

INTEGRATION OF OCEAN ENERGY GENERATION PROJECTS

NORTHWEST WIND INTEGRATION FORUM

THERESE HAMPTON
JUSTIN KLURE

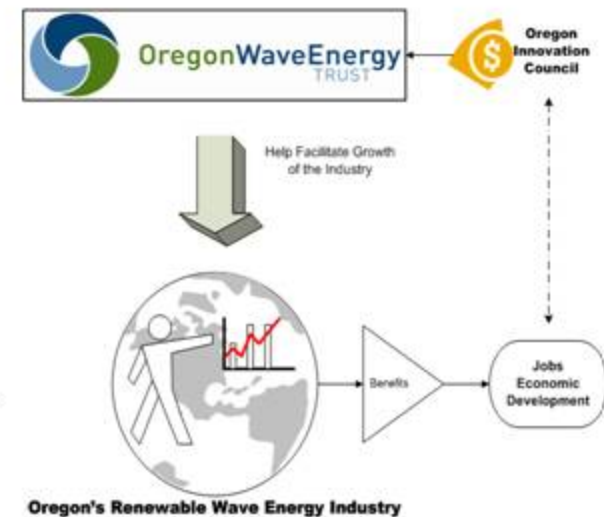


OCTOBER 29, 2009

OREGON WAVE ENERGY TRUST (OWET)

Mission and Scope: *To build and share the expertise needed to accelerate the development of the Wave Energy industry in a responsible manner*

- Environmental Assessment
- Community Outreach
- Economic Assessment
- Academic Partnerships
- Research and Development
- Regulatory Coordination
- Utility Markets



UMI PROGRAM OVERVIEW

1.0 Utility Engagement

Establish effective mechanisms to engage utility planners and industry to accelerate market growth.

2.0 Resource Potential

Provide concise, comprehensive information to utilities and industry on technology and resource.

3.0 Business Model

Create effective business protocols, determine 'value', identify incentives, and develop technical standards.

4.0 Grid Integration Tools

Develop technical tools for utility integration.

UMI PROGRAM OUTCOME: *Engaged and informed utility and industry partners armed with useful **tools** and **strategies** to successfully integrate wave energy into NW power grid.*

