U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Water Power Technology Office Marine Energy Projects in USA

Bill McShane, Marine Energy Technology Manager — Water Power Technologies Office

Maritime Hydrogen & Marine Renewable Energy Conference 18th – 19th September 2019

Agenda

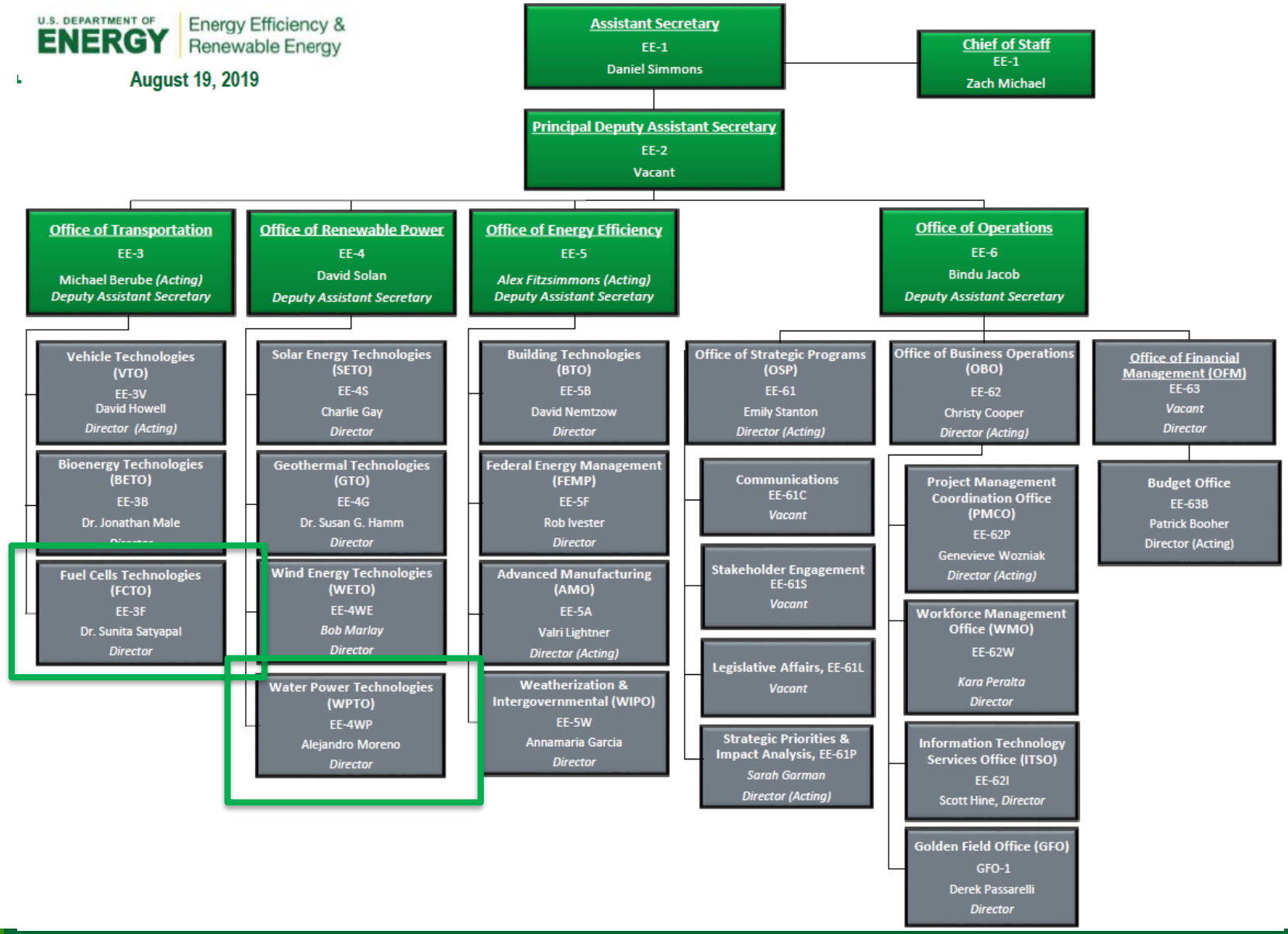
Three Goals:

1. **Introduce the US Department of Energy's**
   - Water Power Technology Office (WPTO)
   - Fuel Cell Technology Office (FCTO)

2. **Introduce the US Marine Energy Industry**

3. **Introduce the Powering the Blue Economy Initiative**

EERE Organizational Chart



Water Power Technologies Office

Hydropower

Upgrades for Existing Hydropower

Non-Powered Dams and Conduits

New Low-Impact Projects

Pumped Storage

Marine and Hydrokinetics / Marine Energy

Wave

Tidal

River Current

Ocean Currents

DOE Fuel Cell Technologies Office: R&D Focus Areas

Early R&D Focus

Applied research, development and innovation in hydrogen and fuel cell technologies leading to:

- Energy security
- Energy resiliency
- Strong domestic economy

Early R&D Areas

Fuel Cells

- Cost, durability
- Components - catalysts, electrodes, etc
- Increase focus beyond LDVs

