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Marcus@calwave.energy

Fulltime team since 2014

CALWAVE

Marcus Lehmann, MBA
CEO, 2014

cyclotronroad SIEMENS
Forbes 30 UNDER 30

Dan Petcovic, MS, P.E.
COO, joined 2018

LOCKHEED MARTIN

Thomas Boerner, PhDc
Technical Lead, 2014

Berkeley UNIVERSITY OF CALIFORNIA
Rexroth Bosch Group

Nigel Kojimoto, MS
Lead Mechanical Design, 2014

MIT
HNEI Hawai'i Natural Energy Institute
School of Ocean and Earth Science and Technology
University of Hawai'i at Mānoa

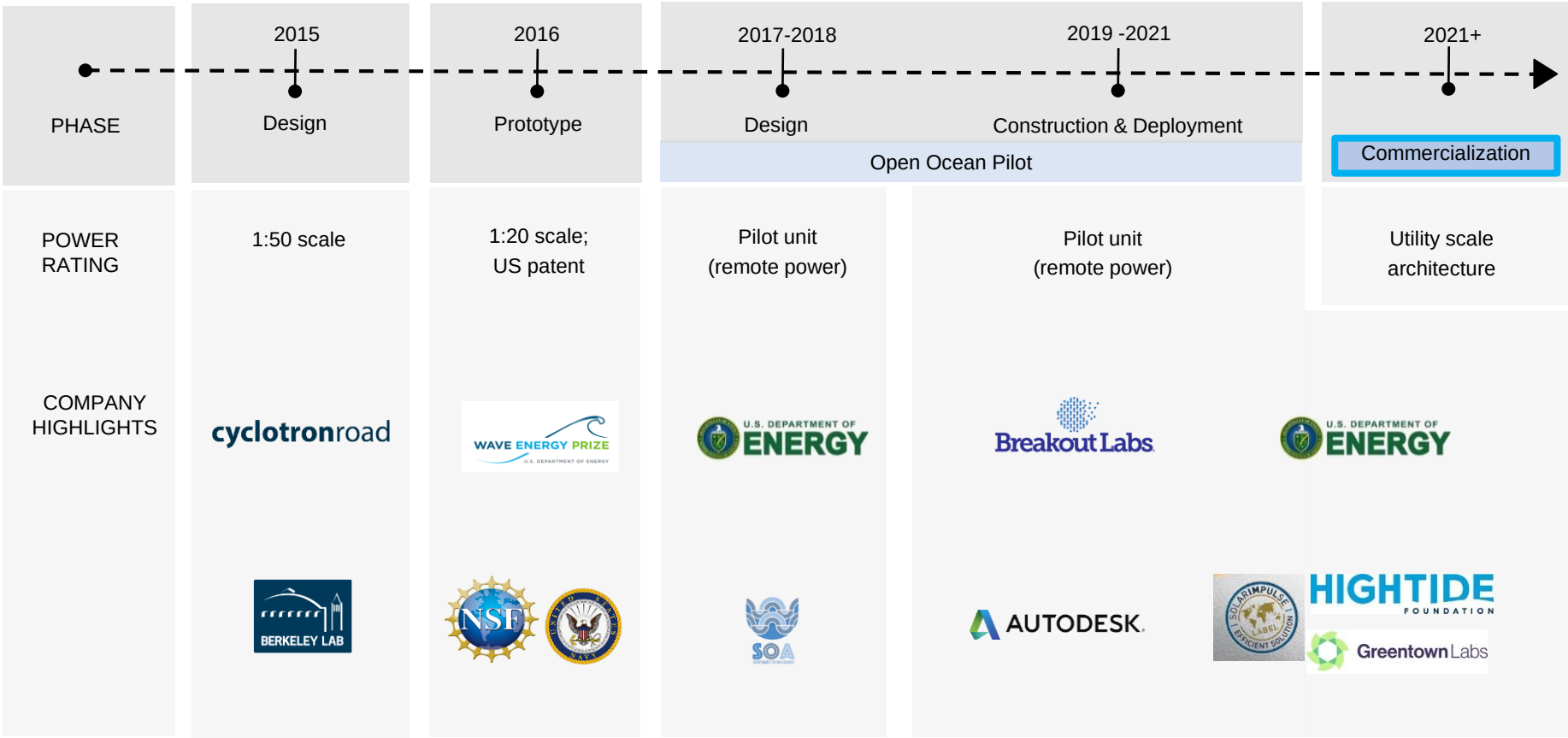
Bryan Murray, BS
Lead Power Electronics, 2014

NOAA
VT

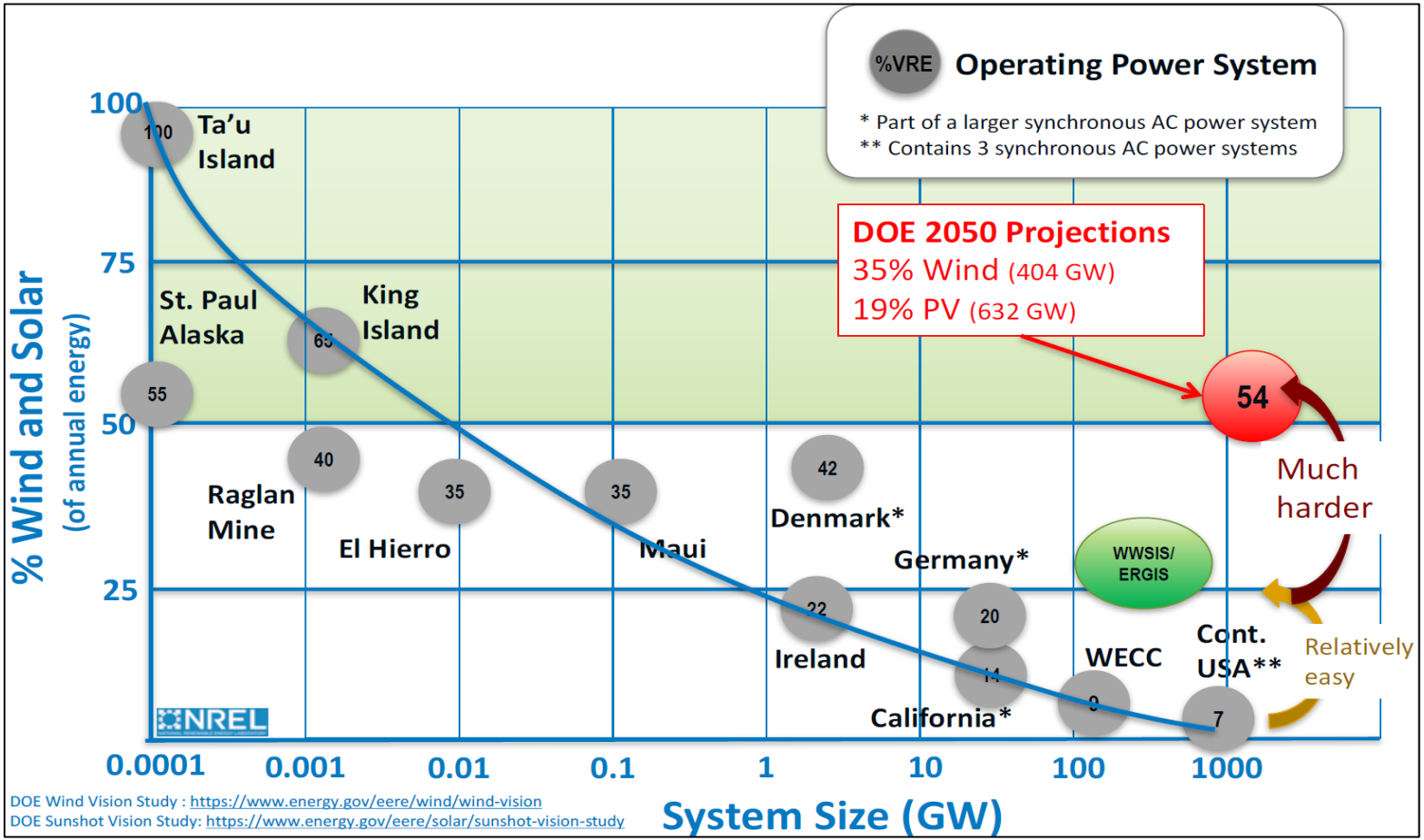
Josiah Clark, BS
Mechanical Design, 2019

Stanford University

CalWave's Timeline



Motivation & Opportunity



100% renewables requires diversification

1. Solar

2. Wind

AND . . .

