CALWAVE
JUNE 21-22, 2023
Ocean Renewable Energy Conference
LEADERSHIP EXPERIENCE SOLUTIONS
WORLD FORESTRY CENTER PORTLAND, OREGON
poet
PACIFIC OCEAN ENERGY TRUST
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https://youtu.be/61PeHtiDpLg

CalWave Holistic Control Approach

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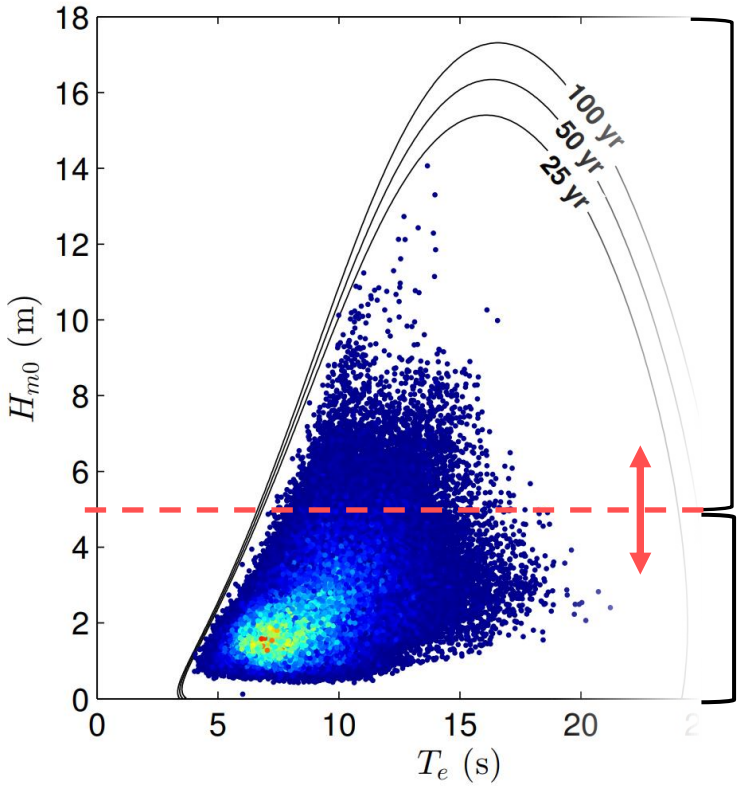
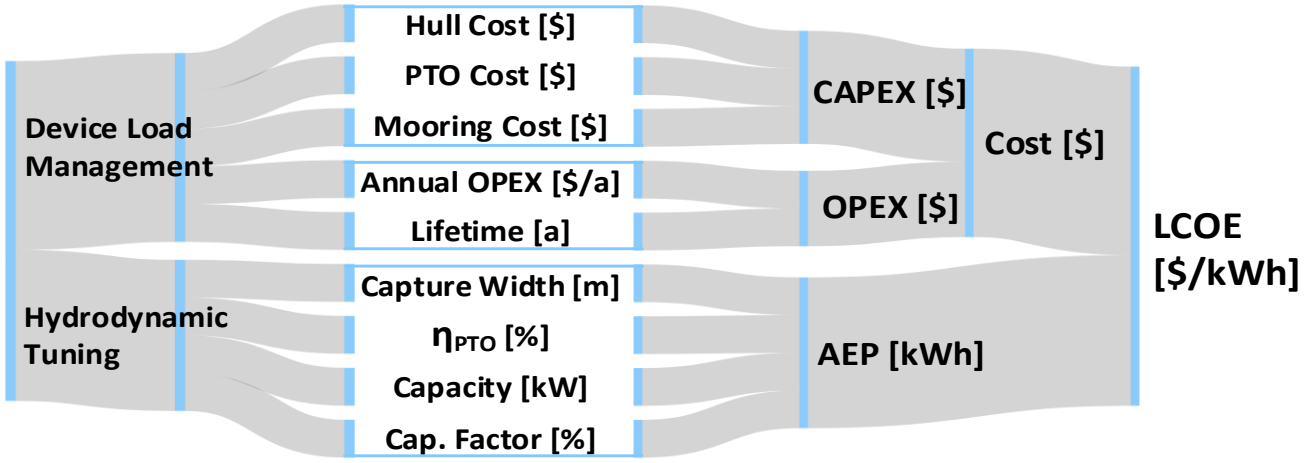
Fundamental Challenge