Hydrogen Fuel

- Cost of production across pathways
- Cost and capacity of storage, including bulk / energy storage

Infrastructure R&D

- Cost and reliability of infrastructure
- Delivery components, supply chain
- Safety

LDV: Light Duty Vehicle

Enabling

H2@Scale
U.S. Department of Energy

National Lab-Based Consortia

HydroGEN Advanced Water Splitting Materials

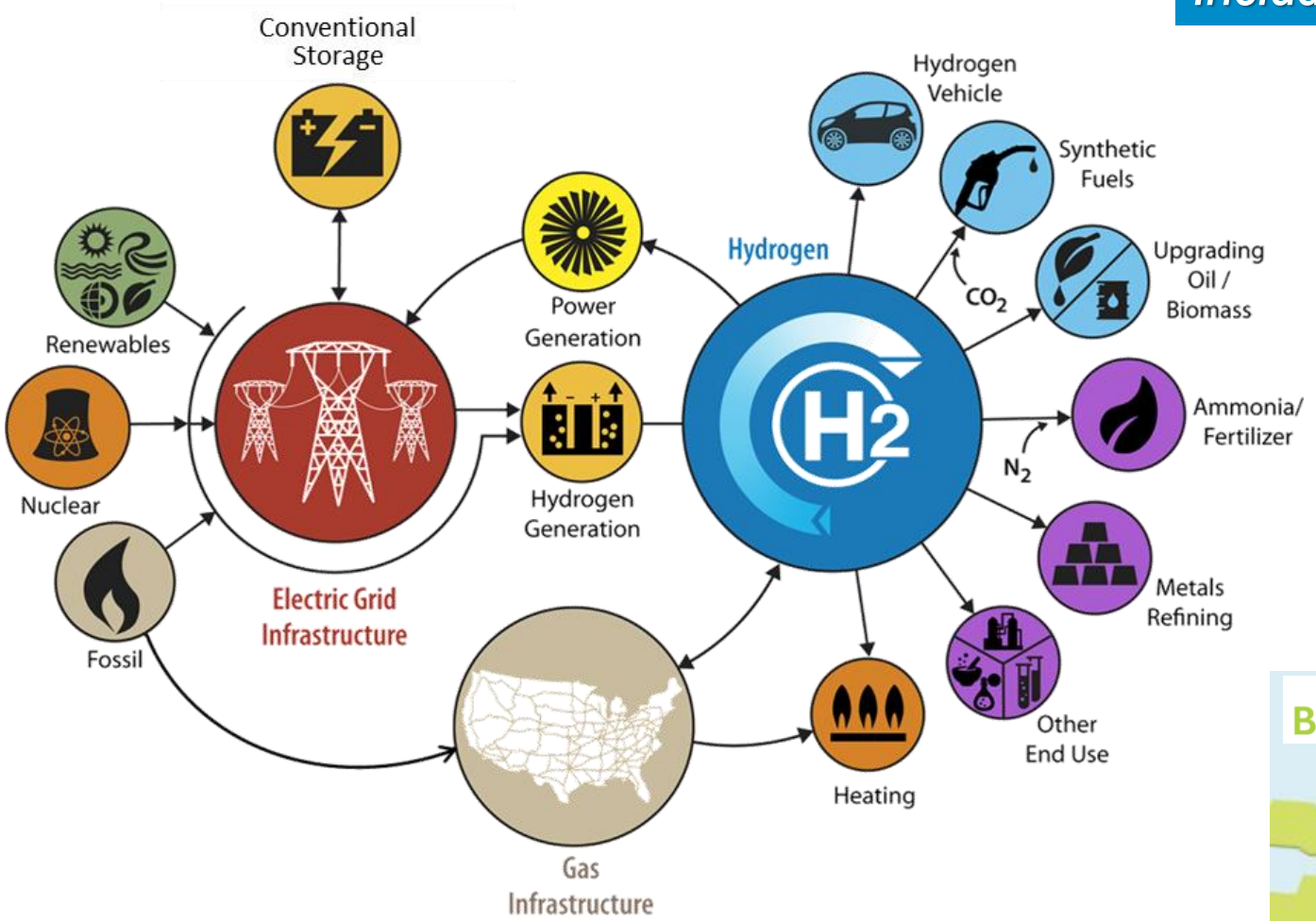
HyMARC Hydrogen Materials Advanced Research Consortium

ElectroCat Electrocatalysis Consortium

FCPAD Fuel Cell Performance and Durability

H-Mat Hydrogen Materials Compatibility Consortium

H_2@Scale: Affordable, Reliable & Clean Energy Across Sectors



Including Marine & Maritime Sectors

Large-Scale LH_2 Energy Transport (5 - 500 GWh)