3. WAVE POWER

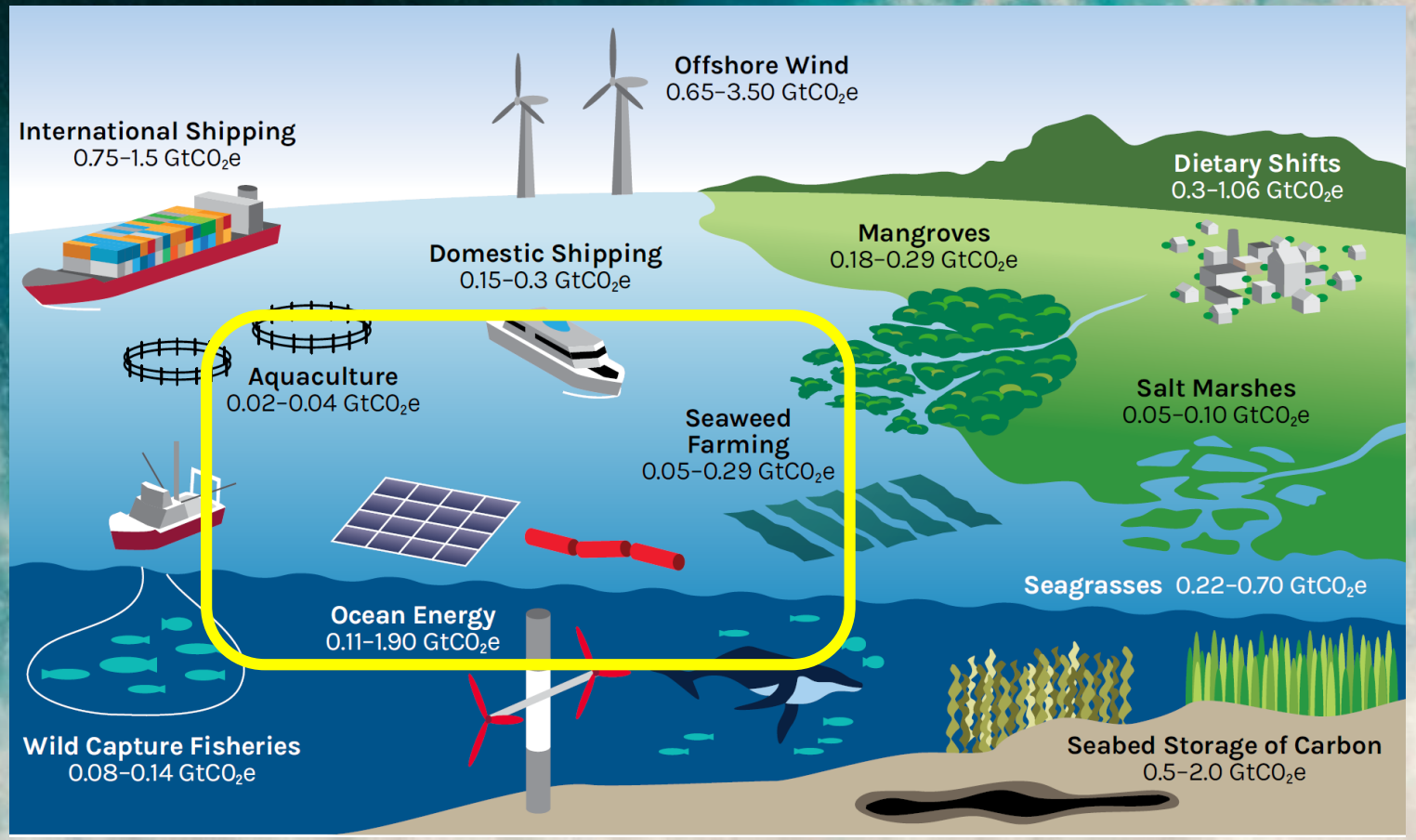
~50x
Denser

Consistent

Predictable

Ocean based solution to tackle climate change:

CalWave Power Technologies

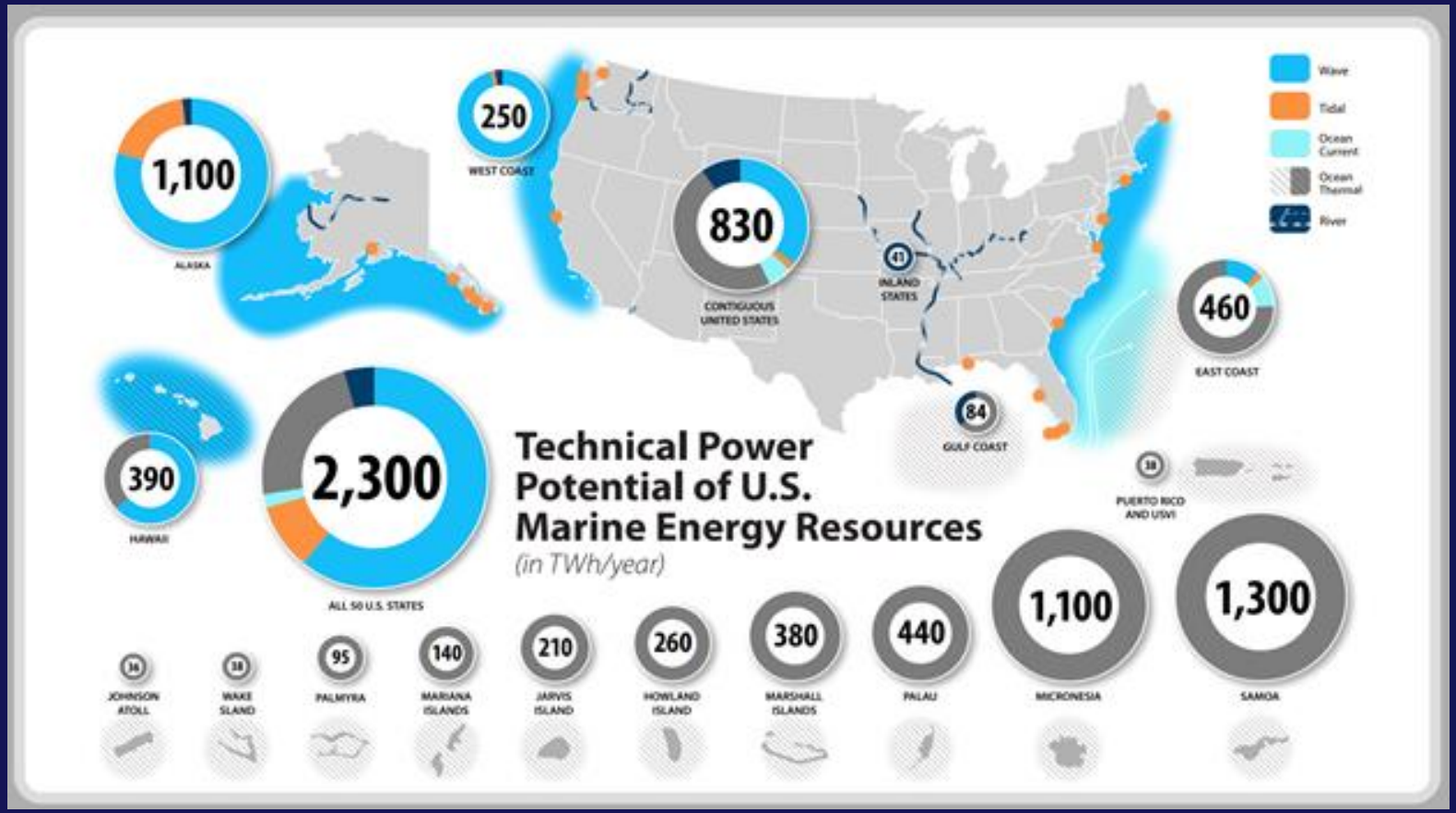


Motivation & Opportunity

Emissions of selected electricity supply technologies in gCo2eq/kWh.
Source: IPPC, 2018.

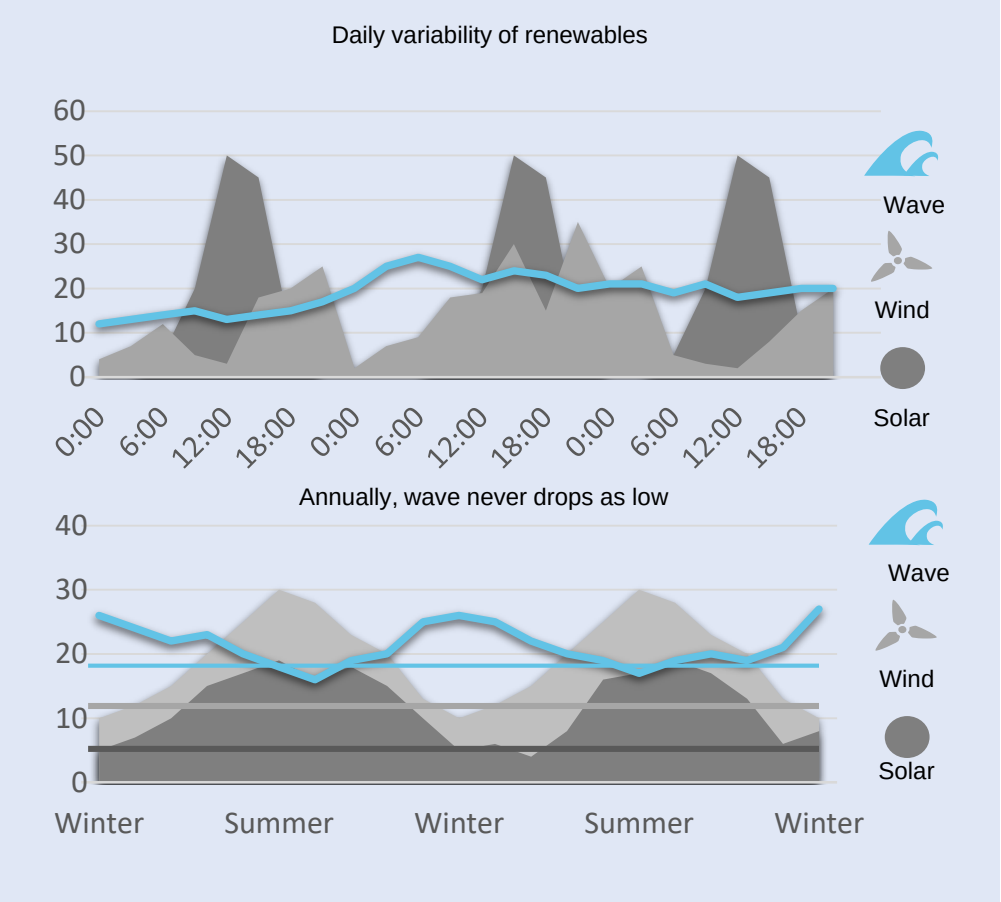
Options	Direct emissions	Infrastructure & supply chain emissions	Lifecycle emissions (incl. albedo effect)
	Min/Median/Max		Min/Median/Max
Currently Commercially Available Technologies			
Geothermal	0	*45*	**6.0/38/79**
Hydropower	0	*19*	**1.0/24/2200**
Nuclear	0	*18*	**3.7/12/110**
Concentrated Solar Power	0	*29*	**8.8/27/63**
Solar PV—rooftop	0	*42*	**26/41/60**
Solar PV—utility	0	*66*	**18/48/180**
Wind onshore	0	*15*	**7.0/11/56**
Wind offshore	0	*17*	**8.0/12/35**
Pre-commercial Technologies			
CCS—Coal—Oxyfuel	14/76/110	*17*	**100/160/200**
CCS—Coal—PC	95/120/140	*28*	**190/220/250**
CCS—Coal—IGCC	100/120/150	*9.9*	**170/200/230**
CCS—Gas—Combined Cycle	30/57/98	*8.9*	**94/170/340**
Ocean	0	*17*	**5.6/17/28**