Drives System Cost (CAPEX) and Operating Risks (OPEX)

AEP/Revenue generating sea states



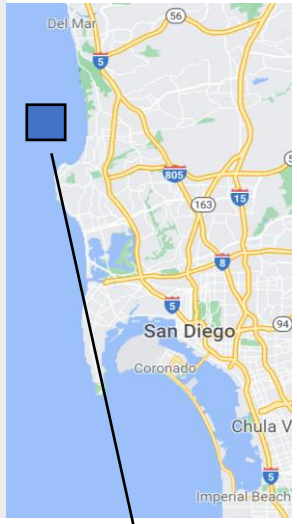
San Diego Ocean Pilot

Location: SIO, San Diego

Duration: 10 months

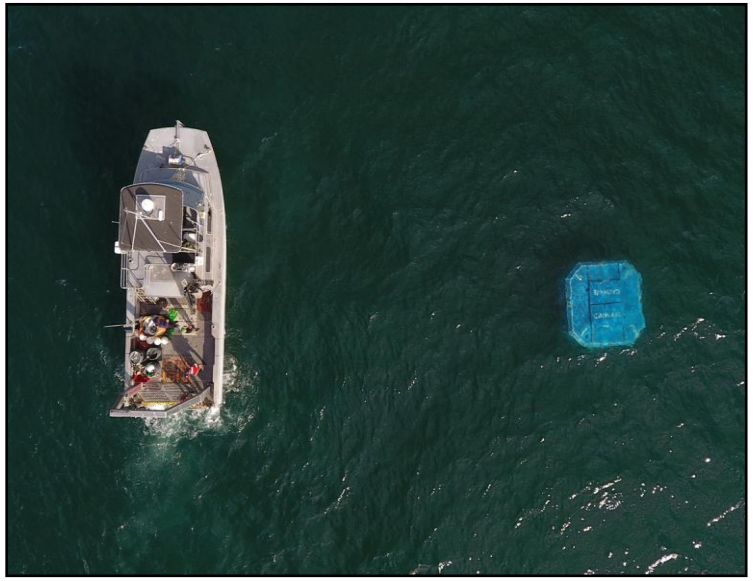
Pilot campaign goals:

