



PacWave

TESTING WAVE ENERGY FOR THE FUTURE

A Wave Energy Test Facility off Oregon, USA

Updated March 2021

- Wave energy overview
- PacWave overview
- PacWave South
- Wave energy technology
- Alternative applications
- Next steps



- Significant potential for wave energy
- Global marine energy market is projected to reach nearly \$700 billion by the year 2050, and the World Energy Council estimates that 10 percent of the worldwide electricity demand could be met by harvesting ocean energy
- Over 80% of this energy is estimated to be along the outer continental shelf
- Ocean waves are relatively constant and are increasingly predictable
- The US Department of Energy actively supports development of innovative technologies capable of generating renewable, environmentally responsible, and cost-effective electricity from US water resources, including waves

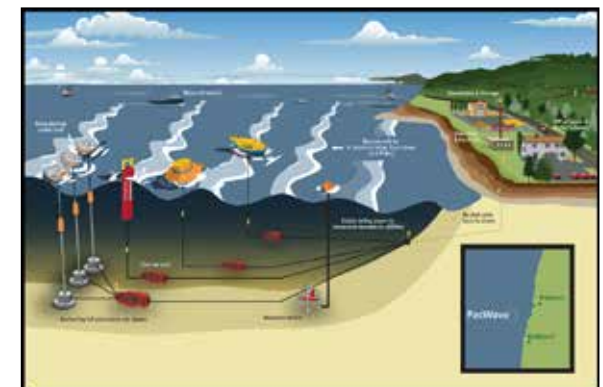


Oregon is uniquely positioned to be North America's leader in the emerging wave energy industry due to its:

- Wave energy resource
- Robust electrical transmission system located close to coastal communities
- Transportation and port infrastructure
- Experienced and established manufacturing and supply chain
- There is strong support in Oregon for testing activities associated with the marine energy industry
- Leading research institutions



Affiliated Facilities



Energy System
Integration

wesrf.engr.oregonstate.edu

Scaled Tank
Testing

wave.oregonstate.edu

Research,
Development, Testing
& Education

pmec.us

Open Water Testing

pacwaveenergy.org

Highly Qualified Workforce Development:

- > 75 PhD and MS students. Actively hired by marine energy & supply chain industries, National Labs, and academic institutions

Industry Engagement / Collaboration:

- Over 35 different marine energy projects tested at OSU: Hinsdale Wave Research Lab, WERSF, and PacWave



Funding

- Limited public and private investment

Testing Infrastructure

- Limited testing infrastructure for technology development

Technology Development

- Lack of technology convergence
- Costs and timeframes associated with emerging marine technologies
- Low cost of competing renewable electricity generation

Regulatory and Environmental

- Multiple federal and state agency jurisdictions and regulations
- Perceived environmental uncertainty



A globally recognized, open-ocean wave energy test facility

Purpose - To provide wave energy converter (WEC) clients the opportunity to:

- Optimize WECs and arrays to increase their energy capture
- Improve their survivability and reliability,
- Refine deployment, recovery, operations, and maintenance procedures
- Collect grid interconnection data
- Gather information about potential environmental effects, and economic and social benefits



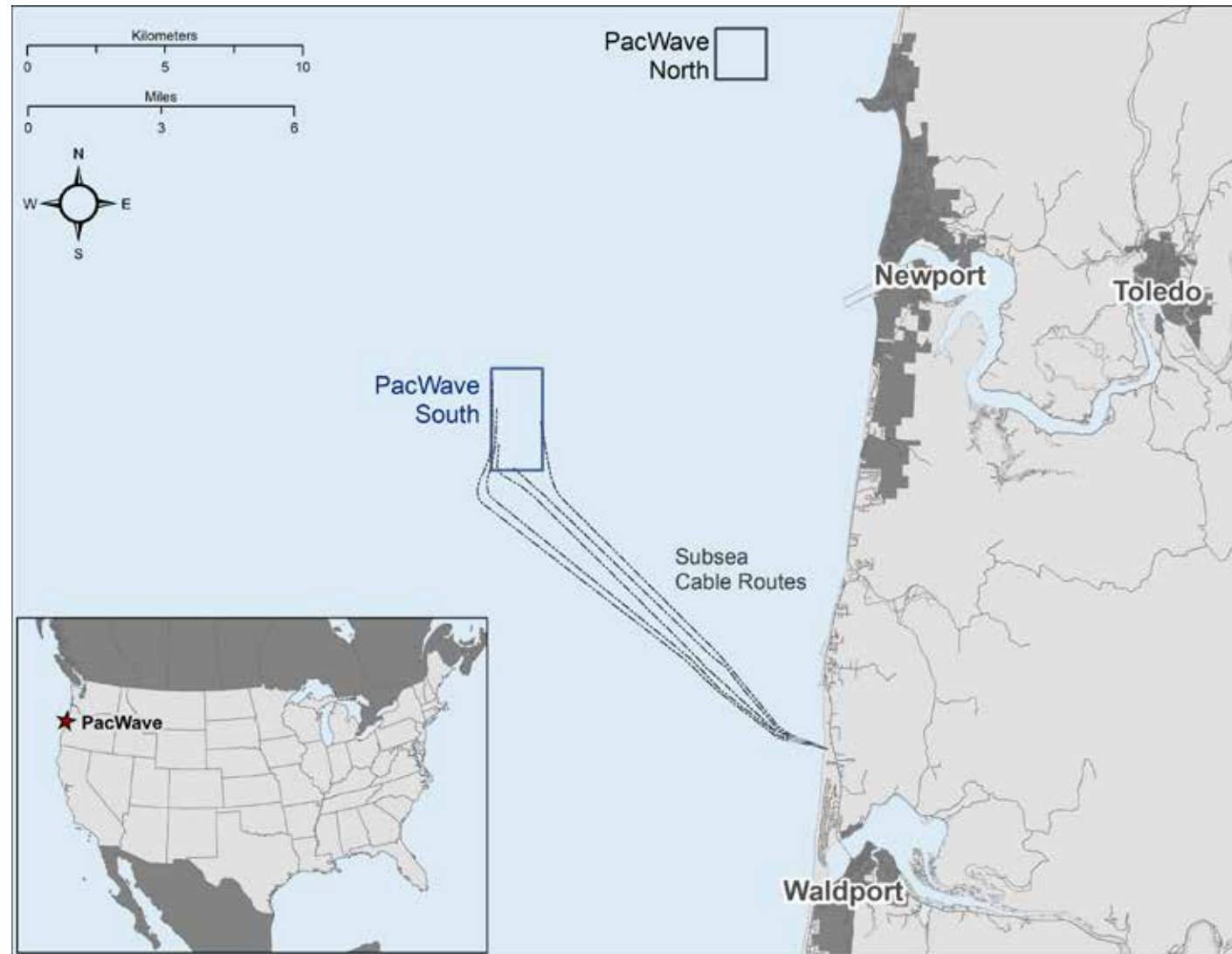
PacWave North

Existing, standalone, test site for small-scale, prototype or maritime market technologies