https://global.kawasaki.com/en/stories/articles/vol18/

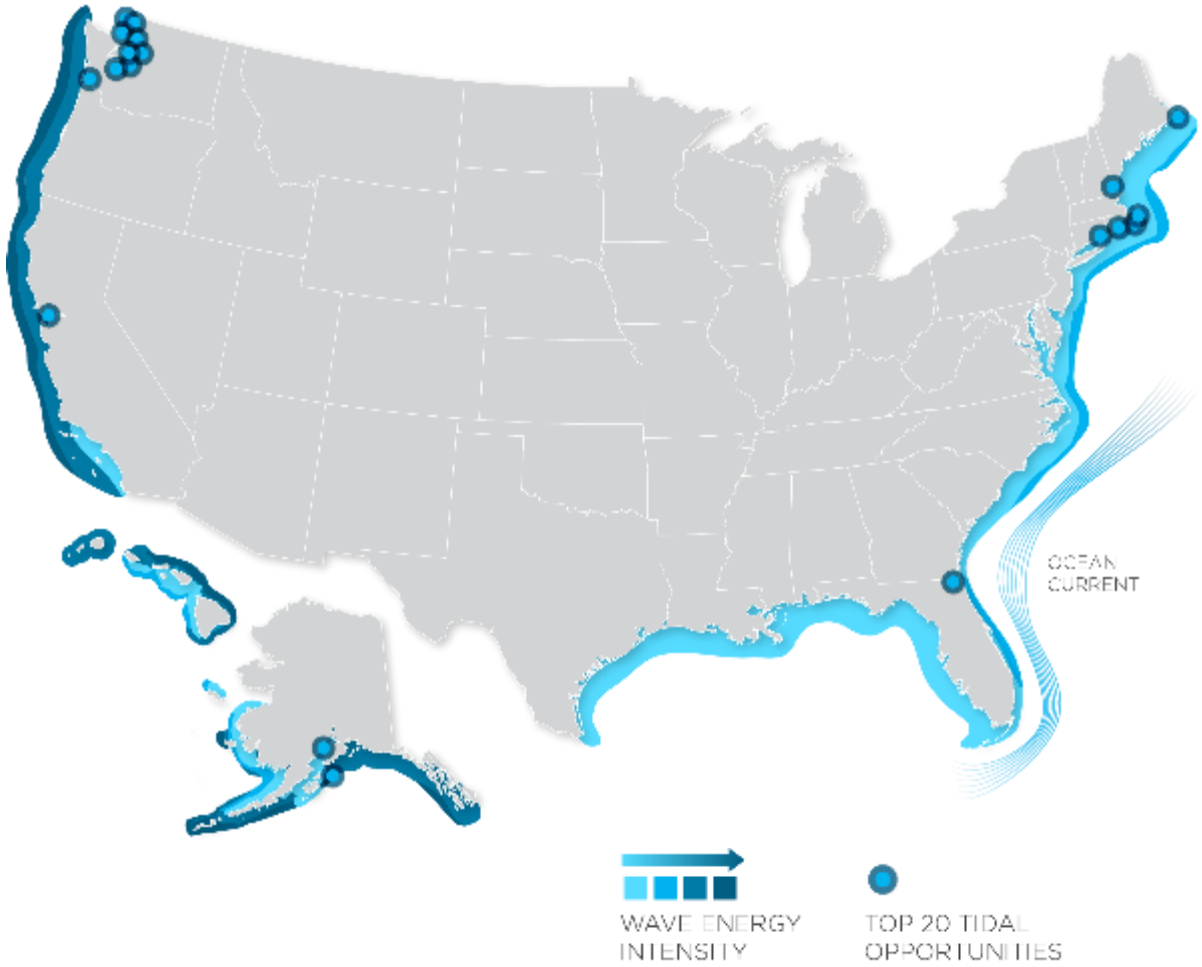
Water-Go-Round H_2 Passenger Ferry

San Francisco

H_2 Power @ Ports

Orkney Islands

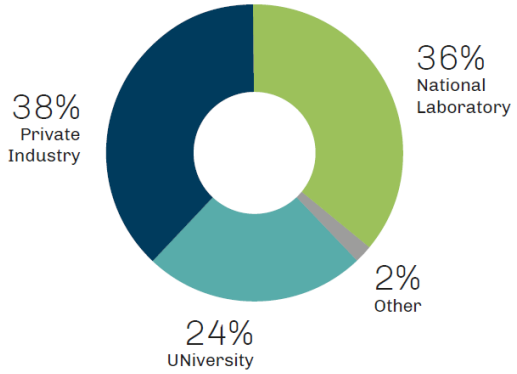
Marine Energy Resource Potential



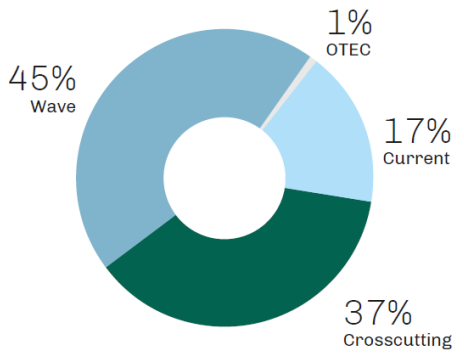
Resource	Total US Theoretical Resource		Total US Technical Resource		CONUS Technical Resource	
	TWh/year	% 2012 U.S. Net Electricity Generation	TWh/year	% 2012 U.S. Net Electricity Generation	TWh/year	% 2012 U.S. Net Electricity Generation
Wave Energy (2,3)	1594–2640	39–65	898–1229	22–30	378–472	9-12
Tidal Current Energy (4)	445	11	222–334	5.5–8.2	15–22	0.4-0.5
Ocean Current Energy (5)	200	49	45–163	1.1–4.0	45–163	1.1-4.0
River Current Energy	1381	34.1	120	3	100	2.5
Total	3620–4666	89-115	1285-1846	31.6–45.2	538-757	13-19

Marine and Hydrokinetic Resource Assessment and Characterization
https://www.energy.gov/eere/water/marine-and-hydrokinetic-resource-assessment-and-characterization

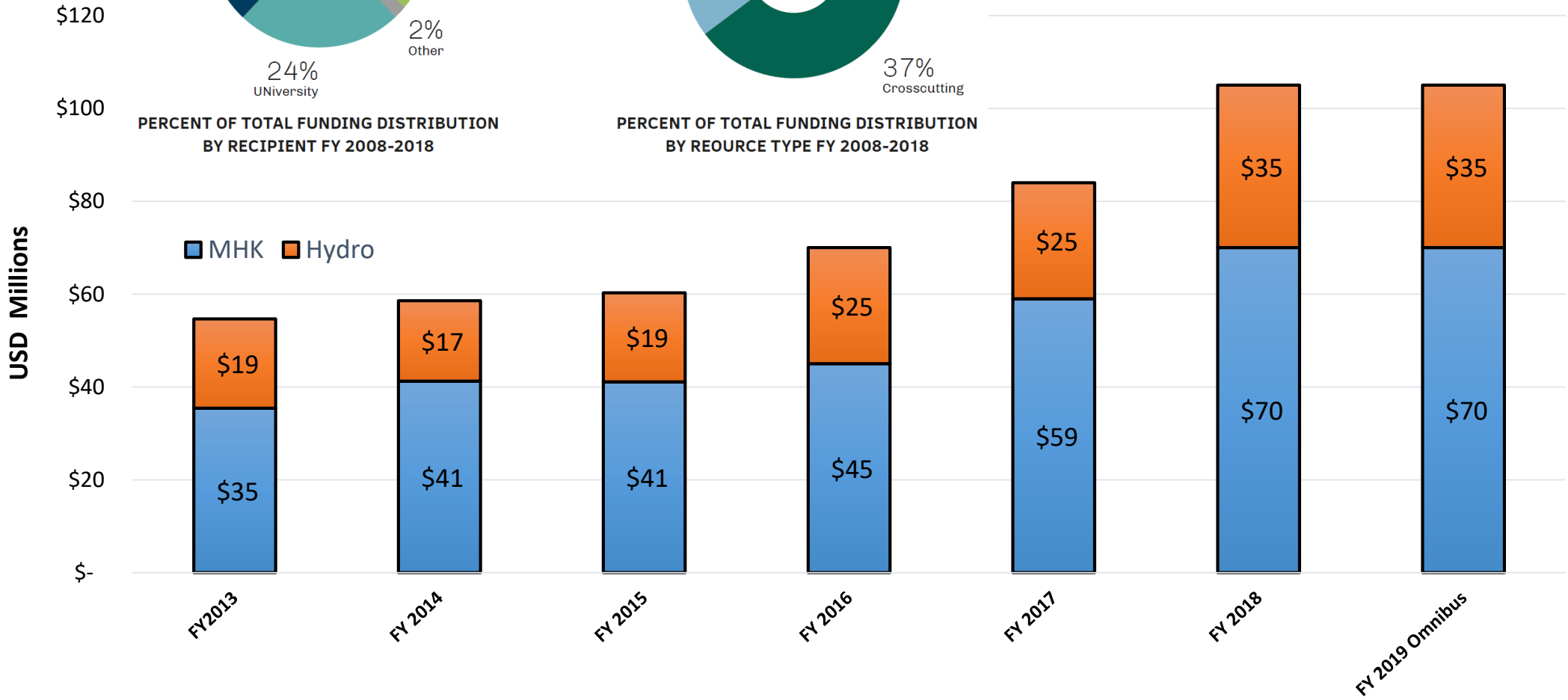
U.S. DOE Marine Energy Funding



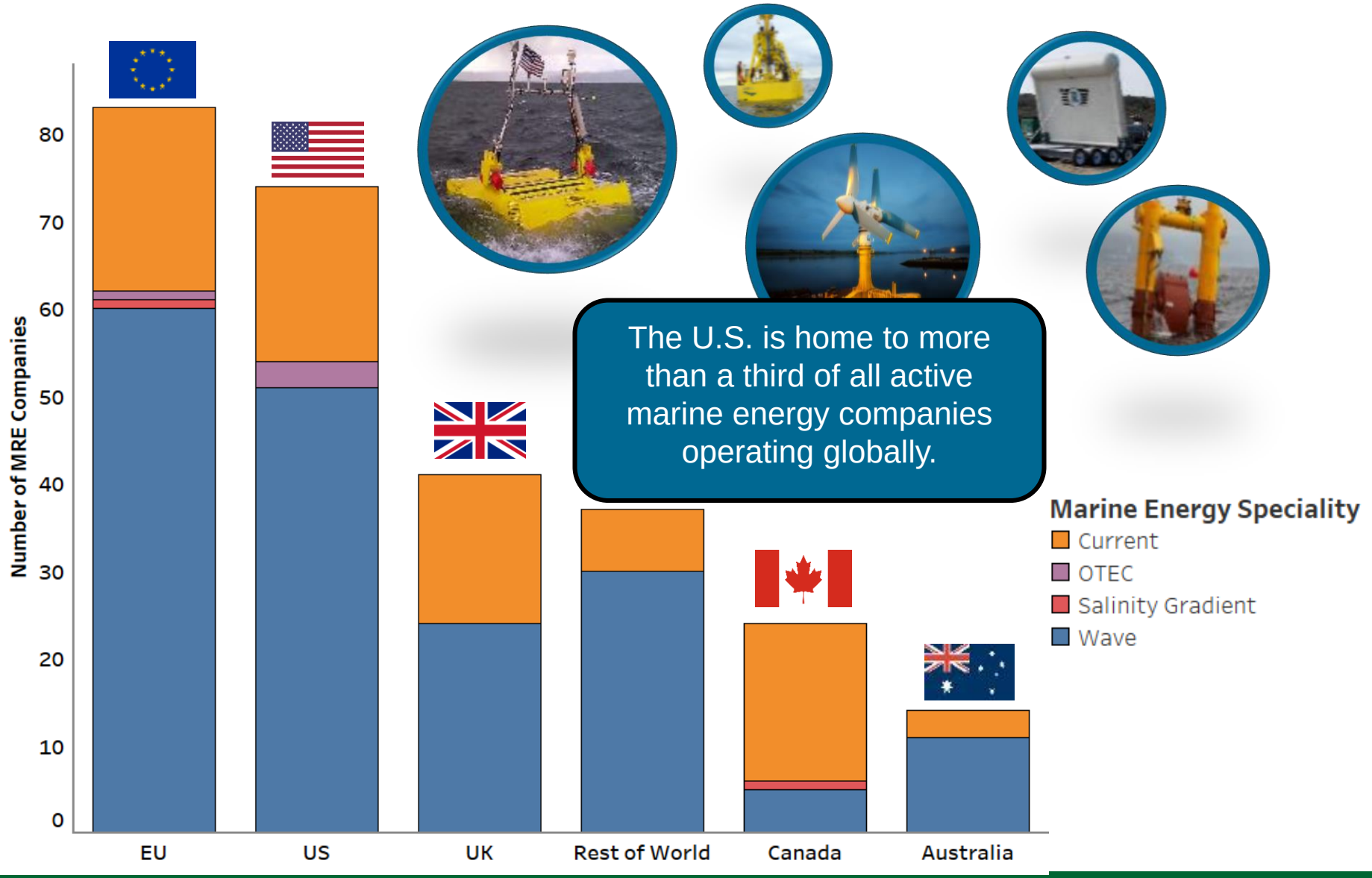
PERCENT OF TOTAL FUNDING DISTRIBUTION BY RECIPIENT FY 2008-2018



PERCENT OF TOTAL FUNDING DISTRIBUTION BY REOURCE TYPE FY 2008-2018

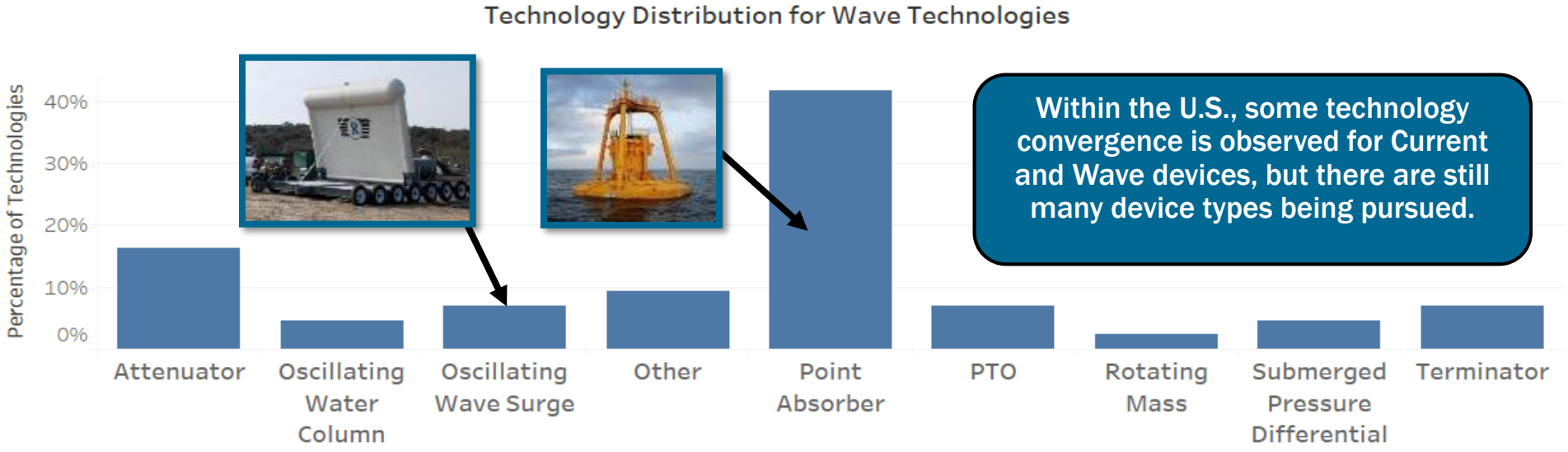


Global Marine Energy Industry

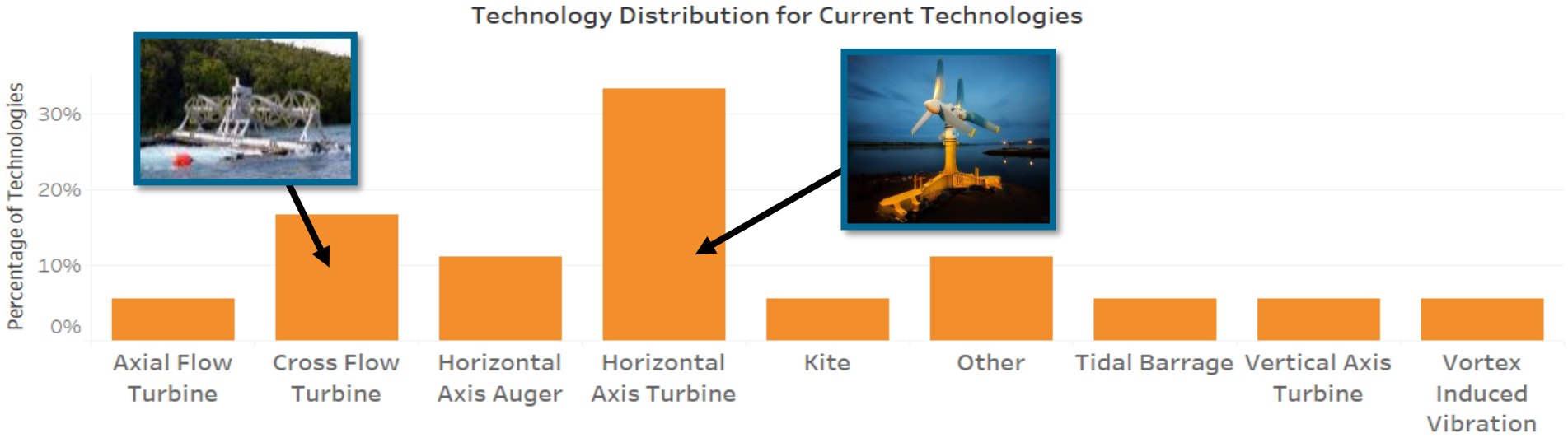


Significant U.S. Marine Energy R&D Base

U.S. Marine Energy Technologies



Within the U.S., some technology convergence is observed for Current and Wave devices, but there are still many device types being pursued.



Recent U.S. Tidal and Current Energy Developments

Verdant Power operated a grid-connected demonstration array of six KHPS turbines (1.05 MW) in the East River near NYC, referred to as the RITE Demonstration. In December 2006, the first grid-connected KHPS turbine was installed, followed by the other five turbines in 2007 marking the world's first grid-connected array of tidal turbines. With DOE funding Verdant is currently advancing their latest design for future testing at this site scheduled for Spring 2020.

ORPC has been developing the Western Passage Tidal Energy Project that will feature 15 tidal turbines, each consisting of a 500 kW turbine-generator unit. The project is expected to deliver 3.5 GWh annually to the local grid. ORPC received a preliminary permit from FERC for the project in 2016. A 30 kW RivGen device was deployed in the Summer of 2019.

MRECo –Bourne Bridge Tidal Test Site (BTTS) Bourne, MA

The **Bourne Tidal Test Site** (BTTS), located in Cape Cod Canal, was established in 2017 and in 2018 was allocated a $205k grant. The test site is currently in the process of obtaining a FERC license to obtain grid interconnection.

UNH/CORE–Tidal Energy Test Site –Portsmouth, NH

Living Bridge Project. At the General Sullivan Bridge, located in Portsmouth NH, the project team completed design and fabrication of a new testing platform in 2018 for testing small scale tidal energy devices.

Recent U.S. Wave Energy Developments

Ocean Energy USA (OE): A 500 KW OE Buoy, an oscillating water column design, has completed construction at Vigor Shipyard in Oregon and is slated for testing in 2019 at WETS. The deployment will last approximately one year and will provide useful performance data for model validations, reliability performance, and opportunities for cost reductions.

Columbia Power Technologies (C-Power):C-Power has completed physical testing of its novel, direct-drive PTO at NREL. The PTO, which includes a 6.5 m diameter, 4 mm airgap, permanent-magnet 500 kW generator, is being updated in preparation for use in their grid connected, open-water testing at WETS in 2021.

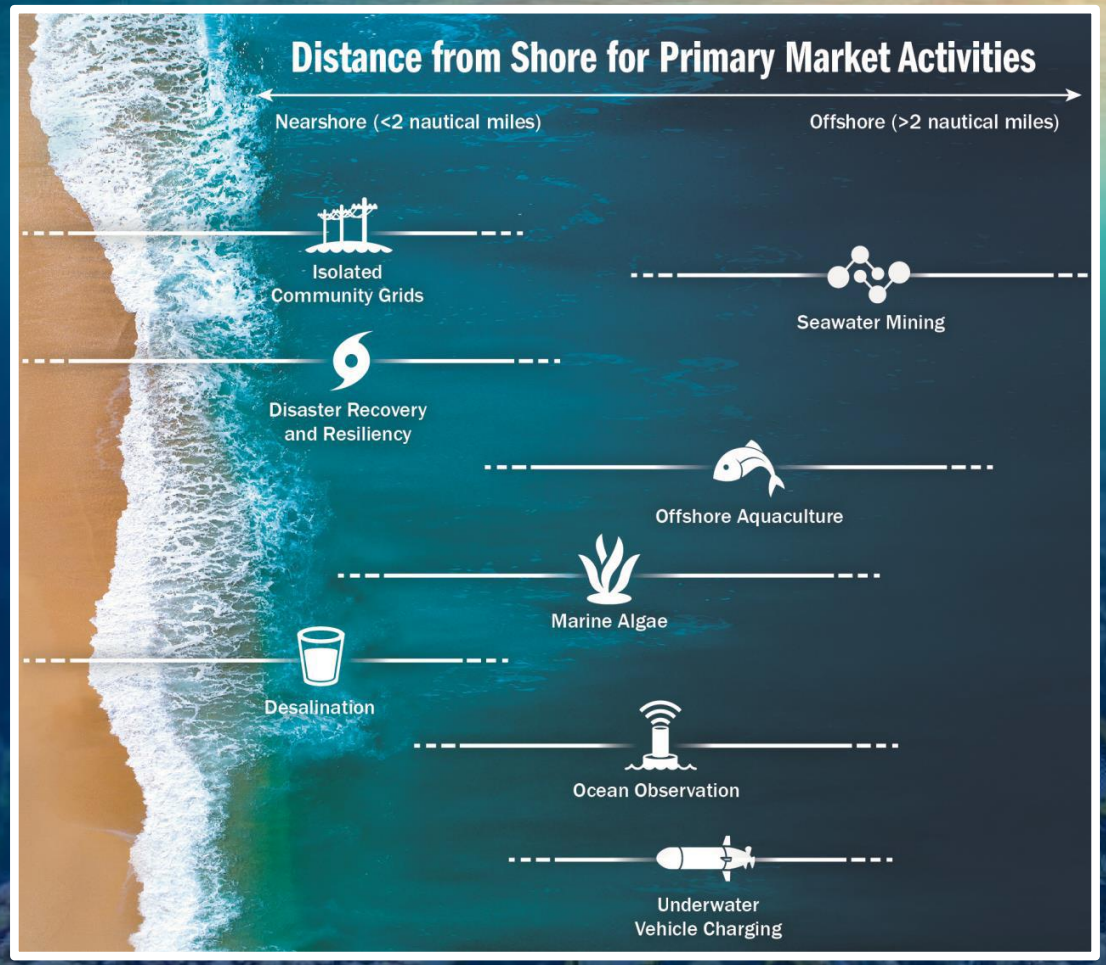
Ocean Power Technologies (OPT) has a contract to supply Oil & Gas company, Premier Oil, with one of its PowerBuoy systems for the deployment in an oil and gas field in the Central North Sea. The PowerBuoy will serve as an intelligent platform to provide communications and remote monitoring services at the site in support of Oil & Gas operations. OPT is targeting a deployment date in the summer of 2019. (Not affiliated with WPTO)

Oscilla Power: Oscilla Power is developing a point absorber with a heave plate type WEC called the Triton WEC. The company has done extensive testing at scale and recently concluded WPTO-funded testing on survivability design methodologies. The company is aiming to test their system in the first half of 2020 at WETS in Hawaii.

Both **AquaHarmonics** and **CalWave**, first and second place winners of the 2016 Wave Energy Prize respectively, have been advancing their designs. CalWave is planning to test a scaled version of their WEC off the coast of California in 2020, while AquaHarmonics is planning to test a scaled version of their WEC at WETS in 2021.

Powering the Blue Economy Report

https://www.energy.gov/eere/water/powering-blue-economy-exploring-opportunities-marine-renewable-energy-maritime-markets



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water.energy.gov

May 19-21, 2020

ICOE INTERNATIONAL CONFERENCE ON OCEAN ENERGY

2020 Washington, D.C

NHA OES

THANK YOU!

Public FCTO (H_2) Annual Merit Review is the same week as ICOE2020 – see their entire project portfolio

Bill McShane, Marine Energy Technology Manager — Water Power Technologies Office

william.mcshane@ee.doe.gov

You can reach out **to WPTO** to ask a question, offer feedback, or request a meeting by writing to waterpowertechnologiesoffice@ee.doe.gov

ORPC 35 kW RivGen Deployed

- In June 2019, the Alaska village of Igiugig became the first U.S. tribal entity to receive a Federal Energy Regulatory Commission permit for a water-powered project not connected to a dam.

- On July 16, **Igiugig Village**, in partnership with **Ocean Renewable Power Company**, deployed a 35-kW cross-flow turbine (RivGen Power System) in the Kvichak River

- The RivGen device could provide up to half of the community's electricity and greatly reduce its dependency on costly diesel fuel. Plans are underway for installation of a second RivGen device in conjunction with smart microgrid electronics and energy storage. When completed, the system will reduce diesel usage by 90 percent.

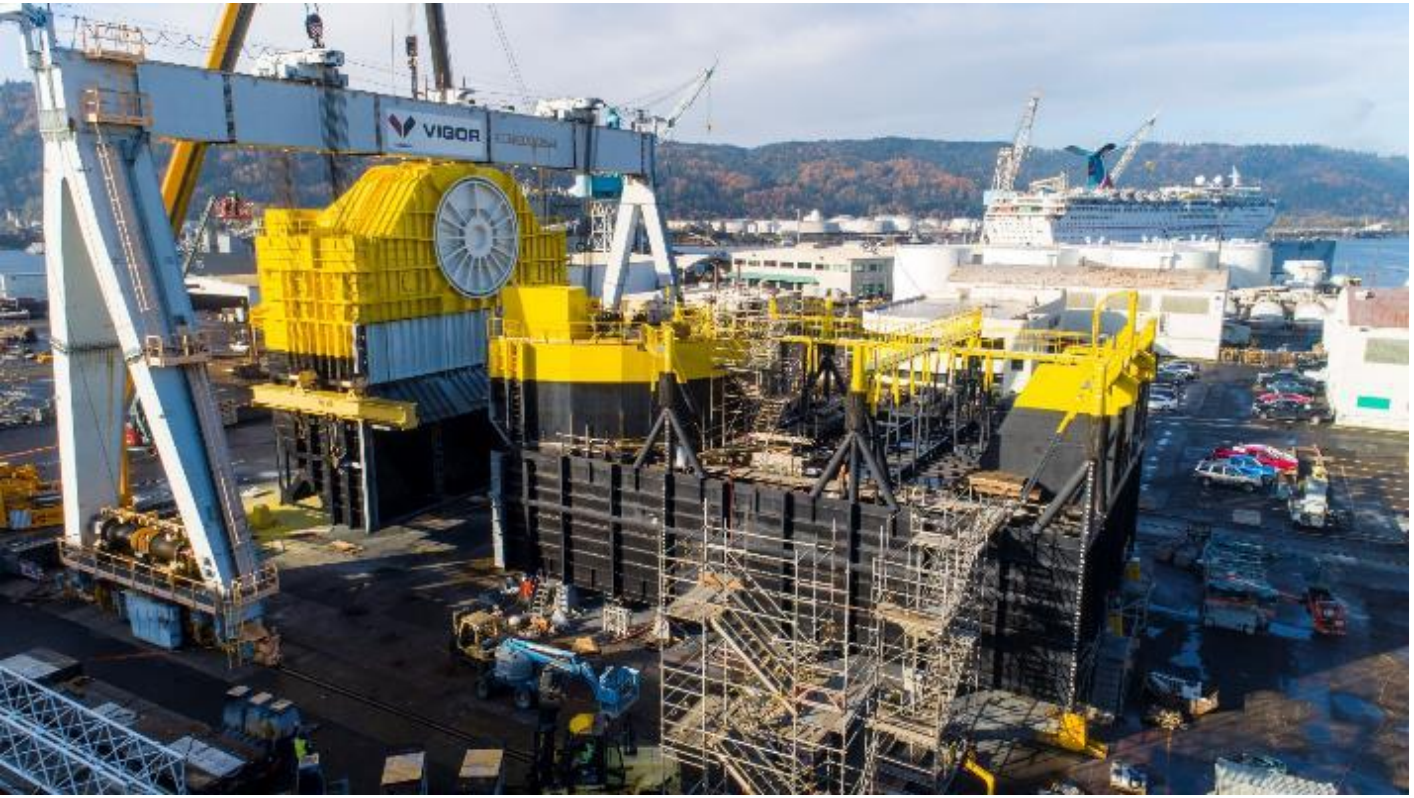
OPT 3 kW PB3 Deployed in North Sea

- **Ocean Power Technologies** (the only publicly-listed wave energy company in the US), in partnership with the Acteon Group, has recently unveiled the PB3 PowerBuoy in Montrose – prior to its demonstration in the North Sea on Premier's Huntington field.

- During the field trial, the PB3 will be deployed on Premier's Huntington field to support oil field decommissioning activities.

- OPT notes that the PB3 can be equipped with different payload configurations, such as to support small field developments or as a charging/communications hub for Autonomous Underwater Vehicle (AUV) applications.

Ocean Energy 500 kW Buoy



- Built at Vigor Iron Works in Portland, OR, preparing for a tow to Hawaii where it will be tested for a year at the U.S. Navy's Wave Energy Test Site (WETS)
- Ocean Energy received WPTO funding in 2013 to research alternative manufacturing methods for its OceanEnergy Buoy hull.
- The 35-meter device will have a 500-kilowatt HydroAir turbine designed by Dresser Rand. The turbine has its own controls system and has already been successfully tested at sea in Galway Bay, Ireland.

US DOE and Ireland's Sustainable Energy Authority are both providing research funding that will support the in-water testing of the new OceanEnergy Buoy.