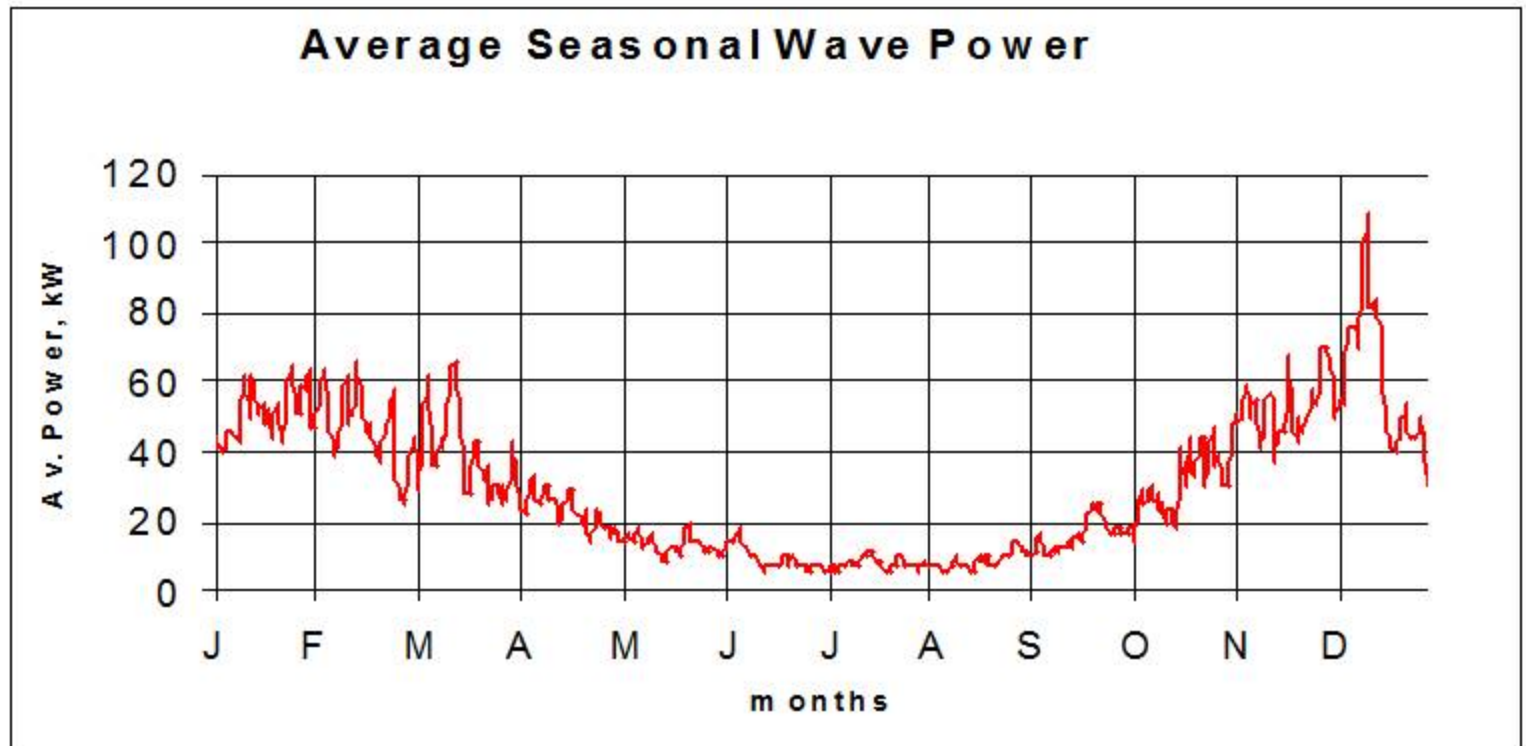
OPERATIONAL / TRANSMISSION ISSUES

Issues

- Limits of existing transmission and distribution infrastructure
- Interconnection Issues - power quality, reliable supply, safety
- Forced outages
- Resource profile
 - ✓ Integrating into existing resource portfolio
 - ✓ Within hour variability
 - ✓ Hour to hour
- Forecasting/Predictability

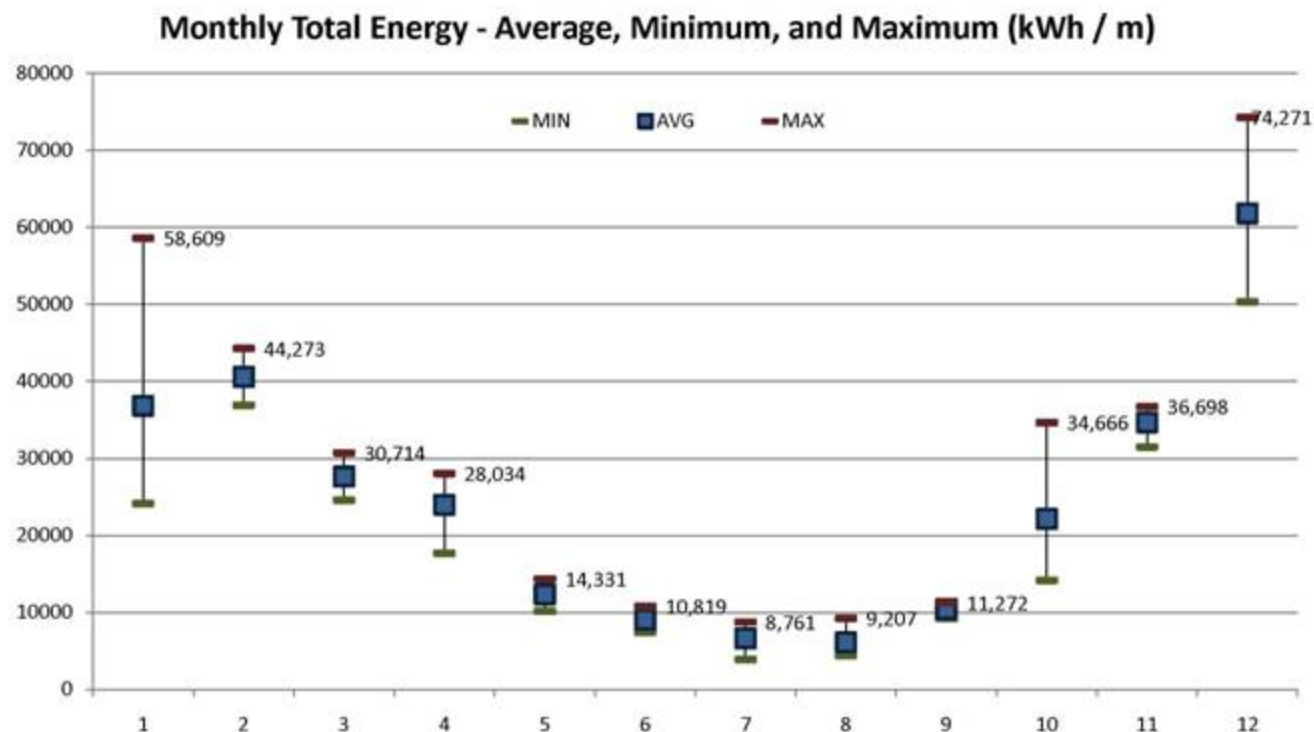


RESOURCE PROFILE (ANNUAL)