Wave energy potential in the US

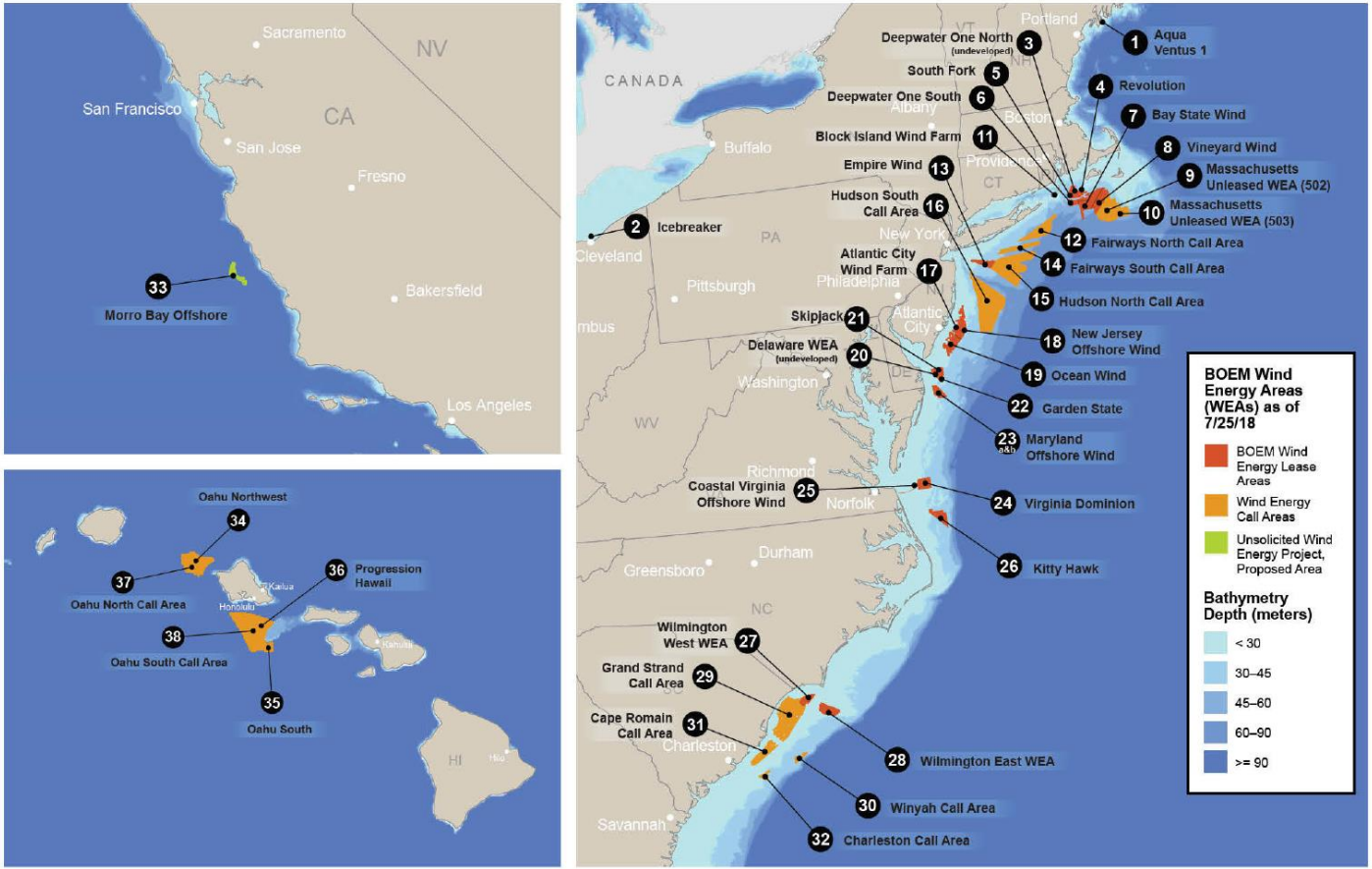


Wave power is stable and abundant

Wind and solar are volatile.



U.S. Lease and Call Areas



Map of U.S. Offshore Wind Lease and Call Areas

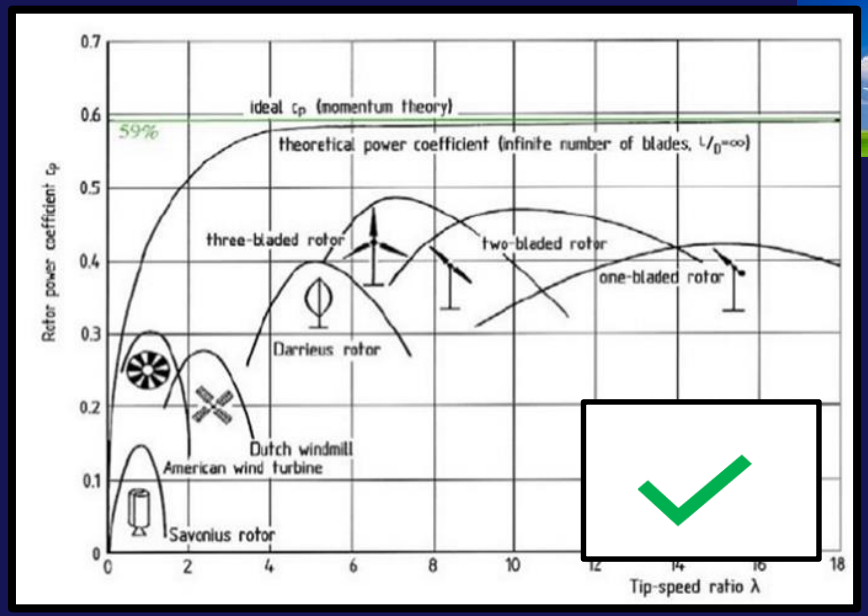
Beginning of Wind Power

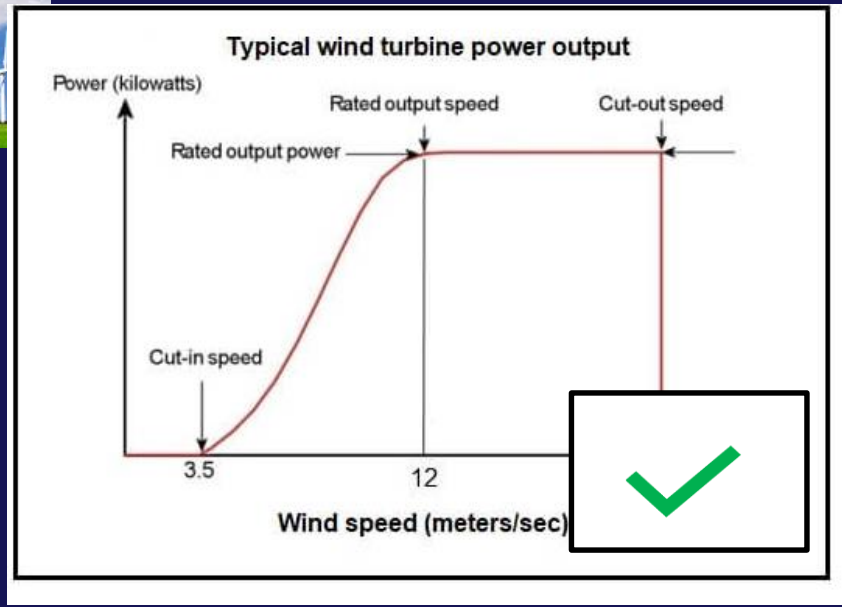



Main functions of a wind turbine

Main function 1:
High Annual Energy Production

Main function 2:
Device Load Management/Shut down

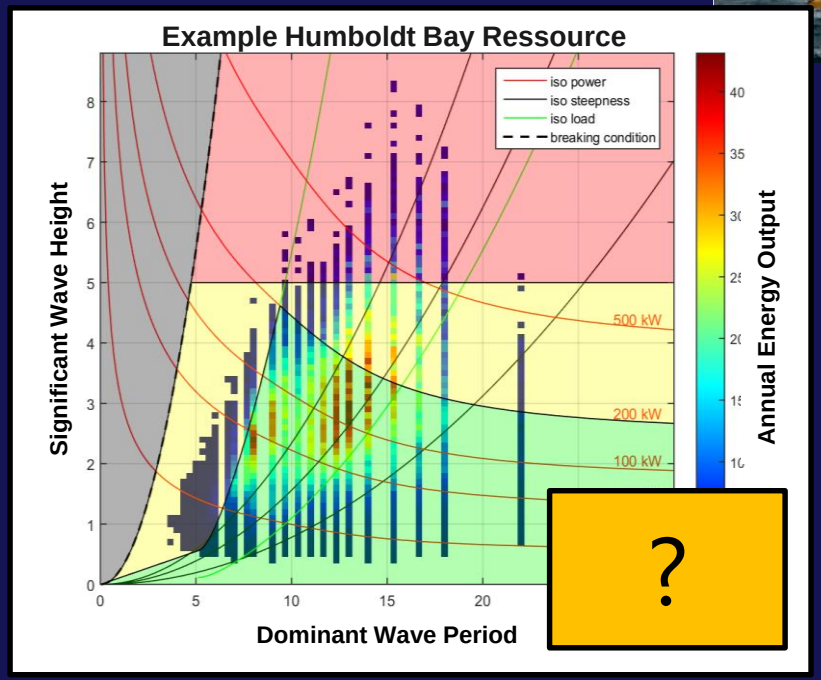


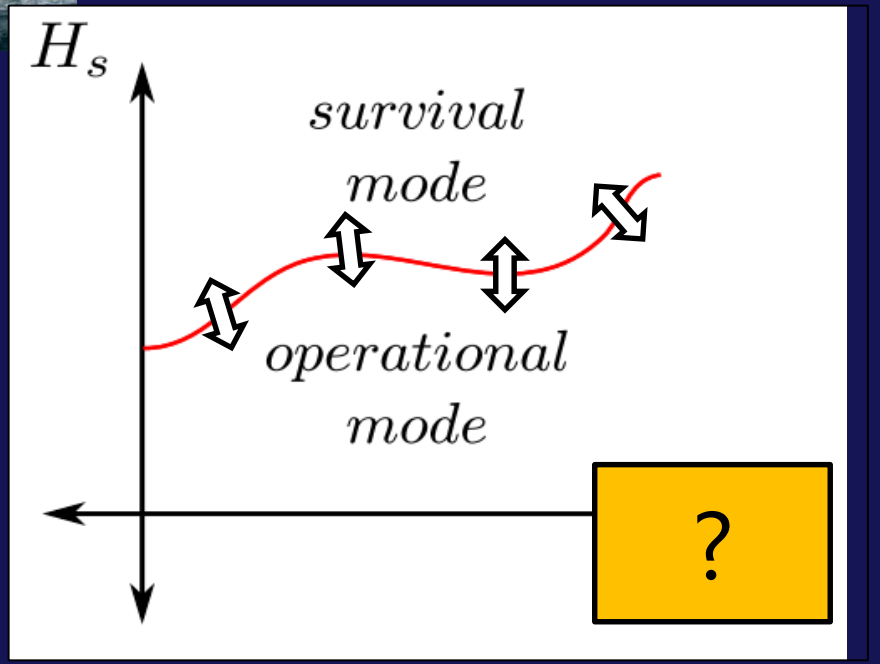


Main functions of a WEC

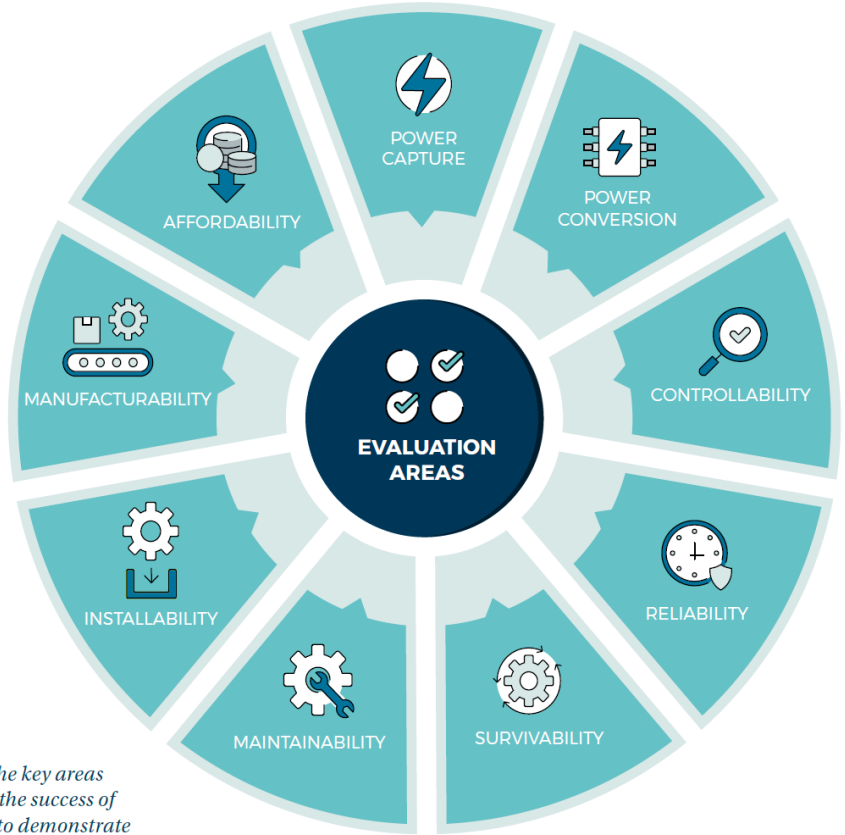
Main function 1:
High Annual Energy Production

Main function 2:
Device Load Management/Shut down



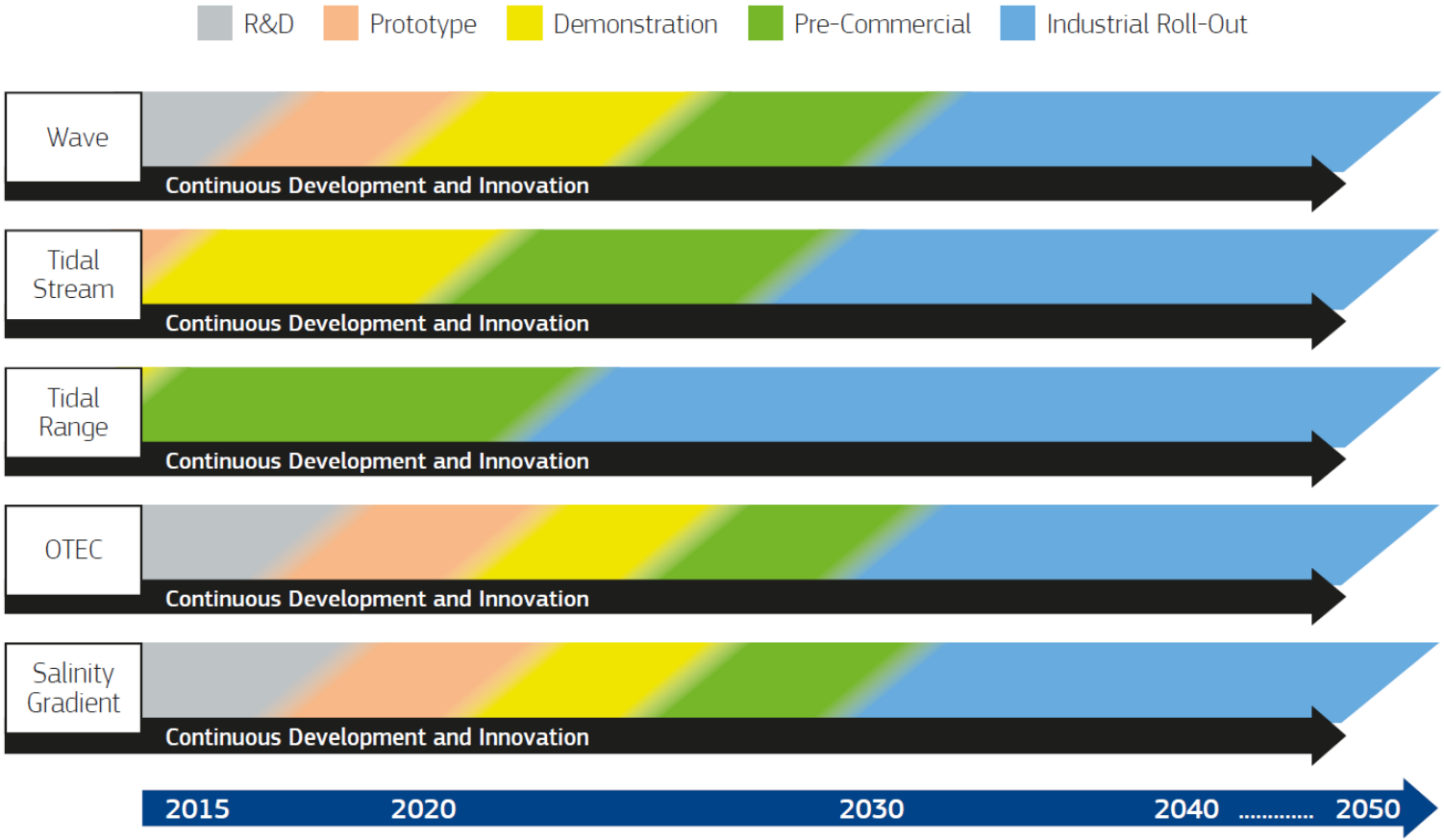


Secondary functions of a marine energy system



Evaluation Areas - The key areas in which to measure the success of technology, in order to demonstrate progress and achieved performance

TRL Status of ocean energy – 2015 (outdated)



2020 statistics

Tidal energy hits

60 GWh

power production milestone.