PacWave South

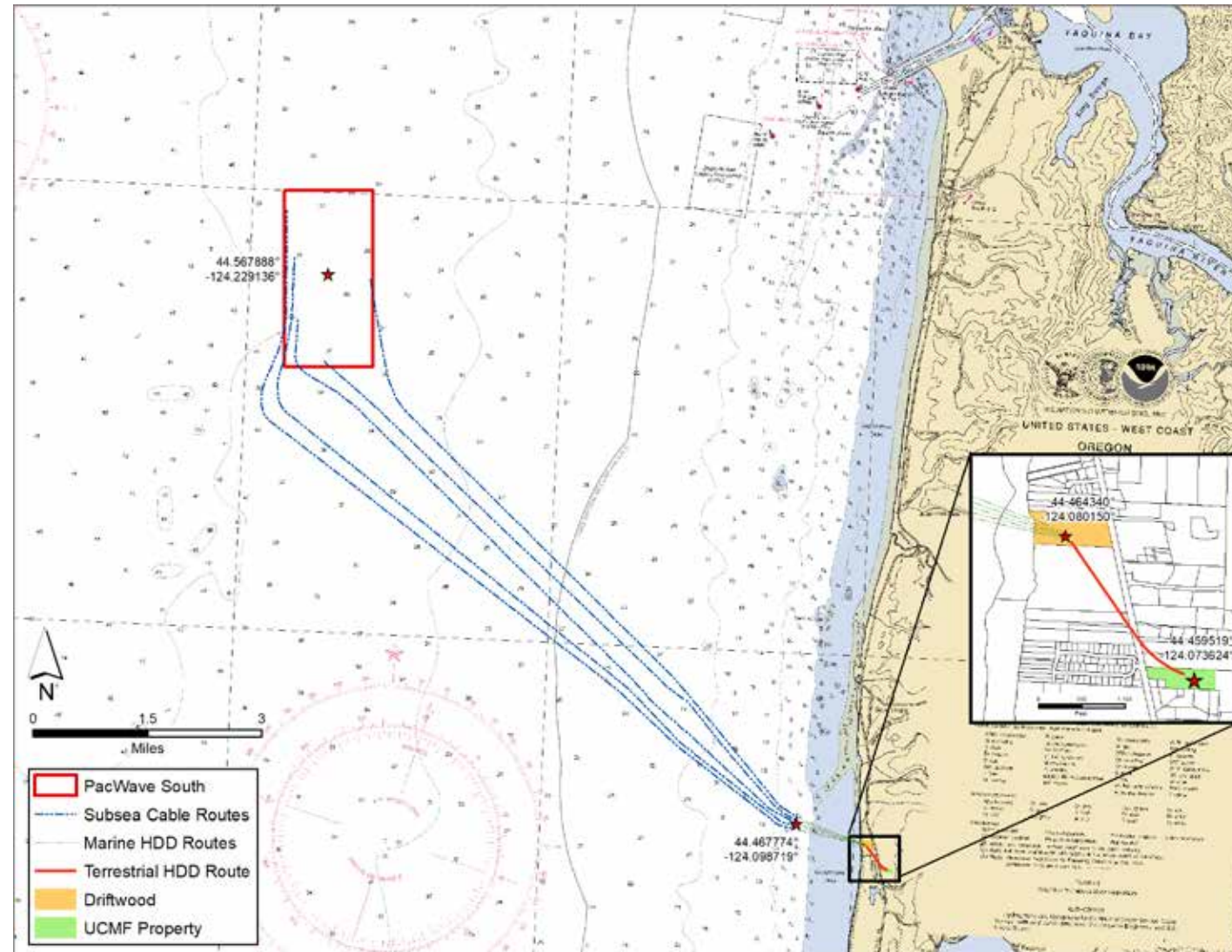
An in-development, state-of-the-art, pre-permitted, accredited, grid-connected wave energy test facility

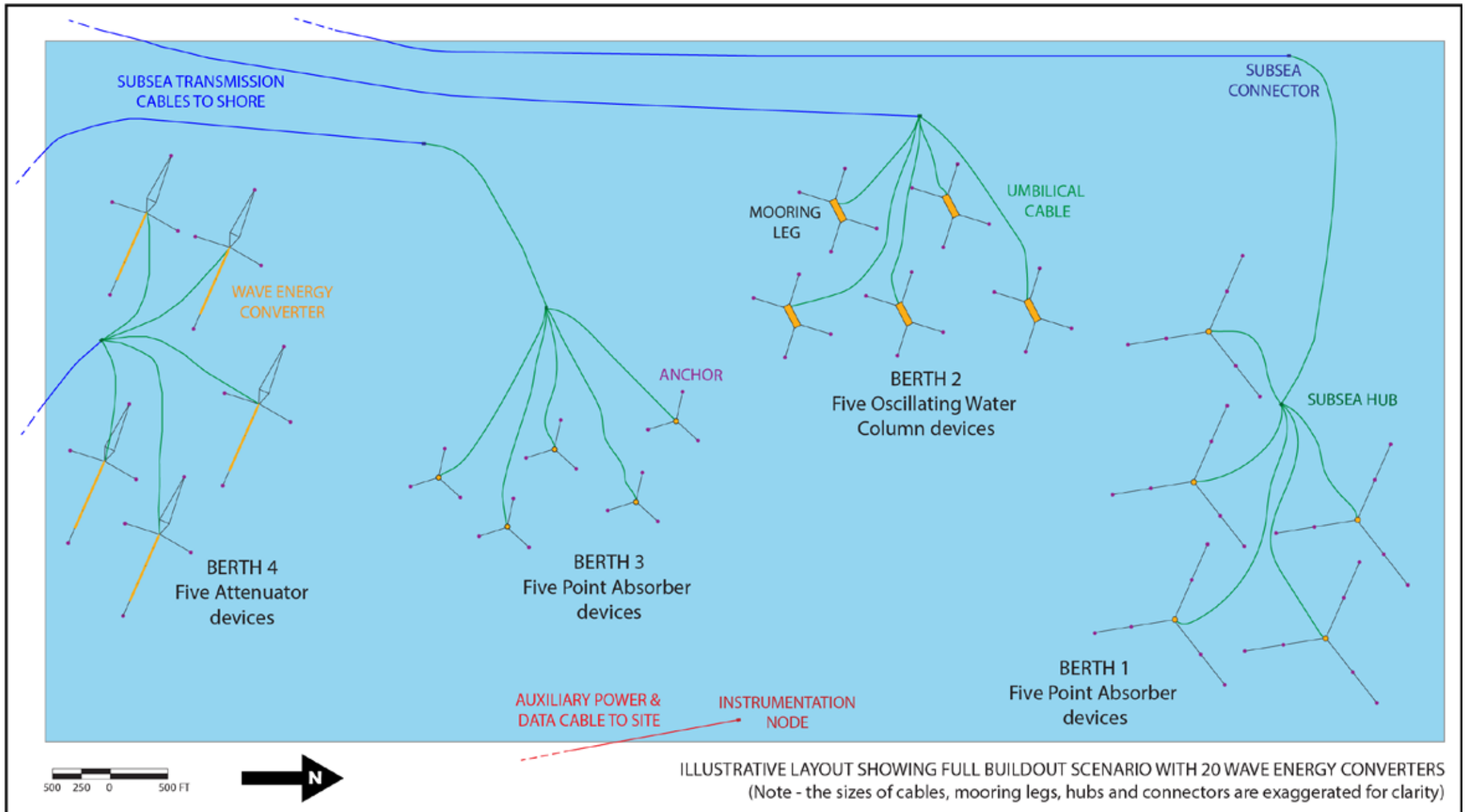
Developed in partnership with the US Department of Energy, the State of Oregon and the local community