- TRL 7
- Performance
- Reliability

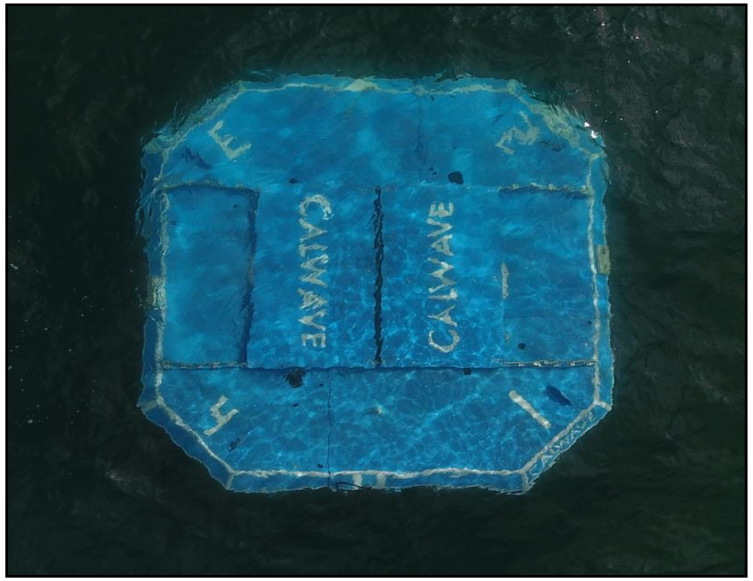


Scripps Pier, CalWave deployment site

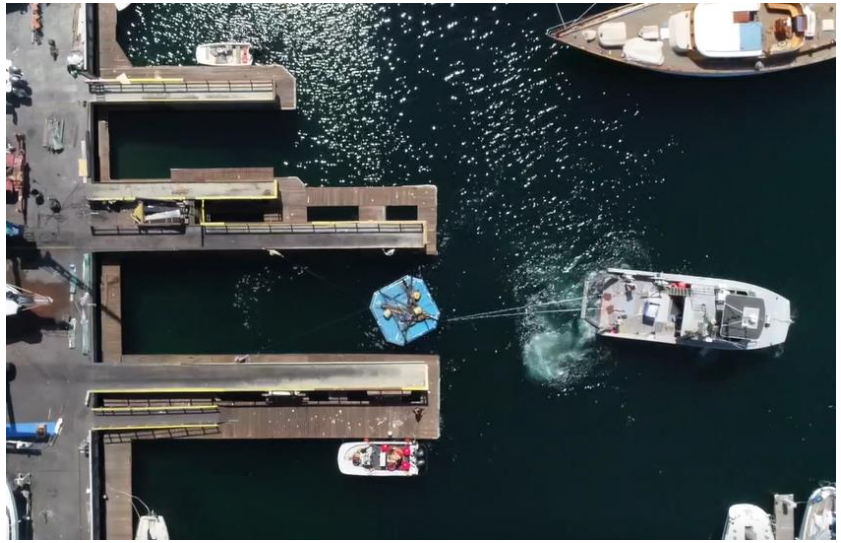
Installation and maintenance on the surface.



Operations and shelter fully submerged!



San Diego Ocean Pilot – Main Results:



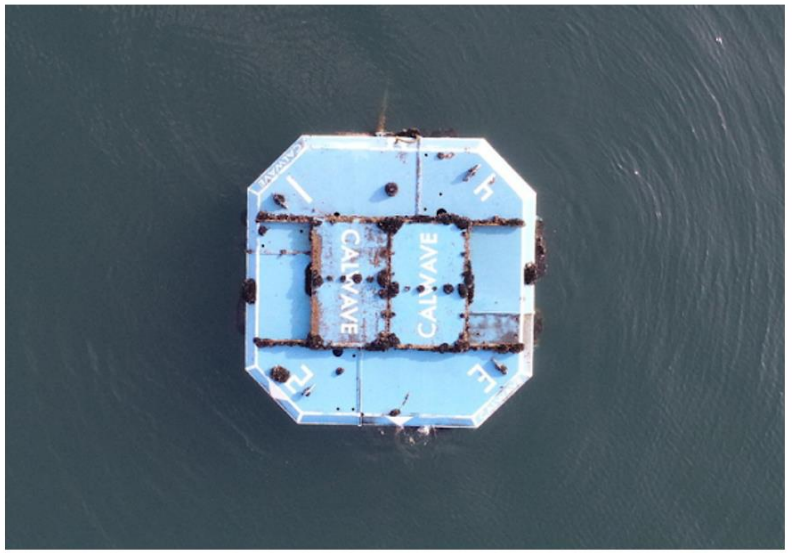
#	Test objective	Findings
1	**Installation & recovery procedures**	- Installation & recovery procedure: ~1.5 h
2	**Operations**	- Safe operation in all sea state conditions.
3	**Autonomous controls**	- Tidal adjustment, performance optimization and shut down mechanism reliable and robust. - Fully autonomous since November 3rd 2021.
4	**Performance**	- Loads, motions, and power output agree well with forecasts and simulations.
5	**Reliability**	- No intervention, no visible hardware damage; no decline of performance - 99.8% system uptime.
6	**Survivability**	- Survived 2 x 10-year storm (50 ft representative waves) using Holistic (Load) Controls - Continued power output at operating point

