Oregon Wave Energy Trust
Utility Market Initiative

Task 2.1.2: Garrad Hassan Wave Energy Technology Review

www.oregonwave.org

www.peventuresllc.com

The Utility Market Initiative was prepared by *Pacific Energy Ventures* on behalf of the Oregon Wave Energy Trust.

Task 2.1.2 was completed by Garrad Hassan.

December 2009

This work was funded by the Oregon Wave Energy Trust (OWET).

OWET was funded in part with Oregon State Lottery Funds administered by the Oregon Business Development Department. It is one of six Oregon Innovation Council initiatives supporting job creation and long term economic growth.

This Utility Market Initiative was prepared by Pacific Energy Ventures on behalf of the Oregon Wave Energy Trust. Task 2.1.2 was completed by Garrad Hassan.

For information about this project, please contact Justin Klure at Pacific Energy Ventures:

Phone: (503) 475-2999

Email: jklure@peventuresllc.com

About Oregon Wave Energy Trust

The Oregon Wave Energy Trust – (OWET) - with members from fishing and environmental groups, industry and government - is a nonprofit public-private partnership funded by the Oregon Innovation Council in 2007. Its mission is to serve as a connector for all stakeholders involved in wave energy project development - from research and development to early stage community engagement and final deployment and energy generation - positioning Oregon as the North America leader in this nascent industry and delivering its full economic and environmental potential for the state. OWET's goal is to have ocean wave energy producing 2 megawatts of power - enough to power about 800 homes - by 2010 and 500 megawatts of power by 2025.

WAVE ENERGY TECHNOLOGY REVIEW

Client	Oregon Wave Energy Trust
Contact	Kevin Banister
Document No	40721/AR/01
Issue	C
Status	FINAL
Classification	Client's Discretion
Date	December 7, 2009

Author: J Cruz, C Elkinton

Checked by: R I Rawlinson-Smith

Approved by: R I Rawlinson-Smith

Important notice and disclaimer

This Report shall be for the sole use of the Client for whom the Report is prepared. The document is subject to the terms of the Agreement between the Client and Garrad Hassan America, Inc. and should not be relied on by third parties for any use whatsoever without the express written authority of Garrad Hassan America, Inc. The Report may only be reproduced and circulated in accordance with the Document Classification and associated conditions stipulated in the Agreement, and may not be disclosed in any offering memorandum without the express written consent of Garrad Hassan America, Inc.

Garrad Hassan America, Inc. does not provide legal, regulatory, tax and/or accounting advice. The recipient must make its own arrangements for advice in these areas.

This document has been produced from information at the date of this document and, where applicable, information relating to dates and periods referred to in this document. The Report is subject to change without notice and for any reason including, but not limited to, changes in information, conclusion and directions from the Client.

Key To Document Classification

Strictly Confidential	:	Recipients only
Private and Confidential	:	For disclosure to individuals directly concerned within the recipient's organization
Commercial in Confidence	:	Not to be disclosed outside the recipient's organization
GH only	:	Not to be disclosed to non GH staff and affiliates
Client's Discretion	:	Distribution at the discretion of the client subject to contractual agreement
Published	:	Available to the general public

Revision History

Issue	Issue Date	Summary
A	09/06/29	Original release – electronic only
B	09/09/01	Final version – inc. Client feedback (teleconference with EPRI)
C	09/11/04	Final version – Minor update at Client's request

Distribution:	Copy No:
Client	1
GH America	2
GH Bristol	3
GH Portugal	4

Copy No: _____

Table of Contents

List of Figures

List of Tables

EXECUTIVE SUMMARY

The Oregon Wave Energy Trust (OWET) has commissioned Garrad Hassan America (GH) and its partner companies to conduct a high-level technology review of the wave energy sector. GH has undertaken a 3rd party assessment of the most promising wave energy conversion technologies being developed worldwide. The assessment provides OWET and other energy sector entities, in particular those active in Oregon, with an overview of the range of existing technologies.

The review incorporates both technical and commercialization aspects of the concepts, but does not include detailed analyses such as numerical simulation and cost of energy modeling. The assessment focuses on key parameters that may be used to classify and rank the several technologies, although a ranking is outside the scope of this report.

The review has been undertaken in two phases:

- Phase 1: Overview of the Existing Technologies
- Phase 2: Description of the Shortlisted Technologies

In both phases GH made extensive use of an in-house developer database that contains information relating to wave (and tidal) energy technology developers. Such exercise allows the identification of the leading technologies. Further steps may lead to additional phases, in which the developers with the highest ranking would be engaged after the establishment of non-disclosure agreements to obtain commercially sensitive information. As such tasks are highly dependent on the type of investor (utility, project developer, bank, etc.) and their objectives, they are better suited for a specific due diligence exercises.

This report describes the approach taken in each of the two phases and presents key findings and statistics extracted from the GH developer database. Lists of the technologies which have reached the sea trial and full-scale stages are also given; these are described more fully in individual datasheets that summarize four categories (Company Information; History; Working Principle; Key Milestones). Such datasheets provide a readily available, easy-access mechanism for the assessment of the most developed technologies to date (July 2009).

1 PHASE 1

In Phase 1, using an existing in-house, GH identified 73 wave energy technology developers. The database contains information regarding all the reviewed technologies in MS Access and can be consulted in a user-friendly format that relies on a graphical user interface.

Figure 1.1 Main GUI – GH Marine Energy Developer Database (V. 1.2)

The categories originally suggested in GH's proposal (document 40721/AP/01) – Project Development, Technology Classification, Evidence of Modeling Program and Full-Scale Design – were surveyed. For the first high-level selection (i.e. transition between Phases 1 and 2) a cut-off criterion was established by searching for evidence of significant progress in at least five of the following sub-categories:

- Project Development
  - Company History (>5 years)
  - Staff (>10 full-time)
  - Investment (>$1.5M)
  - Investment (>$15M)
- Technology Classification
  - Power Take-Off (PTO)
  - Deployment Strategy
  - O&M Strategy
- Evidence of Modeling Program
  - Numerical Modeling
  - Experimental Modeling
  - Prototype Deployed at Sea (>1:5 scale)
- Full-Scale Design
  - Independent Verification
  - Full-Scale Prototype (FSP)

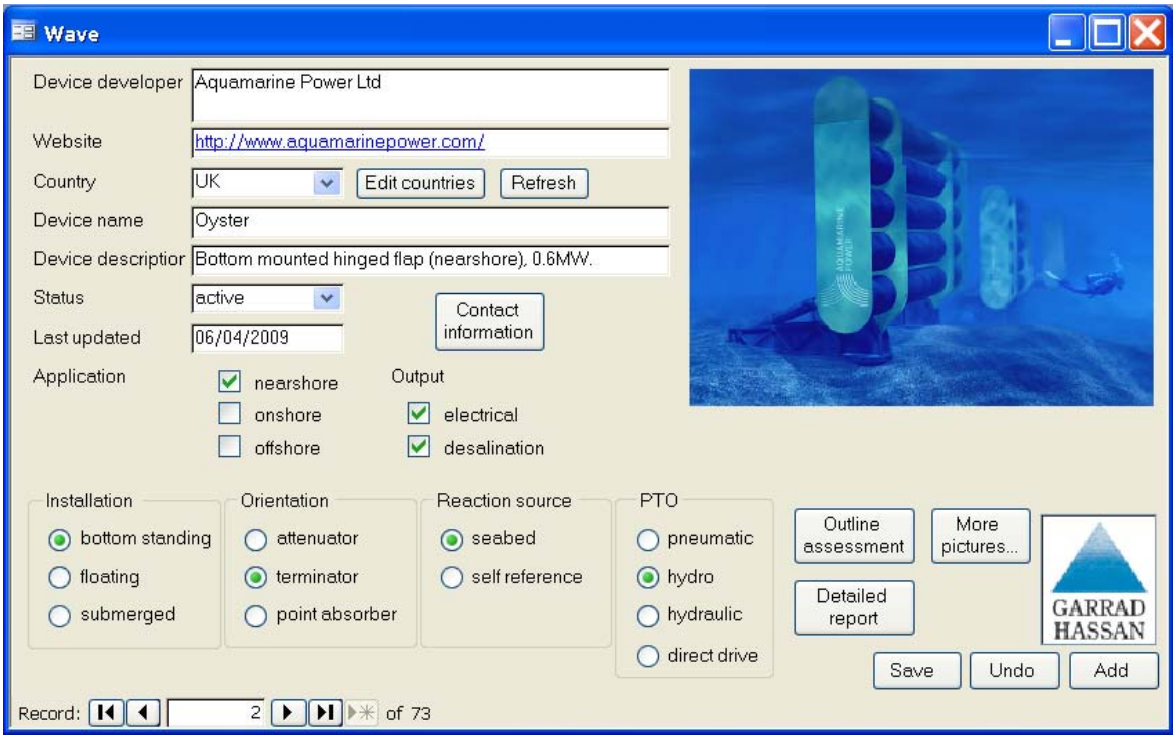


Figure 1.2 Example of a record from the GH device developer database

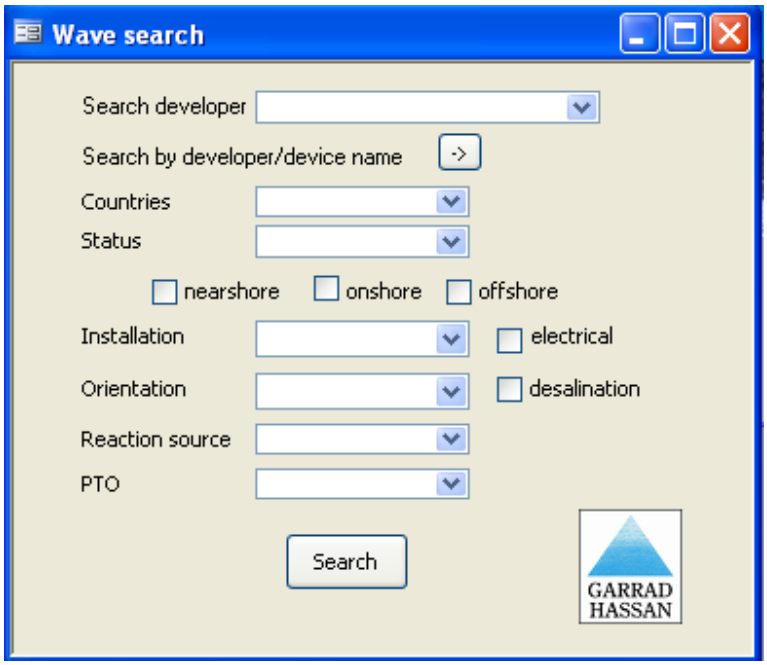


Figure 1.3 Main search options – wave energy device developers

In each of the 73 individual records the user can find a summary of the technology as described by the following key characteristics:

- Application (onshore, nearshore, offshore)[1];
- Output (electrical, desalination);
- Installation (bottom standing, floating, submerged);
- Orientation (attenuator, terminator, point absorber);
- Reaction Source (seabed, self-referenced);
- PTO (pneumatic, hydro, hydraulic, direct drive).

The previously mentioned categories (page 1), which describe the status of the company and of the technology, were used to create individual 'Outline assessment' tables. If more than five of the sub-category requirements are satisfied, the concept is included in a shortlist of technology developers (Phase 2) and a datasheet is created (and included in the database).

To summarize the work conducted under Phase 1, some statistical indicators are presented in Table 1.1. For comparison, the analogous information for tidal energy technologies is presented in Table 1.2. It is interesting to note the similarities between the two summary tables, which emphasize the resemblance between the status of wave and tidal energy conversion technologies; the major discrepancies are associated with the number of concepts that have reached the full-scale stage (considerably larger for wave energy) and with the level of detail given to define the deployment and O&M strategies (considerably larger for tidal energy). A table that names the 73 developers listed in the GH database is given in Appendix A.

Total Number of Developers	73
Nationalities	20
Average Number of Sub-Categories Fulfilled	3.62 (out of 12)
Standard Deviation	3.09
Company History (> 5y)	45.83%
Staff (>10 ft)	19.44%
Investment	33.33% (>£1m); 13.89% (>£10m)
PTO	49.23%
Deployment Strategy	13.89%
O&M Strategy	4.17%
Numerical Modeling	44.00%
Experimental Modeling	70.83%
Real sea experience	36.11%
Independent Verification	11.11%
FSP (Full-Scale Prototype)	8.33%

Table 1.1 Statistical Summary (Phase 1 - Wave)

[1] Distinction between the several types of wave energy converters is based on the installation depth: up to the 20m contour (onshore), between the 20m and the 50m contour (nearshore), and beyond the 50m contour (offshore).

Total Number of Developers	75
Nationalities	13
Average Number of Sub-Categories Fulfilled	3.68 (out of 12)
Standard Deviation	3.02
Company History (> 5y)	45.33%
Staff (>10 ft)	14.67%
Investment	38.67% (>£1m); 5.33% (>£10m)
PTO	49.33%
Deployment Strategy	38.67%
O&M Strategy	25.33%
Numerical Modeling	44.00%
Experimental Modeling	49.33%
Real sea experience	32.00%
Independent Verification	10.67%
FSP (Full-Scale Prototype)	1.33%

Table 1.2 Statistical Summary (Phase 1 - Tidal)

2 PHASE 2

A shortlist of technology developers was created for Phase 2, by identifying those that showed evidence of activity on at least five of the sub-categories studied under Phase 1. This high-level criterion resulted in a shortlist of 22 wave energy technology developers. Table 2.1 compares the same statistical indicators originally presented in Table 1.1, focusing exclusively on the shortlisted developers. The names of the shortlisted technology developers are presented in Table 2.2. Note that for wave energy 77% of these companies were originally formed in Europe, with 27% being based in the UK. Two of the 22 shortlisted technology developers (9%) are based in the USA.

Total Number of Developers	22
Nationalities	13
Average Number of Sub-Categories Fulfilled	7.45 (out of 12)
Standard Deviation	2.05
Company History (> 5y)	77.27%
Staff (>10 ft)	54.55%
Investment	29.17% (>£1m); 45.45% (>£10m)
PTO	86.36%
Deployment Strategy	36.36%
O&M Strategy	13.64%
Numerical Modeling	81.82%
Experimental Modeling	100%
Real sea experience	68.18%
Independent Verification	29.55%
FSP (Full-Scale Prototype)	27.27%

Table 2.1 Statistical Summary (Phase 2 - Wave)

The core of the work undertaken in Phase 2 resided in the creation of individual datasheets for the shortlisted technologies. These datasheets include details related to the Company Information, History, Working Principle, Key Milestones and Strengths & Weaknesses. The individual datasheets are presented in Section 3.

Company	Device / Concept	Country
Aquamarine Power Ltd	Oyster	UK
AW-Energy Oy	WaveRoller	Finland
AWS Ocean Energy Ltd	AWS	UK
Carnegie Corporation Ltd	CETO	Australia
Columbia Power Technologies LLC	SeaBeav I	USA
Ecofys BV	Wave Rotor	The Netherlands
Ecole Centrale de Nantes	SEAREV	France
Fred Olsen Renewables	Buldra	Norway
Hidroflot SL	Hidroflot	Spain
MARTIFER Energy Systems SA	FLOW	Portugal
Ocean Energy Ltd	OE Buoy	Ireland
Oceanlinx Ltd	Oceanlinx OWC	Australia
Ocean Power Technologies Inc	PowerBuoy	USA
ORECon Ltd	MRC1000	UK
Pelamis Wave Power Ltd	Pelamis	UK
Seabased AB	Seabased Point Absorber	Sweden
SyncWave Energy Inc.	SyncWave	Canada
Trident Energy Ltd	Trident Energy Converter	UK
Wave Dragon ApS	Wave Dragon	Denmark / UK
Wavebob Ltd	Wavebob	Ireland
Wave Energy Centre	Pico OWC	Portugal
Wavegen (Voith Siemens Hydro Power Generation)	Limpet	UK

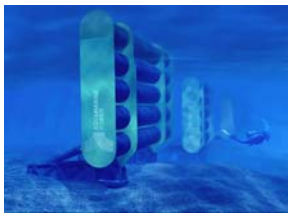
Table 2.2 Shortlisted Developers (Phase 2 - Wave)

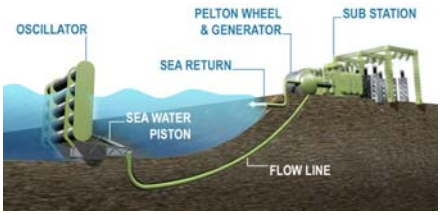
3 INDIVIDUAL DATASHEETS (SHORTLISTED DEVICES)

The 22 shortlisted technology developers shortlisted in Phase 2 are described more fully in Section 3... The main objective of the datasheets is to provide a summary description of the main concepts currently being developed by listing some key characteristics of both the company and the wave energy converter such as:

- Company Information;
- History;
- Working Principle;
- Key Milestones.

The individual datasheets are presented in the following pages, following Table 2.2 (alphabetical order).





Aquamarine Power Ltd

COMPANY INFORMATION

Company Name:	**Aquamarine Power Ltd**
Website:	**www.aquamarinepower.com**
Device:	**Oyster**
Device Type:	**Bottom mounted hinged flap (nearshore)**

HISTORY

The Oyster was originally studied at Queen's University Belfast by Prof. Trevor Whittaker's team. Numerical and experimental modelling (1:40 and 1:20 scale) exercises were performed, defining the design of the device. Aquamarine Power secured funding from the Scottish Executive, and later joined a subsidiary of Scottish and Southern Energy to form Aquamarine Power Ltd (initial investment of £6.3M). Additional investment (£1.5M) has been provided by the Sigma Capital Group plc. The engineering team has been working with Atkins, RCID, QUB and Bennet Associates, and Oyster is among the devices which secured a berth at the European Marine Energy Centre (EMEC) for full-scale testing (scheduled for summer 2009).

WORKING PRINCIPLE

The Oyster is a bottom mounted, surface piercing hinged flap which converts the wave energy available in one horizontal mode of motion (surge). It is designed for nearshore deployment (around 10 m water depth). The device has been developed in two versions: electricity production and a desalination module. The wave is converted to mechanical energy resulting in pressurized water. All components after this stage are kept onshore in the substation. In the electricity generation version, the power take-off consists of a Pelton turbine, while the desalination version uses a reverse osmosis module to produce freshwater.

KEY MILESTONES

- Joint venture with Scottish and Southern Energy (SSE)
- Secured berth at EMEC for deployment of a full-scale prototype (scheduled for 2009)
- Agreement with Airtricity to develop 1GW of marine energy projects by 2020

AW-Energy Oy

COMPANY INFORMATION

Company Name:	**AW-Energy Oy**
Website:	**www.aw-energy.com**
Device:	**WaveRoller**
Device Type:	**Bottom mounted hinged flap (nearshore)**

HISTORY

AW-Energy was founded in 2002 in Finland to develop the WaveRoller concept. Fundamental R&D focused on experimental modelling, which culminated in the deployment of a 1:3 scale prototype at the European Marine Energy Centre. The technological experience of the company is derived from Fortum, the largest Finnish company in energy industry. Recently the company has been active in the Portuguese market and a joint venture with a large Portuguese civil engineering group (Lena Group) has been created to develop the technology in Portugal. A 10 kW prototype was deployed near Peniche (central Portugal) in 2007 (with no connection to the national grid).

WORKING PRINCIPLE

WaveRoller, like Aquamarine's Oyster, is a bottom mounted hinged flap which converts the wave energy available in one horizontal mode of motion (surge). Unlike Oyster it does not pierce the free surface, hence it converts only the (less powerful) bottom waves. It is designed for nearshore deployment and for electricity generation (although there are no details on the actual power take-off solution to date).

KEY MILESTONES

- 1:3 scale testing at EMEC (no grid connection)
- Joint venture with the Lena Group (Portuguese civil engineering company)
- 10 kW prototype deployed off the coast of Peniche (Portugal) in 2007 (no grid connection)
- Sale of 8.4% of the company to Fortum (late 2007)

AWS Ocean Energy Ltd

COMPANY INFORMATION

Company Name:	**AWS Ocean Energy Ltd**
Website:	**www.awsocean.com**
Device:	**AWS (Archimedes Wave Swing)**
Device Type:	**Submerged point absorber (offshore)**

HISTORY

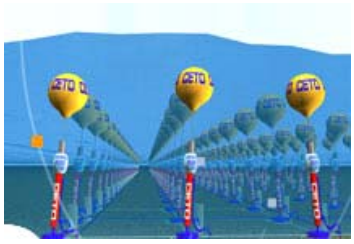
AWS Ocean Energy Ltd was founded in 2004 to develop the AWS device. Based in Scotland, it builds upon the work led by Teamwork Technology BV, the Dutch company responsible for the development of the device from its inception in 1994 to the full-scale prototype testing off the coast of Portugal in 2004. Model testing was conducted at the 1:50 scale and 1:20 scale at HMRC (University College Cork) and WL Delft Hydraulics, respectively. Extensive numerical modelling was performed at IST (Technical University Lisbon). In 1997 AWS BV was formed, joining NUON, ECN, Delft Hydraulics, Teamwork Technology and a private investor. By 1999 the AWS design was ready. The pilot plant, rated at 2 MW, was then assembled in Romania, with two main additions to the original concept: a pontoon used as support for the submergence operation and a vertical guidance structure to assist the floater's motion. Both these features were intended to add additional control to operations with the prototype. Two unsuccessful attempts to submerge the device preceded the final submersion operation in 2004. The pilot plant was then tested in several sea states and operational conditions.

WORKING PRINCIPLE

The AWS pilot plant consisted of an air filled chamber fixed to the seabed and open at the top (the silo), closed by another cylinder (the floater). An air lock is created between the two cylinders and so water can not flood the silo. The floater can move up (or down), due to the pressure increase (decrease) related to the incoming wave crest (trough) directly above the device. By tuning the system frequency to the mean wave frequency, the stroke of the linear motion can be made larger than the wave height. In the AWS pilot plant, the power take-off included a permanent-magnet linear generator, but the new AWS Ocean design uses high pressure oil hydraulics as an intermediate step prior to the generation of electricity. Other differences can be found in the connection of the device to the seabed, but overall the wave energy conversion mechanism remains unchanged.

KEY MILESTONES

- Grid connected 2 MW FSP deployed off the coast of Póvoa de Varzim (Portugal) in 2004
- Establishment of AWS Ocean Ltd, based in Inverness
- Investor portfolio including RAB Capital plc, Isleburn Group, Tersus Energy plc, STV Fund and the Tudor Group
- £2.1m grant from the Scottish Gov. for the deployment of a 250 kW prototype at EMEC



Carnegie Corporation Ltd

COMPANY INFORMATION

Company Name:	**Carnegie Corporation Ltd**
Website:	**www.ceto.com.au**
Device:	**CETO (Cylindrical Energy Transfer Oscillating)**
Device Type:	**Submerged point absorber (nearshore / offshore)**

HISTORY

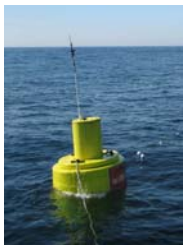
The CETO concept was firstly tested in 1999 (small scale prototype) in wave flumes. Work on a demonstration prototype began in 2003 and was culminated with its deployment in late 2005 (CETO I). A new design (CETO II) was deployed in February 2008; the new design is closer to the full-scale CETO III (although it is around 1/6 of the size). Commercially, the IP was owned by Renewable Energy Holdings Plc, listed on the London Stock Exchange's AIM Market, until May 2009. ASX-listed Carnegie Corporation Ltd, which develops the CETO technology and will own and operate CETO throughout the Southern Hemisphere, recently acquired the rights for CETO and will collaborate with EDF EN in the Northern Hemisphere.

WORKING PRINCIPLE

CETO has been envisaged in two versions: electricity production and desalination. In the latter it is very similar to the Oyster concept (reserve osmosis desalination) as all major electrical generation components are in an onshore substation. CETO comprises a spherical buoy which under the action of the waves directly above compresses water via a mechanical pump (one degree-of-freedom approach: heave). The pressurised water is pumped to shore and passed through a Pelton turbine or a reverse osmosis unit to produce electricity or freshwater.

KEY MILESTONES

- Deployment and operation of a technology demonstrator (CETO I)
- Deployment of a pre-commercial design (CETO II)
- Agreement with EDF EN for the Northern Hemisphere



Columbia Power Technologies LLC

COMPANY INFORMATION

Company Name:	**Columbia Power Technologies LLC**
Website:	**www.columbiapwr.com**
Device:	**SeaBevI**
Device Type:	**Floating point absorber (offshore)**

HISTORY

Columbia Power Technologies was founded in 2005 by Greenlight Energy Resources, Inc. In partnership with Oregon State University (USA), the company intends to develop and commercialise a wave energy converter using novel direct drive generator topologies. Greenlight Energy Resources, Inc. was formed by the principals of the Greenlight Energy, Inc. (GEI) following the sale of their wind energy company to BP Alternative Energy North America, Inc.

WORKING PRINCIPLE

The concept is still at an early stage (numerical and experimental models being developed), but the main characteristics are clear: the device will be a floating point absorber to be deployed in water depths around 30-50 m, and the power take-off will be a direct drive linear generator. Several generator topologies are being tested in a linear test bed at Oregon State University. Two main alternatives regarding the final design are still being studied with regard to the source of reference: if moored the reference will be seabed by default, but the possibility of including a damper plate as an additional source or reaction is also being evaluated. Full-scale unit rating should not exceed 1 MW.

KEY MILESTONES

- Deployment of SeaBev I (1 kW prototype) by Oregon State University

Ecofys BV

COMPANY INFORMATION

Company Name:	**Ecofys BV**
Website:	**www.ecofys.nl**
Device:	**Wave Rotor**
Device Type:	**Bottom mounted Darrieus / Wells rotor**

HISTORY

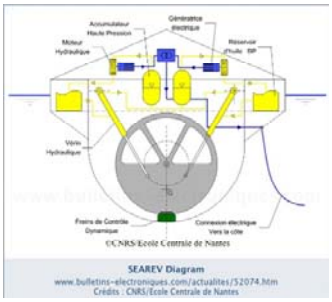
Ecofys, a Dutch renewable energy consultancy, together with a Danish partner (Ingenioerfirma Rossen), has been developing a device called Wave Rotor since the early 2000s. The concept underwent a series of tests at NaREC, and the same 1:10 scale model was installed in the Nissum Bredning peninsula in Denmark.

WORKING PRINCIPLE

The Wave Rotor aims to convert the roll motion associated with the orbital movements from the circulating water particles in the waves, which create local currents. The developers discovered that these circular currents can directly drive a rotor, avoiding intermediate conversion steps. In order to tap energy directly from both the up and down and back and forward currents, two types of rotors were combined on the same axis of rotation: a Darrieus rotor and a Wells rotor. These are respectively omni- and bi-directional rotors, which can operate in currents of changing directions.

KEY MILESTONES

- Testing of a 1:10 scale model in Nissum Bredning (Denmark) and NaREC



Ecole Centrale de Nantes

COMPANY INFORMATION

Company Name:	**Ecole Centrale de Nantes**
Website:	**www.ec-nantes.fr**
Device:	**SEAREV (Système Electrique Autonome de Récupération de l'Energie des Vagues)**
Device Type:	**Floating attenuator (offshore)**

HISTORY

Ecole Centrale de Nantes has been involved in marine hydrodynamics since the early 1980s. The Fluid Mechanics Department has a team with strong numerical modelling background and a state-of-the-art laboratory which includes a 50x30x5m deep water multidirectional wave basin which has been used by several technology developers, including Pelamis Wave Power Ltd. The same team has been developing the SEAREV concept since 2003.

WORKING PRINCIPLE

The SEAREV is an offshore floating attenuator (orientated head-on with regard to the incoming waves) which uses a large internal mass as the source of reference. All moving parts are confined in the structure and the power take-off system is similar to the one proposed by Pelamis Wave Power Ltd. (high pressure oil hydraulics). The control strategy applied to the SEAREV is called latching: the body's position is held fixed during certain time intervals to match the motion of the device to the one from a body with a large mass and hence with a period of oscillation similar to the wave period (resonance). The geometry of the SEAREV has been optimised using genetic algorithms allowing the test of more than 100,000 different designs.

KEY MILESTONES

- Construction and testing of a 1:12 scale model in the ECN wave tank (2006)

Fred Olsen Renewables

COMPANY INFORMATION

Company Name:	**Fred Olsen Renewables**
Website:	**www.fredolsen-renewables.com**
Device:	**Buldra**
Device Type:	**Offshore platform (point absorber array)**

HISTORY

The Buldra platform, developed in Norway, is a miniature offshore rig with several point absorbers attached to its deck. The PTO is based on hydraulics and the rig structure is built using lightweight composite material instead of steel to reduce the overall cost. A 1:20 scale model was built at the MARINTEK/Sintef laboratories in Trondheim, and later a 1:3 scale research model was tested off the coast of Norway.

The full-scale version will be 36 by 36 metres. Few results have been presented; the company claims that the rating of each platform will be similar to a modern wind turbine (figures around 3 MW have been suggested), but there is little available information to evaluate the performance of the concept.

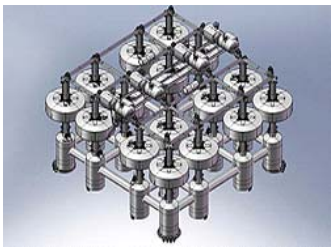
WORKING PRINCIPLE

An array of heaving point absorbers is attached to the platform, which can be bottom mounted or moored to the seabed. The motion of the floaters is used to compress oil (hydraulic PTO). Little detail has been disclosed about the full PTO system. Fred Olsen Renewables is also involved in the SEEWEC consortium, which involves among others ABB and Natural Power Consultants Ltd.

Currently (mid 2009) Fred Olsen Renewables is studying the use of a single (isolated) point absorbed rather tan the Buldra arrangement; first in-house calculations show a significant reduction in cost.

KEY MILESTONES

- 1:20 scale model testing at MARINTEK/Sintef (2004)
- Offshore trials of a 1:3 scale model (2005)



Hidroflot SL

COMPANY INFORMATION

Company Name:	**Hidroflot SL**
Website:	**www.hidroflot.com**
Device:	**Hidroflot**
Device Type:	**Floating offshore platform**

HISTORY

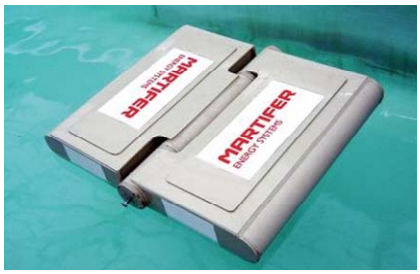
Established in 2005, Hidroflot SL is a Spanish engineering company based in Barcelona which has been developing the Hidroflot concept over the last few years. The design consists of a floating platform, each with 16 individual units. It is envisaged that a wave farm will consist of 8 platforms, resulting in a 50 MW production plant.

WORKING PRINCIPLE

In a similar way to the Buldra (Fred Olsen) and Manchester Bobber (University of Manchester) concepts, Hidroflot consists of a series of heaving point absorbers connected to a small offshore platform which provides the reference. Each float is allowed to heave independently, which provides potential for a farm control strategy per platform (exploring the potential for constructive interference, in particular given the proximity between floats).

KEY MILESTONES

- Certification of the Hidroflot concept by Germanischer Lloyd (GL)
- €12m agreement with the FDO group (Portugal) for a 4MW pilot project in Portugal



Martifer Energy Systems SA

COMPANY INFORMATION

Company Name:	**Martifer Energy Systems SA**
Website:	**www.martifer.pt**
Device:	**FLOW (Future Lives in Ocean Waves)**
Device Type:	**Floating terminator (offshore)**

HISTORY

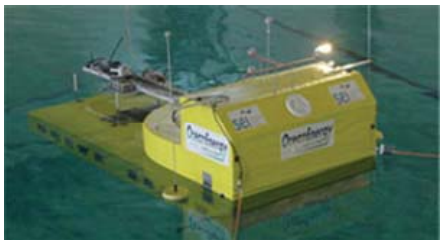
The Martifer Group is divided into four core business units: Metallic Construction, Energy Equipment, Advanced fuels and Electricity Generation. Since its inception in 1990, Martifer has grown approximately 30% each year and the group's assets now exceed €300m. Martifer joined the Wave Energy Centre (Portugal) in 2005. Through that partnership IST (Technical University of Lisbon) conducted several numerical modelling exercises on different candidate devices. Martifer recently (February 2008) acquired a shipyard near Aveiro and announced a partnership with Briggs Marine for the installation of their first full-scale prototype.

WORKING PRINCIPLE

Martifer has studied two concepts which underwent most of the modelling exercises. Both are floating, offshore terminators: one absorbs power by the relative motion (pitch) between two barges, while the other consisted of a set of circular cylinders (beam-on orientation) linked by hydraulic rams. The final power take-off is a hydraulic system, with the FLOW system being a combination of the two initial concepts.

KEY MILESTONES

- Creation of the wave energy team (2005)
- Acquisition of NAVALRIA (shipyard) in 2007
- Over €20M invested in the development of the technology (2008)



Ocean Energy Ltd

COMPANY INFORMATION

Company Name:	**Ocean Energy Ltd**
Website:	**www.oceanenergy.ie**
Device:	**OE Buoy**
Device Type:	**Floating Oscillating Water Column (nearshore / offshore)**

HISTORY

The company was founded in 2002 to develop the technology. The company directors have experience in offshore operations and the company has relied on its close links to the Hydraulics and Maritime Research Centre (HMRC) at the University College Cork, which has led the experimental modelling programme.

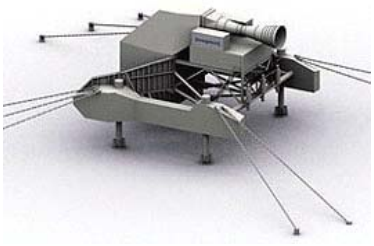
WORKING PRINCIPLE

The principle of operation is similar to that of fixed OWCs designed for shoreline and fixed installations (incoming waves pressurise and rarefy the water column in the chamber and air is forced to pass through a turbine). As in SPERBOY, more energetic wave climates are available offshore, and the possibility of mooring the device in a variety of depths and seabed conditions enhances the flexibility of the device (when compared to the traditional bottom mounted OWC shoreline plants).

KEY MILESTONES

- 1:50 scale tests at HMRC (Cork)
- 1:15 scale tests at Ecole Centrale de Nantes
- 1:4 scale model sea trials at the Marine Institute test site (Galway)

Oceanlinx Ltd



COMPANY INFORMATION

Company Name:	**Oceanlinx Ltd**
Website:	**www.oceanlinx.com**
Device:	**Oceanlinx OWC**
Device Type:	**Bottom mounted Oscillating Water Column (nearshore)**

HISTORY

Previously known as Energetech Australia Pty Ltd, the company was founded in 1997 by Dr. Tom Denniss. It raised around £3.5M up to 2007, with the most prominent partnership being three European investment groups specialised in innovative energy technology and German based RWE Dynamics. In early 2007 it changed its name and raised a further £6M.

WORKING PRINCIPLE

The principle of operation is similar to that of fixed OWCs designed for shoreline installations (incoming waves pressurise and rarefy the water column in the chamber and air is forced to pass through a turbine). The basic difference to other OWC devices is the type of turbine: Oceanlinx developed a novel turbine (Denniss-Auld turbine) which, with variable pitch blades, aims to optimise the efficiency of the plant. A desalination version is also envisaged.

KEY MILESTONES

- Development, construction and test of a novel air turbine (Denniss-Auld turbine)
- Deployment and operation of a 300 kW demonstrator in Port Kembla
- Sale of 60%+ of the company to the New Energy Fund (Portugal)

Ocean Power Technologies Inc

Company Information

Company Name:	**Ocean Power Technologies Ltd**
Website:	**www.oceanpowertechnologies.com**
Device:	**PowerBuoy**
Device Type:	**Floating point absorber (offshore)**

History

Ocean Power Technologies (OPT) was formed in 1994 to develop the PowerBuoy technology, a floating point absorber moored to the seabed. Since 1997 sea trials have been performed off the coast of New Jersey. The technology is among those approaching a pre-commercial scale; recent examples of which are the 40 kW-rated PowerBuoys installed in Hawaii and New Jersey. Ocean Power Technologies Inc. was floated on the London Stock Exchange's AIM market in October 2003 following a successful IPO, and is traded on the AIM market under the symbol "OPT". The Company completed its US IPO and listing on Nasdaq in April 2007 (in which it raised over $90M), and is traded on Nasdaq under the symbol "OPTT".

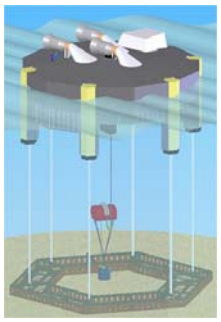
OPT has begun the initial phase of installation of a 1.39 MW wave farm off the northern coast of Spain. The project is a joint venture with the Spanish utility Iberdrola SA. A full size demonstration plant of up to 5MW capacity is planned for installation in UK waters.

Working Principle

There is little detail on the actual configuration of the power take-off (PTO) mechanism in the PowerBuoy, although the principle is clear: a heaving point absorber reacting against the seabed. It has been made public that the PTO is based on oil hydraulics, and the unit rating of each prototype has also been announced (10, 40 and 100 kW).

Key Milestones

- Completed Initial Public Offering in the US and listing on Nasdaq, raising net proceeds of US$90.0 million
- Awarded a grant of £640k from the Scottish Executive for the construction, installation and in-ocean demonstration of a 150 kW prototype
- Selected to occupy a position at the South West Wave Hub project for installation of a 5MW OPT wave power station
- Signed agreement with Iberdrola SA for the construction and installation of a 1.25MW PowerBuoy wave farm on the north coast of Spain
- Signed agreement with Total S.A. of France to develop a wave power station on the west coast of France
- Installed a 40 kW-rated PowerBuoy (PB-40) off Tuckerton, New Jersey as part of the New Jersey Board of Public Utilities Renewable Energy and Economic Development program
- In addition, OPT has reached an agreement with PNGC, a Northwestern US generating co-op, on a grid-connected deployment in Reedsport, Oregon, USA. One 150 kW unit is planned for installation in mid 2010, with 9 additional units to follow in mid 2011.



ORECon Ltd

COMPANY INFORMATION

Company Name:	**ORECon Ltd**
Website:	**www.orecon.com**
Device:	**MRC (Multi Resonant Chambers)**
Device Type:	**Floating Oscillating Water Column (nearshore / offshore)**

HISTORY

ORECon was established in 2002 as a "spin-off" from a postgraduate project at the University of Plymouth which included sea trials of a 1:12 scale concept prototype. Early industrial seed investment kick-started development of the company and was later followed in 2003, with a DTI SMART Award. Following the SMART funded feasibility work, ORECon raised private investment to match-fund a Carbon Trust grant for the industrial development of the MRC wave energy technology. In February 2008 ORECon secured £12M from a group of international venture capital investors led by Advent Ventures which will allow the construction of the full-scale prototype.

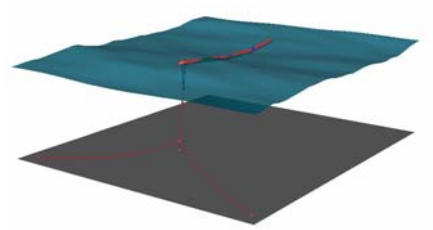
WORKING PRINCIPLE

The principle of operation is similar to that of fixed OWCs designed for shoreline installations (incoming waves pressurise and rarefy the water column in the chamber and air is forced to pass through a turbine). ORECon tries to overcome the underlying low efficiency associated with the use of air turbines in wave energy conversion by redesigning the air chamber and using multiple OWCs in one plant (the Multi Resonant Chambers principle).

KEY MILESTONES

- Recently (February 2008) ORECon secured £12m from a group of international venture capital investors led by Advent Ventures which will allow the construction of the full-scale prototype
- Memorandum of Understanding with Eneolica (Portugal) for demonstration project
- Secured WaveHub (UK) connection point

Pelamis Wave Power Ltd



COMPANY INFORMATION

Company Name:	**Pelamis Wave Power Ltd**
Website:	**www.pelamiswave.com**
Device:	**Pelamis**
Device Type:	**Floating attenuator (offshore)**

HISTORY

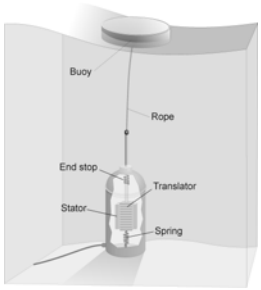
Pelamis Wave Power Ltd (PWP) was founded in 1998 under the name Ocean Power Delivery Ltd. Since its inception it has as sole purpose the development of the Pelamis wave energy converter, and has since followed a detailed numerical and experimental modelling programme. This programme led to the onshore demonstration of a full-scale power conversion module (2002) and to the construction and further deployment of a full-scale prototype (FSP) in 2004 at the European Marine Energy Centre (EMEC). PWP received the first order for Pelamis machines in 2005 from a Portuguese consortium led by Enersis. The FSP was modified in 2006 to match the newer generation of machines, and since then it has been tested both in sea trials and at EMEC. Results from the FSP allowed the validation of the numerical simulation at full-scale. The company was recently restructured with the appointment of a new CEO, and now has over 70 members of staff. To date PWP has secured over £40m of private investment and received a number of prestigious awards.

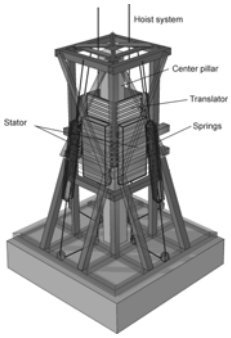
WORKING PRINCIPLE

The Pelamis is a semi-submerged, articulated structure composed of cylindrical sections linked by hinged joints and is held on station by a compliant mooring system that allows the machine to weathervane to align itself head-on to incoming waves (it takes its 'reference' from spanning successive wave crests). As waves travel down the length of the machine they cause the structure to articulate around the joints. The induced motion of these joints is resisted by hydraulic rams that pump high-pressure oil 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 seabed (from: Yemm, 'Pelamis', In: Chapter 7, Ocean Wave Energy, Springer-Verlag).

KEY MILESTONES

- Construction and testing of a full-scale power conversion module (2002)
- Construction, installation and testing of the Pelamis full-scale prototype (2004)
- First commercial orders (2005) with Enersis SGPS
- Announcement of over £4M of funding by the Scottish Gov. for a Pelamis wave farm (4 machines) at EMEC (2007)
- First sale of a P-2 (2nd generation) machine to E-On (2009)





Seabased AB

COMPANY INFORMATION

Company Name:	**Seabased AB**
Website:	**www.seabased.com**
Device:	**Seabased Point Absorber**
Device Type:	**Bottom mounted point absorber (offshore)**

HISTORY

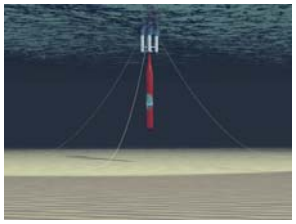
Seabased AB was established in 2001 as a "spin-off" from a postgraduate project at the University of Uppsala (Sweden). The close links to the university and to its facilities have meant that most of the development has been carried out either by university staff or at the university. Several post-graduates have joined Seabased AB in recent years. A test bench for a 10 kW direct drive linear generator was constructed, and following a rigorous environmental impact assessment a test site for real sea deployment was selected off the west coast of Sweden, about 2 km west of the Islandsberg peninsula. In 2005 a 10 kW prototype was deployed and produced electricity no grid connection). Current plans focus the installation of a further nine generators (100 kW farm).

WORKING PRINCIPLE

The Seabased AB concept is a bottom mounted point absorber which uses the heave motion of a float attached to the moving part of the power take-off (the translator) to convert wave energy into electricity. Given that the PTO is a direct drive linear generator no intermediate step exists in the energy conversion chain. The restoration force (i.e. the force that will ensure that the cable linking the floater and the translator is taut at all times) is provided by a spring which connects the translator to the seabed (the reference).

KEY MILESTONES

- Construction and test of a 10 kW prototype (onshore trial of the PTO) in 2003
- Successful deployment of a 10 kW demonstrator off the coast of Islandberg (Sweden) in 2005
- Partnerships with Vatenfall, Statkarft and Fortum
- Planned tests in the Runde test site (Norway)



SyncWave Energy Inc

COMPANY INFORMATION

Company Name:	**SyncWave Energy Inc**
Website:	**www.syncwaveenergy.com**
Device:	**SyncWave**
Device Type:	**Floating offshore platform**

HISTORY

The SyncWave Power Resonator technology was invented and developed by SyncWave Energy Inc. (SEI) of Pemberton, BC (Canada), with scientists and engineers from the University of Victoria, and engineered for the open ocean with Marinus Power LLC, of Houston, Texas.

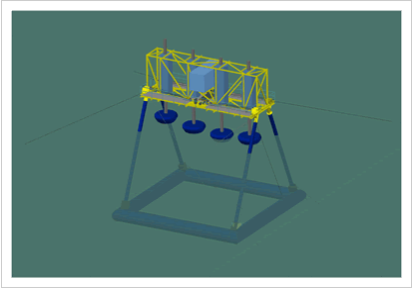
SEI was established in 2004 to develop the SyncWave Power Resonator concept. In March 2009 SEI was awarded CAN $2.7m from Sustainable Development Technology Canada (SDTC) to build and install a full-scale demonstrator unit off the West Coast of Vancouver Island in 2010.

WORKING PRINCIPLE

The SyncWave Power Resonator technology consists of a point absorber with two major floating components, and absorbs power via an hydraulic power take-off which drives a permanent magnet DC generator. The absorption of power is based on the relative motion between the two floating units and it is maximised by a control strategy based on inertia tuning (located inside the large float).

KEY MILESTONES

- CAN $2.7m grant from Sustainable Development Technology Canada (SDTC) to build and install a full-scale demonstrator unit off the West Coast of Vancouver Island in 2010



Trident Energy Ltd

COMPANY INFORMATION

Company Name:	**Trident Energy Ltd**
Website:	**www.tridentenergy.co.uk**
Device:	**Trident Energy Converter**
Device Type:	**Offshore platform (point absorber array)**

HISTORY

Trident Energy was established in December 2003 to develop a technology utilising a linear generator to convert wave energy into electricity. Working in collaboration with the University of Cambridge, numerical models have been developed to evaluate system performance. The numerical predictions were compared with experimental results obtained in three independent tests at the New and Renewable Energy Centre (NaREC).

WORKING PRINCIPLE

The Trident Energy Converter consists of a linear generator attached to an offshore platform which in turn is moored to the seabed. The moving part of the linear generator (translator) is connected to a float which follows the free surface. The heaving motion of the floater is used to directly convert wave energy into electricity. The main distinction from other direct drive concepts is in the location of the stator (fixed part of the linear generator) above the free surface.

KEY MILESTONES

- Test programme at NaREC
- Fabrication of a ocean trial unit (2009)

Wave Dragon ApS

COMPANY INFORMATION

Company Name:	**Wave Dragon ApS**
Website:	**www.wavedragon.net**
Device:	**Wave Dragon**
Device Type:	**Floating overtopping (offshore)**

HISTORY

The Wave Dragon device has been under development since 1994 in Denmark. The project has been supported by a number of EU grants and the key entities involved in the testing programme are Aalborg University and SpoK Aps. A number of studies of structural layout, overtopping of a fixed model, reflector efficiency, financial aspects, geometry, optimal choice of turbine configuration, and movements of the Wave Dragon have been carried out. In parallel the configuration and regulation of the turbines was designed by the following companies: Ossberger Turbinenfabrik (Germany) / Kössler GmbH (Austria), Hälleryd Turbiner AB (Sweden) and Veteran Kraft (Sweden) together with turbine tests and computer simulations conducted at the Technical University Munich (Germany). The structure was designed by the inventor Erik Friis-Madsen (the inventor of Wave Dragon) and adjusted to shipbuilding standards by Armstrong Technology (UK). Electrical components and grid connection were designed by Balslev (Denmark), Belt Electric (Denmark) and Elsam-projekt / Eltra (Denmark). The consortium also involved consultancy groups such as ESBI Engineering Ltd (Ireland) and Niras AS (Denmark). After the initial tests, a 1:4.5 scale prototype was built and deployed in April 2003 in The Nissum Bredning (Broads), an inland sea, connected to the Danish North Sea. Testing has been ongoing since and electricity delivered to the Danish national grid. The current focus for the Wave Dragon technology is to build and deploy a multi MW unit. A European Commission project was begun in May 2006 to implement the design for this commercial size off the coast of Pembrokeshire in South West Wales.

WORKING PRINCIPLE

The Wave Dragon device, although floating, does not convert wave energy through its motion. It gathers wave energy passively by utilising the overtopping principle. The front face of the device is a curved ramp, and incoming waves surge up it, as if it were a beach. Behind the crest of this ramp lies a reservoir which gathers the water "overtopping" the ramp which now has higher potential energy than the surrounding water. Long reflector wings are attached to the reservoir to amplify the overtopping effect. The energy is extracted as the water drains back to the sea through low head hydro (Kaplan) turbines within the reservoir.

KEY MILESTONES

- Construction and deployment of the 1:4.5 prototype
- 3-year record of operation
- Awarded a £5M grant from the Welsh Assembly Government for the development of a full-scale demonstrator off the coast of Pembrokeshire in South West Wales

Wavebob Ltd

COMPANY INFORMATION

Company Name:	**Wavebob Ltd**
Website:	**www.wavebob.com**
Device:	**Wavebob**
Device Type:	**Floating point absorber (offshore)**

HISTORY

Wavebob is an Irish company established in 1999. The company has since been focusing the development of the Wavebob wave energy converter, and claims to have spent over €3.0m in such activities. Following initial sea trials in 2006 Wavebob produced electricity in the Galway test site of the Marine Institute (note that this is claimed by the developer but it has not been independently verified). In December 2007, Wavebob was recognised as "Innovation Company of the Year" by Engineers Ireland at their annual Innovation Awards. Recently (March 2008) the company signed an agreement with Swedish utility Vatenfall to jointly accelerate the design of a full-scale unit.

WORKING PRINCIPLE

Wavebob is a floating, axi-symmetric, point absorber, which converts wave energy in one degree-of-freedom (heave). The relative motion between the floating structure and an inner mass is at the core of the energy conversion process. No details regarding the power take-off approach have been disclosed, although initial drawings point towards high pressure oil hydraulics.

KEY MILESTONES

- Deployment of a prototype (1:4) at the Marine Institute site (Ireland)
- Partnership with Chevron and Vatenfall (Swedish utility)

Wavegen

COMPANY INFORMATION

Company Name:	**Wavegen**
Website:	**www.wavegen.co.uk**
Device:	**LIMPET (Land Installed Marine Power Energy Transmitter)**
Device Type:	**Oscillating Water Column (onshore)**

HISTORY

Initially named Applied Research & Technology Ltd, Wavegen has been developing wave energy projects since 1990. Key projects include the 75kW OWC pilot plant in Islay and the LIMPET (Land Installed Marine Power Energy Transmitter) initially rated at 500kW (subsequently the rating of the plant was halved when it became clear that the pneumatic power capture of the plant had been overestimated at the design stage). In 2005 Wavegen was acquired by Voith Siemens Hydro (Germany). More recent projects include a 300kW OWC plant in a breakwater in Northern Spain, commissioned by Basque Energy Board, Ente Vasco de Energia (EVE), and another breakwater project with npower Renewables off Lewis (Scotland).

WORKING PRINCIPLE

The principle of operation is similar to other OWCs designed for shoreline: incoming waves pressurise and rarefy the water column in the chamber and air is forced to pass through a turbine. Different types of turbines and different turbine configurations have been tested.

KEY MILESTONES

- Track record at LIMPET
- Acquisition by Voith Siemens Hydro
- Projects with EVE (Mutriku) and npower (Siadar)

Wave Energy Centre (Pico OWC)

COMPANY INFORMATION

Company Name:	**Wave Energy Centre**
Website:	**www.pico-owc.net**
Device:	**Pico OWC**
Device Type:	**Oscillating Water Column (onshore)**

HISTORY

The Wave Energy Centre (WavEC) is a non-profit organization founded in 2003 which promotes wave energy in Portugal. It has several members, including EDP (the main utility in Portugal) and EDA, its subsidiary in the Azores islands. The Pico OWC plant, also known as the European Pilot Plant, was built in 1998 with EU funding but due to several construction and operational issues it barely operated until 2004. It then underwent a major refurbishment programme sponsored by the Portuguese government and has since been in regular trials (short periods), delivering power (intermittently) to the Azorean grid.

WORKING PRINCIPLE

The principle of operation is similar to other OWCs designed for shoreline: incoming waves pressurise and rarefy the water column in the chamber and air is forced to pass through a turbine. Different types of turbines and different turbine configurations have been tested.

KEY MILESTONES

- Plant construction – first European pilot plant
- Refurbishment programme sponsored by a DEMTEC grant (Portuguese government)

4 FINAL REMARKS

GH has conducted a two phase high-level review of the wave energy technology developers which included:

- Phase 1: Overview of the Existing Technologies
- Phase 2: Description of the Shortlisted Technologies

As listed in Section 2 (Table 2.2) a significant percentage of the 22 shortlisted concepts have reached the sea trials phase (68.18%). The 15 developers in this category are:

- Aquamarine Power;
- AW-Energy;
- AWS Ocean Energy (in the AWS Mk I version);
- CETO;
- Columbia Power Technologies;
- Fred Olsen Renewables;
- Ocean Energy;
- Oceanlinx;
- Ocean Power Technologies;
- Pelamis Wave Power;
- Seabased;
- Wavebob;
- Wave Dragon;
- Wavegen;
- Wave Energy Centre – Pico OWC.

This percentage is reduced to 27.27% if limited to device developers who have reached the full-scale stage (with grid connected tests). The six technology developers in this category include (note that Wave Dragon was also grid connected but was tested at 1:4.5 scale):

- AWS Ocean Energy (in the AWS Mk I version);
- Oceanlinx;
- Ocean Power Technologies (in several rated versions);
- Pelamis Wave Power;
- Wavegen;
- Wave Energy Centre – Pico OWC.

This report provides OWET with an overview of the status of wave energy technology and acts as a good introduction to the sector for OWET partners and others entering this area.

Other aspects that influence the technology as well as the origin (nationality) of the technology developers are related to the market incentives. The key markets for wave energy that the measures implemented in such locations will be reviewed in GH report 40721/AR/03.

APPENDIX A – WAVE ENERGY TECHNOLOGY DEVELOPERS LISTED IN GH DEVELOPER DATABASE (V1.2)

Company	Device / Concept	Country
Applied Technologies Company Ltd	Float Wave Electric Power Station (FWEPS)	Russia
Aquamarine Power Ltd	Oyster	UK
Arlas Invest SL	TUVALU	Spain
Avrid Nesheim		Norway
AW-Energy Oy	WaveRoller	Finland
AWS Ocean Energy Ltd	AWS	UK
BioPower Systems Pty. Ltd	bioWAVE	Australia
Brandl Motor	Brandl	Germany
Carnegie Corporation Ltd	CETO	Australia
Checkmate Group	Anaconda	UK
College of the North Atlantic	SARAHS Pump	Canada
Columbia Power Technologies LLC	SeaBeav I	USA
C-Wave Ltd	C-Wave	UK
DAEDALUS Informatics Ltd	Wave Energy Conversion Activator (WECA)	Greece
DEXA Wave Energy Ltd	DEXA	Denmark
Ecofys BV	Wave Rotor	The Netherlands
Ecole Centrale de Nantes	SEAREV	France
Embley Energy Ltd	SPERBOY	UK
Engineering Business Ltd	EB Frond	UK
Finavera Renewables	AquaBuOY	Canada
Float Incorporated	PSP (Pneumatic Stabilised Platform)	USA
Floating Power Plant ApS	Poseidon's Organ	Denmark
Fred Olsen Renewables	Buldra	Norway
Green Energy Ocean	Ocean / Wave Treader	UK
Hidroflot SL	Hidroflot	Spain
Hydam Technology	McCabe Wave Pump	Ireland
Hyper Drive Co	EPAM WPGS	Japan
Independent Natural Resources Inc.	SEADOG	USA
JAMSTEC	Mighty Whale / KAIMEI	Japan
Joules Energy Efficiency Services Ltd	TETRON	UK
Kinetic Wave Power	PowerGin	USA
Lancaster University	PS FROG	UK

Langlee Wave Power	WaterWing	Norway
LEANCON Wave Energy Ltd	LEANCON	Denmark
Marine Energy Generation Ltd (MEG) (Tidal Hydraulic Generators and Peter brotherhood)	HydroAir	UK
MARTIFER Energy Systems SA	FLOW	Portugal
Motor Wave Group	Motor Wave	China
Neptune Renewable Energy	Triton	UK
Ocean Energy Ltd	OE Buoy	Ireland
Oceanlinx Ltd	Oceanlinx OWC	Australia
Ocean Motion International	OMI WavePump	USA
Ocean Navitas Ltd	Aegir Dynamo	UK
Ocean Power Technologies Inc	PowerBuoy	USA
Ocean Wavemaster Ltd	WaveMaster	UK
OCEANTEC Energias Marinas SL	-	Spain
Offshore Wave Energy Ltd	Grampus	UK
ORECon Ltd	MRC1000	UK
OSMEGS	OSMEGS (Ocean Swell Momentum Electricity Generation System) Ram	USA
OWEC	OWEC (Ocean Wave Energy Converter)	USA
Pelagic Power AS	-	Norway
Pelamis Wave Power Ltd	Pelamis	UK
Resolute Marine Energy Inc		USA
Scientific Applications & Research Associates Inc	MWEC (Magneto-hydrodynamic Wave Energy Conversion System)	USA
SDE Energy Ltd	SDE Buoy	Israel
Seabased AB	Seabased Point Absorber	Sweden
Seapower International AB	Floating Wave Power Vessel (FWPV)	Sweden
SeaVolt Technologies Ltd	Wave Rider	UK
SeWaveLtd	Wavegen OWC	Faroe Islands
Swell Fuel Inc	Level Operated Pivoting Float	USA
SyncWave Energy Inc.	SyncWave Power Resonator	Canada

Trident Energy Ltd	Trident Energy Converter	UK
The University of Manchester Intellectual Property Limited (UMIP)	Manchester Bobber	UK
Wave Dragon ApS	Wave Dragon	Denmark
Wavebob Ltd	Wavebob	Ireland
WAVEenergy AS	Seawave Slot-Cone Generator (SSG)	Norway
Wave Energy Centre*	Pico OWC	Portugal
Wave Energy Technologies Inc	WET EnGen	Canada
Wave Energy Technology	WET_NZ	New Zealand
Waveberg Development Ltd	Waveberg	USA
Wavegen (Voith Siemens Hydro Power Generation)	Limpet	UK
Wavemill Energy Corp.	Wavemill	USA
Waveplane Solutions	Waveplane	Denmark
Wave Star Energy	Wave Star	Denmark

*Non-profit organization that promotes wave energy