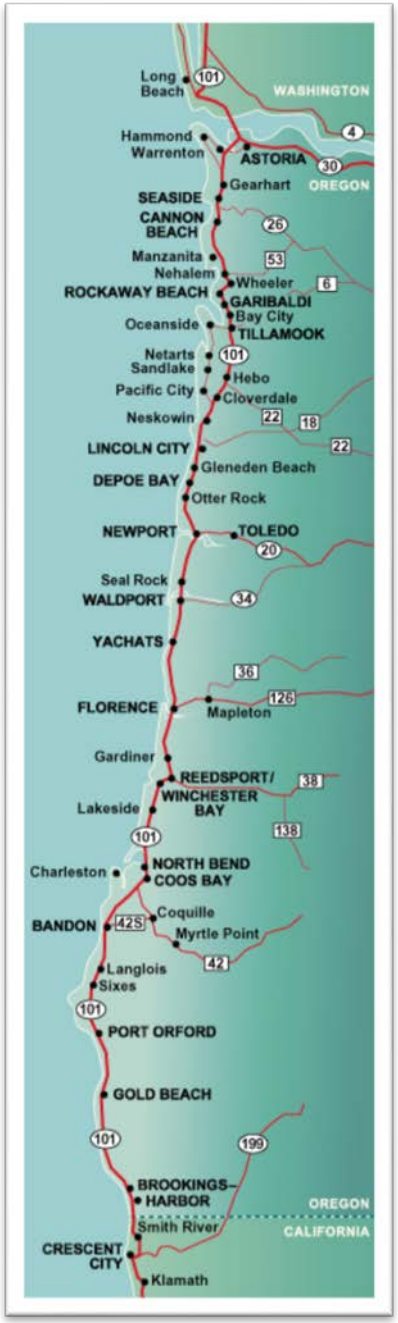
Ocean Renewable Energy:

A Diversity of Technologies for a Diversity of Markets

poet

PACIFIC OCEAN ENERGY TRUST



Types of Ocean Energy Technology

- Marine Hydrokinetic – motion of the ocean
  - Wave Energy – West Coast
  - Tidal Energy – requires the right geography
  - Ocean Current Energy – e.g., California Current
- Ocean Thermal Exchange – OTEC – Equatorial
- Offshore Wind

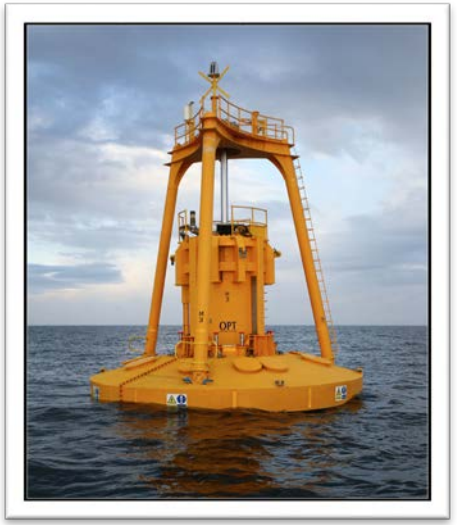
Why wave energy?

- Plentiful
- Inexhaustible
- Predictable
- Close to populations
- Emissions free
- Low environmental impact
- Diversity of generation