Global total

TIDAL STREAM

2020 INSTALLATIONS
865 kW

CUMULATIVE INSTALLATIONS
36.3 MW

WAVE ENERGY

2020 INSTALLATIONS
700 kW

CUMULATIVE INSTALLATIONS
23.3 MW

Tidal Energy – Commercial projects

2020 NY

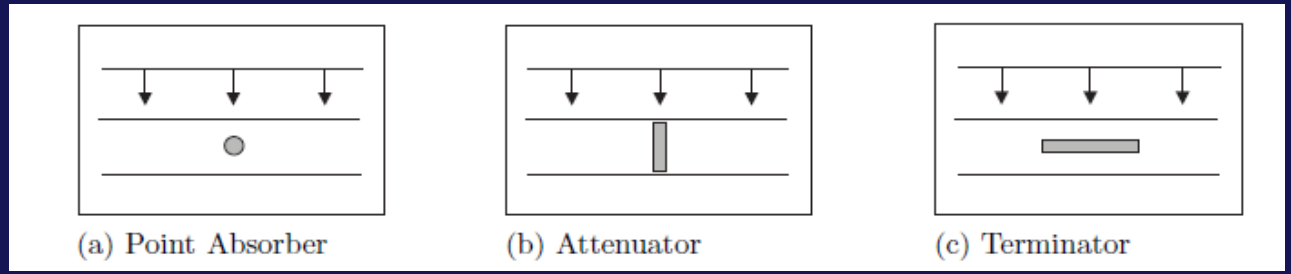
2020 Canada

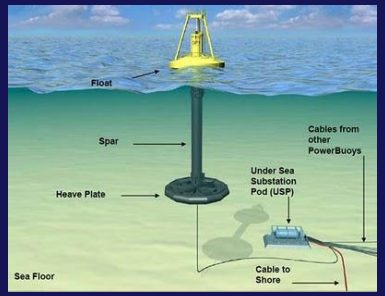
2020 AK

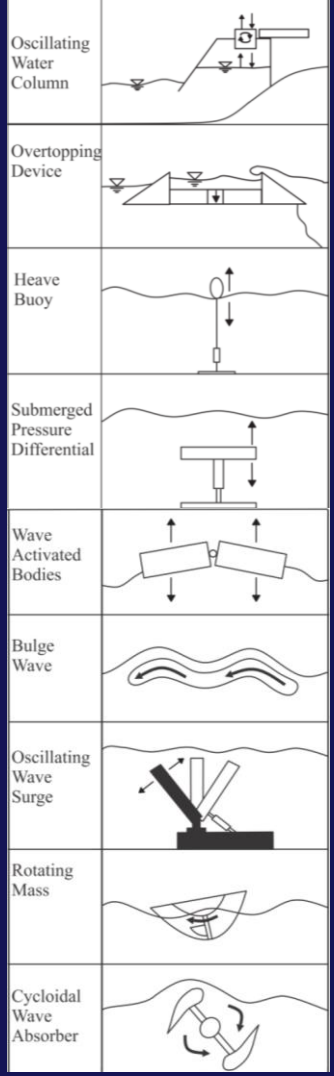
Bottom Piled
Atlantis
17.5 GWh
2020 Japan 500kW

Floating
Orbital Marine Power
3 GWh in 2016
R&D 2 MW since 2018
Construction in 2020

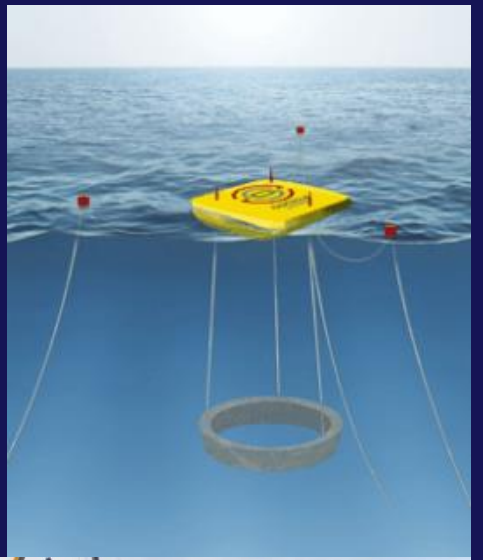
(WEC) Classification – Orientation





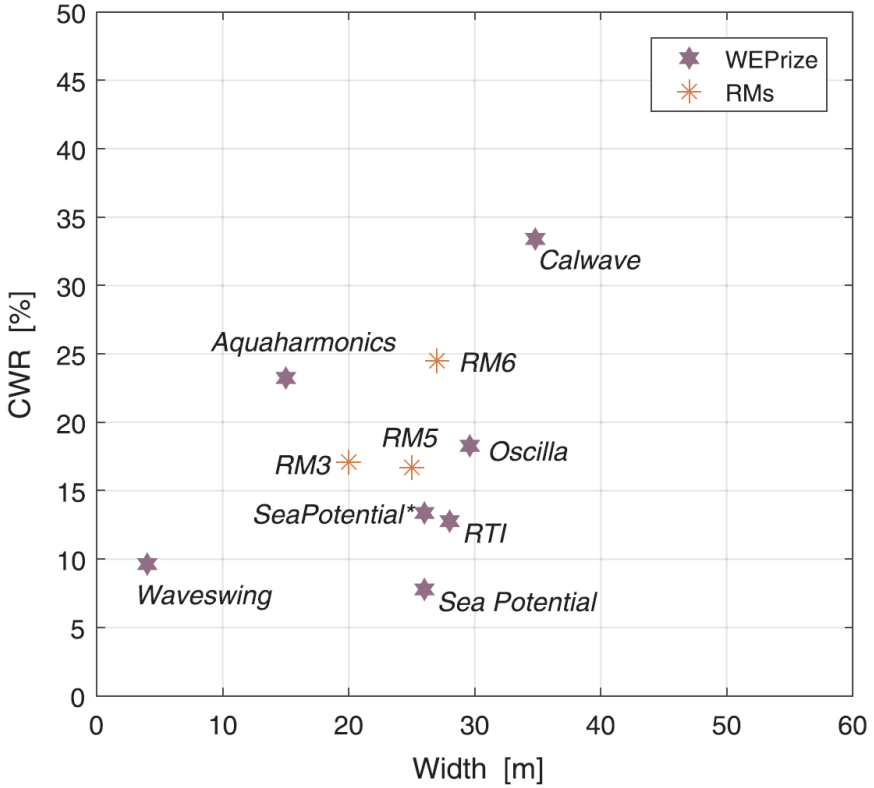


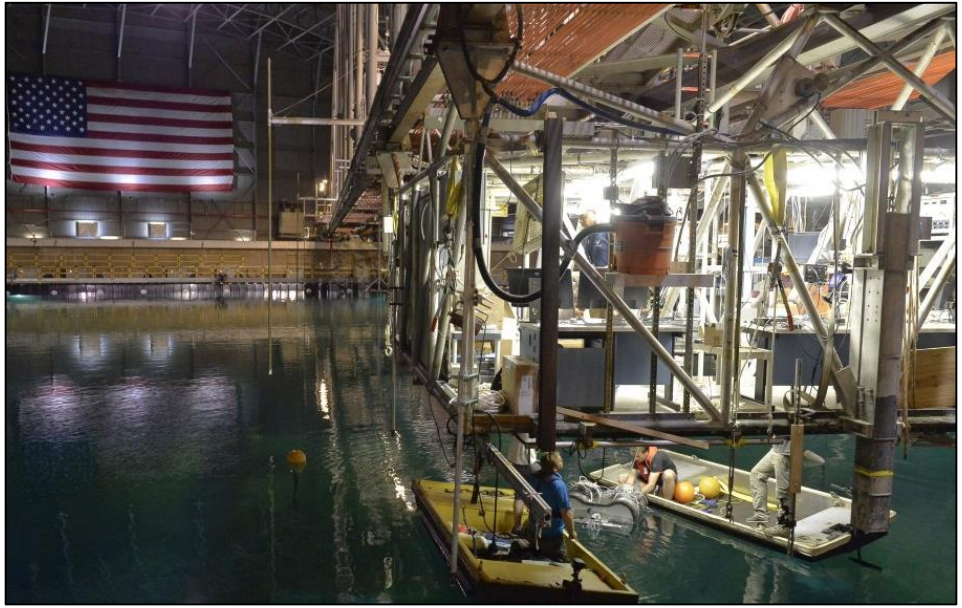
Active demonstrations




In 2015, DOE announces their search for the next generation.
WAVE ENERGY PRIZE
U.S. DEPARTMENT OF ENERGY
92 Teams entered the competiton.

US Wave Energy Prize – 92 teams

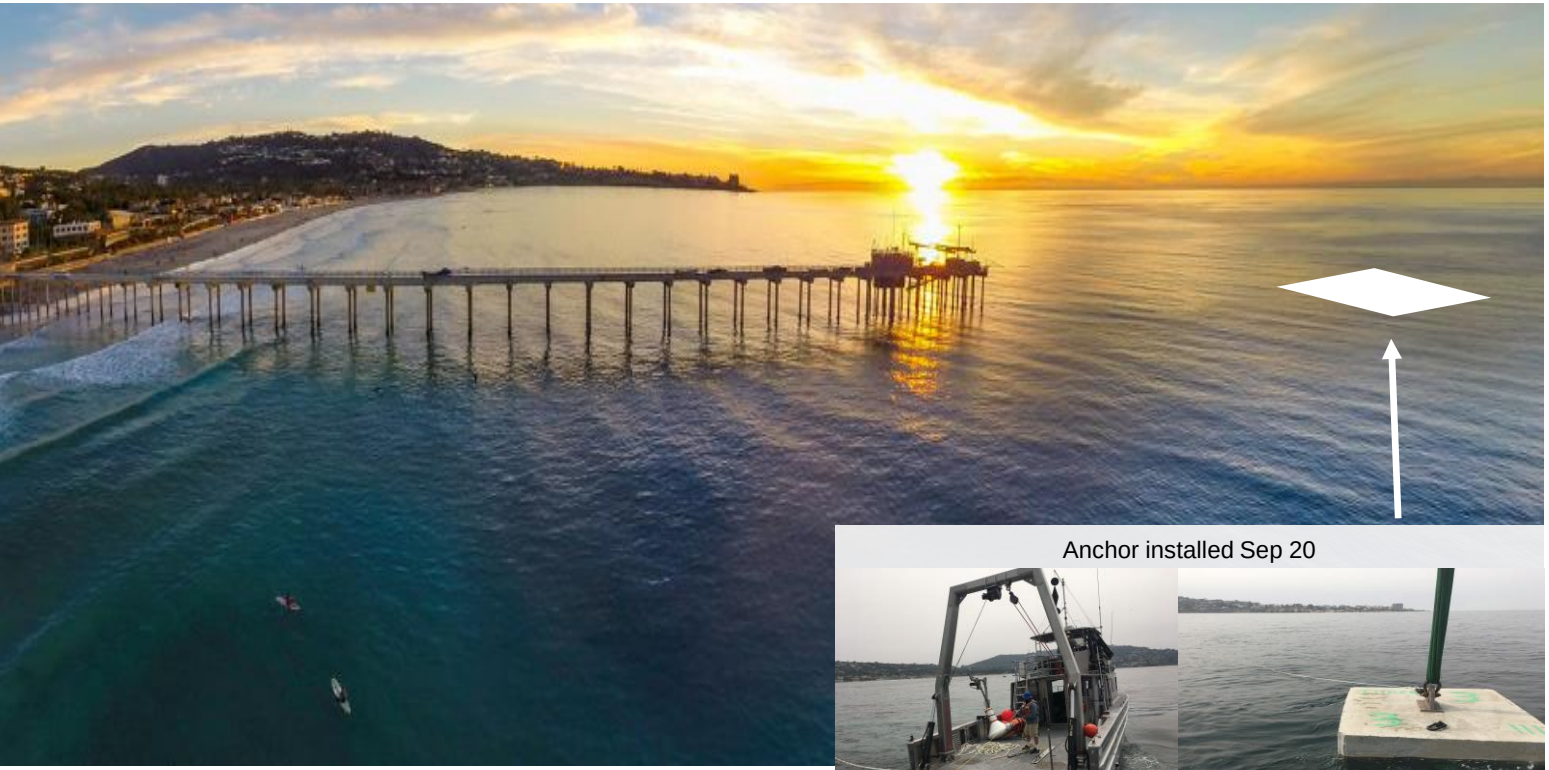




Calwave awarded

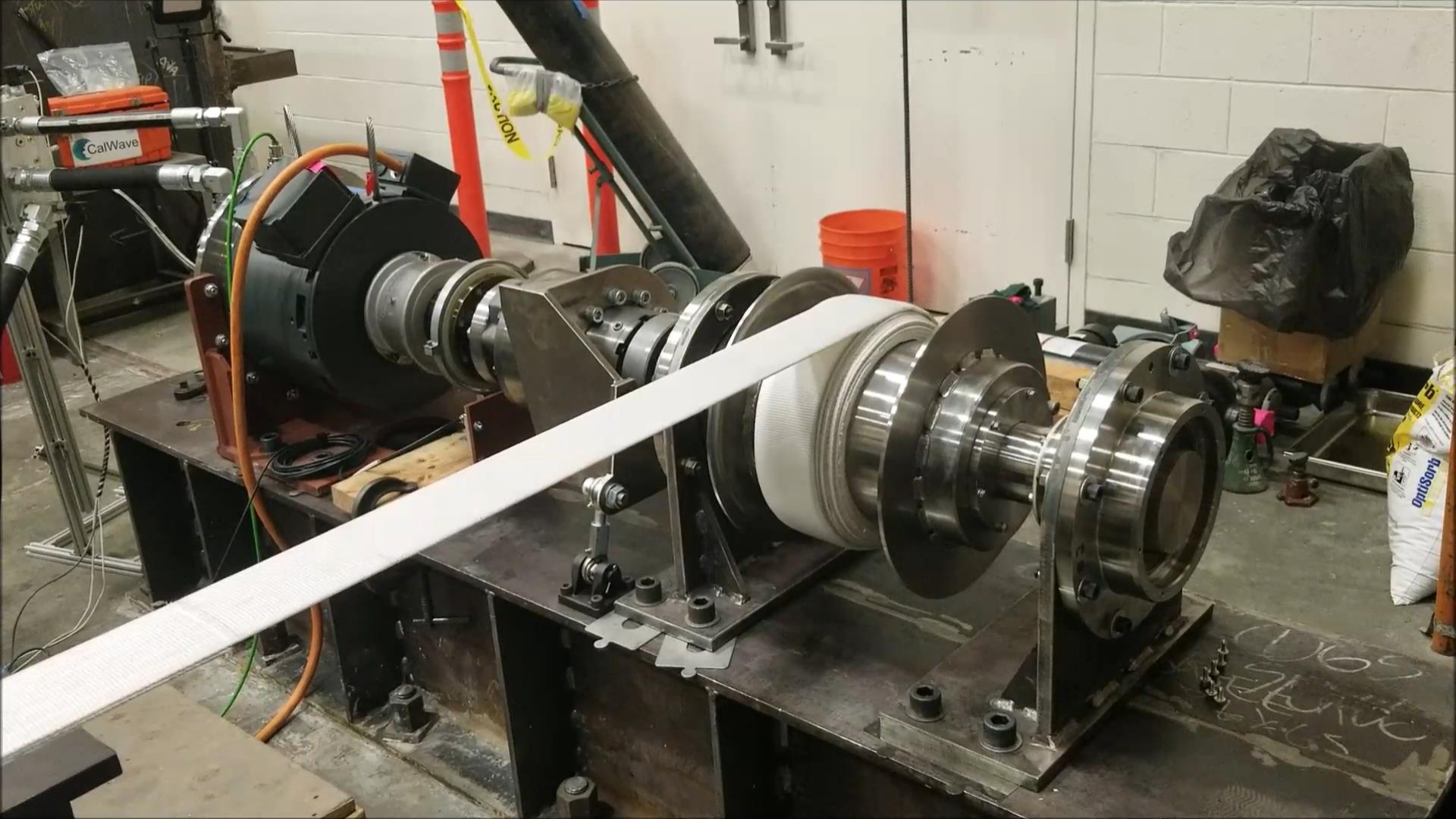
out of 92 teams!

Scripps Ocean Pilot Q2/2021

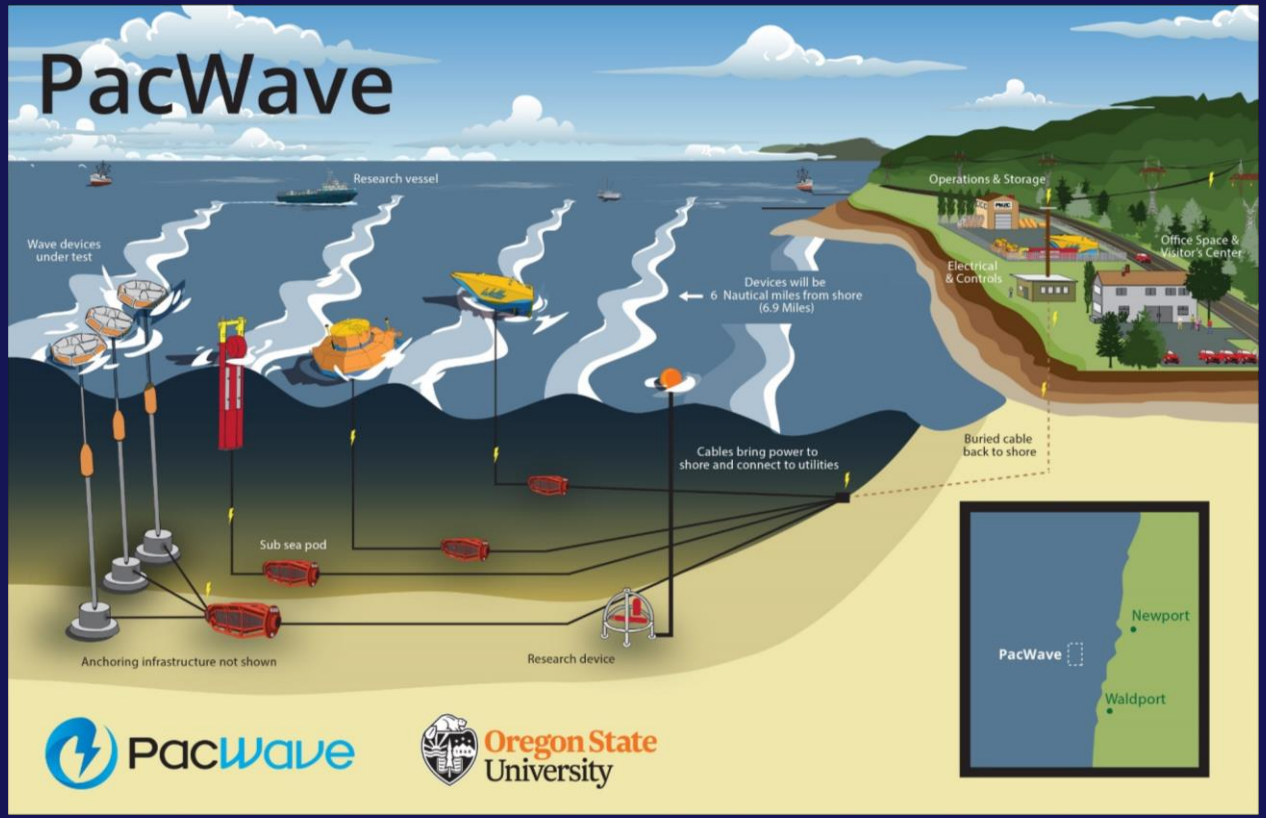


Anchor installed Sep 20

Project partners:


CalWave
OptiSorb

CalWave lined up for PacWave – 20MW test site



Location: Oregon

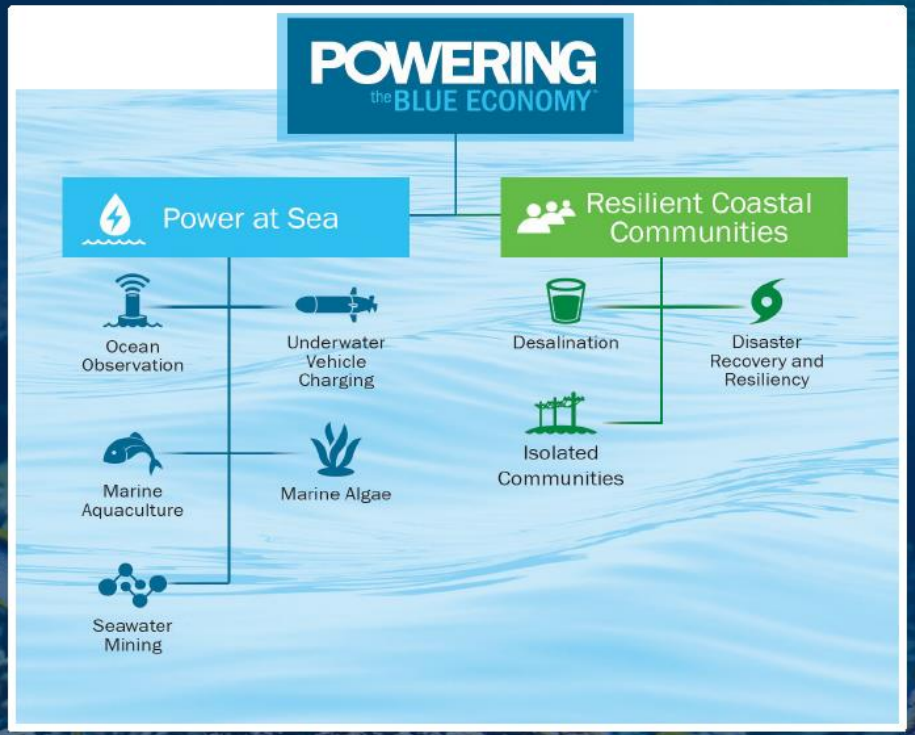
Depth: 60-80 m

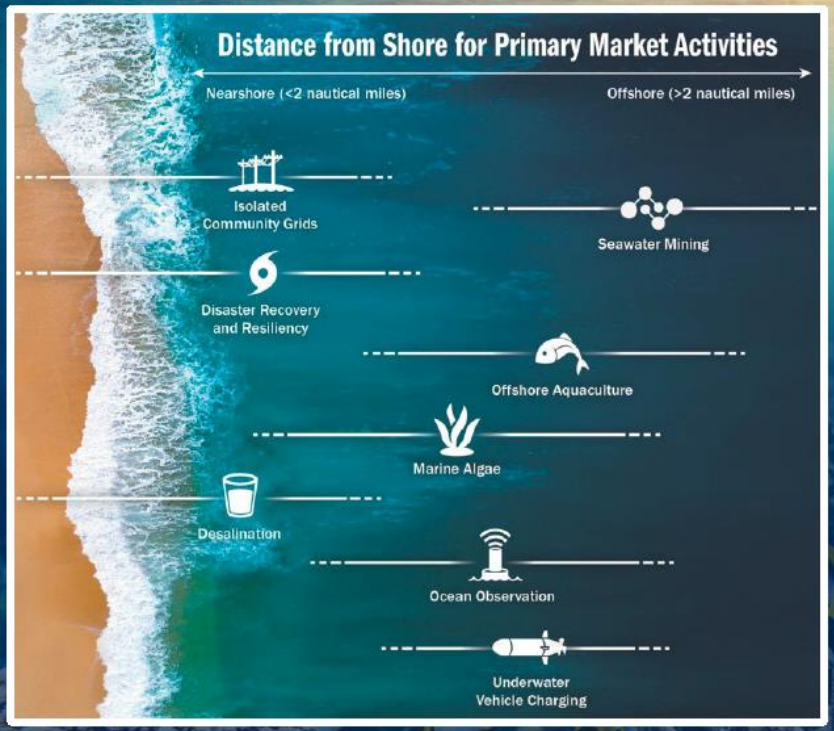
Capacity: 20 utility-scale WECs

http://pacwaveenergy.org/

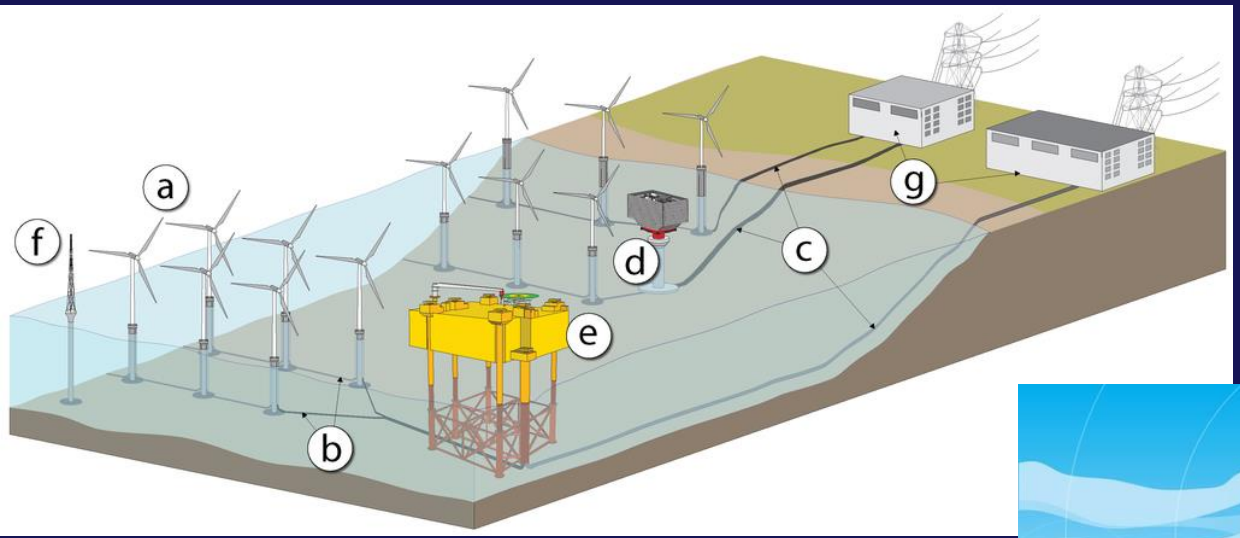
Exploring Coastal and Offshore Markets (Different Sets of Partners)