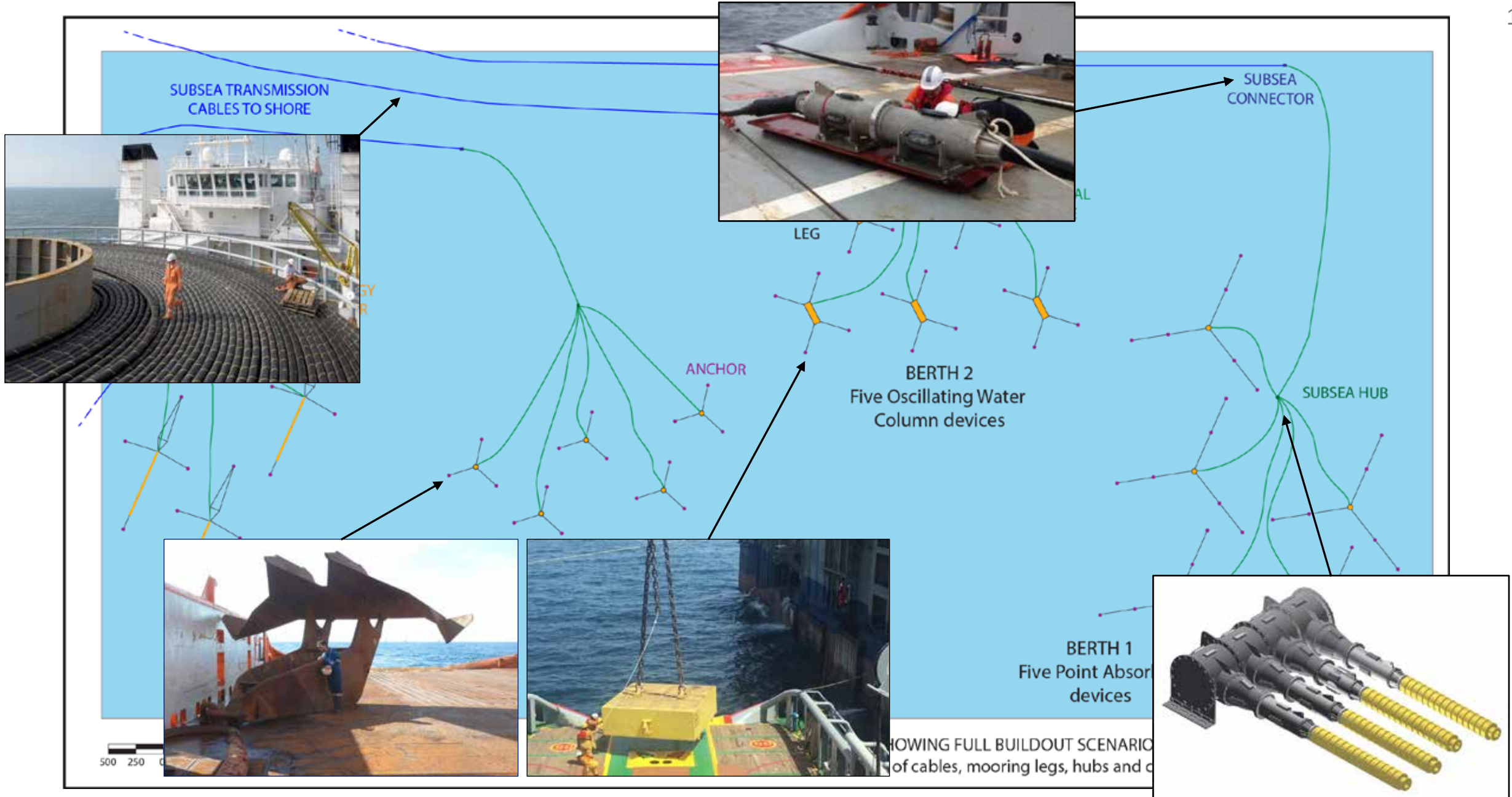


- Test site - OCS
- Cable routes - OCS & Territorial Sea
- Facilities on state & private land
- Four test berths
- Up to 20 MW and 20 devices
- Individual devices or arrays
- Five subsea power and data cables
- Shoreside Utility Connection and Monitoring Facility (UCMF)
- Connection to local utility district