OregonWaveEnergy TRUST

The Technologies

Diversity: power take off, siting, size



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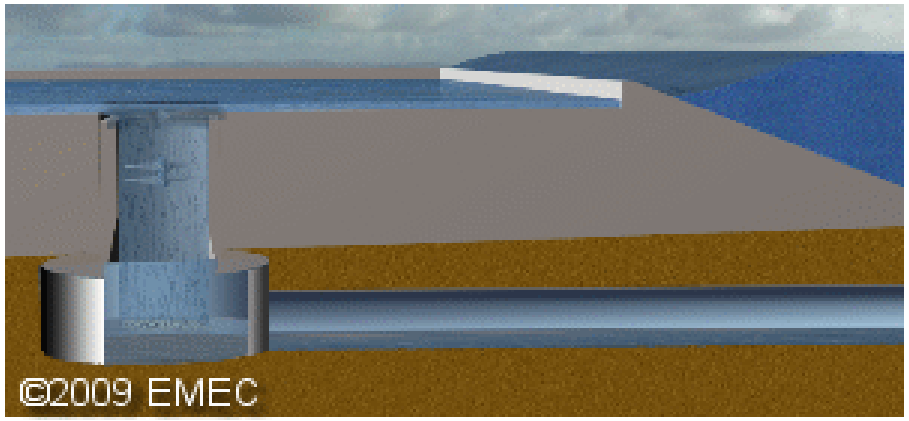
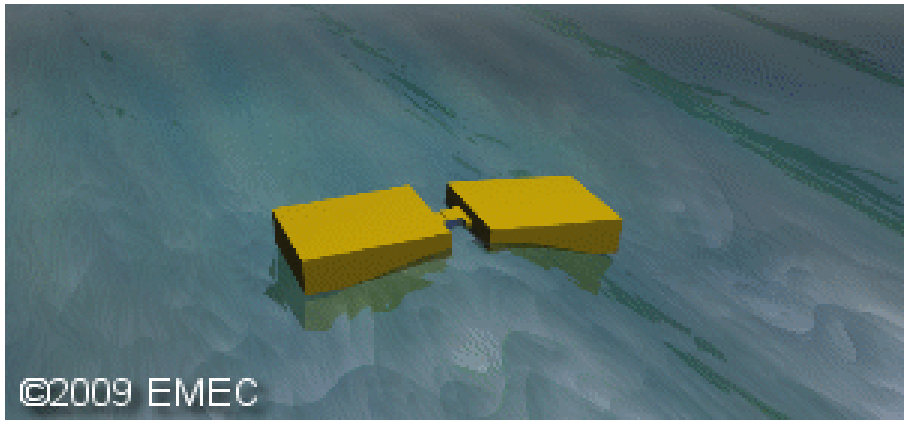
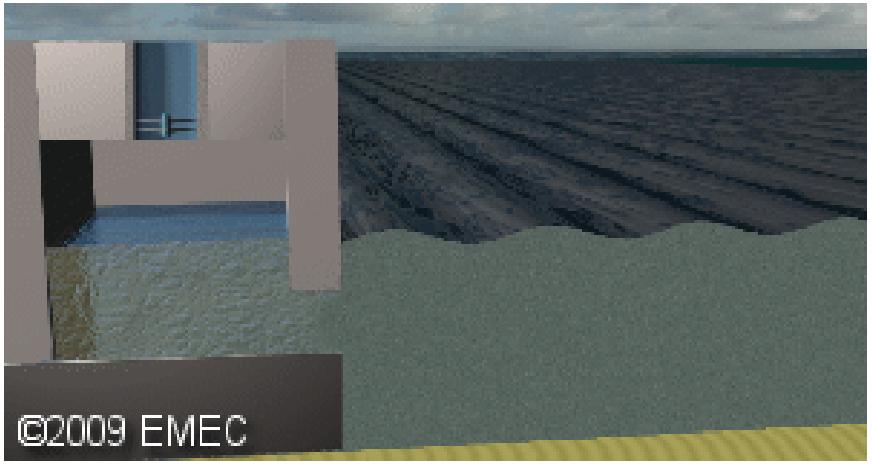


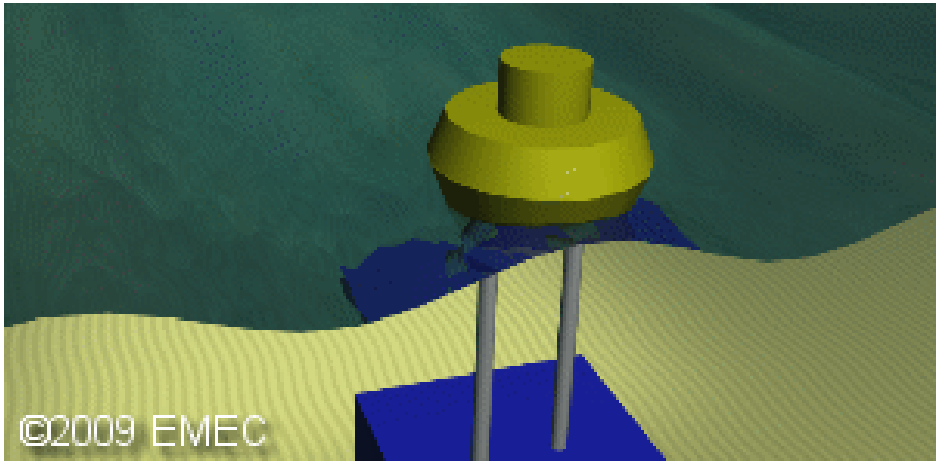
Overtopping



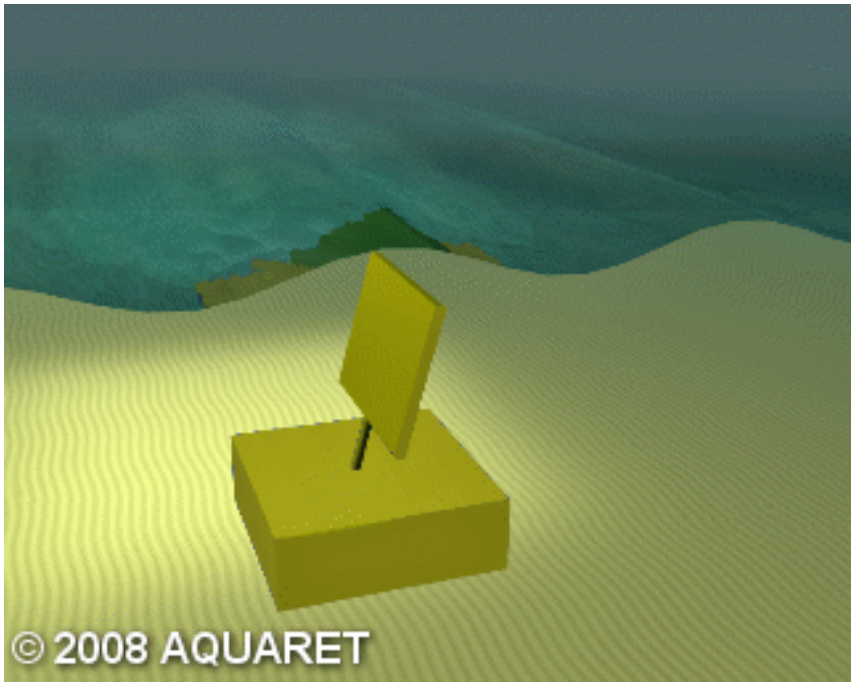
SNAKE / ATTENUATOR



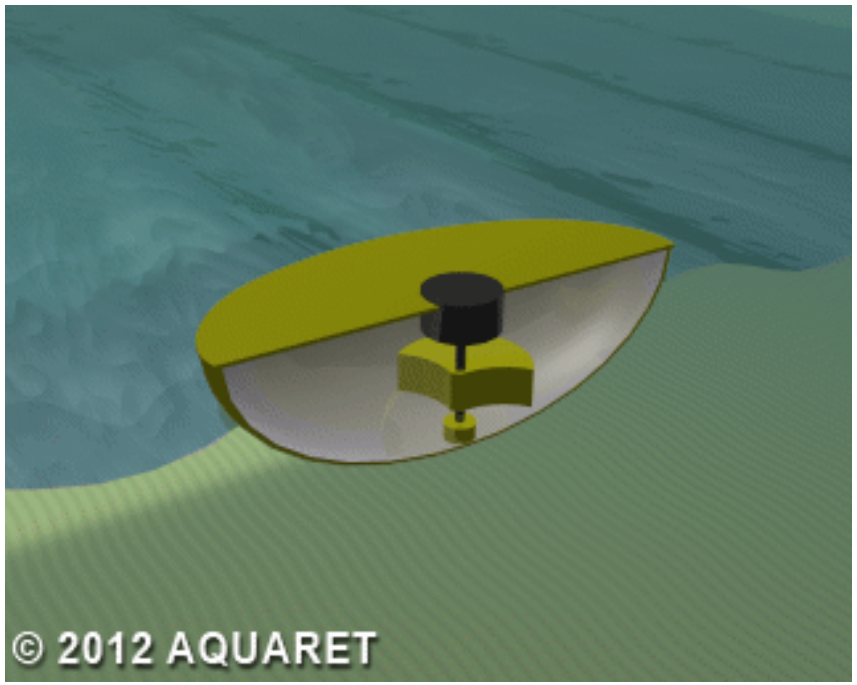
Oscillating Water Column



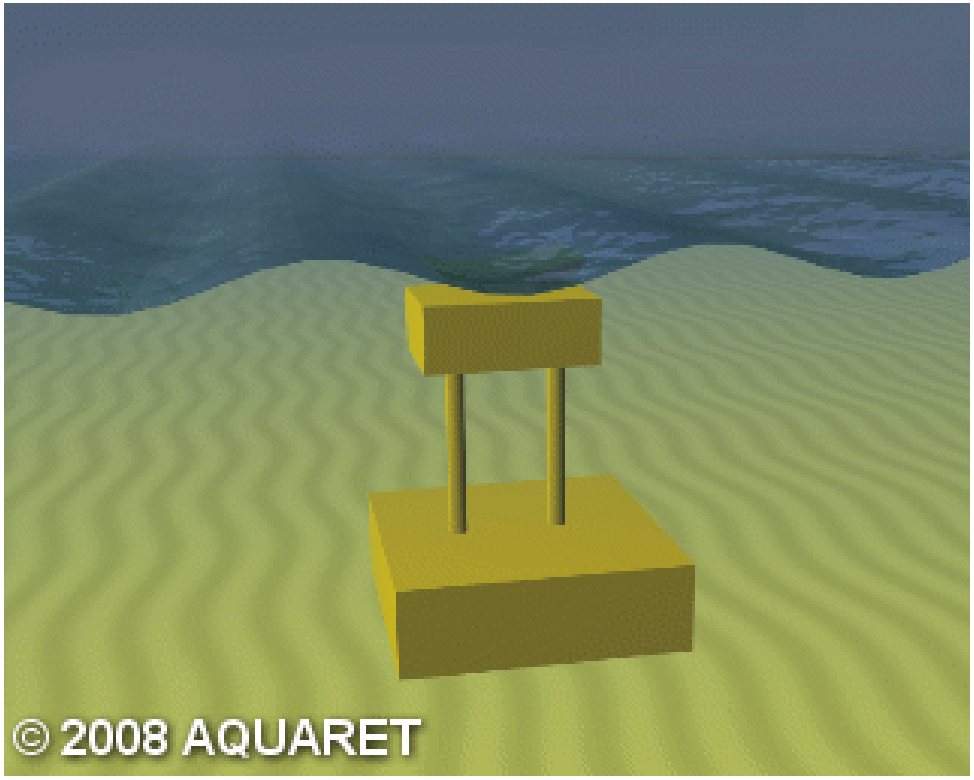
Heaving Buoy/Point Absorber



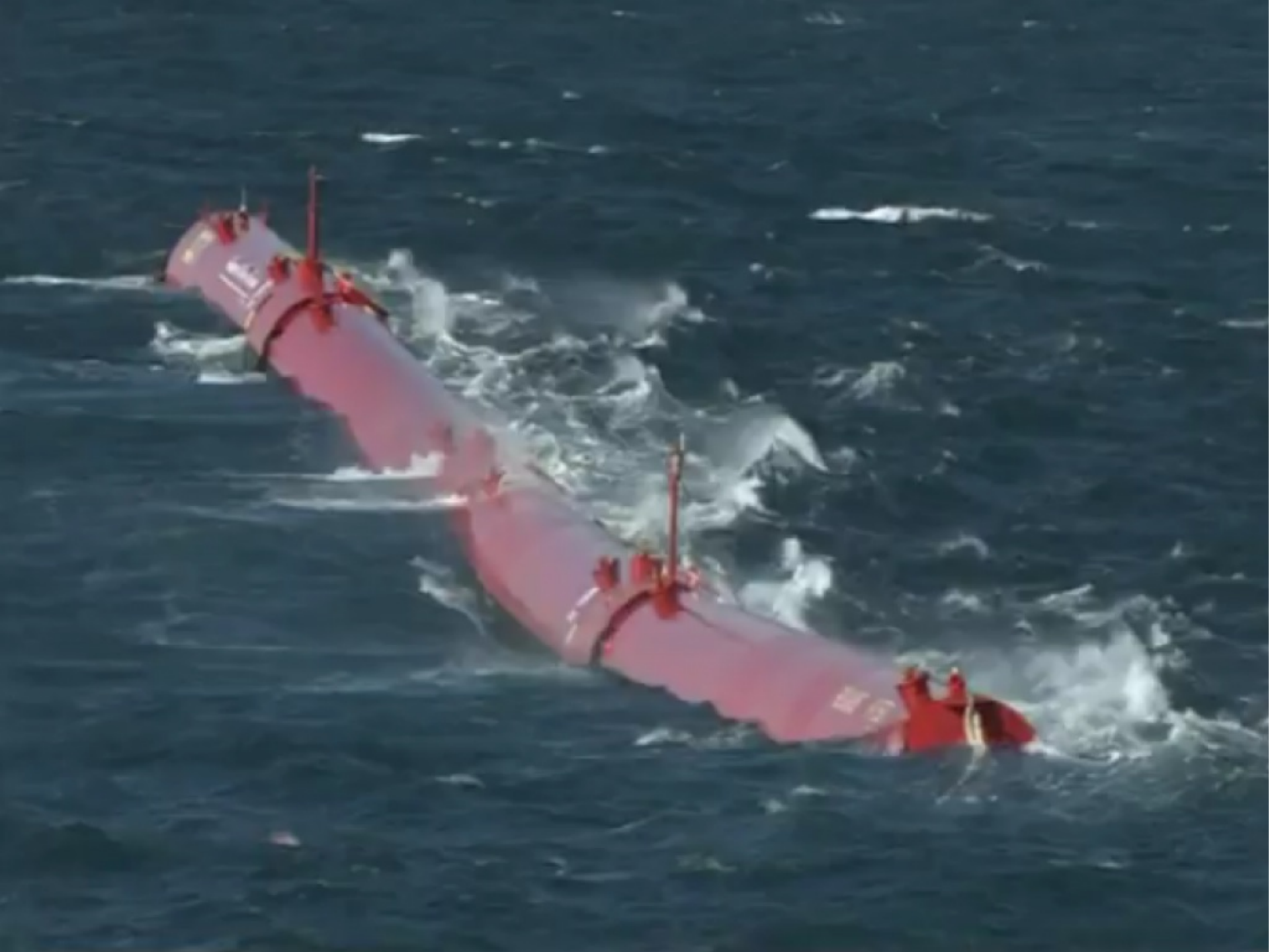
Oscillating Wave Surge Converter



Rotating Mass



Submerged Pressure Differential



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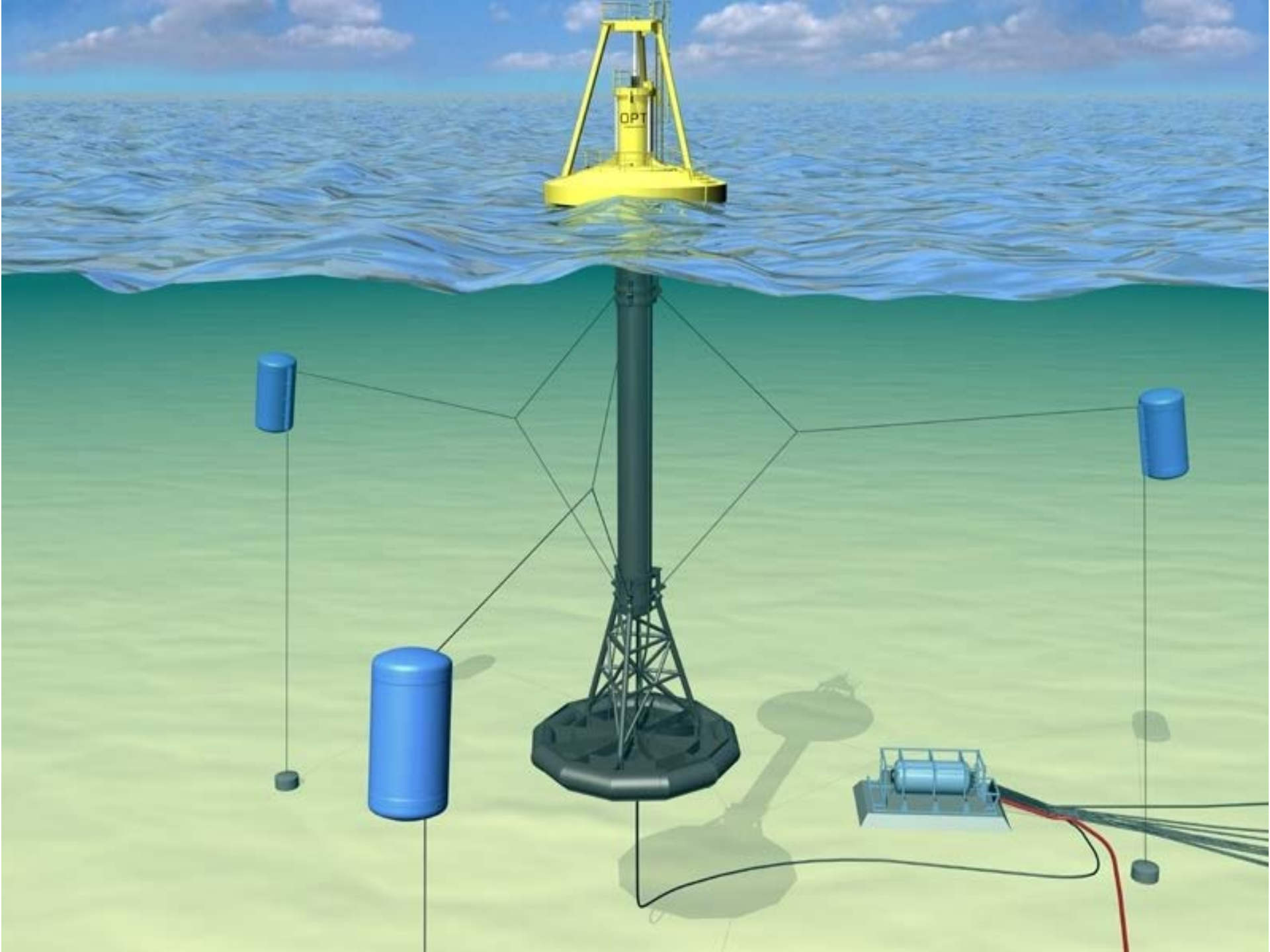
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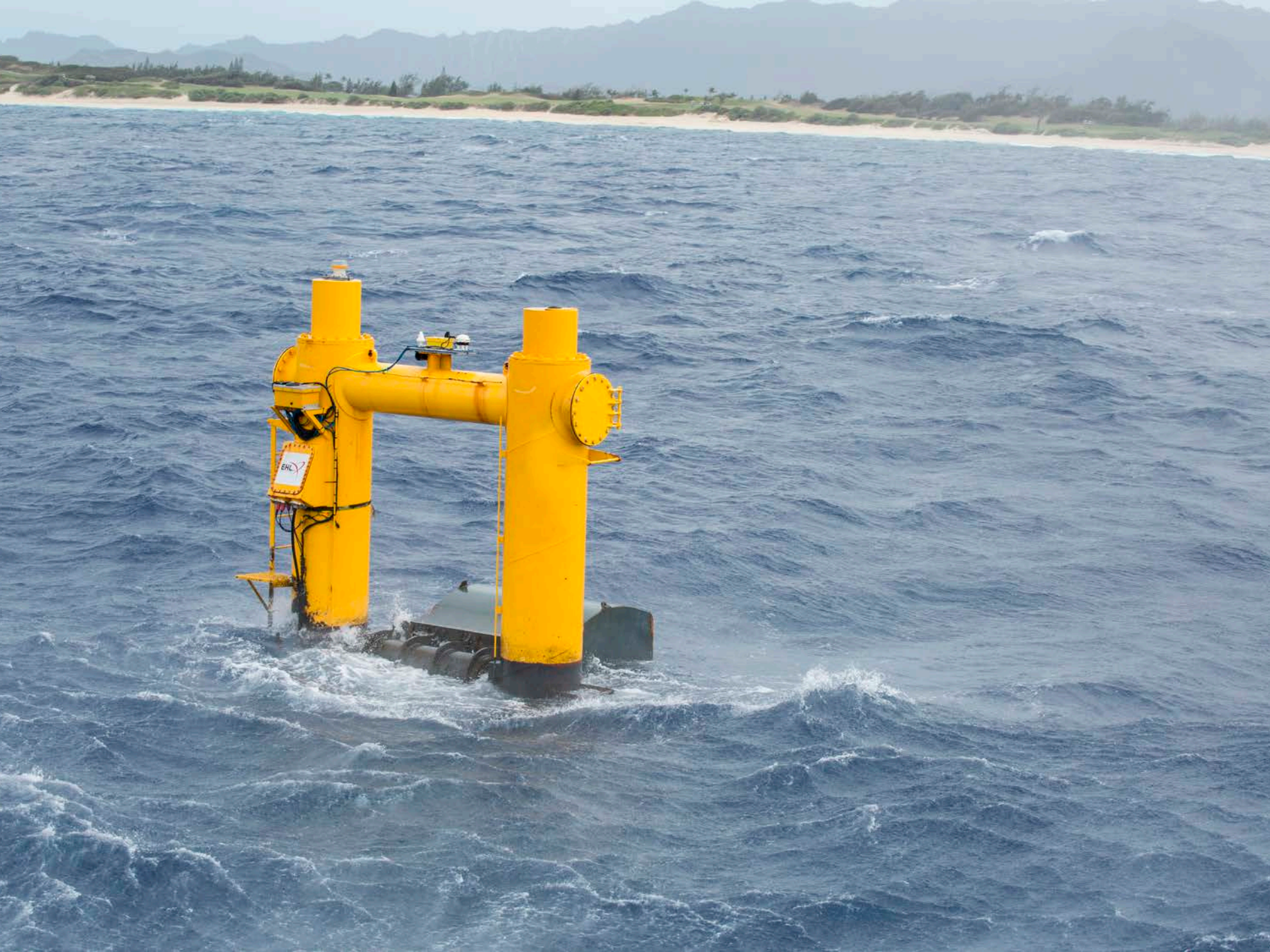
ENTERPRISE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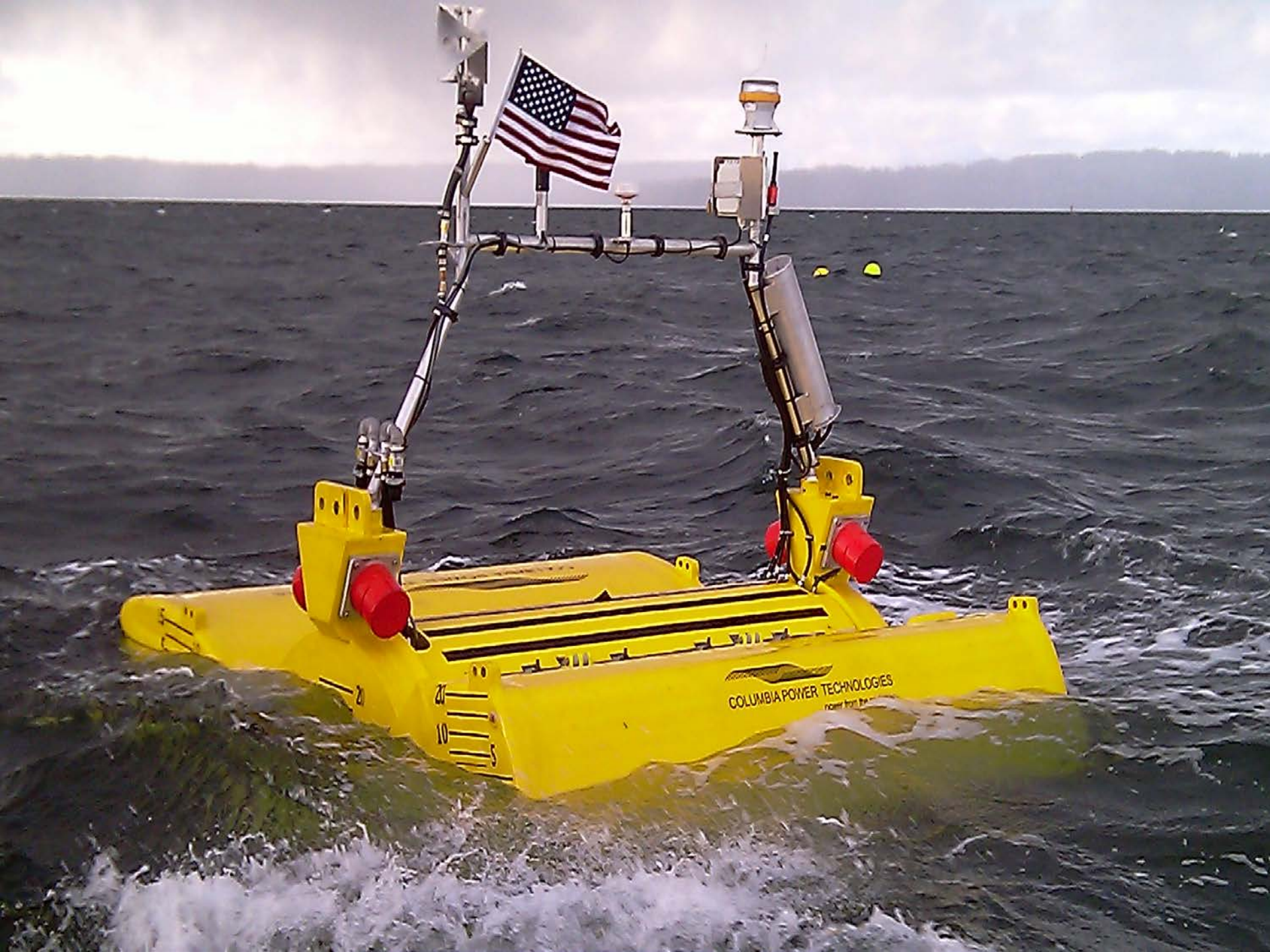
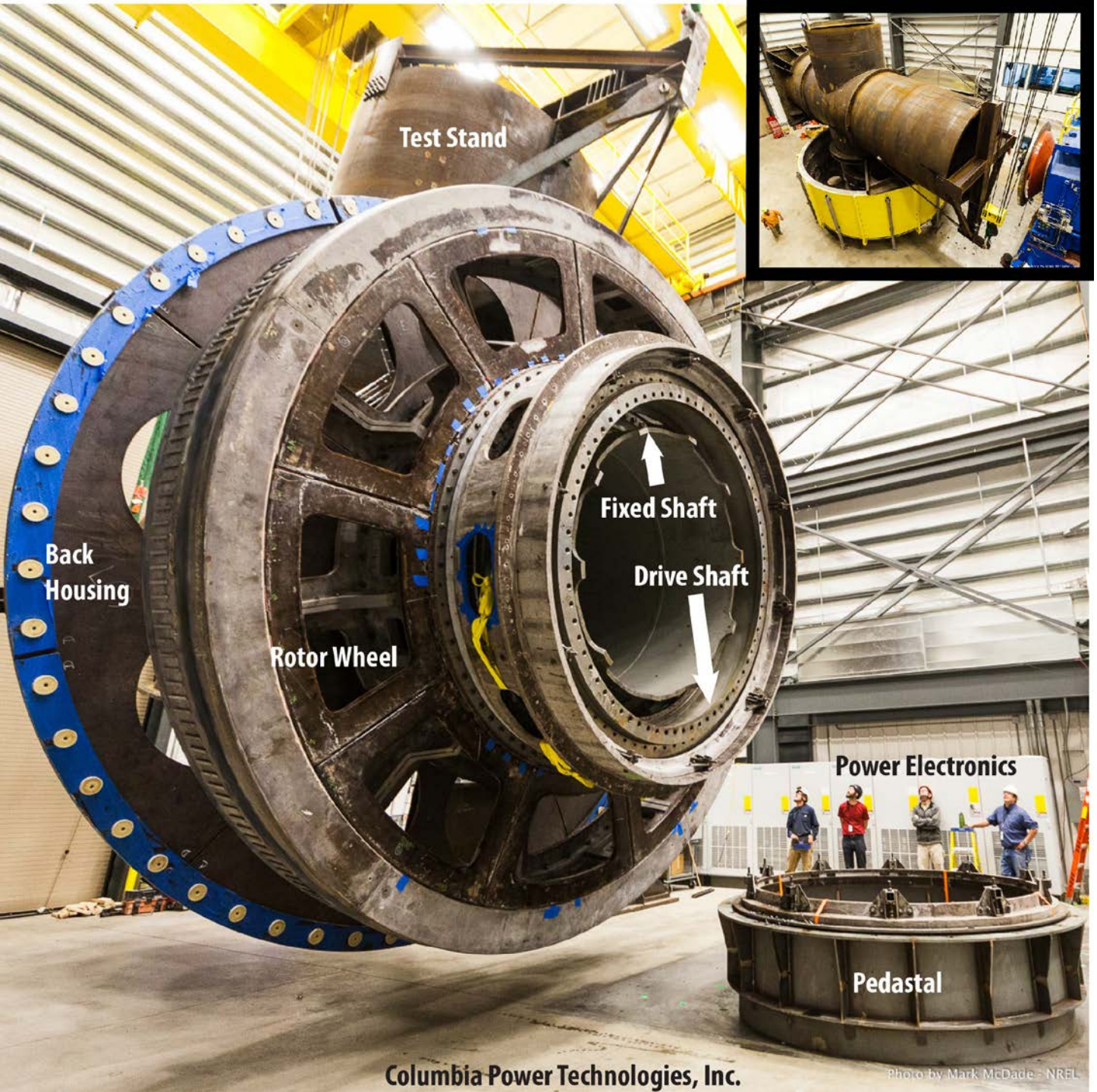
Northwest Energy Innovations
Azura Technology
Wave Energy Test Site - Hawaii

Northwest Energy Innovations: Azura

- Azura was deployed in HI at Navy's WETS site in May '15 and has been operating at sea for consecutive 18 months. Currently in the water.
- Past Deployments: (New Zealand, 2010) (Oregon, 2012)
- Grid Connected: Supplying Electricity to the Grid Since June 2015
- Only US Developer with 3rd Party Data Verification
- Reliable: 97% System Availability Since June 2015
- Durable: Survived 7.5 Meter Waves during Hurricane Ignacio


COLUMBIA POWER TECHNOLOGIES


ANCHOR


Test Stand
Back Housing
Rotor Wheel
Fixed Shaft
Drive Shaft
Power Electronics
Pedastal
Columbia Power Technologies, Inc.
Photo by Mark McDade - NREL

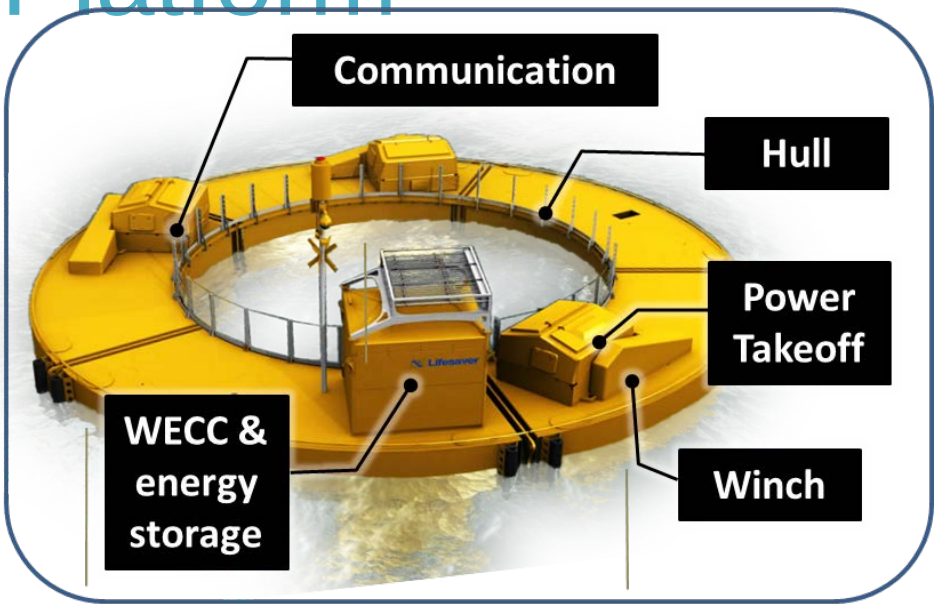
Columbia Power Technologies: StingRAY

- Utility-scale wave power system
- Multiple iterations and deployments of the basic technology
- 3 sea trials, including successful 13 month test in Puget Sound
- 3rd generation system tested over 12,000 hours
- 5 tank tests of prototypes, including extreme survivability testing
- Currently testing generator at the NREL Wind Technology Center
- Planned full-scale deployment in Hawaii, 2018
- Independent, third-party certification
- 14 patents
- 14 competitive federal grants — DOE, Navy & DARPA

Fred. Olson Renewables
Lifesaver Technology
Wave Hub testing facility, U.K.

Lifesaver Energy Platform

- 15-meter diameter torus
- Sized for 5 - 80kw PTOs, 3 installed
- Installed in 60 meters water depth



Fred Olson Renewables: Lifesaver

- Transferred to Wave Energy Test Site (WETS), Oahu, Hawaii early 2015
- Installed at WETS September, 2015
- Approximately 12 month test and demonstration for output and reliability


Ocean Energy LTD: OE Buoy
Oscillating Water Column
sei
www.oceanenergy.ie

Ocean Energy LTD: Ocean Energy Buoy

- Built and deployed three scales: 1:50, 1:15, and 1:4
- Near full scale built for deployment in Hawaii
- Three years of deployment in Atlantic waters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M3 Wave Energy – Oregon Grown


Contingency marker buoy
Recovery Lift Line Can
Acoustic pinger

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29/JUN/2012

DOE Wave Prize: The Third Generation

- M3 Wave Energy LLC
- CalWave Power Technologies
- Oscilla Power
- Sea Potential
- RTI Wave Power
- SEWEC
- Waveswing America
- Harvest Wave Energy
- AquaHarmonics
- Wave Energy Conversion Corporation of America
- Mocean Energy

Companies

- Columbia Power Technologies
- Northwest Energy Innovations
- Ocean Power Technologies
- M3 Wave Energy LLC
- Ocean Energy LTD
- Fred Olson
- Oscilla Power
- Carnegie Wave Energy
- Wello Oy
- Eco Wave Power
- Resolute Marine Energy
- CalWave
- AWS Ocean Energy
- SeaTricity
- AW Energy
- CorPower

U.S. Deployments

- Ocean Renewable Energy Company – tidal – multiple – Maine and Alaska, additional deployments in 2017
- NWEI – Azura – Wave Energy Test Site – Hawaii - current
- Fred. Olson Renewables – Wave Energy Test Site - current
- Ocean Energy LTD – Wave Energy Test Site - 2017
- Oscilla Energy – NETS test site Oregon - 2017
- Columbia Power Technologies – Wave Energy Test Site – 2018
- NWEI – full scale Azura – Wave Energy Test Site –

Questions?

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