Effects on marine ecosystems

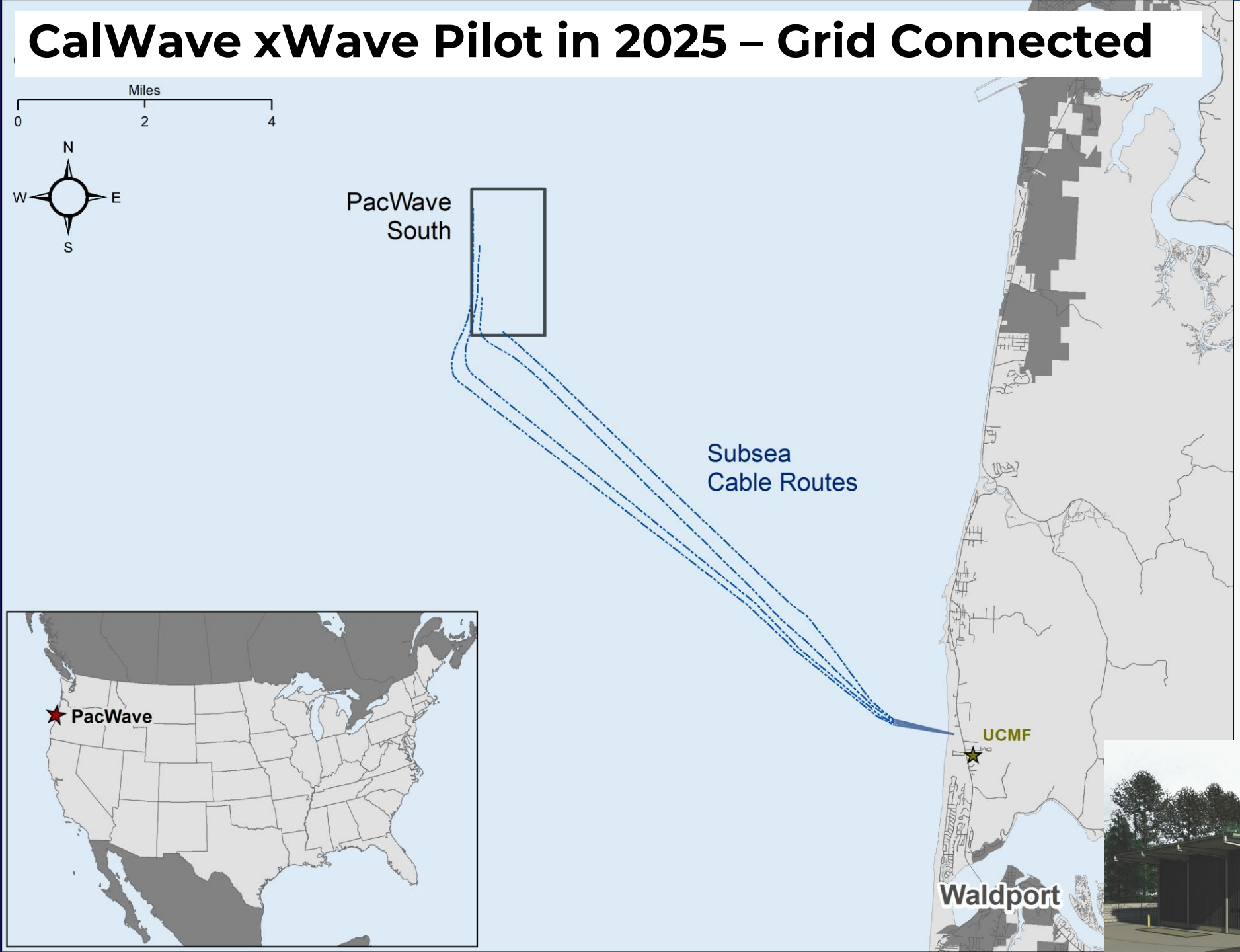
integral consulting inc.

Pacific Northwest NATIONAL LABORATORY

In collaboration with the Pacific Northwest National Laboratory's (PNNL) Triton Initiative the *x1*™ was observed with a Boxfish 360 video camera and three different sound monitoring tools: Integral Consulting, Inc.'s noise spotter buoy, a drifting hydrophone, and three long-term, bottom-mounted hydrophones.



CalWave xWave Pilot in 2025 – Grid Connected



PacWave
TESTING WAVE ENERGY FOR THE FUTURE

Funding: **$8.2M US DOE award**

Location: Oregon

Depth: 60-80 m

Capacity: 20 utility-scale WECs

http://pacwaveenergy.org/

Towards PacWave Deployment

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Sandia National Laboratories