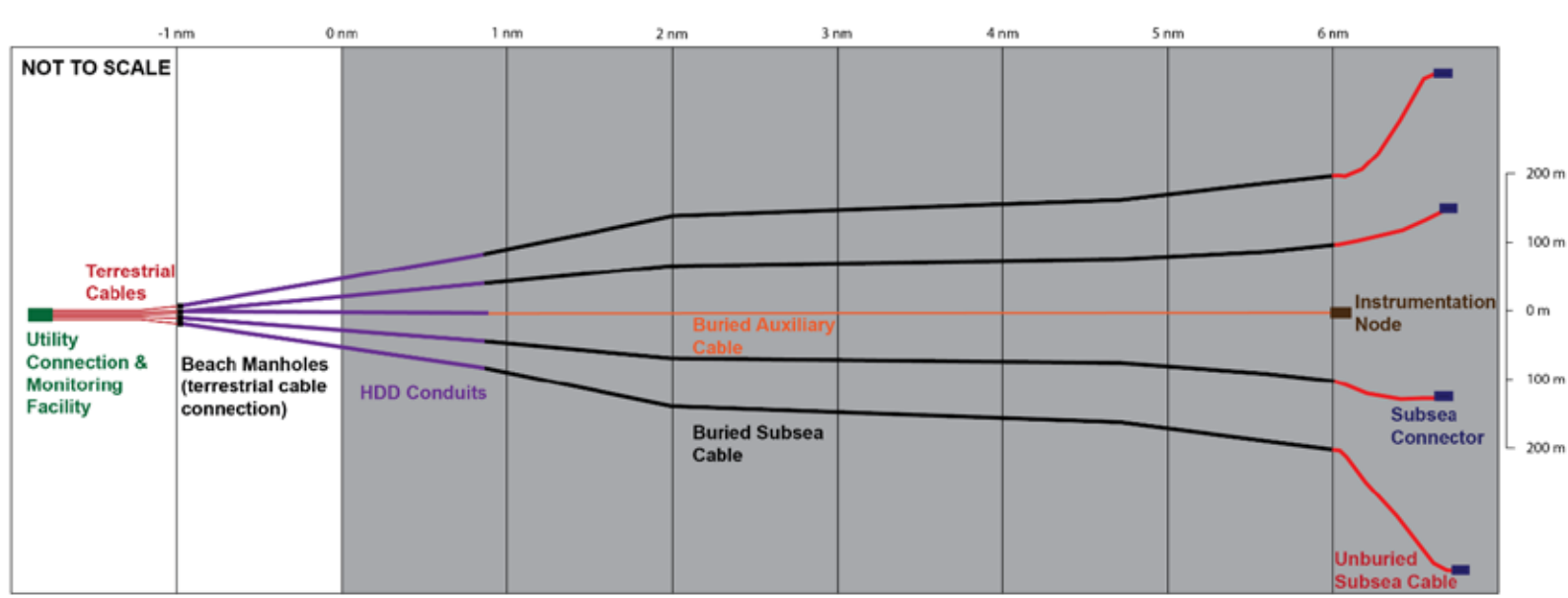
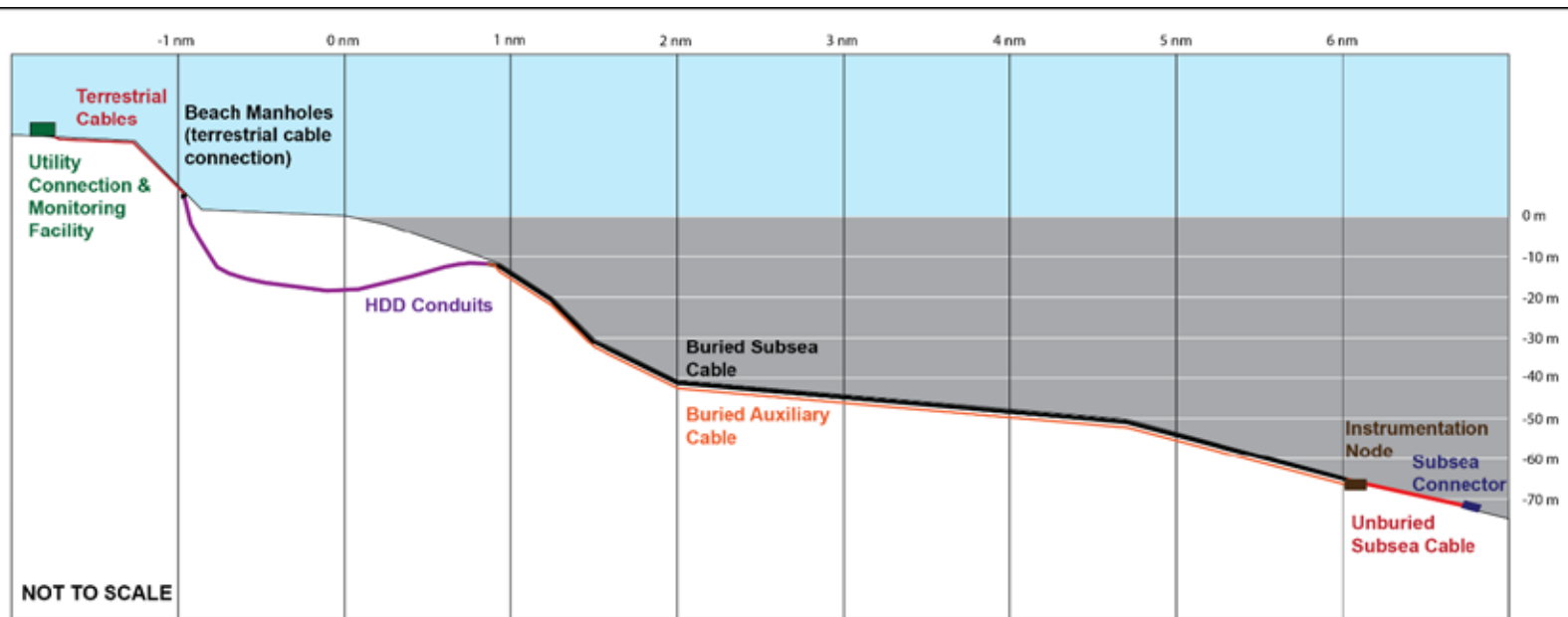
- Ø *Design & permitting phase (complete)*
- Ø *Construction phase (2021-2022)*
- Ø *Operational phase (2023 onwards)*

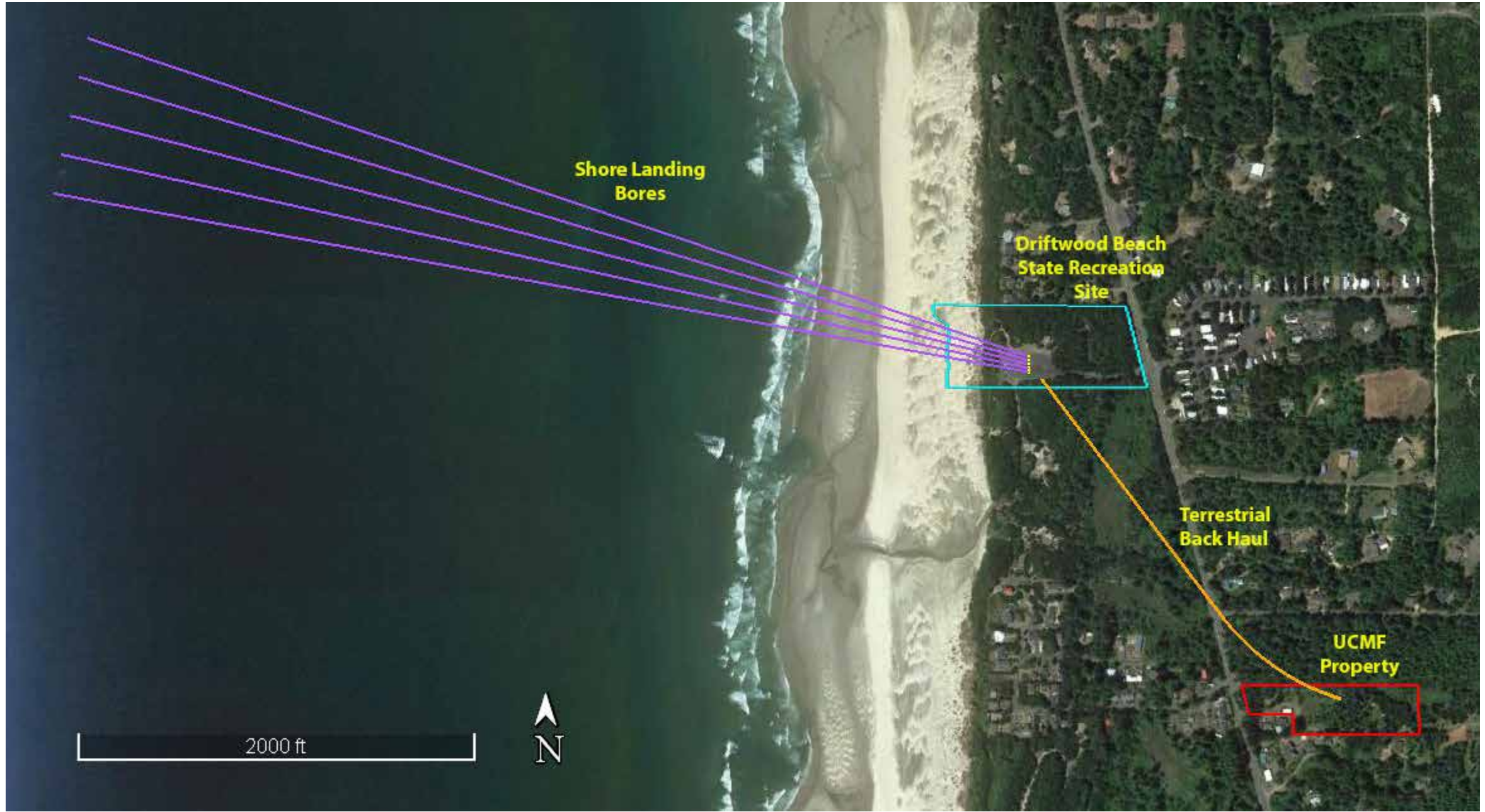


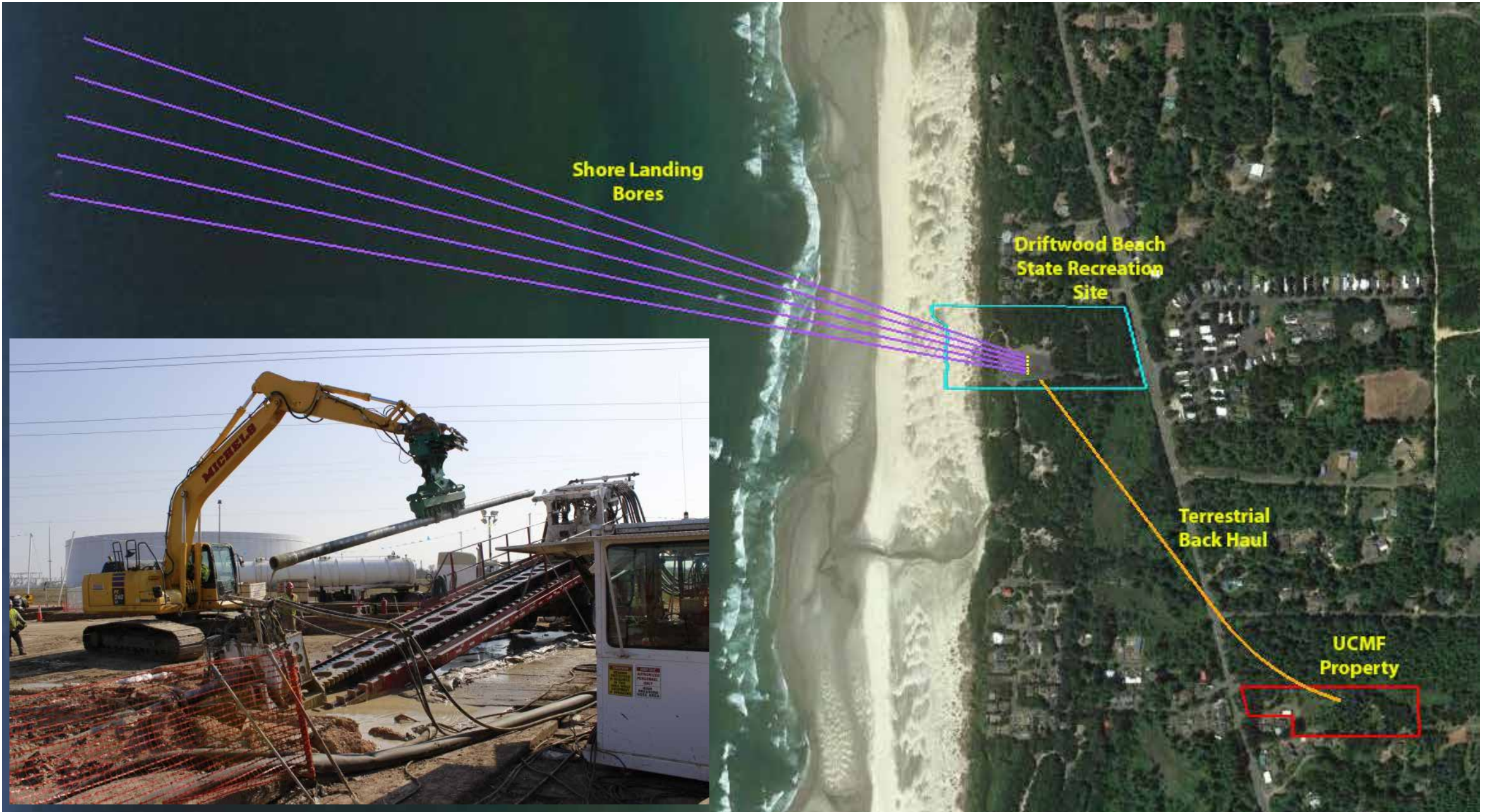




Subsea Cables

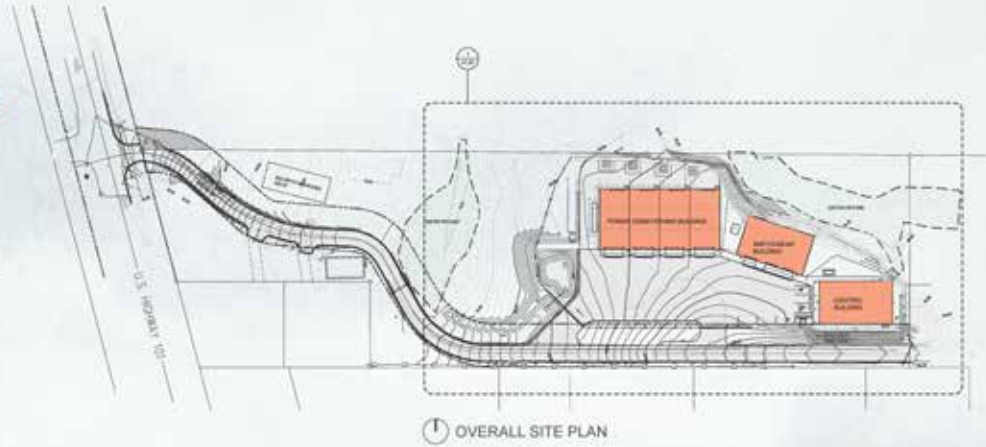








Terrestrial Bore Path to UCMF



OVERALL SITE PLAN



SITE ENTRY PERSPECTIVE

The PacWave Utility Connection and Monitoring Facility, or UCMF, located off Highway 101 at the Oregon Coast, will be the power and data center for Oregon State University's world leading wave energy test site, PacWave South. The UCMF consists of three buildings: the Power Conditioning Building, which receives power from the offshore test site via five underground cables; a Switchgear Building that transfers the wave-generated electricity to the grid; and the Control Building, which is the data, communications and monitoring center of PacWave. The buildings are arranged on the site to accommodate existing habitat and steep grades, resulting in a stepped elevation between each of the four bays of the Power Conditioning Building and the adjacent buildings. Color and materials were selected for their durability, daylighting qualities and to blend with the natural surroundings.



POWER CONDITIONING BUILDING



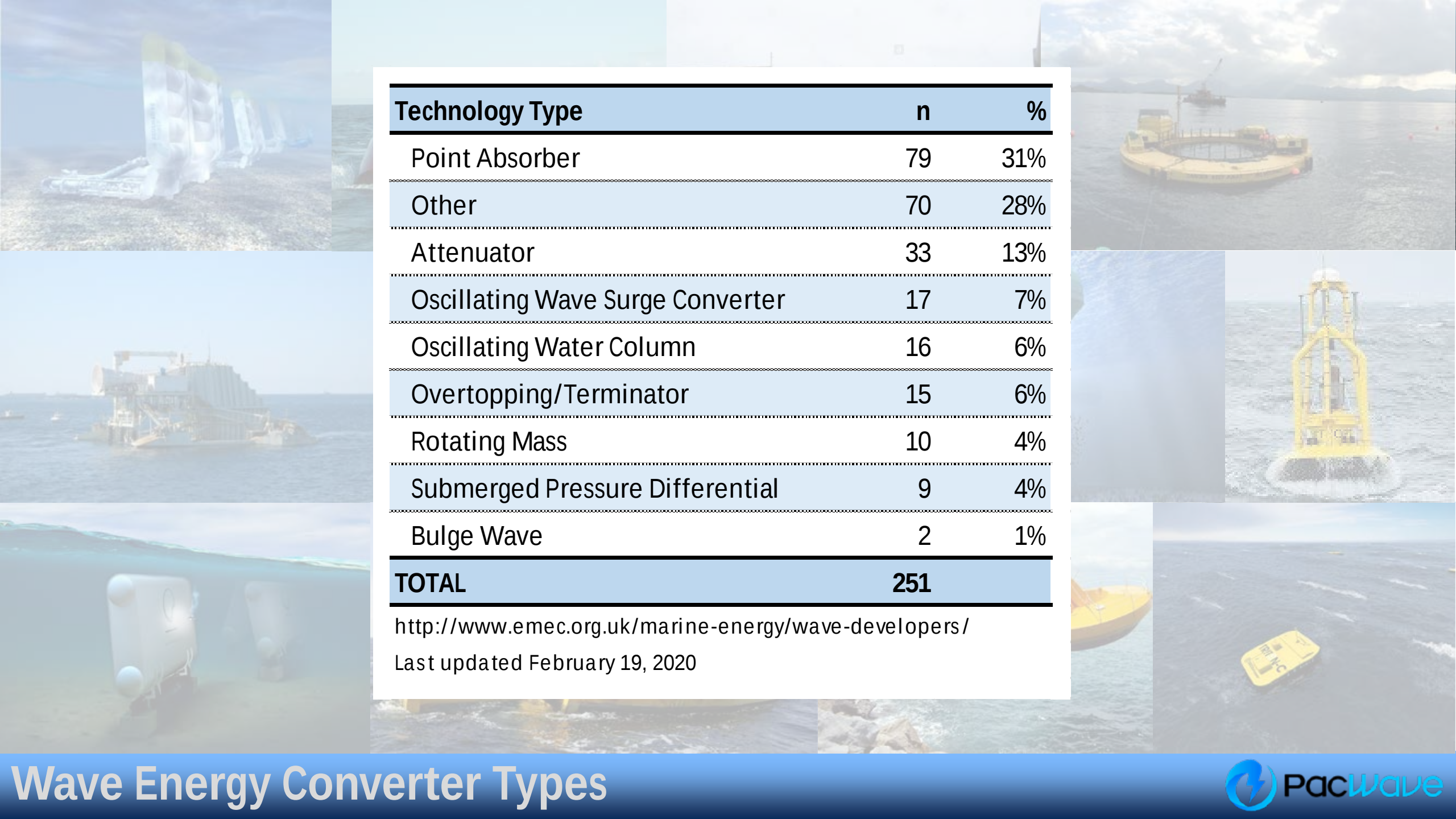
SWITCHGEAR & CONTROL BUILDINGS

Utility Connection & Monitoring Facility





Wave Energy Converter Types

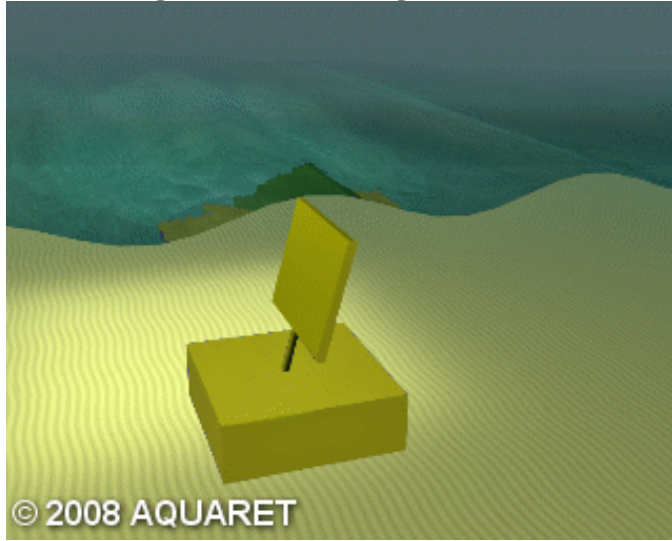


Technology Type	n	%
Point Absorber	79	31%
Other	70	28%
Attenuator	33	13%
Oscillating Wave Surge Converter	17	7%
Oscillating Water Column	16	6%
Overtopping/Terminator	15	6%
Rotating Mass	10	4%
Submerged Pressure Differential	9	4%
Bulge Wave	2	1%
TOTAL	251	

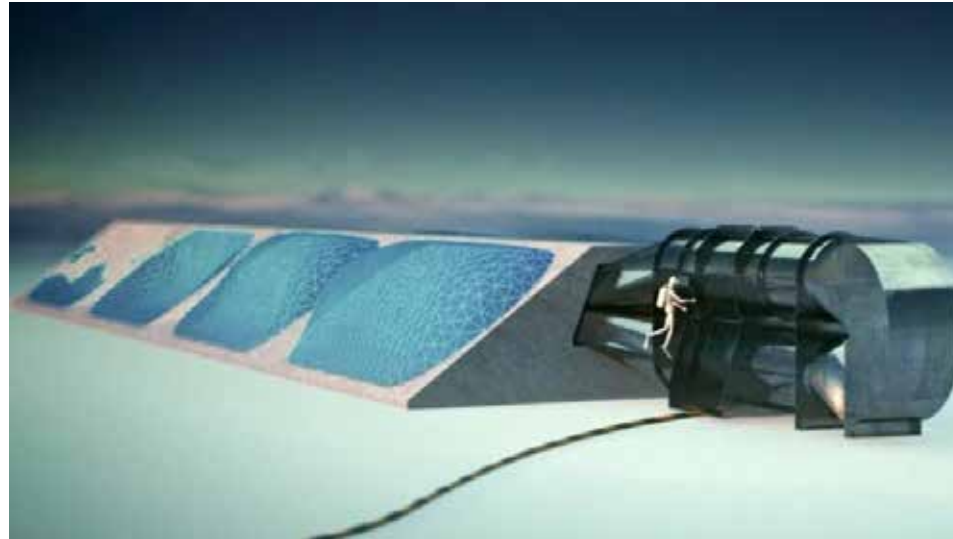
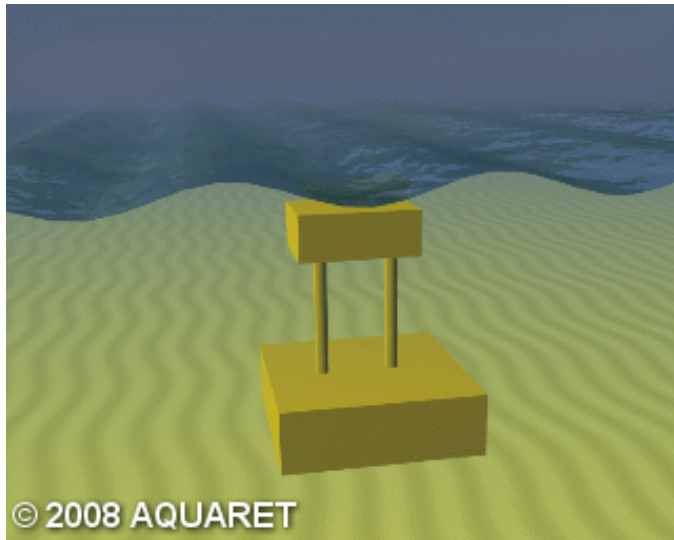
<http://www.emec.org.uk/marine-energy/wave-developers/>

Last updated February 19, 2020

Oscillating Wave Surge



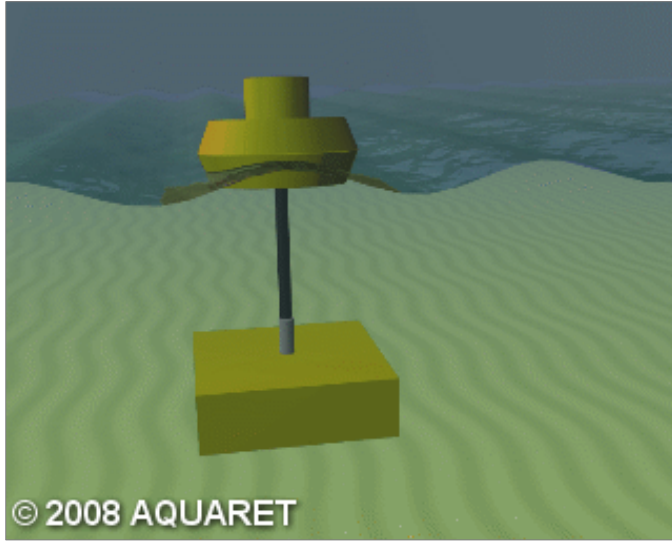
Submerged Pressure Differential



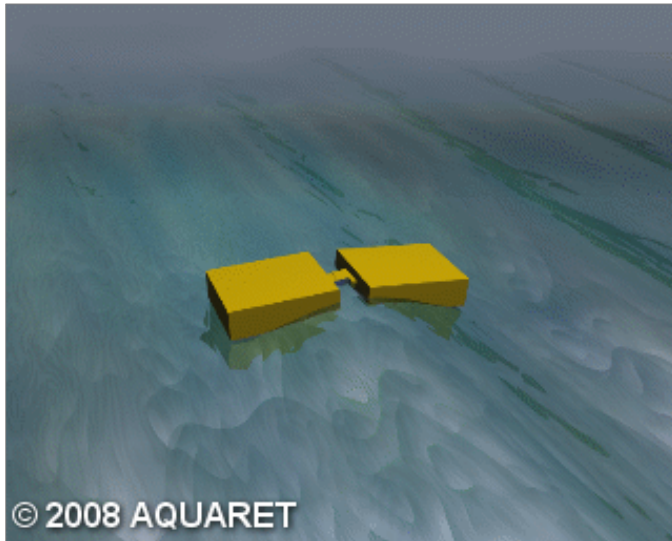
Wave Energy Converter Types

Point Absorber

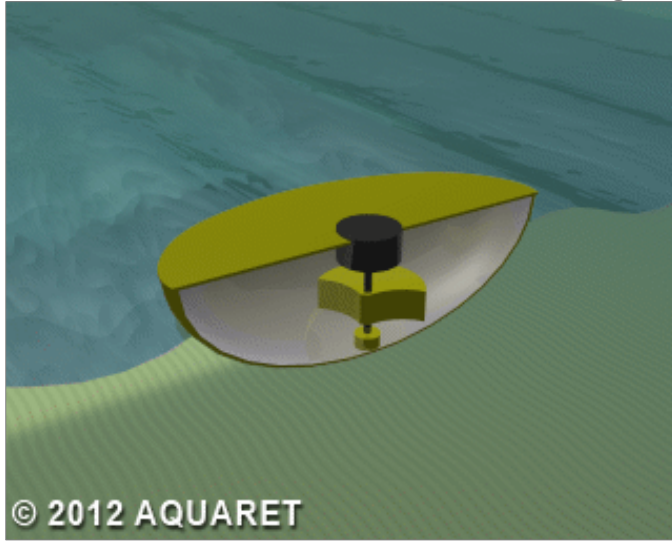
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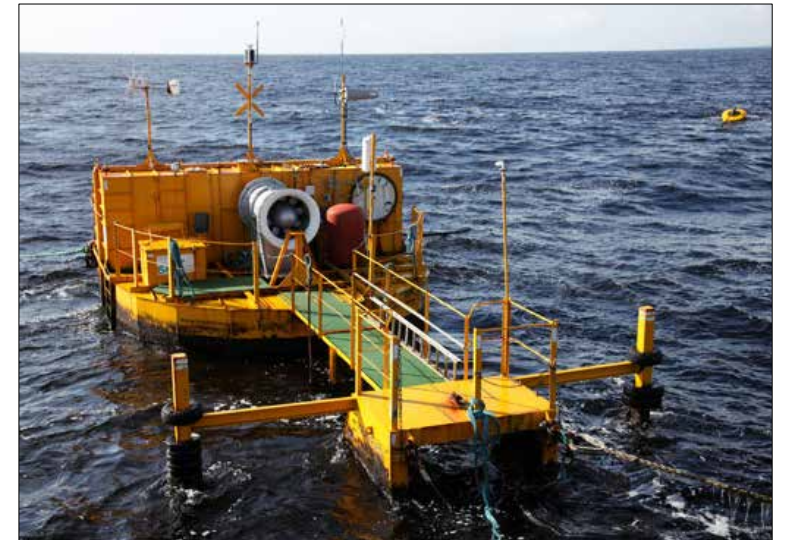
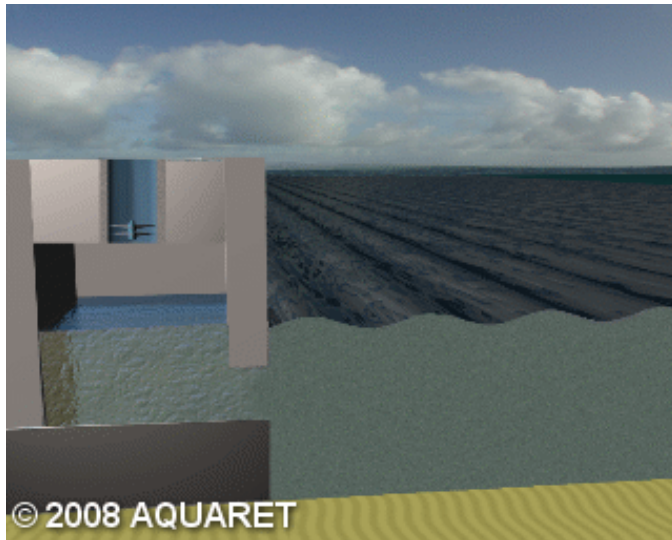
Attenuator



Horizontal Pendulum / Rotating Mass Device

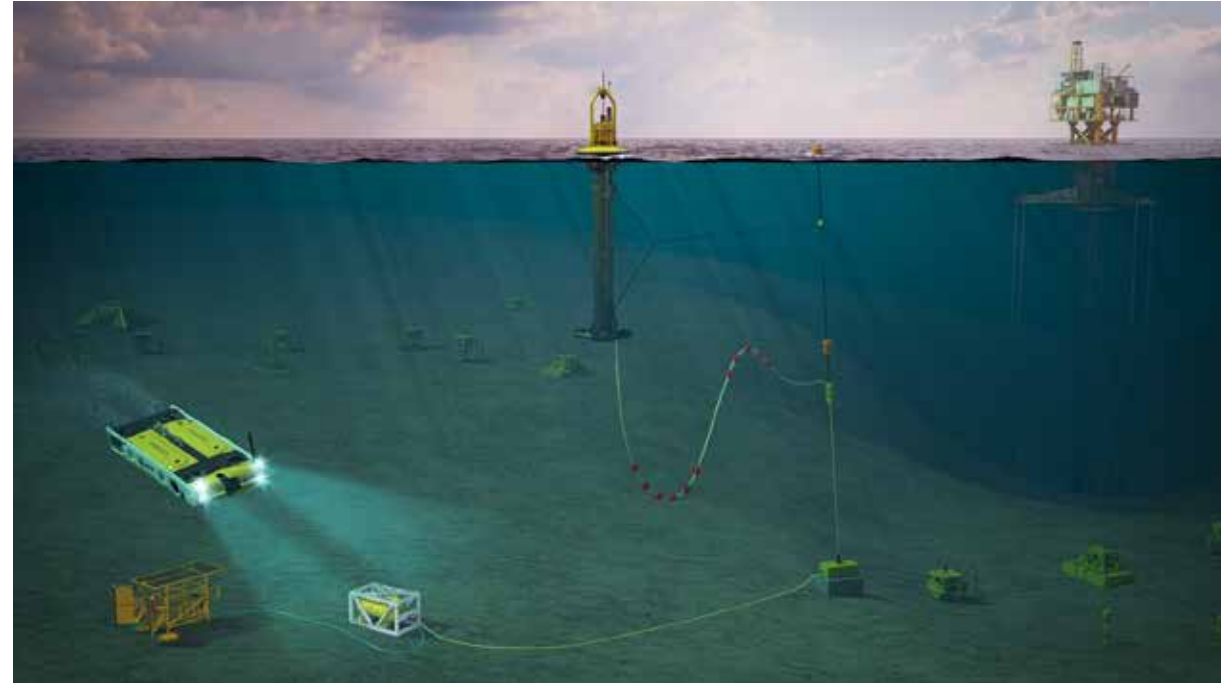


Oscillating Water Column Device



Alternative Maritime Markets

- Isolated Power Systems: Community Scale
- Desalination
- Autonomous Underwater Vehicles Recharge
- Ocean Observations & Navigation
- Offshore Data Centers
- Disaster Resiliency & Recovery
- Marine Aquaculture
- Seawater Mining
- Constructed Waterways
- Shoreline Protection



- Feasibility analysis of Oregon Coast (2011)
- Preliminary design and planning initiated (2012)
- Community Site selection (2012)
- Federal and State permitting process (January 2013 to March 2021)
- Construction phase (2021-2022)
- Operational phase (2023 onwards)



Core Team

- Pacific Energy Ventures
- 3U Technologies
- European Marine Energy Centre
- National Renewable Energy Lab.
- Williwaw Engineering
- HDR Engineering
- HT Harvey & Associates
- Stoel Rives
- Aquatera

Funding

- US Department of Energy
- State of Oregon
- Oregon State University
- Corporations & Foundations

Design & Engineering

- HGE Architects
- David Evans & Associates
- The HDD Company
- Jacobs
- Siemens & Associates
- TerraSond
- Foundation Engineering
- Terracon
- Field Engineering
- R&G Excavating
- Central Lincoln PUD
- Bonneville Power Administration



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