Annual average wave energy flux per unit width of wave crest (kilowatts per meter crest length)

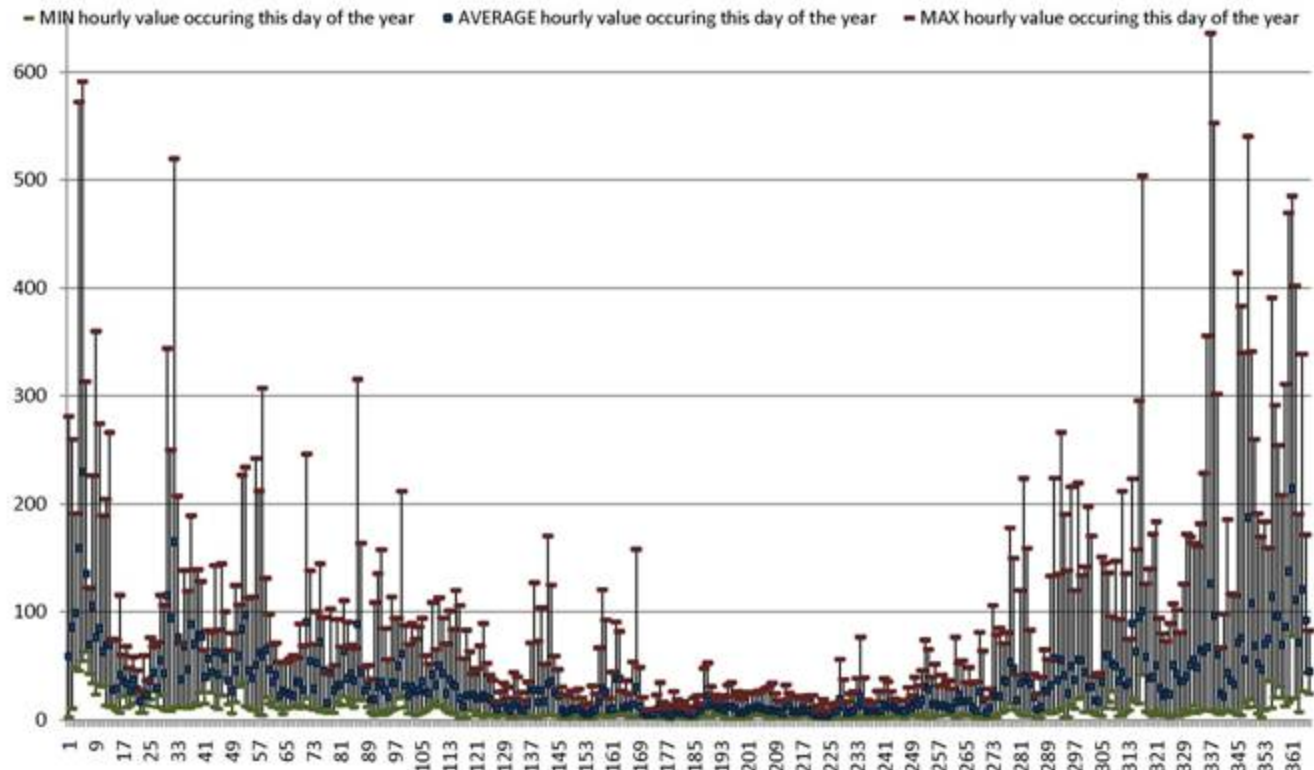
RESOURCE PROFILE (MONTHLY)



This graph displays the range of total resource energy per month throughout the dataset. Note that for some months we only have two years' worth of good data, so the actual range may be greater over a longer period. One issue to note in comparison to the previous graph (Hourly Power Variability by Month) is that while the power available during any given hour in an April month may vary significantly (from about 2 kW/m to 200 kW/m), over the course of the entire month the resulting total energy available is much more predictable for planning purposes (17.5 MWh/m to 20 MWh/m).

RESOURCE PROFILE (DAILY)

Hourly Power Variability by Day of Year (kW / m)

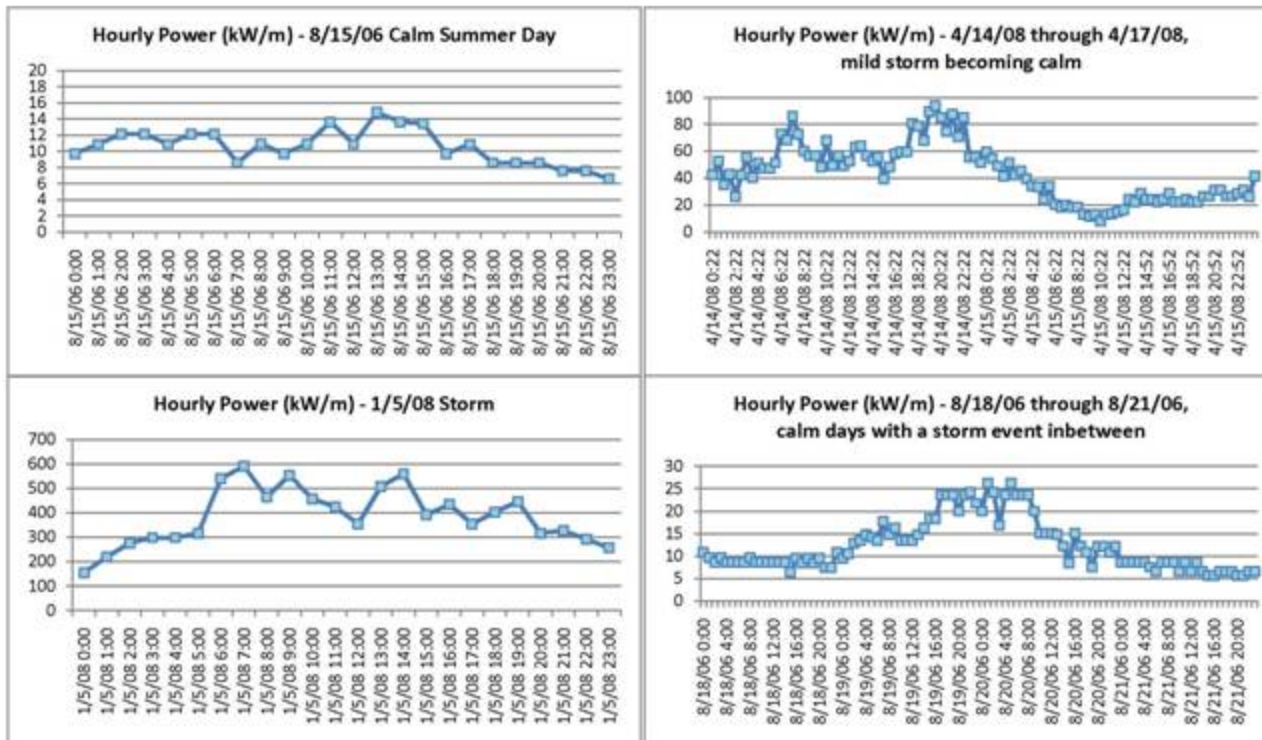


This graph demonstrates the hourly power variability from day-to-day. For example, given all "January Firsts" in the dataset, the hourly values ranged anywhere from 2kW/m to 280 kW/m, with an average of 59 kW/m. The winter days show the greatest variability, as they can range from very calm to extreme storms.

RESOURCE PROFILE (HOURLY)

Daily Scenarios

Here are a few selected days pulled out from the dataset to show the difference in variability, and the range from calm to severe weather events.



FORECASTING

Current Approach

- Wave Watch III – Existing forecast tool used by NOAA to predict storms and manage large vessel activity.
- Provides forecasts for same day and 1, 2, and 3 days out.

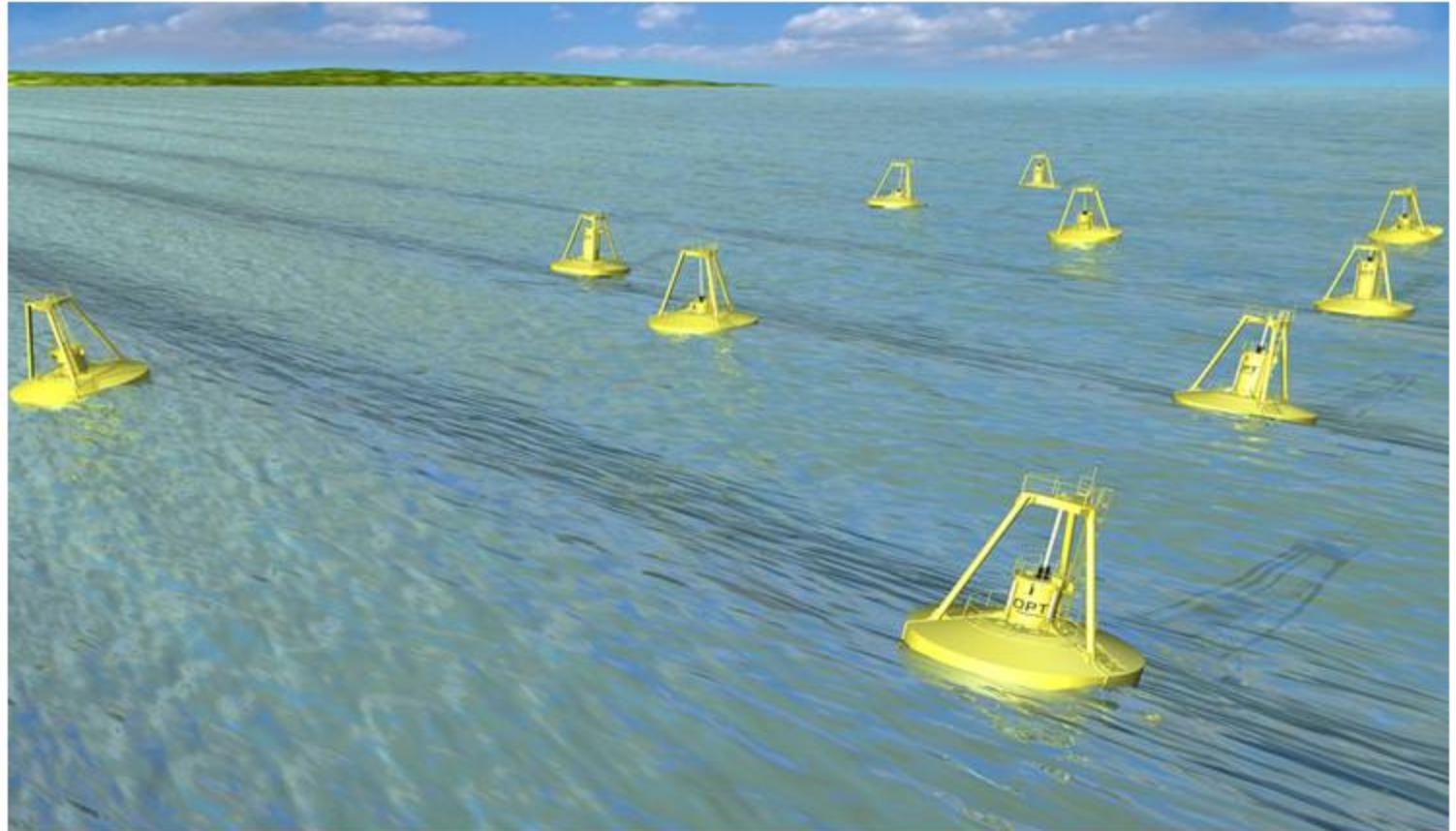
Recent Evaluation

- EPRI conducted an assessment of the forecast accuracy to assess the appropriateness of the tool for wave energy.
- Deemed to be a highly valuable tool especially if enhancements are made.

Next Steps

- 1) Continued evaluation of Wave Watch III over longer time horizons and at multiple locations.
- 2) Include advanced predictive techniques – regression analysis and neural nets.
- 3) Enhance the frequency of forecasts.
- 4) Evaluate forecast error as it relates to wave energy conversion technology.

QUESTIONS?



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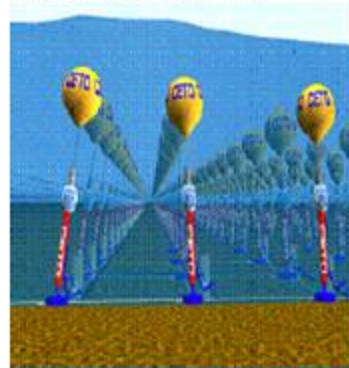
Supplemental Slides on Wave Energy Technologies and Companies

WAVE ENERGY TECHNOLOGIES

Point Absorber



Pressurized
Seawater



Oscillating Water Column



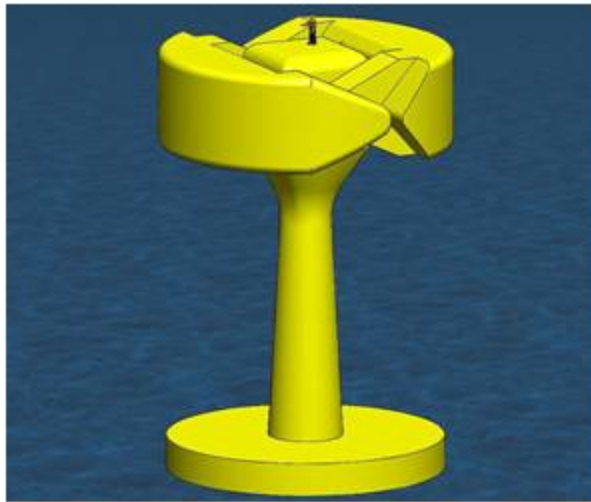
Attenuator



Overtopping



COLUMBIA POWER LLC



Principle of Operation:
Magnetic Direct Drive

Specifications:
Rated Capacity 250 kW - 1 MW
Deployment Depth >50 m

Development Milestones:
2007: Ocean deployment of heave only prototype
2009: Wave tank tests
2009: Preliminary full scale testing

Company Profile:
Founded in 2005
> \$3 million invested to date
7 employees



PELAMIS WAVE POWER



Principle of Operation:
Attenuator

Specifications:
Rated Capacity 750 kW
Length: 150 m Diameter: 3.5 m
Nominally 50 m Depth

Development Milestones:

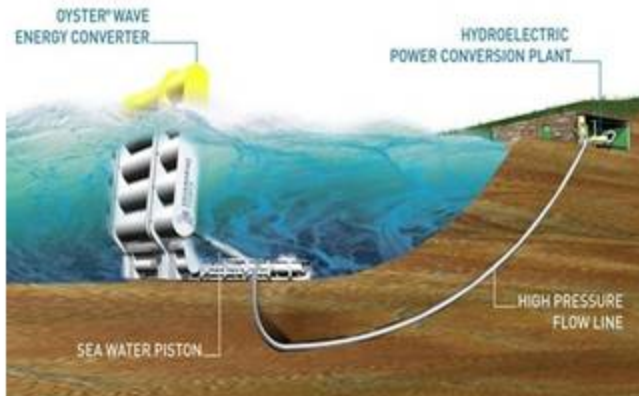
2004: Full scale deployment (EMEC)
2005: Received order for devices
2009: 3 units installed producing
power to Portuguese power grid

Company Profile:

Founded in 1998
\$70 million invested to date
75 employees



AQUAMARINE POWER



Principle of Operation:
Pressurized Hydro

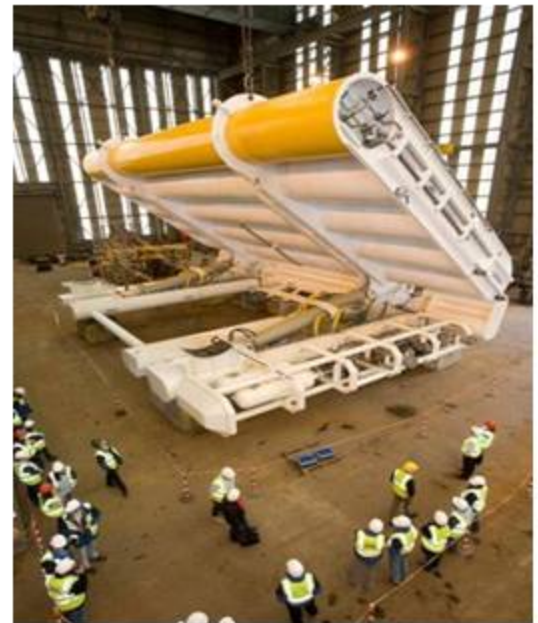
Specifications:
Rated Capacity 300-600 kW
Minimum Deployment Depth: 10 m

Development Milestones:

2003: Subscale testing
2009: Announces 1000 MW of site development w/ Airtricity
2009: Plans for full scale deployment

Company Profile:

Founded in 2005
> 10 employees



BIOPOWER SYSTEMS (BIOWAVE)

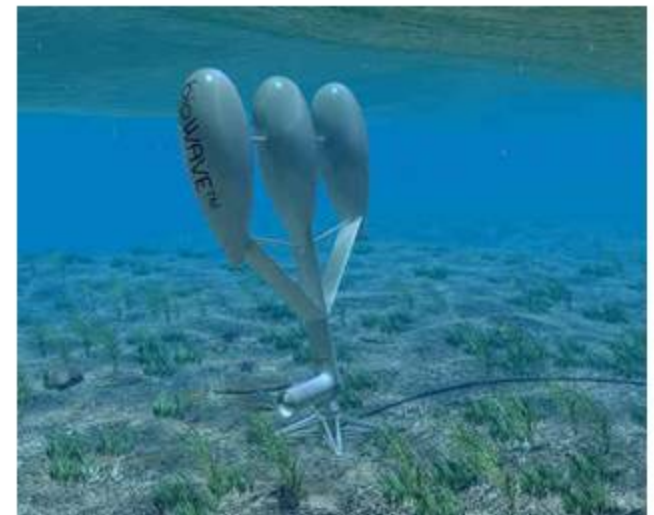


Principle of Operation:
Oscillating Flow Field

Specifications:
Rated Capacity 250 kW
Deployment Depth: 25-30 m

Development Milestones:
2008: Signed MOU to test and demonstrated in Tasmania
2008: Raised \$6 million

Company Profile:
Founded in 2006
\$7.2 million invested to date
11 employees



OCEANLINX



Principle of Operation:
Oscillating Water Column

Specifications:
Rated Capacity 500 kW
Deployment Depth: 10 m

Development Milestones:
2005: Installation of 500 kW
prototype
2009: New prototype in
development

Company Profile:
Founded in 1997
\$50 million invested to date
25 employees



OCEAN POWER TECHNOLOGIES



Principle of Operation:
Point Absorber

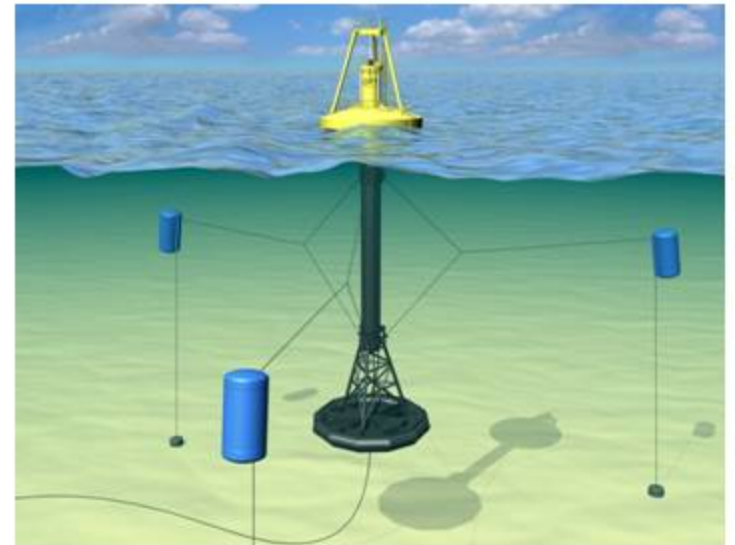
Specifications:
Rated Capacity 150 - 500 kW
Deployment Depth: 50 m

Development Milestones:

2007: 1st PPA issued by FERC in Oregon
2007: \$100 M IPO (Nasdaq)
2009: FERC license application

Company Profile:

Founded in 1994
Worlds 1st publically traded Co
50 employees



WAVEBOB LTD



Principle of Operation:
Point Absorber

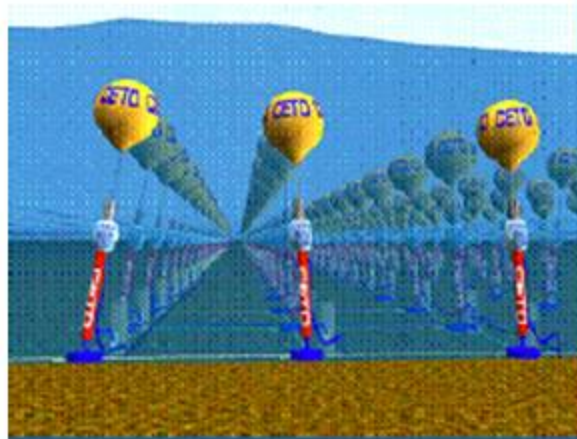
Specifications:
Rated Capacity > 1 MW
Deployment Depth: N/A

Development Milestones:
2006: Prototype sea trials
2009: Commercial testing
planned

Company Profile:
Founded in 1997



CETO (RENEWABLE ENERGY HOLDINGS)



Principle of Operation:
Pressurized Seawater

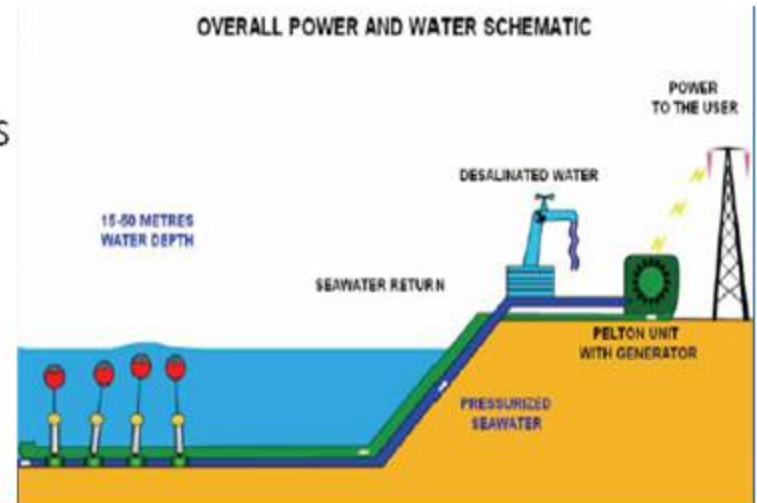
Specifications:
Rated Capacity 180 kW
Deployment Depth: 15 -100 m

Development Milestones:

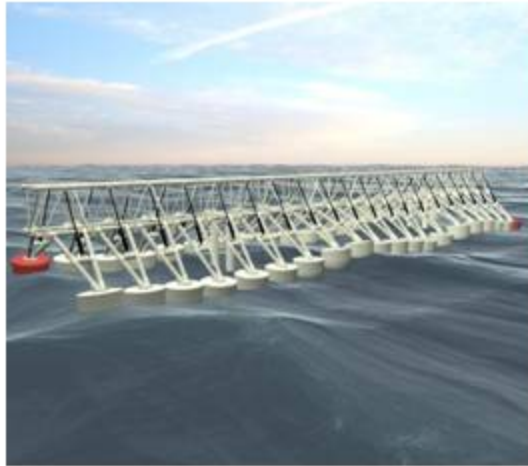
2006: 1 year of testing
2008: Pre commercial sea trials
2009: Commercial launch of CETO

Company Profile:

Founded in 2004
\$5 million invested to date
9 employees



WAVE STAR ENERGY



Principle of Operation:
Point Absorber

Specifications:
Rated Capacity 6 MW
Deployment Depth: 15 m

Development Milestones:

2008/9: Section of 500kW to be deployed in North Sea
2009: Half scale model planned for deployment

Company Profile:

Founded in 2003
\$15 million invested to date
14 employees



HIDROFLOT



Principle of Operation:
Point Absorber

Specifications:
Rated Capacity 6 MW
Deployment Depth: 60 – 100 m

Development Milestones:

2007: Design, construction and testing

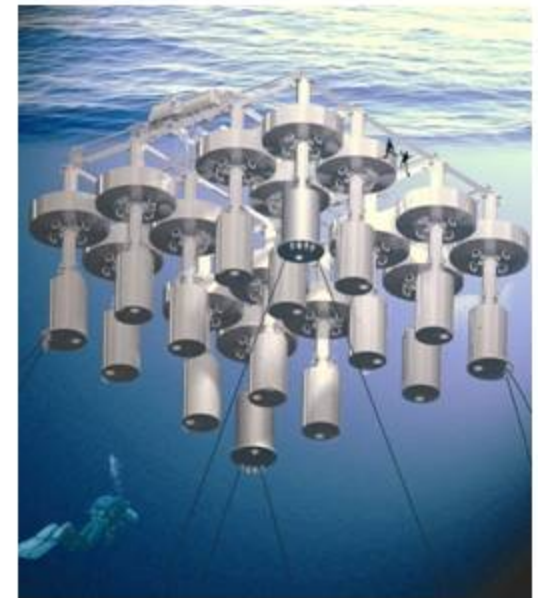
2009: Begin building of full scale prototype

Company Profile:

Founded in 2005

\$2 million invested to date

14 companies involved



WAVEGEN



Principle of Operation:
Oscillating Water Column

Specifications:
Rated Capacity 300 kW
Deployment Depth: Shore based

Development Milestones:
2000: Grid connected test facility
2009: Begin building of full scale prototype

Company Profile:
Founded in 1990
Voith Hydro Company
14 companies involved



WORLD'S FIRST WAVE FARM