Amazon EC2

Sandia National Laboratories

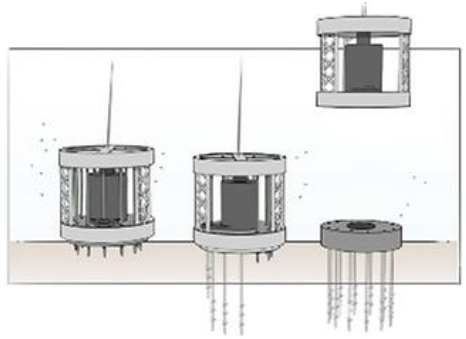
Full System Control Co-Design

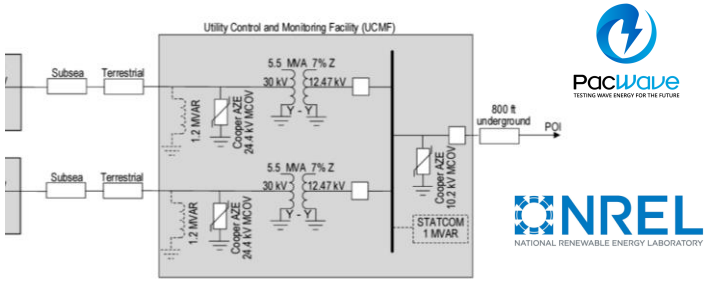
- WecOpt Tool collaboration with Sandia
- Scaleup to Amazon Web Services
- Million of sets evaluated
- Actual component properties
- Hydrodynamics – Anchor setups - Geometries – PTO components - Controls

PacWave Scale PTO Test Rig

- PTO test rig for Hardware In The Loop testing 2023 / 2024
- Testing at exact PacWave scale
- Supported via Sandia National Labs

Towards PacWave Deployment





Path towards product certification

- IEC (Subject matter expert, shadow committees)
- Accredited test planning with NREL and PacWave
- IEC-RE Certification Body discussions

Mooring Design & Deployment

- Detailed anchor design
- Anchor sharing for multiple devices
- Anchor deployment (2024)

Grid Integration

- Detailed grid integration studies
- Enables power Quality optimization
- Direct power electronic supplier support

Pipeline and Network

25

Active opportunities

With:

- Large utilities
- Island utilities
- Offshore wind developers
- Oil and gas majors
- Eco-resorts

Network

U.S. Department of Energy
Berkeley Lab
NREL
Third Derivative
nationalgrid
Scripps Institution of Oceanography
cyclotronroad
Greentown Labs
Pacific Northwest National Laboratory
Baker Hughes
startR Blue
Activate
SOA Sustainable Ocean Alliance
Sandia National Laboratories
Launch Alaska
Michelin
NHA National Hydropower Association

CALWAVE

nationalgrid

Baker Hughes

Wave Farms for US East Coast

nationalgrid

Location:	**Nantucket, MA**
Phase 1:	**Feasibility study**
Phase 2:	**FEED study**
Phase 3:	**800 kW pilot**
Phase 4:	**30-50MW wave farm**

Evaluating the ability of wave to alleviate the need for a new subsea transmission line from mainland, lowering costs for the island's residents and businesses.

COMMUNITY offshore wind

Location:	**New York Offshore Wind**
Phase 1:	**Co-location study**
Phase 2:	**FEED study**
Phase 3:	**800 kW pilot**
Phase 4:	**100MW+ joint farms**

Exploring opportunities to co-locate offshore wind and wave farms to increase the capacity factor and lower costs for offshore renewable energy projects.

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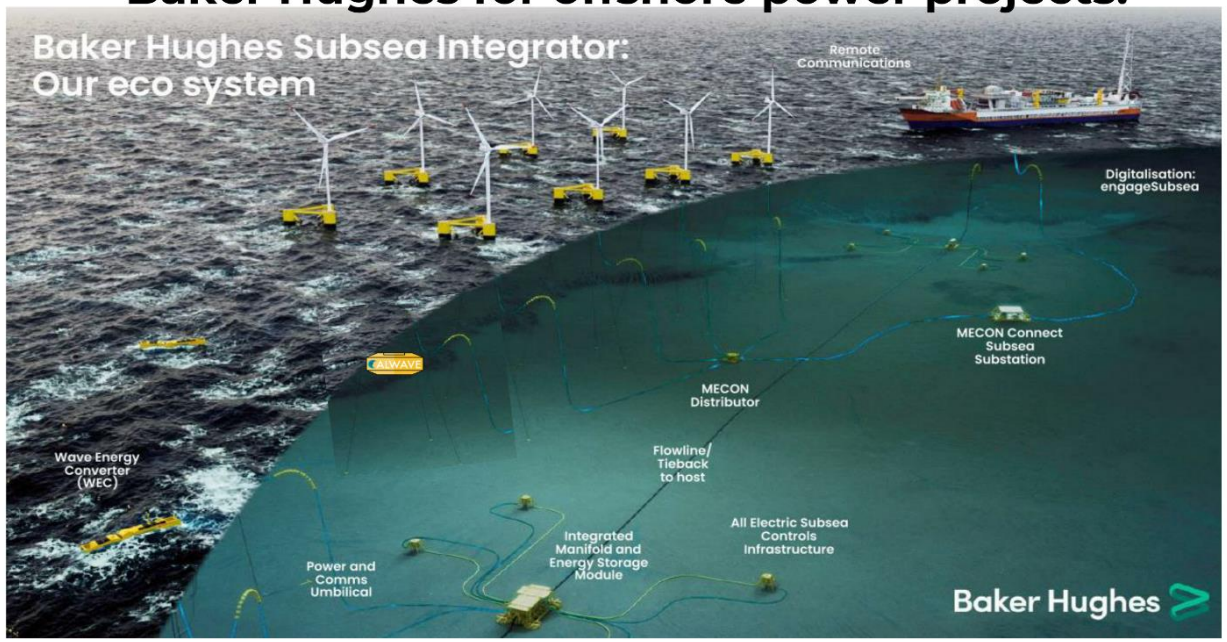
March 2023 - CalWave enters MOU with Baker Hughes for offshore power projects.