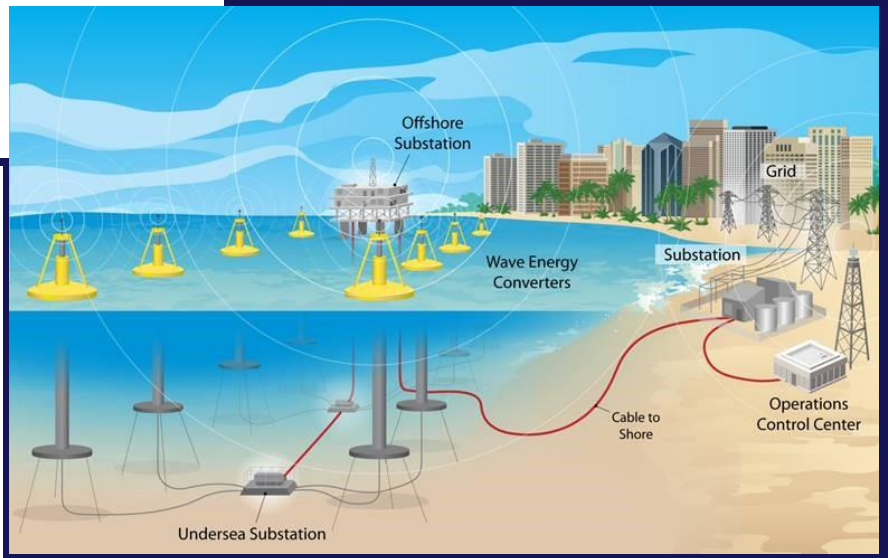
U.S. DEPARTMENT OF ENERGY



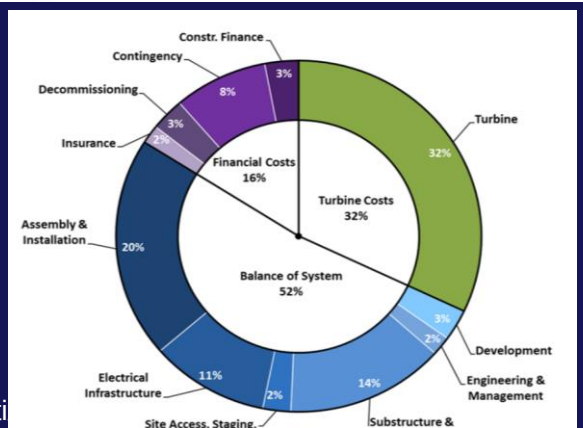


Outlook: Utility scale wind and wave farm layout



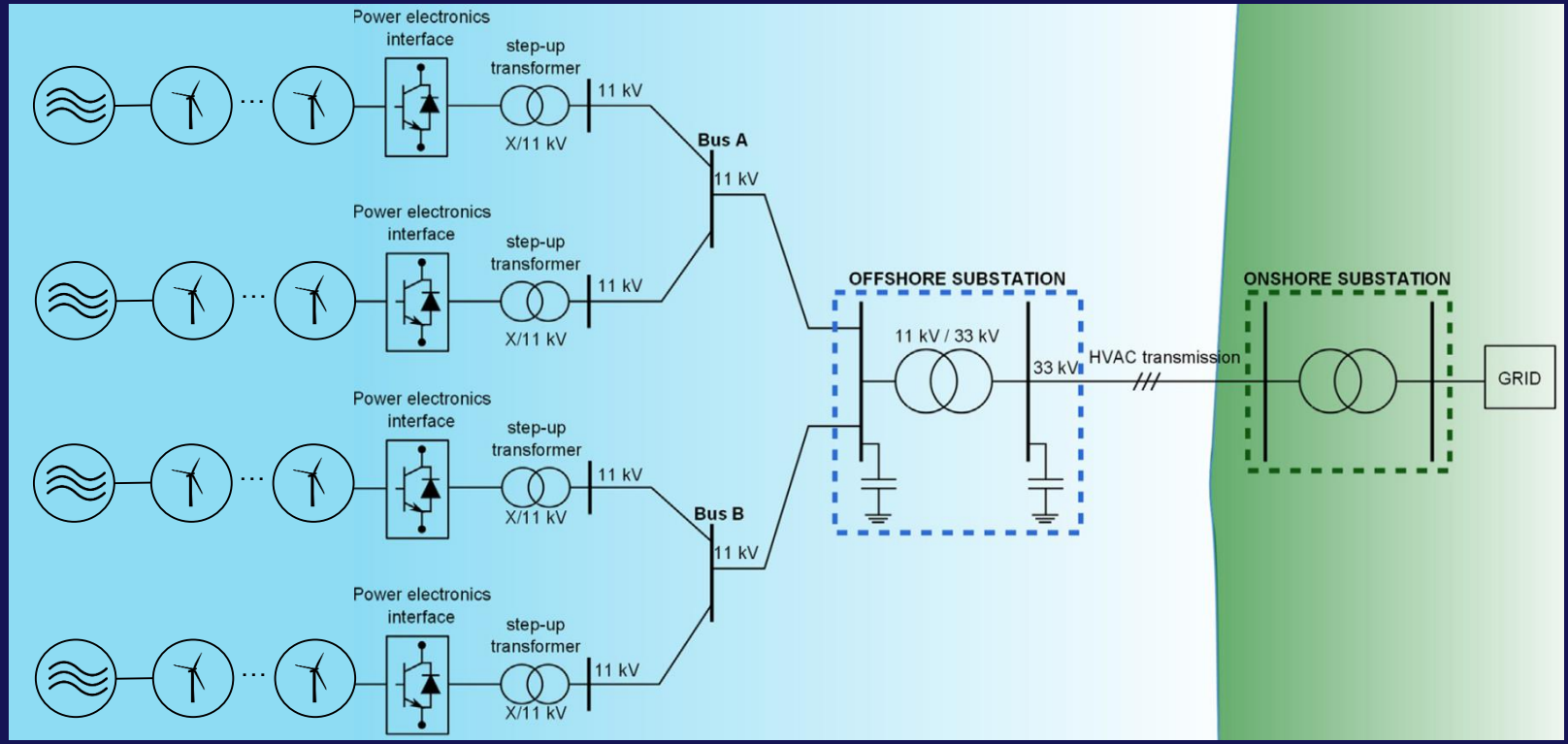


- **Total Cost – Turbine Cost = large of project development costs are mutual**

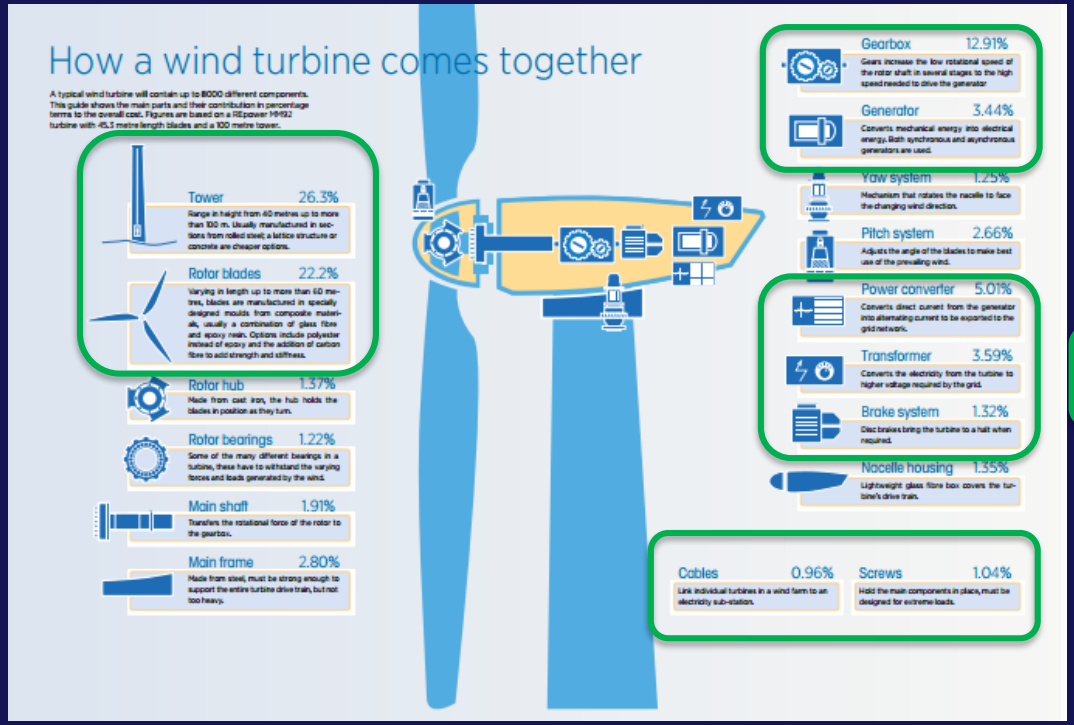


Source: NREL, https://www.nrel.gov/docs/fy15osti

Ideal layout of combined offshore wind and wave farm – wave shelters wind and reduces total CAPEX and OPEX for both!



Wind turbine CAPEX



Wave converter similar components

→ **Comparable manufacturing requirements –**
A tower manufacture can produce a wave converter hull

Source:
https://www.sciencedirect.com/science/article/pii/S1364032108001299

Lifecycle of an Offshore Wind Floating

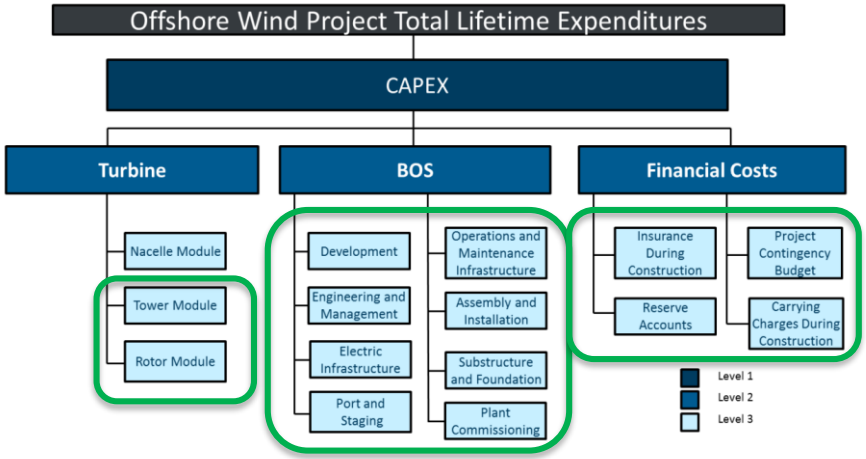


Figure 2. Wind system cost breakdown structure: CapEx levels 1 to 3

Wave farm similar CAPEX

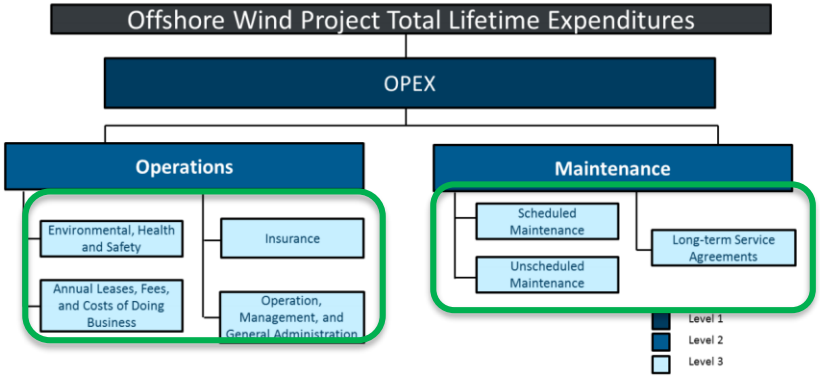


Figure 3. Wind system cost breakdown structure: OpEx levels 1 to 3

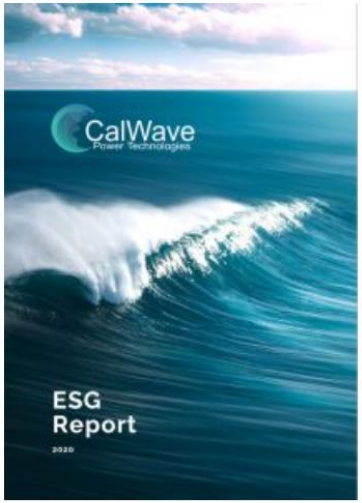
Source: NREL

Wave farm similar OPEX

Offshore hydrogen

CALWAVE

Please subscribe for ESG Report:



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