon.co.uk/welsh-pre-commercial-demonstrator/eia-statement.html); May - Dec 2007 - final design and procurement; end 2007 - consent applications; Jan 2008 - constructions (initially planned deployment and grid connection was 2008; now delayed to 2009).

The applications for consent were submitted in April 2007. Pending consent, device construction will start and deployment at site is proposed for summer 2009.

Map of southwest Wales with the proposed project location

The Technology

The Wave Dragon is a slack-moored, overtopping wave energy converter. Two curved arms focus waves onto a central ramp which the waves travel up and 'overtop' into a reservoir. At the bottom of the reservoir is a set of low-head hydro turbines, through which the collected water flows back out to sea. The reservoir has a smoothing effect on the water flow, and the turbines are coupled directly to variable speed generators. Since the head of water in the reservoir accounts for the energy, the concept is similar to a hydroelectric power plant.

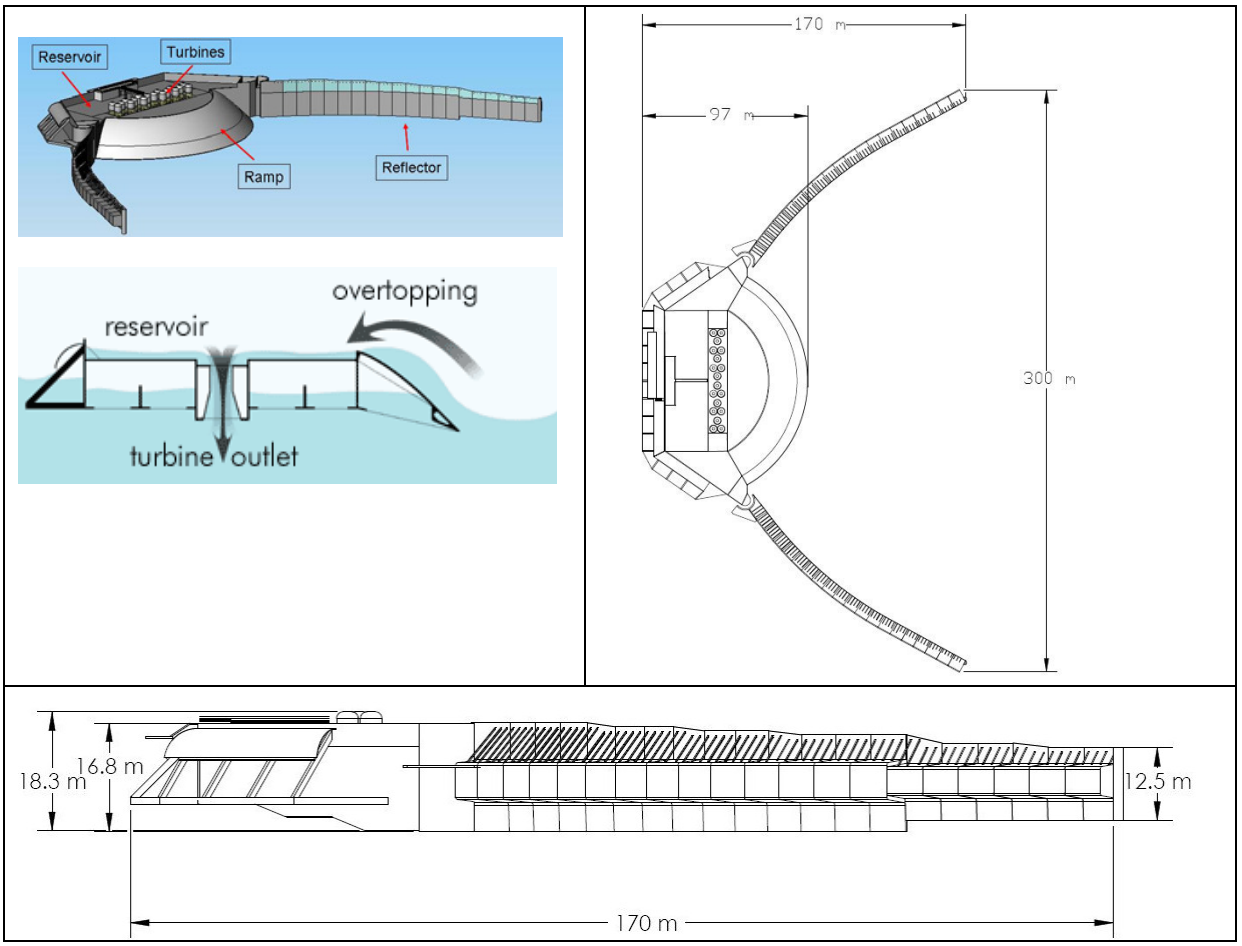
The Wave Dragon consists of three main components:

• Two wave reflectors, attached to the central platform; these act to focus the incoming waves;

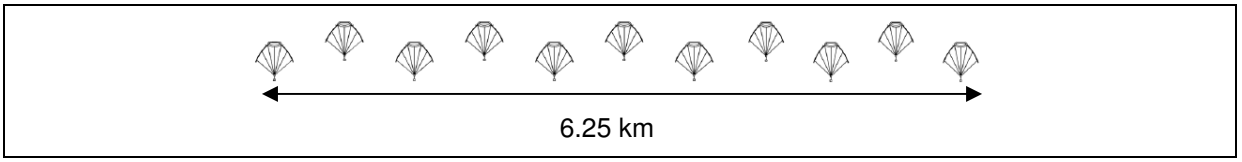
• The main platform; a floating reservoir with a double curved ramp facing the incoming waves. The waves overtop the ramp which has a variable crest freeboard 1 to 4 m.

• Hydro turbines; a set of low head Kaplan turbines converts the hydraulic head in the reservoir. These turbines are attached to PMG allowing variable speed operation. The produced electricity is converted using AC/DC/AC power electronic converters to the grid frequency.

Concerns have been raised by potential buyers about the risk associated with the long reflectors and the joint to the platform. The Wave Dragon concept, including the layout of the reflectors and the joint, is well described and tested. To address this concern, however, another reflector layout has been developed. This has an effect on cost and performance profile. This design has shorter reflectors integrated in to the platform structure and has lower energy conversion performance, lower capital costs, and lower risk. These shorter reflectors can be replaced with longer reflectors. This can be done without changes to the Wave Dragon structure or the anchor arrangement and only minor changes to the mooring line arrangement between the CALM buoy and the platform reflectors (see illustration).



Wave Dragon and basic principle of operation (left); Side view of the Wave Dragon (right) and top view (below); *[1]; www.wavedragon.co.uk*



Possible Wave Dragon farm layout (www.wavedragon.co.uk)

Related projects

Wave Dragon Pilot plant 1:4½ deployed in 2003, Denmark, Wave Dragon ApS: a 20 kW, 1:4.5 scale sea prototype launched in Nissum Bredning; power production and O&M tested from 2003 to 2005 and again from April 2006 onwards.

In Portugal, the company TecDragon aims at a 50 MW wave farm composed of Wave Dragon devices in Portuguese waters; advances from this undertaking are not yet known.

The Wave Dragon has similarities with the Swedish technology FWPV (Floating Wave Power Vessel): pilot plant developed and deployed in the 1980s near Stockholm. This project is no longer active. The Norwegian concept WaveSSG (developer Wave Energy AS) is an overtopping concept; prototype only proposed as shoreline-integrated plant. While the current WaveSSG shoreline device might be an interesting niche application for innovative breakwater solutions, the company's statement to develop an offshore (floating) device has not yet been supported by published studies.

Project Partners

Wave Dragon Ltd is the British offspring of Wave Dragon ApS, the Danish company set up for the technology development of the Wave Dragon device. Due to the favourable conditions for prototype development, the activities were shifted to the UK, since the decision for the Welsh demonstrator was made.

Spok ApS is the Danish consulting company whose CEO, Hans Christian Soerensen, has pushed forward the Wave Dragon development to date.

Aalborg University (Denmark) – Civil Engineering Department performed substantial part of modelling and monitoring work, in particular with respect to the Nissum Bredning pilot plant.

Swansea University (Wales) has collaborated in environmental impact and public consultation, as well as electrical issues.

Technica University of Munich (Germany) has been responsible for the development of the special low-head hydraulic turbines used in Wave Dragon technology.

Cost and Financing

To realise this project support has been given from the Welsh Development Agency for three years. Wales has a commitment to renewable energy and to build up experience with this industry. A £5 million (€7.4 million) grant has been awarded by the Welsh Assembly Government as an Objective One project. The project is also supported by the EC 6th Framework Programme.

The Welsh Demonstrator device will initially be deployed in a wave climate much lower than its rated power and size justifies, to allow for proper testing. The demonstrator project has been linked to a 77MW wave energy farm in the Celtic Sea following testing. Significant cost savings can be achieved when a series of reinforced concrete structures and hundreds of turbines are constructed, making it possible to put together a commercial project. The total project investment for this 77MW project is approximately £1,740 per installed kW.

Wave Dragon has been awarded a €2.4 million grant from the European Commission for research related to the Welsh Demonstrator project.

(Friis-Madsen E, Christensen L, Kofoed, JP and Tedd J. Worlds Largest Wave Energy Project 2007 in Wales. Powergen Europe Conference Proceedings, Cologne 2006).

Further Information

www.wavedragon.net

[1] Friis-Madsen E, Christensen L, Kofoed, JP and Tedd J.: Worlds Largest Wave Energy Project 2007 in Wales. Powergen Europe Conference Proceedings, Cologne 2006.

[2] Report prepared by PMSS Ltd to Wave Dragon Wales Ltd, “Wave Dragon Pre-Commercial Wave Energy Device” - Environmental Statement Volume 1: Non-Technical Summary, April 2007