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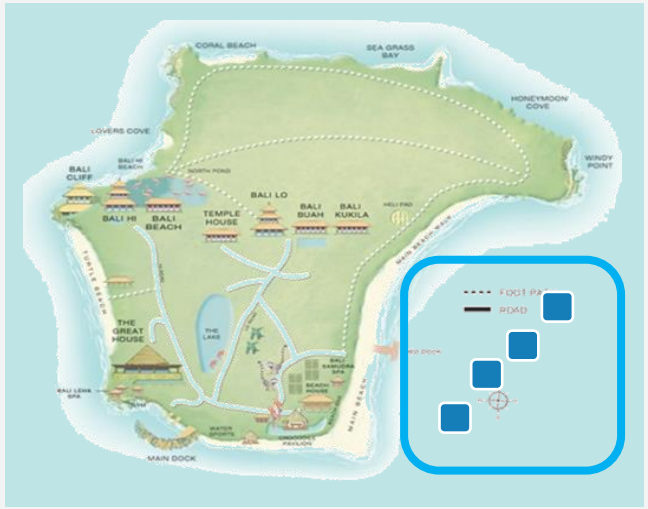
Short-term Impact

<u>Replacing Heavy Fuel Oil & Diesel</u>
for Small Island Developing States (SIDS)

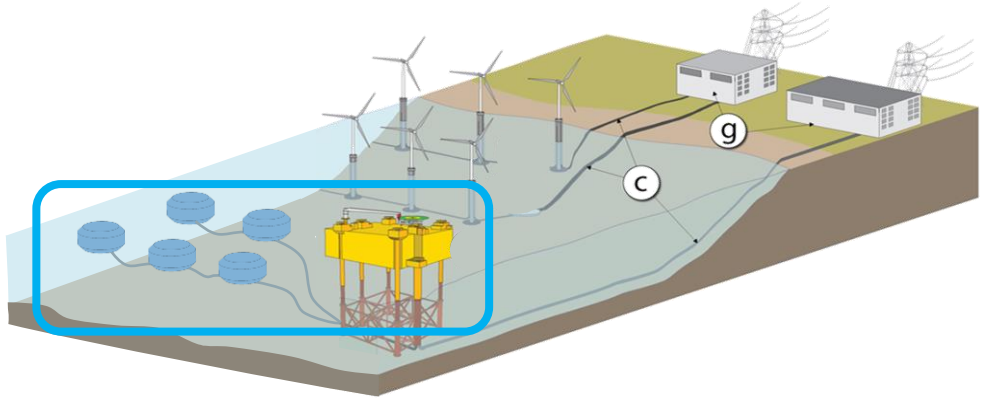
Large population get 90% of power from diesel,
Emissions higher than coal.



Long-term Impact

<u>Filling the renewable energy gap</u>
by complementing existing resources with
the cleanest source of electricity

60 GW in 2026
of unused electrical cable from offshore wind
500 - 1,500 GW Green Fuels (H2, NH3)



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7 AFFORDABLE AND CLEAN ENERGY

13 CLIMATE ACTION

8 DECENT WORK AND ECONOMIC GROWTH

11 SUSTAINABLE CITIES AND COMMUNITIES

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE