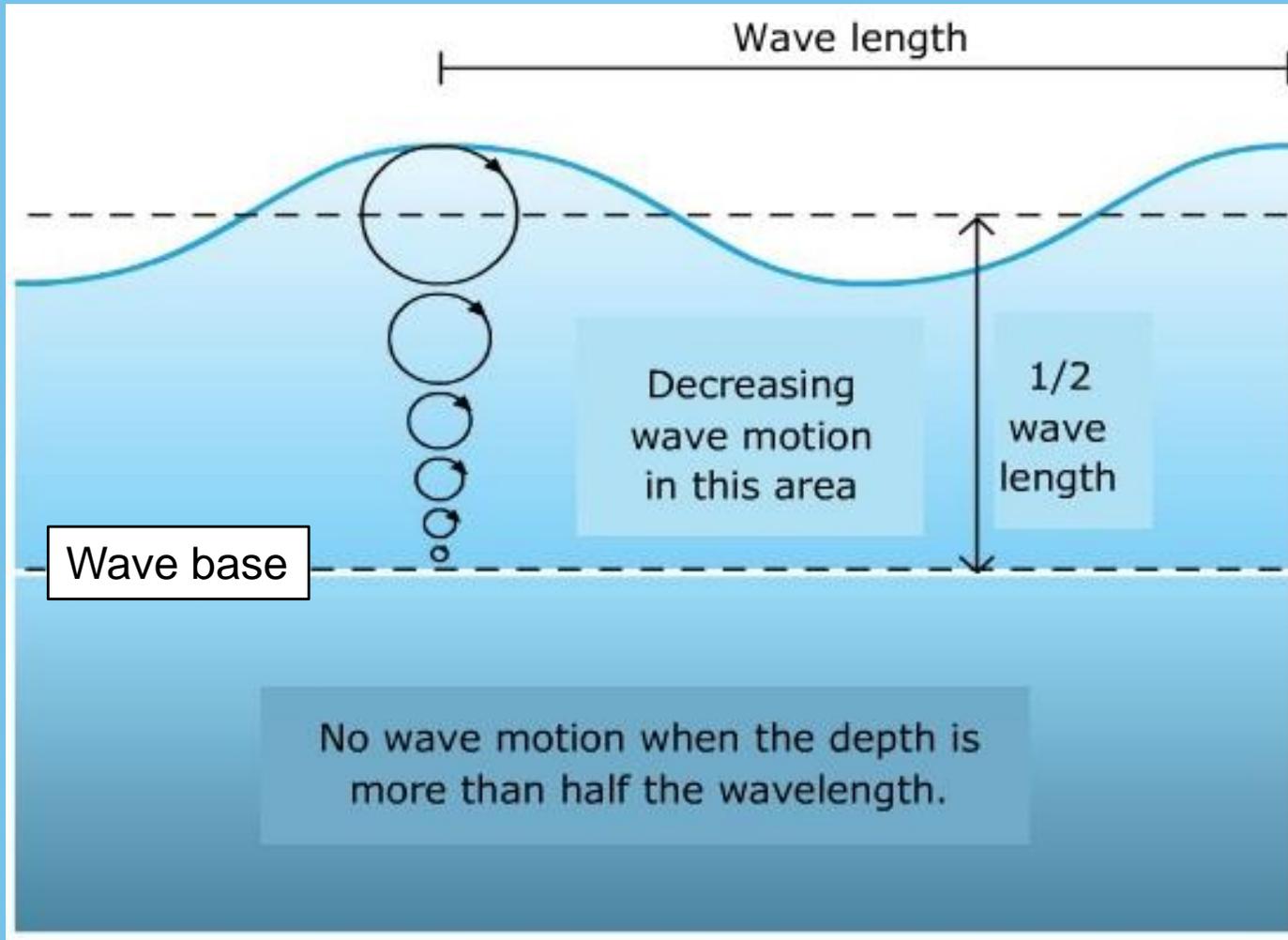


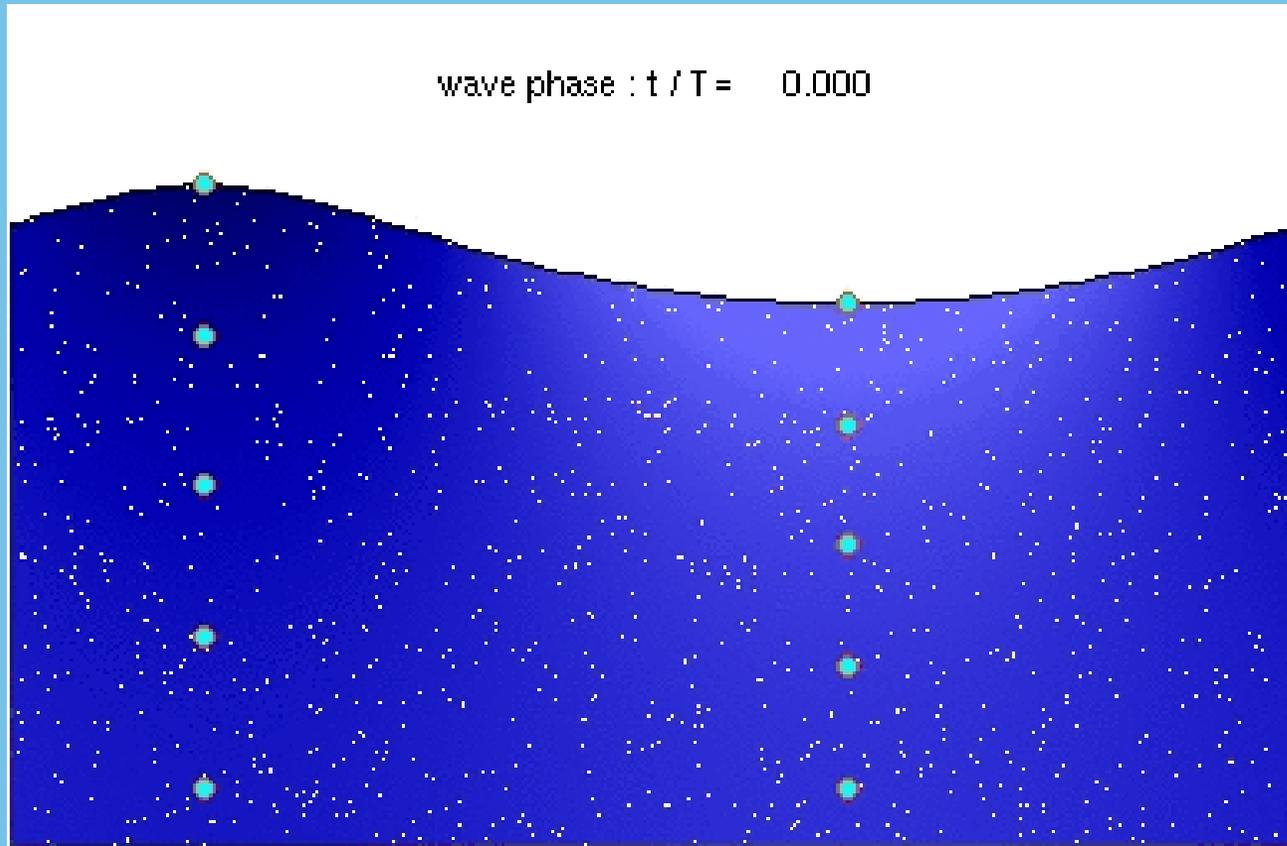
Wave Energy

A global overview

Inge Bakke, Wavenco AS



Waves and Water Dynamics



From Wikipedia

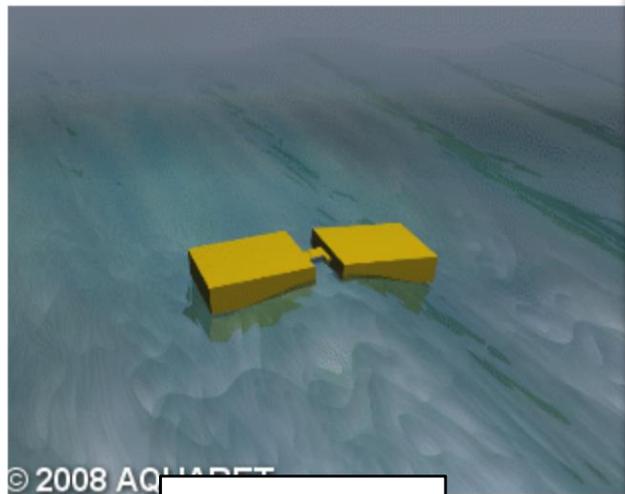
Waves and Water Dynamics



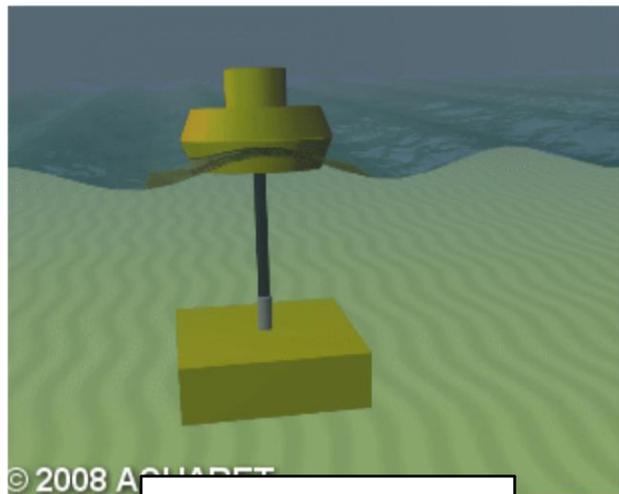
From Wikipedia

Waves and Water Dynamics

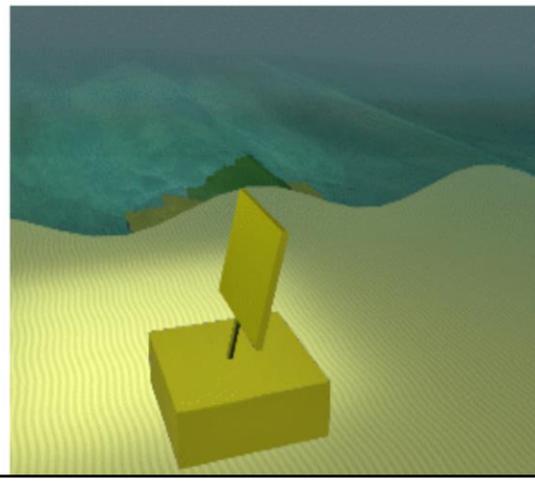
Wave Conversion Principles



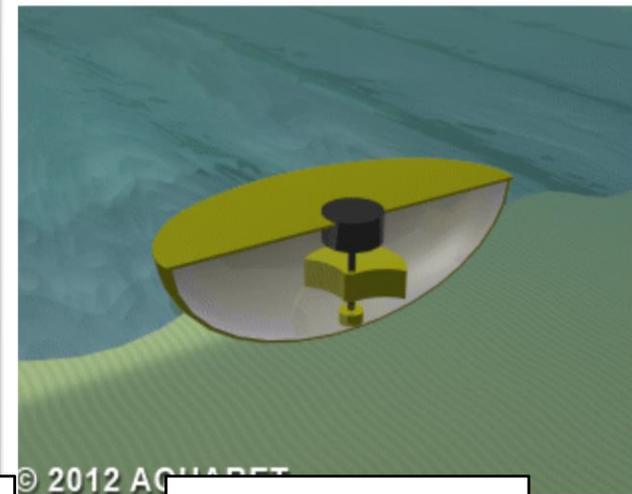
Attenuator



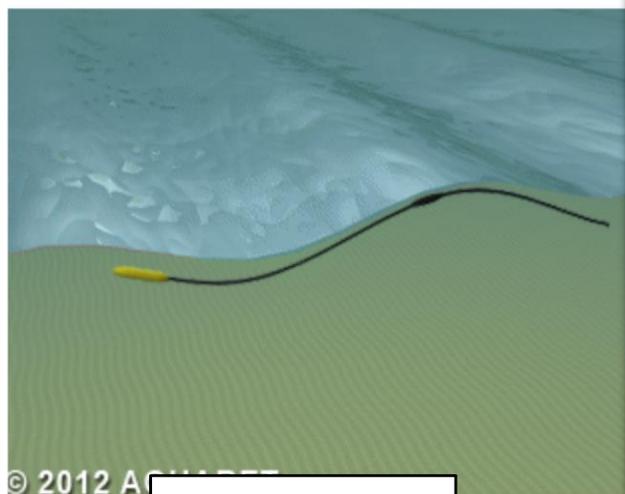
Point Absorber



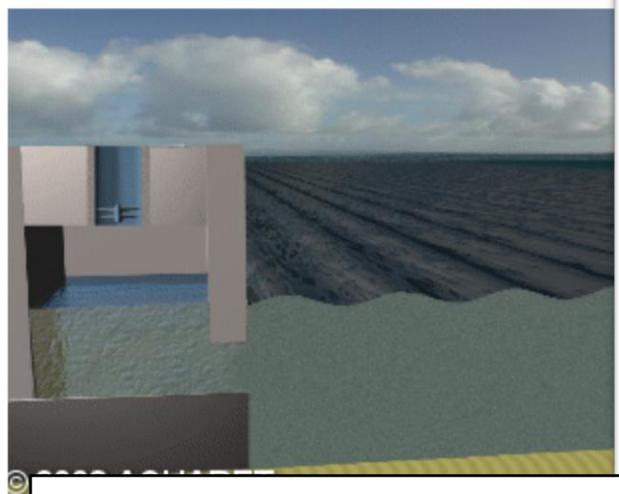
Oscillating Wave Surge



Rotating Mass



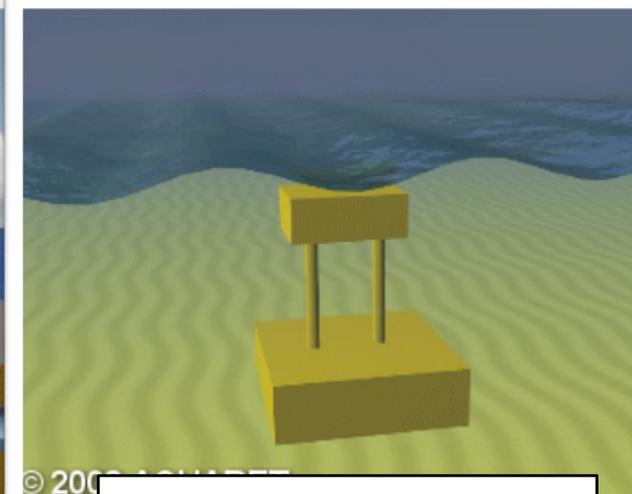
Bulge Wave



Oscillating Water Column

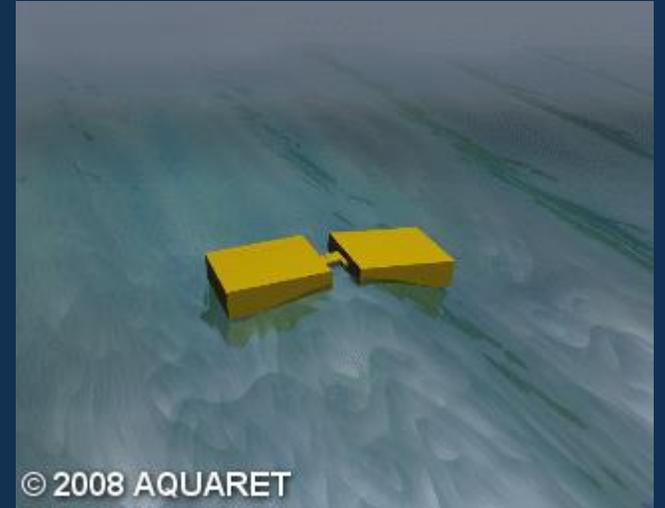


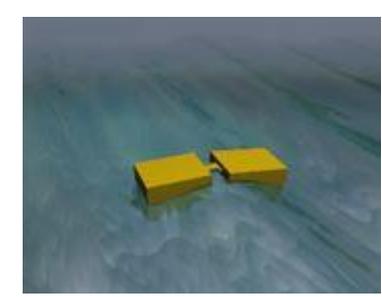
Overtopping



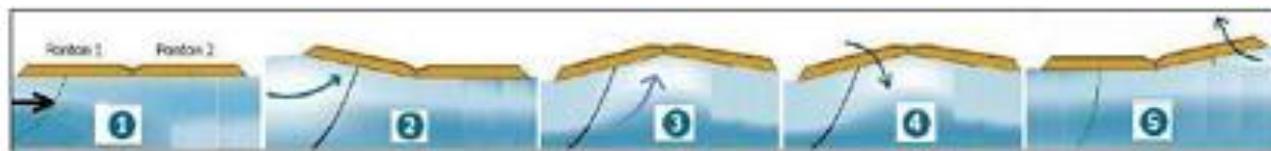
Submerged Pressure
Differential

Attenuator





Crestwing, Denmark



1 + 2: Den indkomne bølge aktiverer PTO-systemet

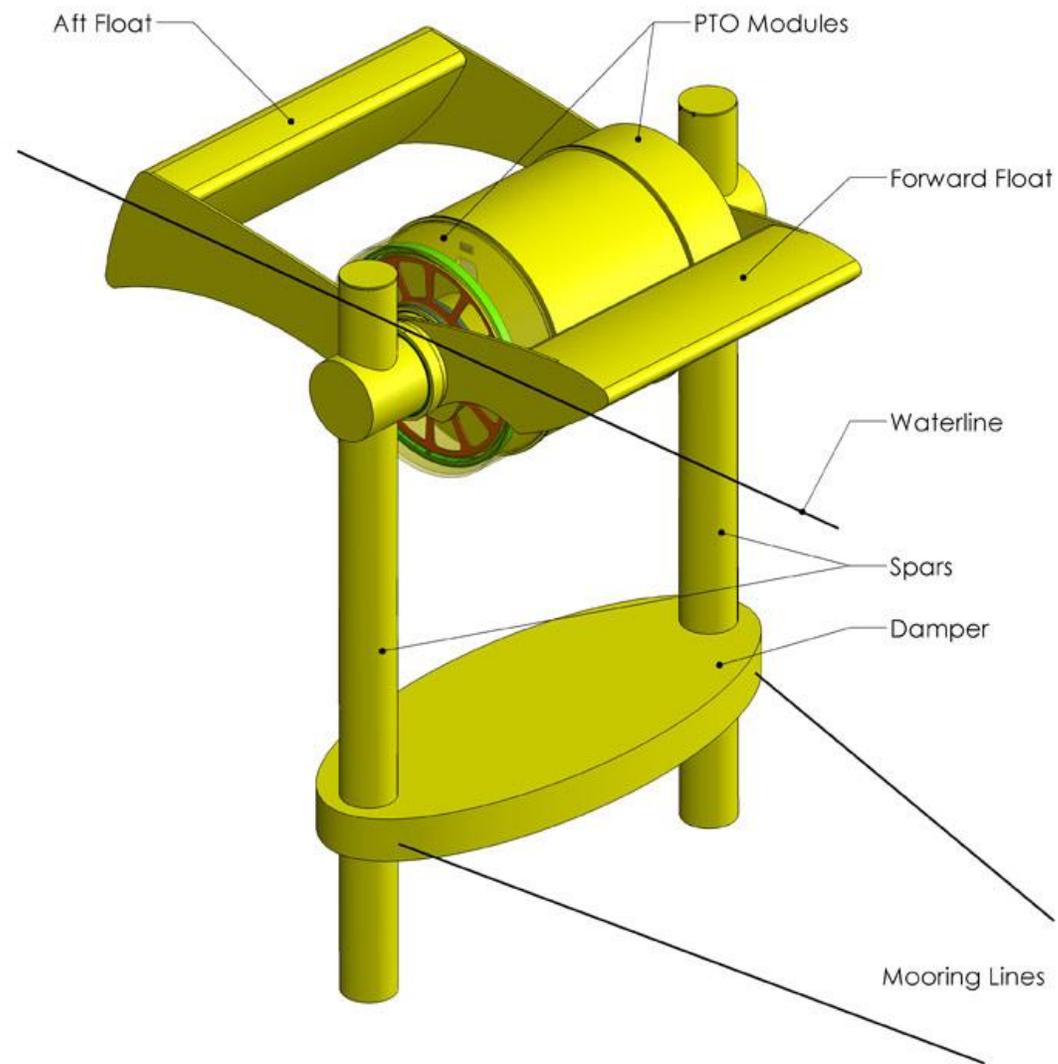
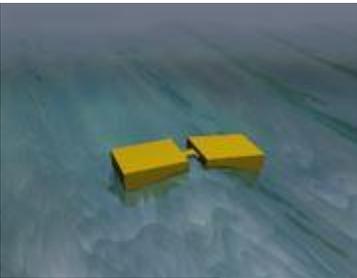
3: PTO i friløb

4: Hovedslaget af PTP

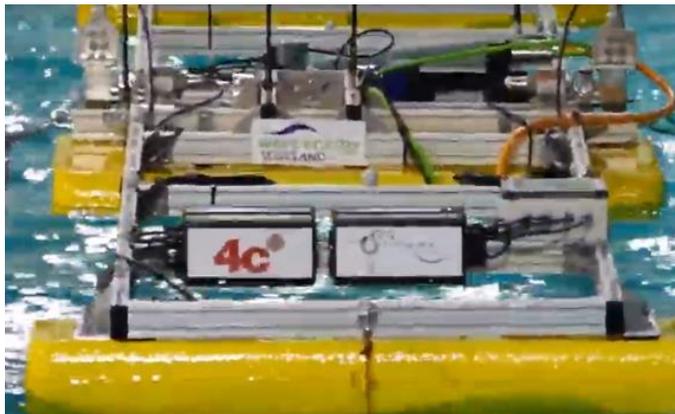
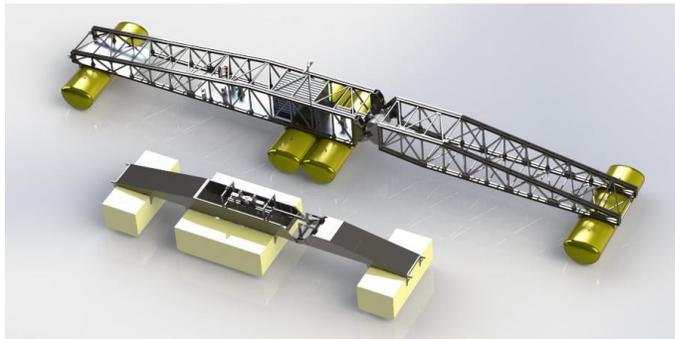
5: Afslutning aktiverer PTO

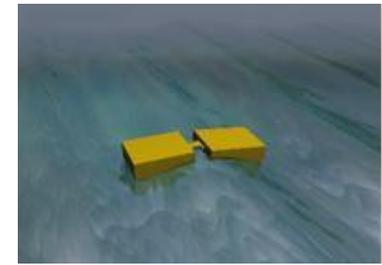


Columbia Power Technologies, Inc, USA



4c Engineering, UK (England)

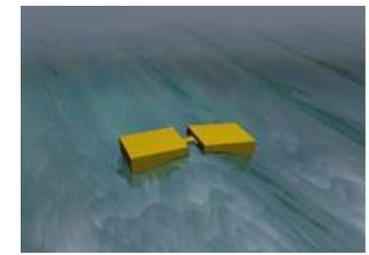




Sea Wave Energy, UK (England)



Cyprus, July 2016



Pelamis Wave Power, UK (Scotland)

1998-2014



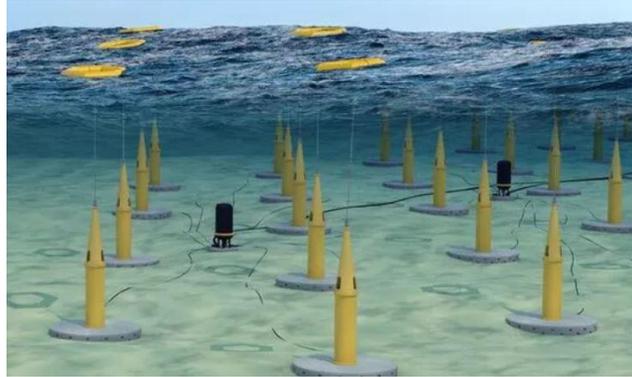
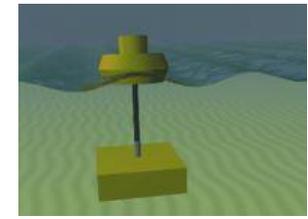
Hailong 1

China Shipbuilding Industry Corporation,
China

Point Absorbers



Seabased, Sweden



LATEST NEWS

Seabased to bring wave energy to the Caribbean

Seabased to set up production facility in Norway

Seabased teams up for pilot project in Canary islands

Seabased in Forbes: World-Leading Wave Park Startup Crowdfunds

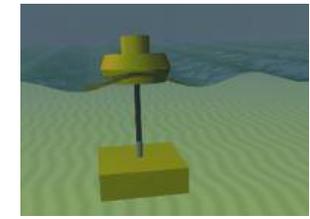
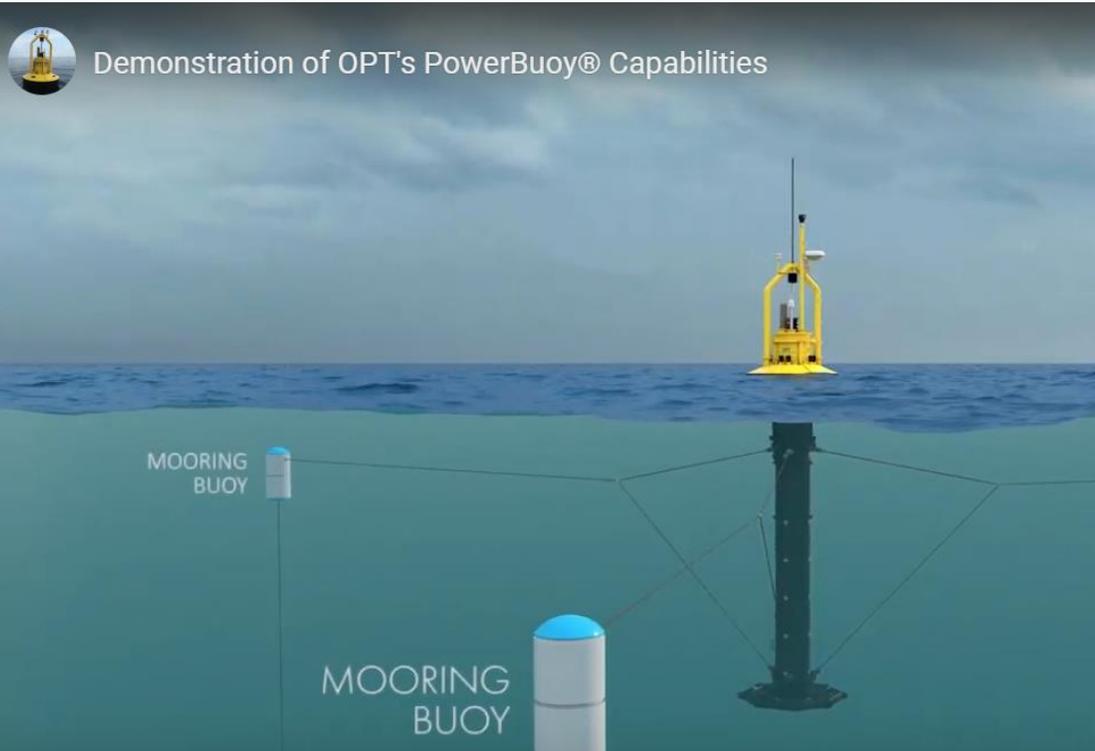
Seabased Rides Sri Lanka Wave

Interview: Seabased rides the crest of a wave for people, planet & profit

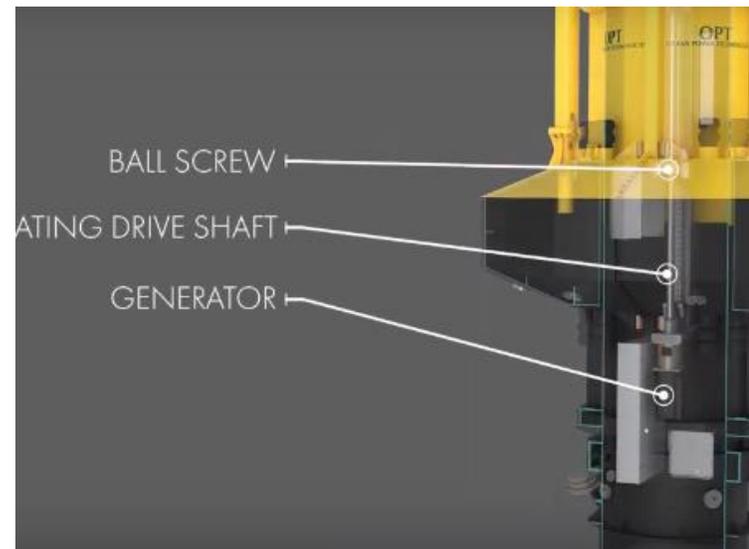


Seabased is proud to receive co-funding from phase 1 of the **Horizon 2020 SME Instrument programme** of the European Union under grant agreement No. 826910



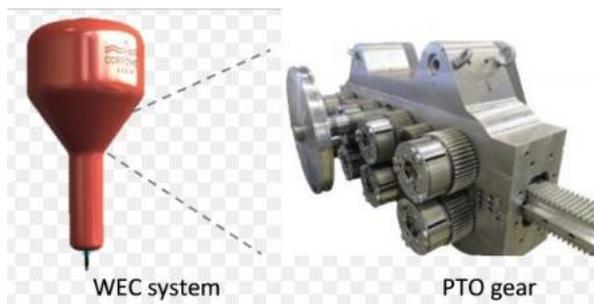


Ocean Power Technologies, USA

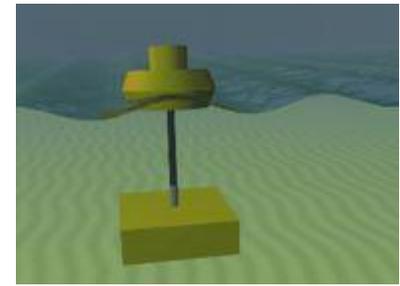




CorPower Ocean, Sweden



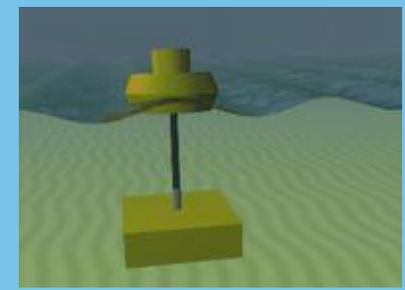
Eco Wave Power, Sweden



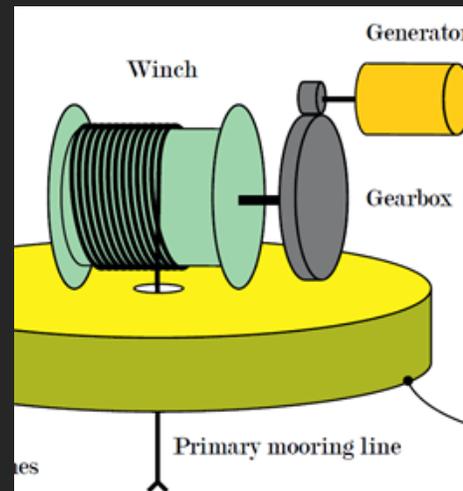
ENERGY RE-INVENTED

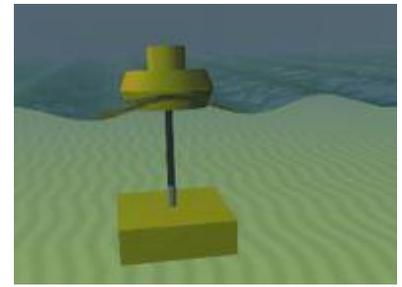
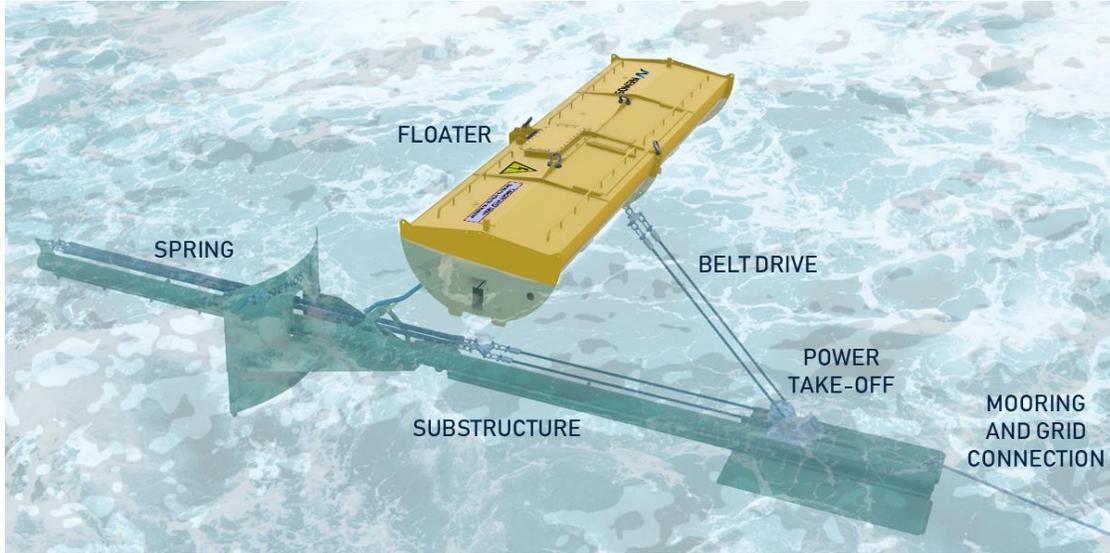


BOLT Lifesaver at US Navy test site, Hawaii
2016 - 2019



Bolt Lifesaver, Norway

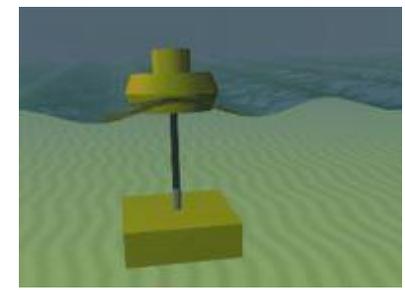


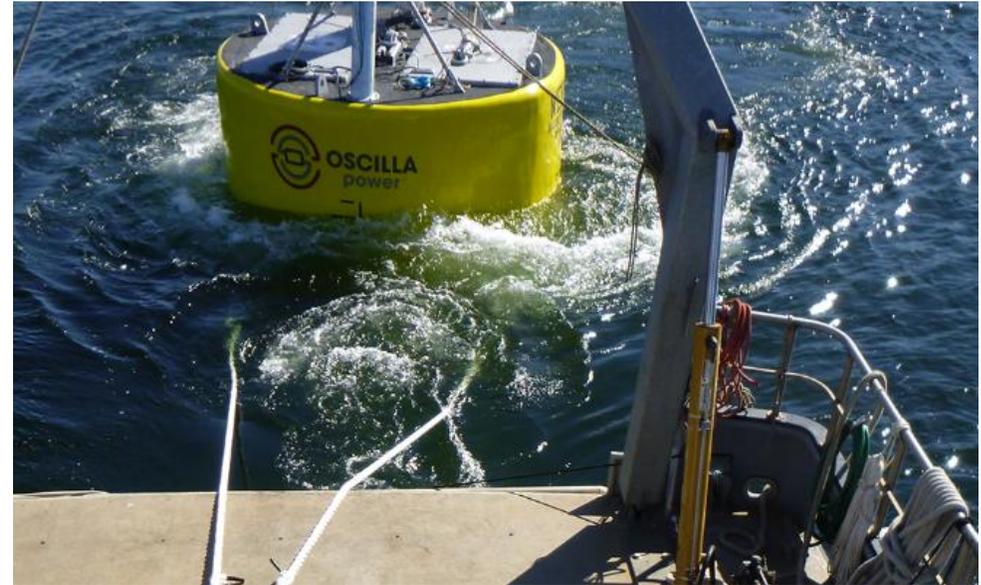
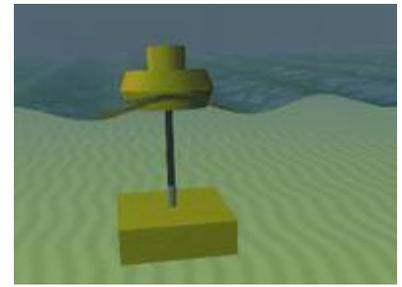
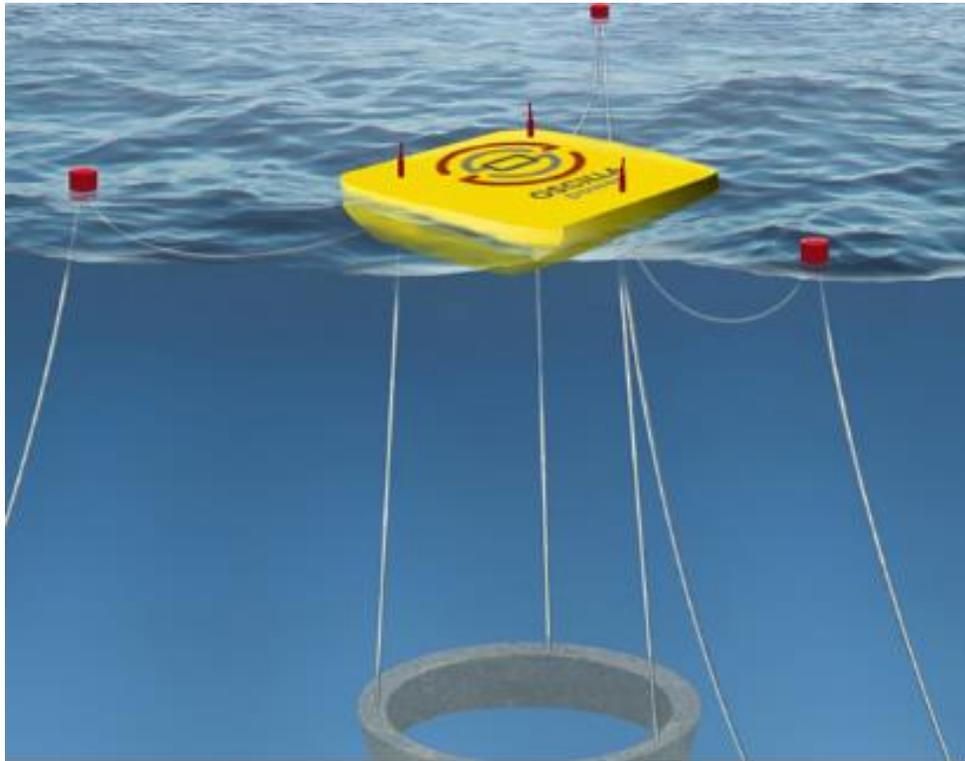


NEMOS, Germany



Northwest Energy Innovation, USA





Oscilla Power, USA

Wavestar, Denmark





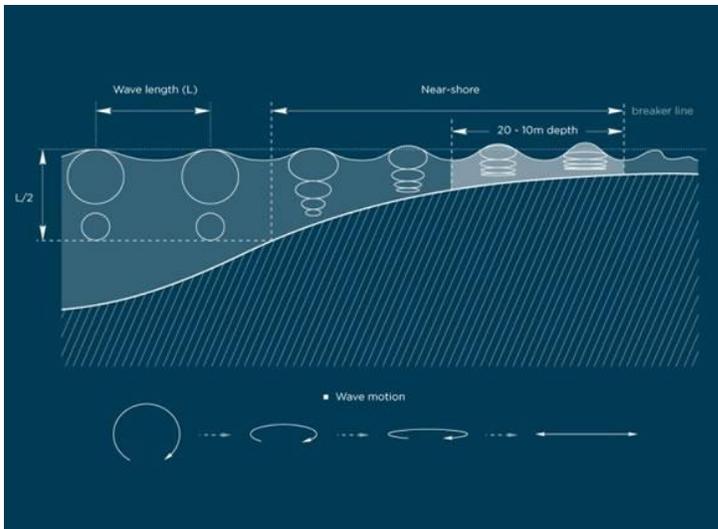
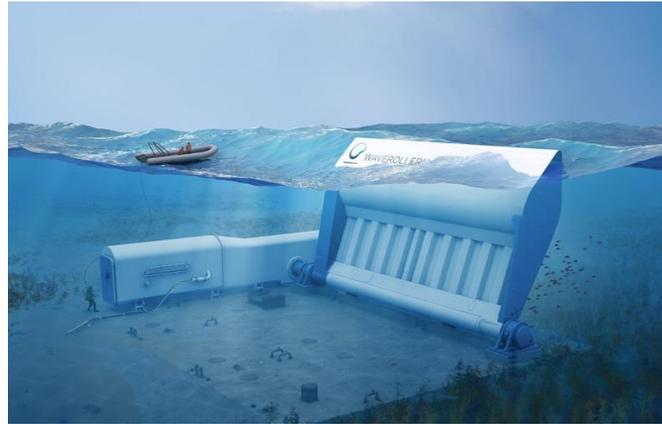
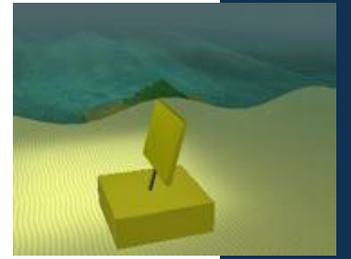
Wavebob, Ireland

1999-2013

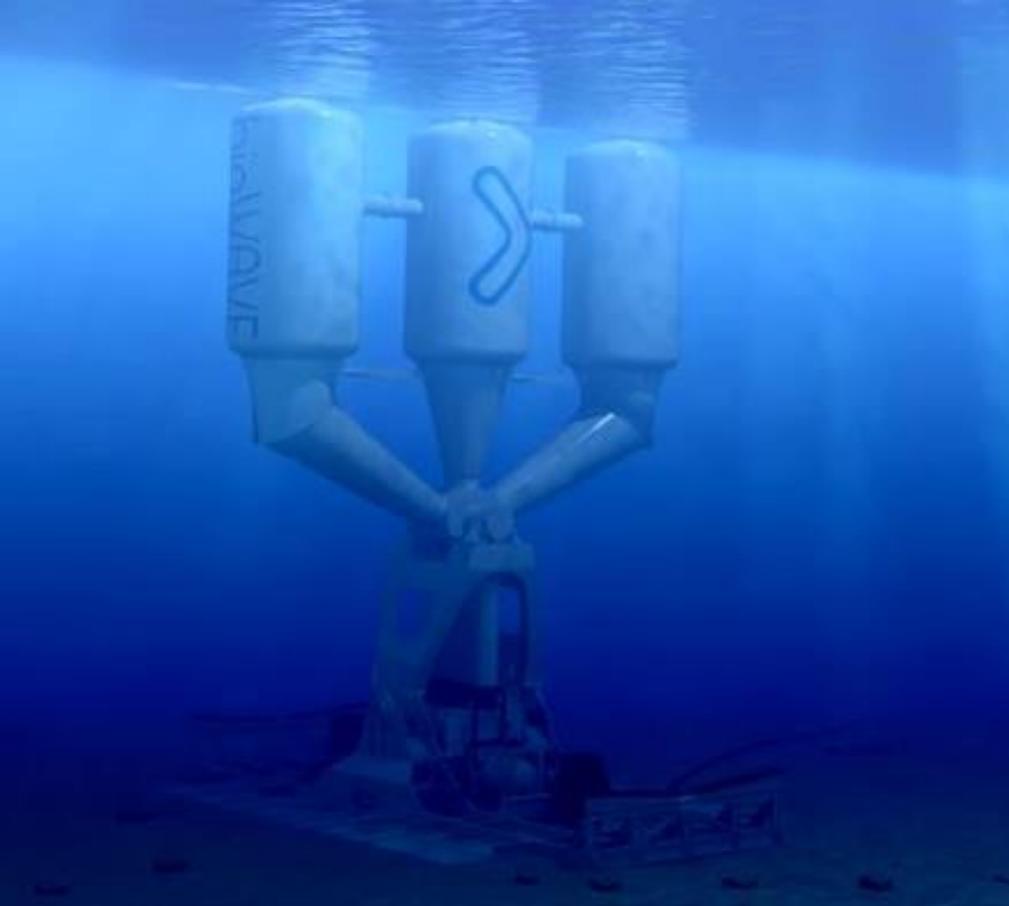
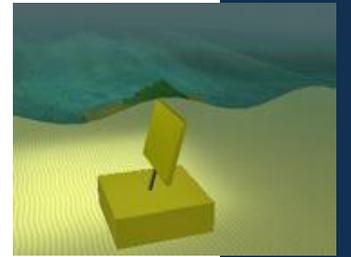
Oscillating Wave Surge



AW-Energy, Finland (Waveroller)



BioPower Systems, Australia



1

Wave motions cause the pivoting structure to sway back-and-forth like a pendulum.

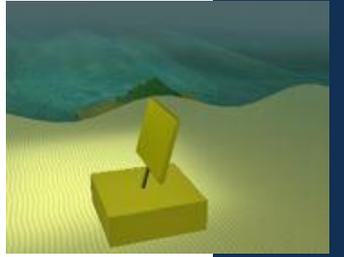
2

The pivoting structure drives **two hydraulic cylinders**, which deliver high-pressure fluid to the **O-Drive**.

3

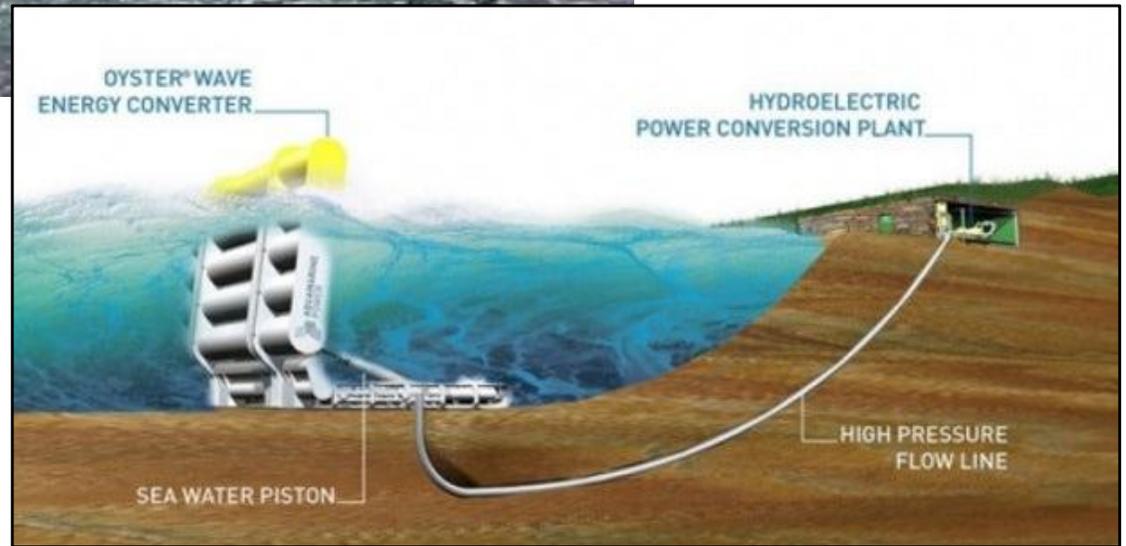
The O-Drive converts the energy in the high-pressure fluid into smooth AC electricity, and power is delivered to shore by cable.

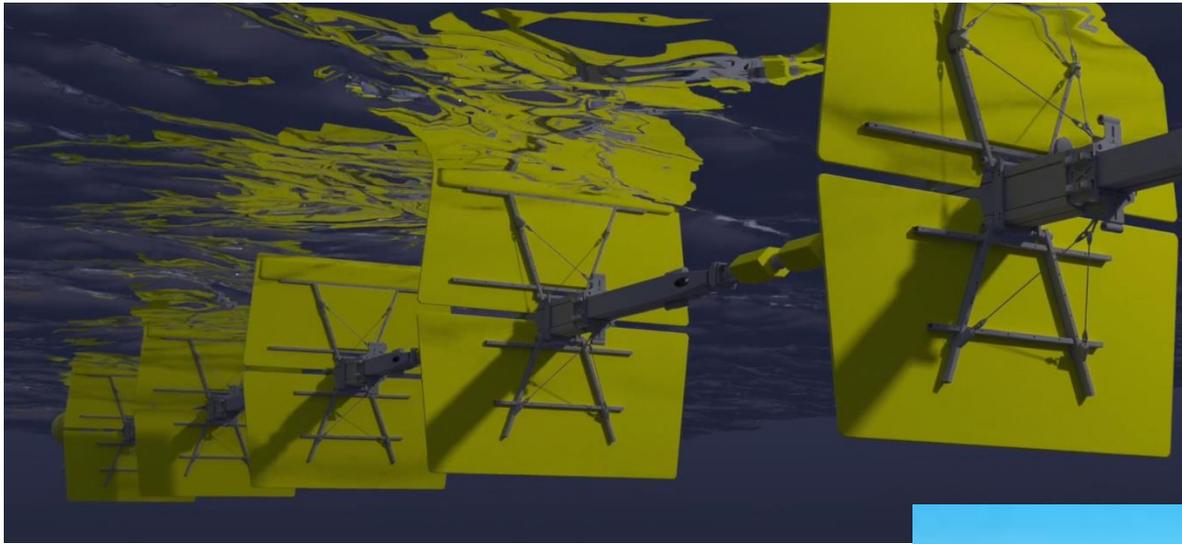




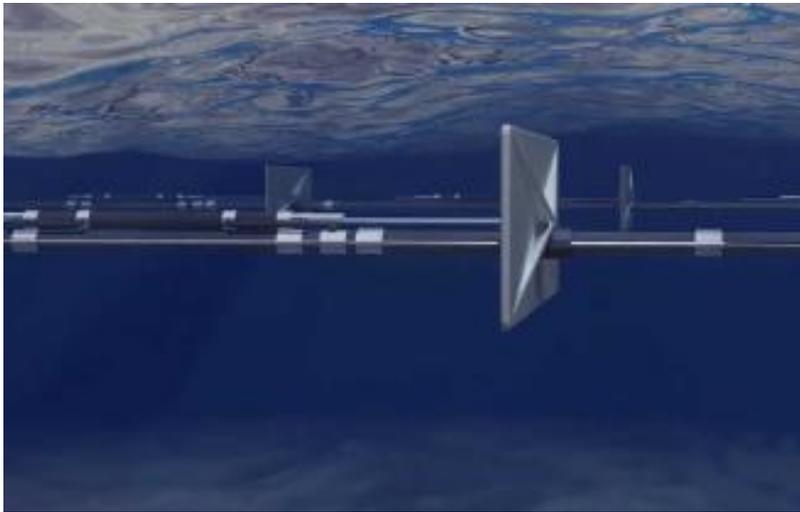
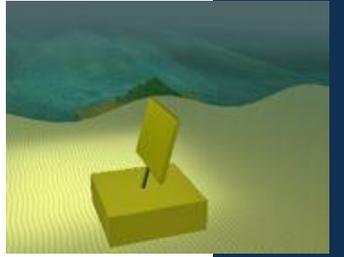
The Oyster, at EMEC 2013

Aquamarine Power, Scotland (2005-2015)





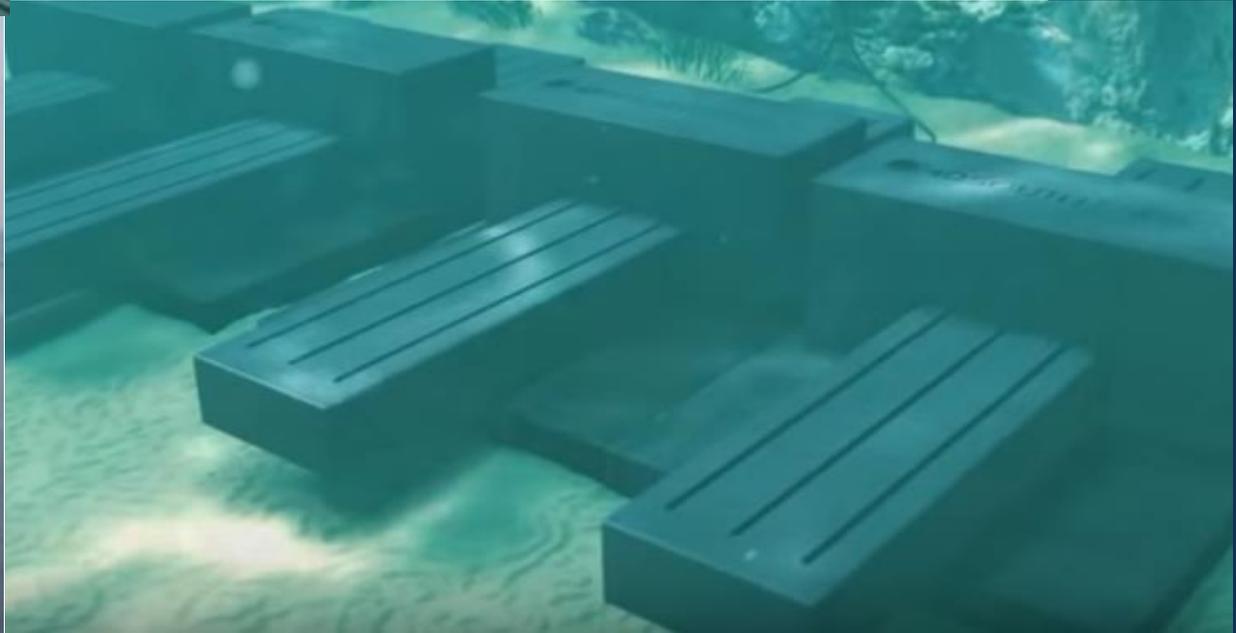
Wavepiston, Denmark



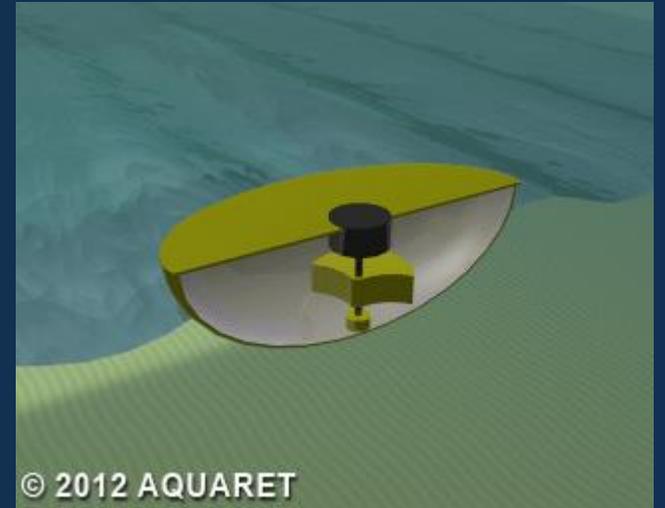
Deployment of the first H24 wave energy converter



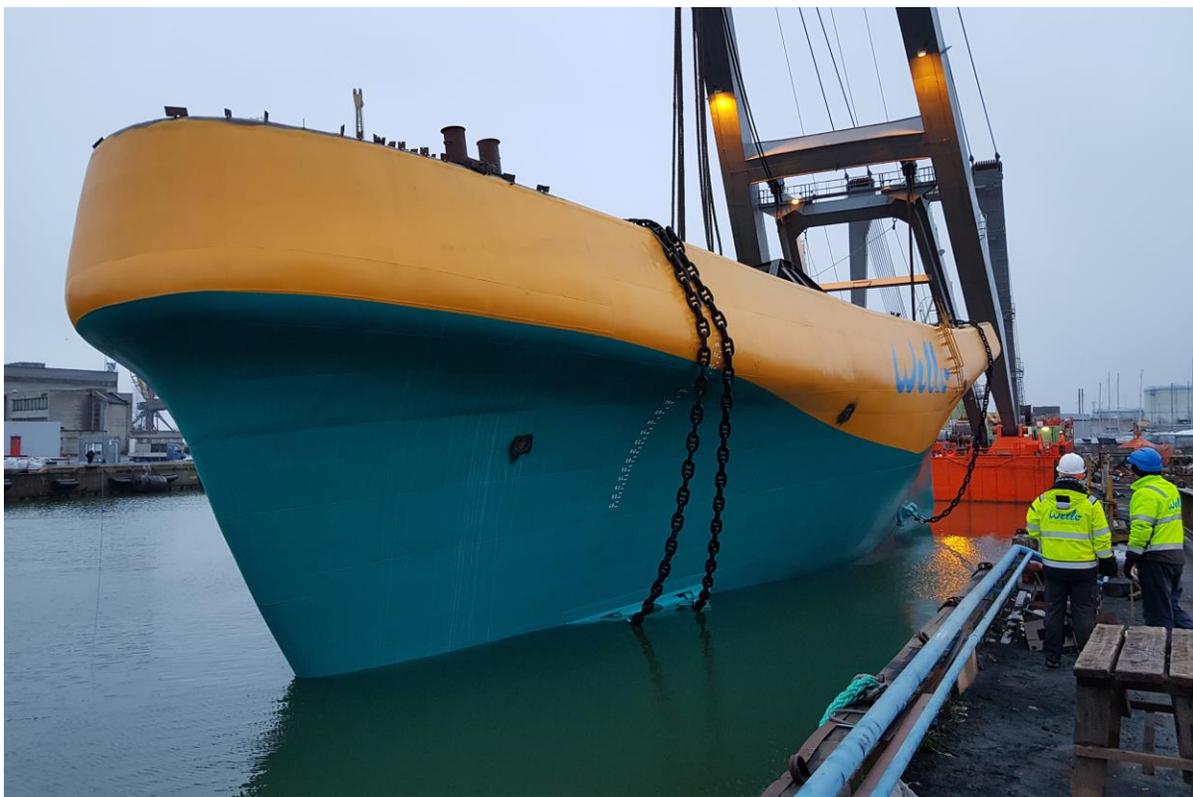
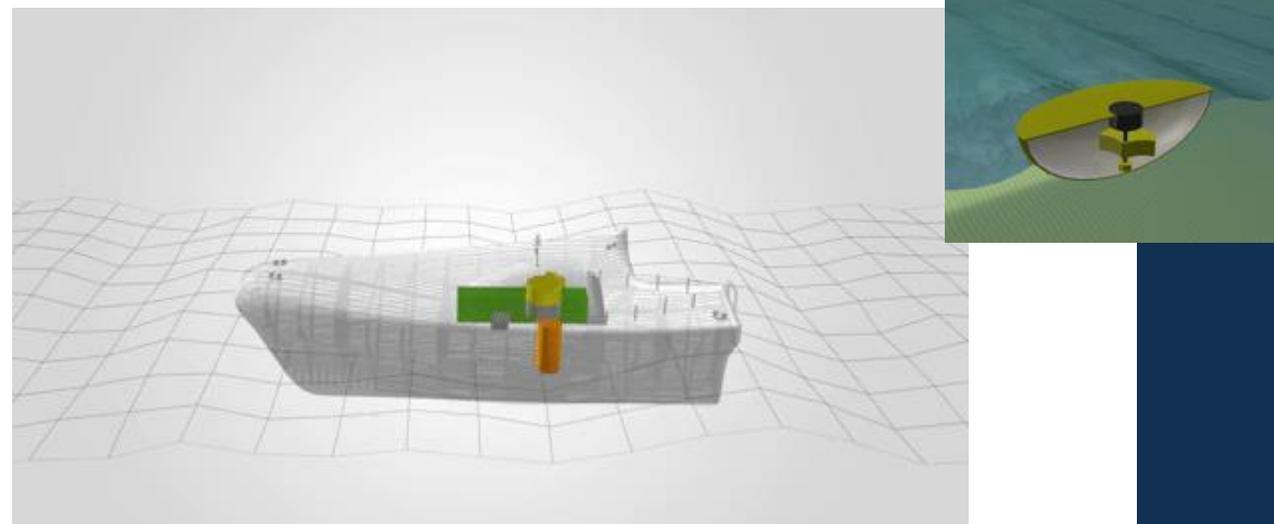
40 South Energy, Italy



Rotating Mass



Wello Oy, Finland



The Penguin

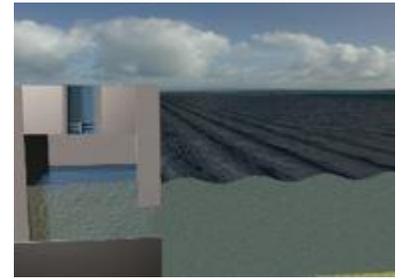


Oscillating Water Column

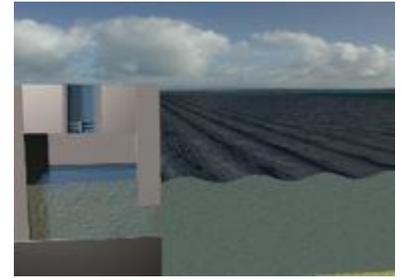


Kverner Brug, Norway

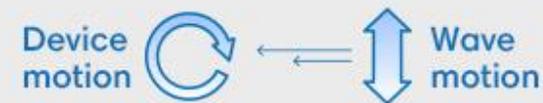
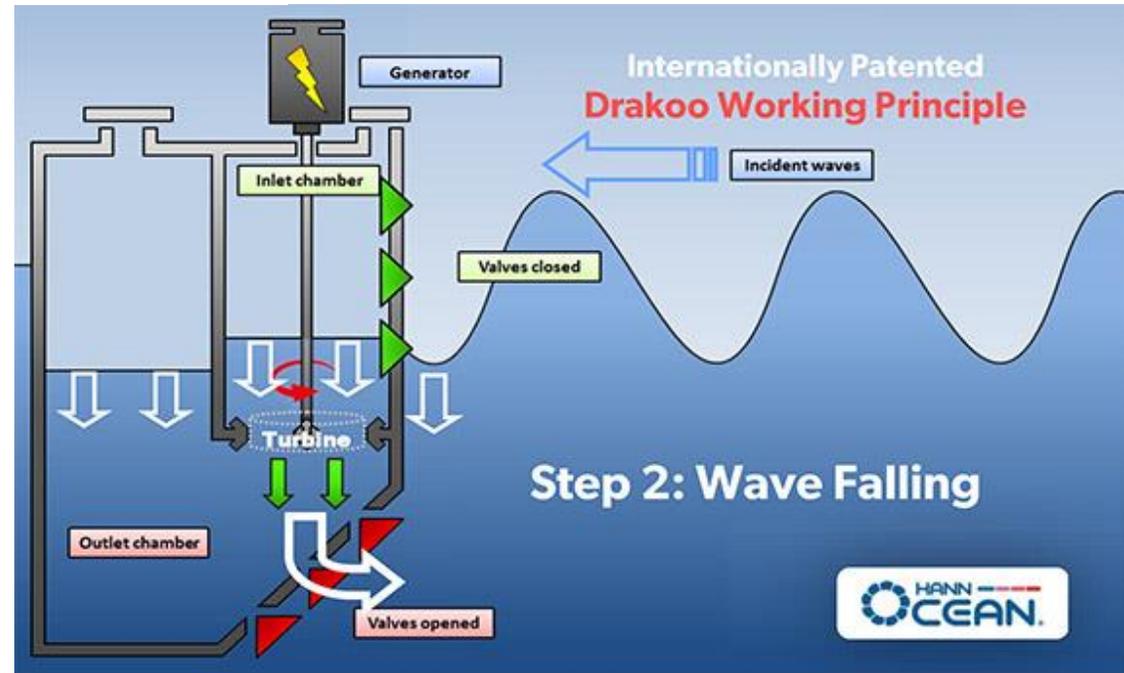
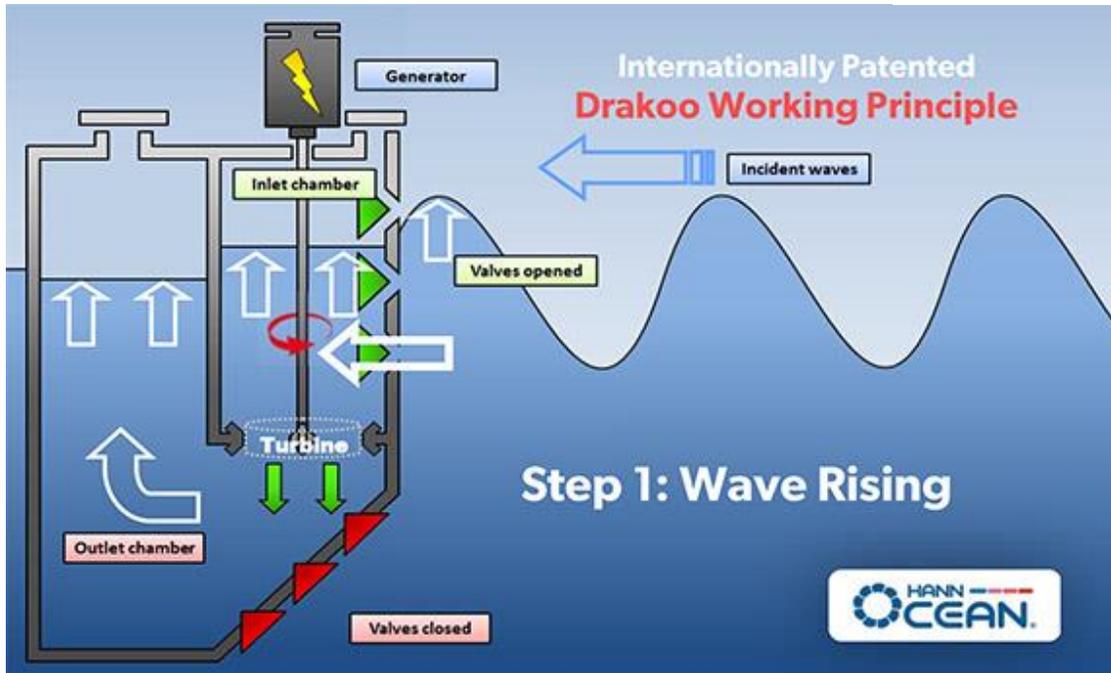
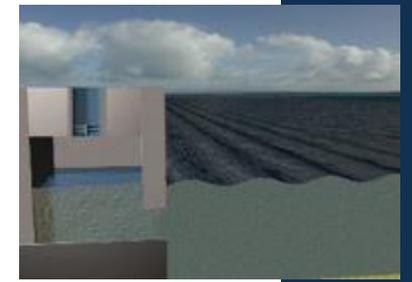
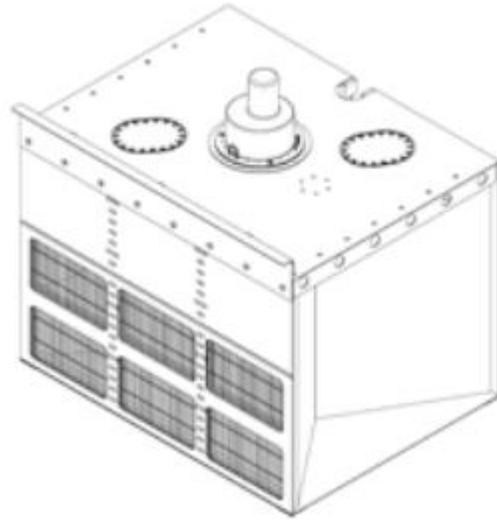
1985-1988

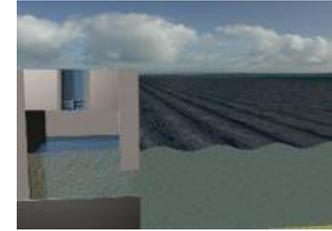


Unknown



Hann-Ocean Co.,Ltd, China

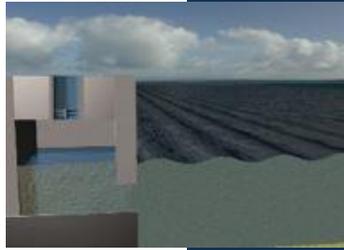




Havkraft AS, Norway



Oceanlinx Ltd, Australia (1998-2014)

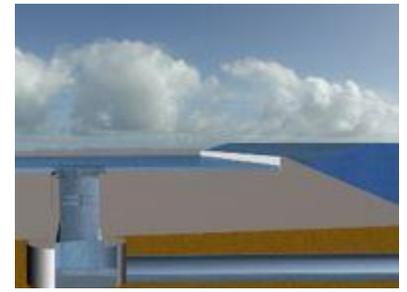


Overtopping

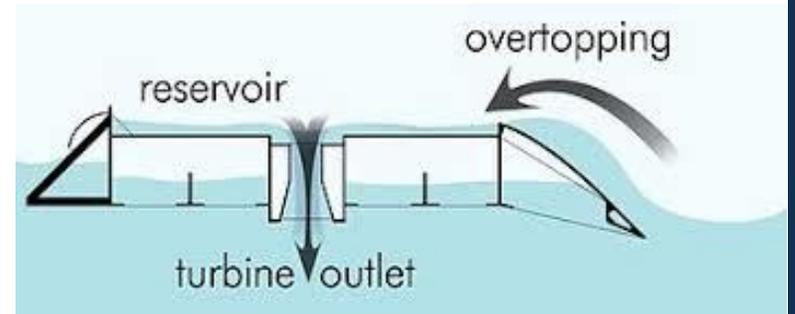
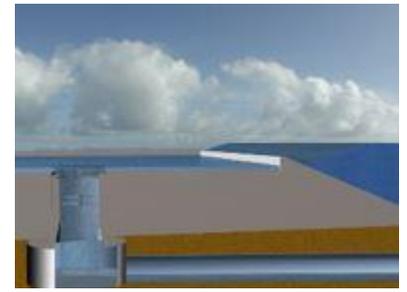




Picture taken 2018

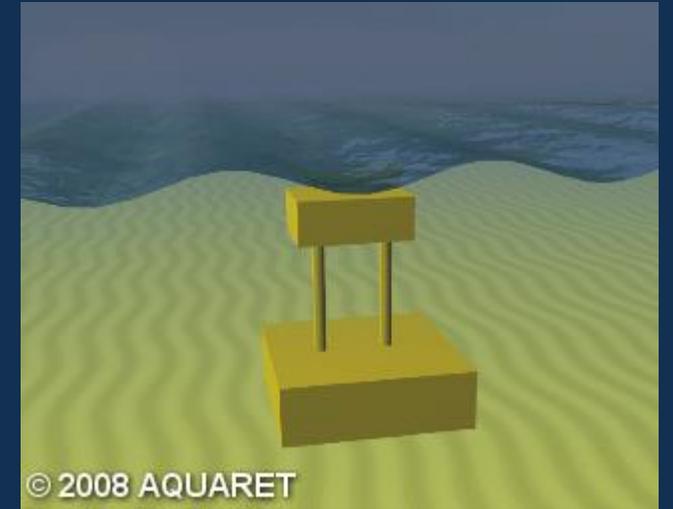


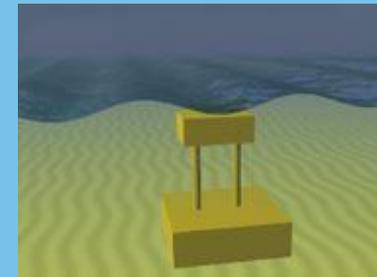
Norwave , Norway 1988-91



Wave Dragon, Denmark

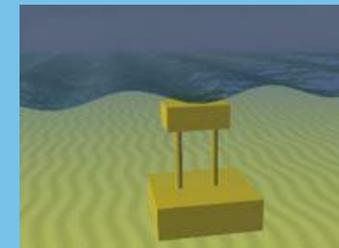
Submerged Pressure Differential

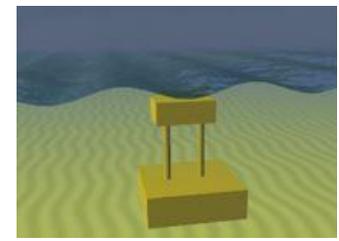
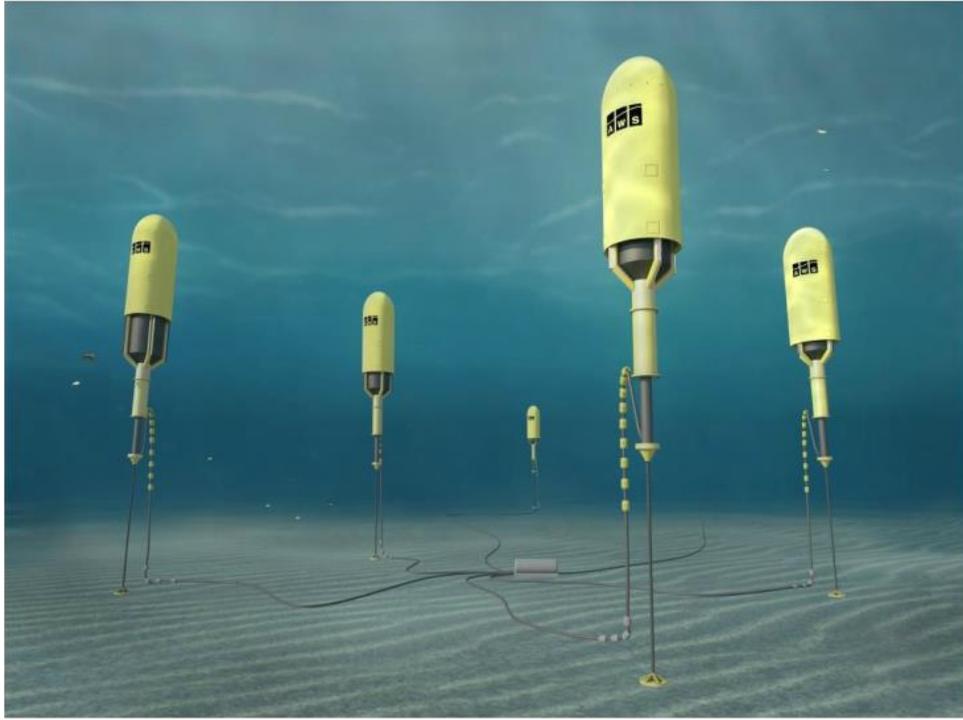




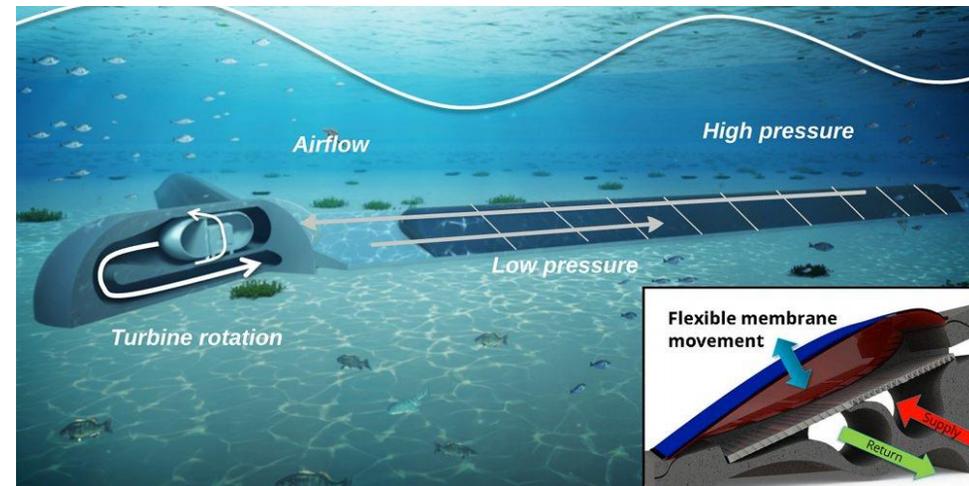
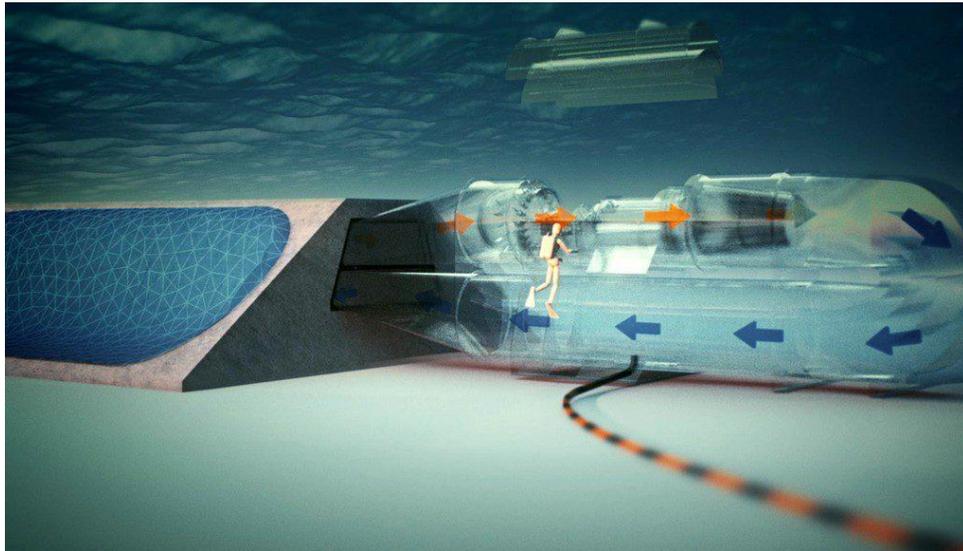
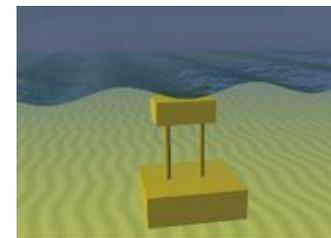
Carnegie Clean Energy, Australia

Marine Power Systems, UK





AWS Ocean Energy Ltd, Scotland

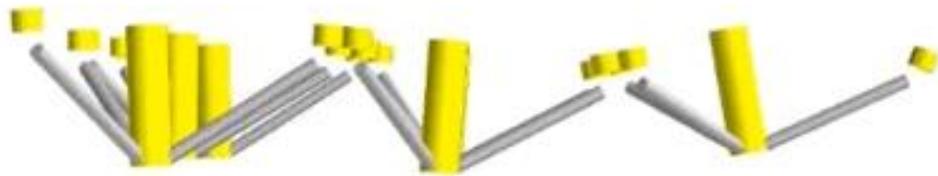


Bombora, Australia

Other



Albatern Wave Energy, UK (Scotland)

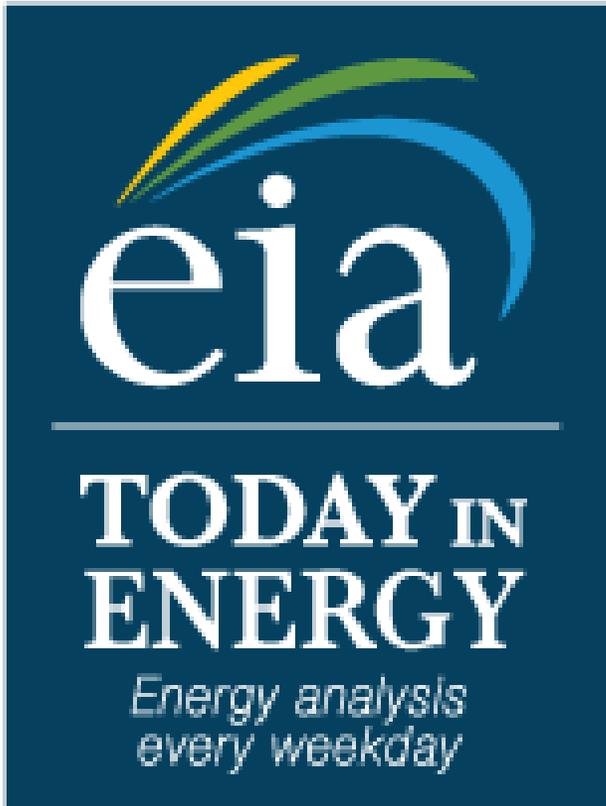


Wave Energy Companies

| | | |
|--|----|---|
| Laminaria | Be | http://www.laminaria.be/ |
| Arrecife Energy Systems | Es | https://www.arrecifesystems.com/ |
| Wello Oy | Fi | https://wello.eu/ |
| Atmocean | US | https://atmocean.com/ |
| SINN Power | De | https://www.sinnpower.com/ |
| Oceantec | ES | http://www.oceantecenergy.com/ |
| HACE Wave | FR | http://hacewave.com/ |
| Carnegie Clean Energy | Au | https://www.carnegiece.com/ |
| Waveswell Energy | Au | http://waveswellenergy.com.au/ |
| Ocean Power Technologies | US | http://www.oceanpowertechnologies.com/ |
| Aqua Harmonics | US | https://www.facebook.com/aquaharmonics/ |
| CalWave Power Technologies | US | http://calwave.org/ |
| Bombora | Au | http://www.bomborawave.com/ |
| AWS Ocean Energy Ltd | UK | http://www.awsocan.com/ |
| Pelagic Wave Power | No | http://www.pelagicpower.no/ |
| Brimes Energy | US | http://www.brimesenergy.com/ |
| Witt Energy | UK | http://www.witt-energy.com/ |
| Mocean Energy | UK | http://www.moceanenergy.com/ |
| Marine Power Systems | UK | http://marinepowersystems.co.uk/ |
| Wavepiston | Dk | http://wavepiston.dk/ |
| Waves4Power | Se | https://www.waves4power.com/ |
| Seabased | Se | https://seabased.com |

| | | |
|----------------------------------|--------|---|
| Columbia Power Technologies, Inc | US | http://columbiapwr.com/ |
| Ecomerit Technologies | US | http://www.ecomeritech.com/centipod.php |
| Etymol Ocean Power | Chile | http://www.etymol.com/intro.html |
| Fred Olsen | No | http://www.boltwavepower.com/ |
| Floating Power Plant | Dk | http://www.floatingpowerplant.com/ |
| Hann Ocean | Sing | http://www.hann-ocean.com/ |
| Seadog systems | US | http://seadogsystems.com/ |
| WavEC Offshore Renewables | Pt | http://www.pico-owc.net/ |
| Intentionum | No | http://www.intentionum.com/index.html |
| Inter Project Services | Se | http://www.ips-ab.com/ |
| Kinetic Wave Power | US | http://www.kineticwavepower.com/ |
| Ocean Energy | Irl | http://www.oceanenergy.ie/ |
| Crestwing Wave Energy | Dk | https://crestwing.dk |
| Pontoon Power | No | www.pontoon.no |
| Eco Wave Power | Israel | http://www.ecowavepower.com/ |
| Waveco | No | http://www.waveco.no/ |
| Nye etter sending til Trond | | |
| AMOG Consulting | Au | https://amog.consulting/ |
| 40South Energy | It | http://www.40southenergy.com/ |
| Sea Power | Ir | http://www.seapower.ie/ |
| Oscilla Power | US | https://oscillapower.com/ |
| Life Demo Wave | Es | http://www.life-demowave.eu/en/ |

| | | |
|----------------------------------|--------|---|
| Ocean Harvesting Technologies AB | Sweden | http://www.oceanharvesting.com/infinitywec-technology/ |
| Yam Pro Energy | Israel | http://yamproenergy.com/ |
| CCell (Zyba Ltd) | UK | http://www.ccell.co.uk/index.html |
| UmbraGroup | Italia | https://www.umbragroup.com/ |
| Resolute Marine | USA | http://www.resolutemarine.com/ |
| Slow Mill | NL | http://www.slowmill.nl/Home/index.php/ |



Last updated: June 27, 2019

What is renewable energy?

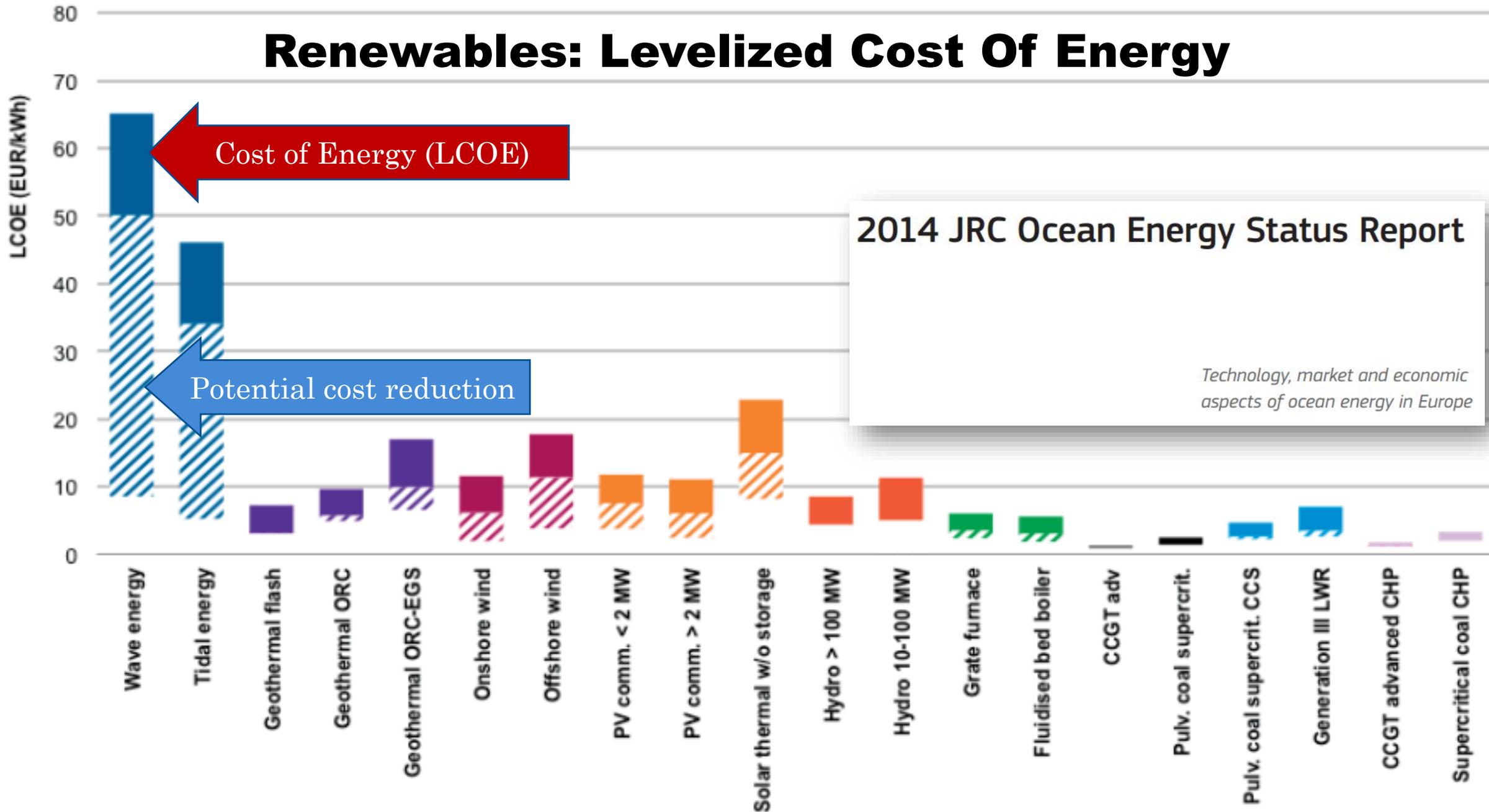
Renewable energy is energy from sources that are naturally replenishing but flow-limited; renewable resources are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time.

The major types of renewable energy sources are

- Biomass
 - Wood and wood waste
 - Municipal solid waste
 - Landfill gas and biogas
 - Ethanol
 - Biodiesel
- Hydropower
- Geothermal
- Wind
- Solar

Wave?

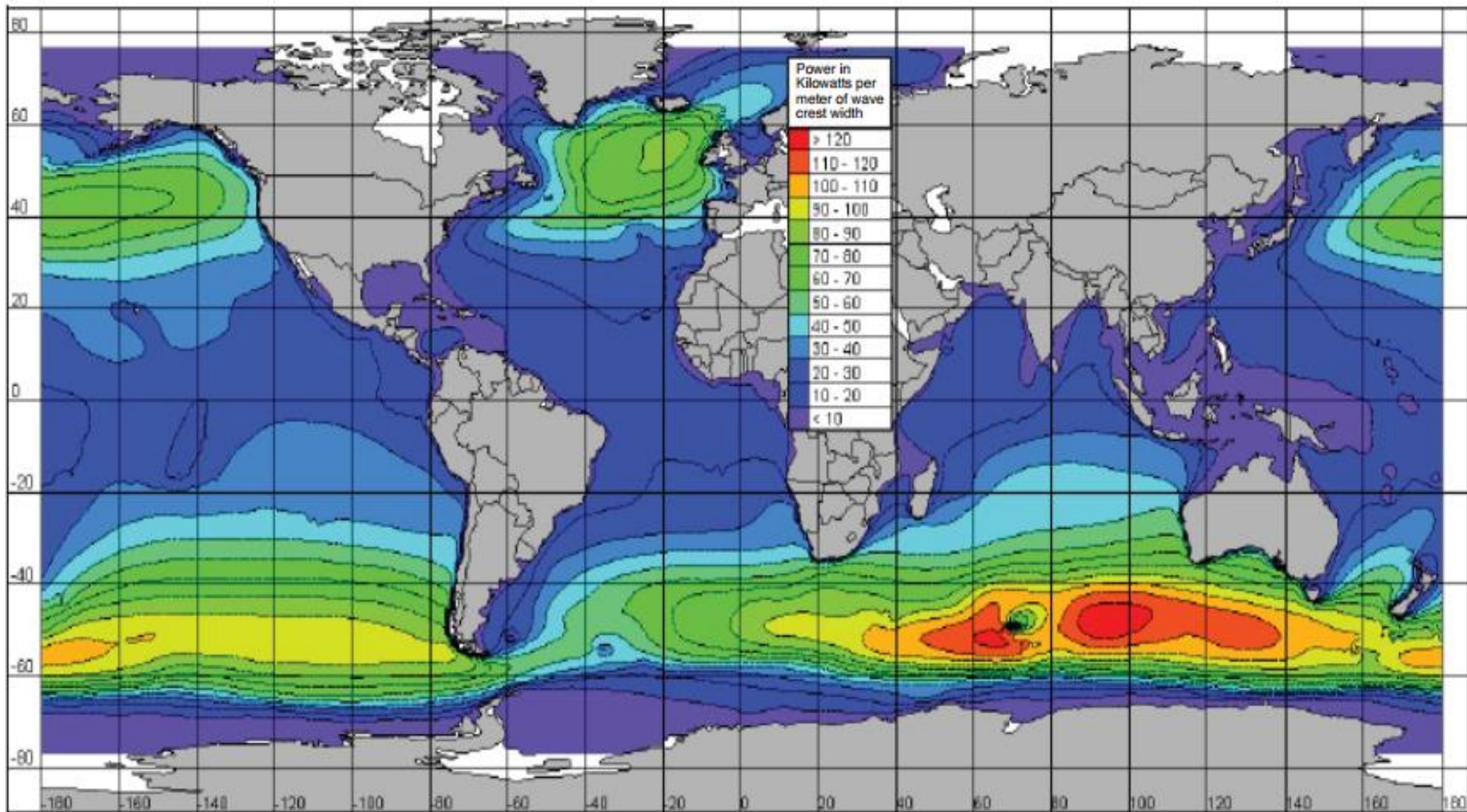
Renewables: Levelized Cost Of Energy



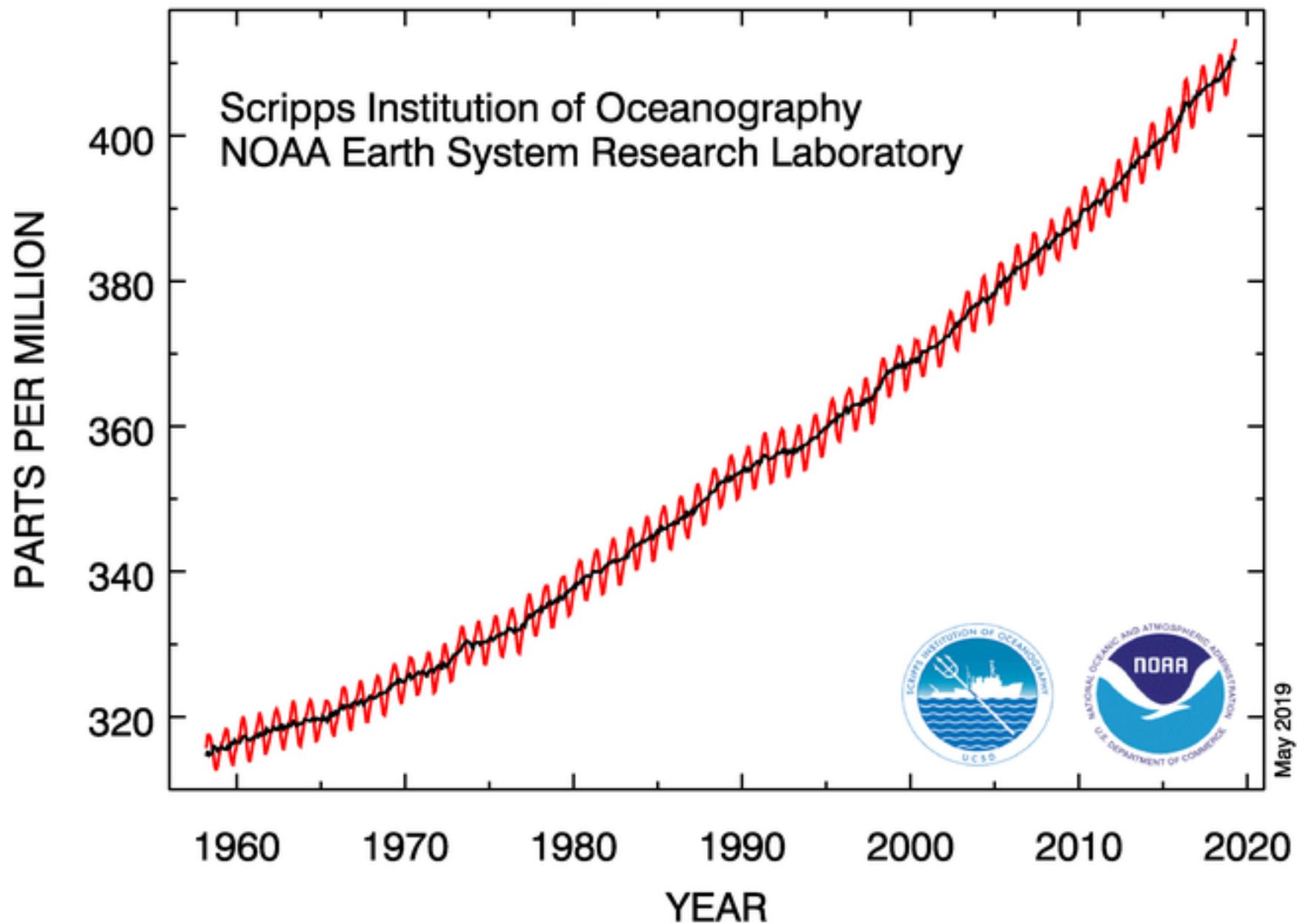
1. Wave energy has a very high ratio of peak to average power, necessitating costly structural components.
2. There is no established consensus for wave power conversion. Completely different concepts are put forth by developers making it hard to develop a uniform supply chain.
3. Wave Energy Converters need to be deployed in areas of high sea states, therefore deployment, maintenance and decommissioning is an issue.
4. The Power Take-off system of a wave energy converter needs to convert high power low frequency oscillations to lower power high frequency electricity suitable for a grid connection.
5. The wave energy industry does not have a good track record of success and cost reductions, necessary to attract investors for large projects.

Hurdles





Atmospheric CO₂ at Mauna Loa Observatory



Thank you!

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