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Overview of Wave Energy Technology

Mirko Previsic

Technology Lead – EPRI Ocean Energy Programs

Agenda

- The Resource in perspective
- Siting Considerations
- Technology Examples

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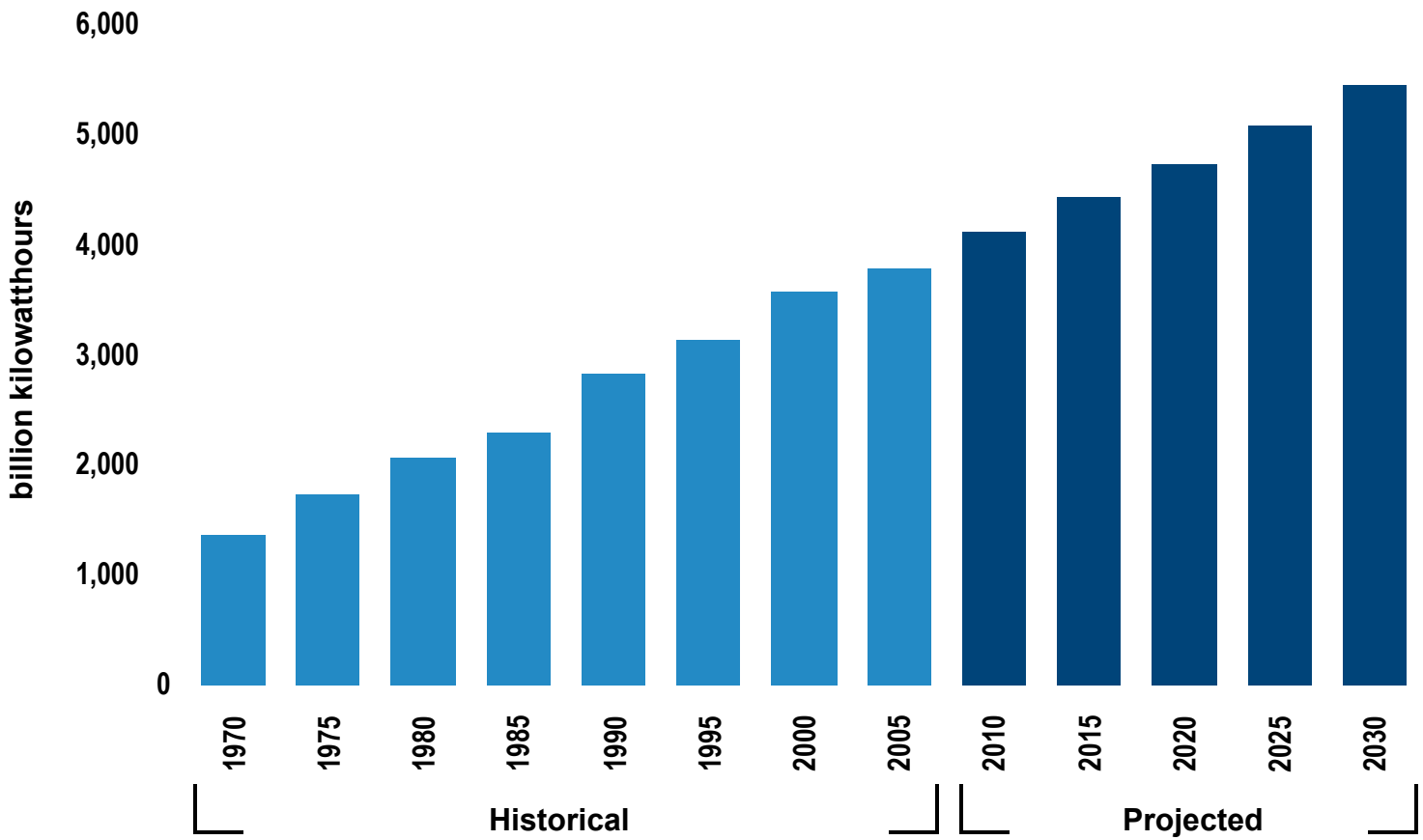
The source of the issue is you and me … increasing energy demand



Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 2005* and *Annual Energy Outlook 2007 Early Release*

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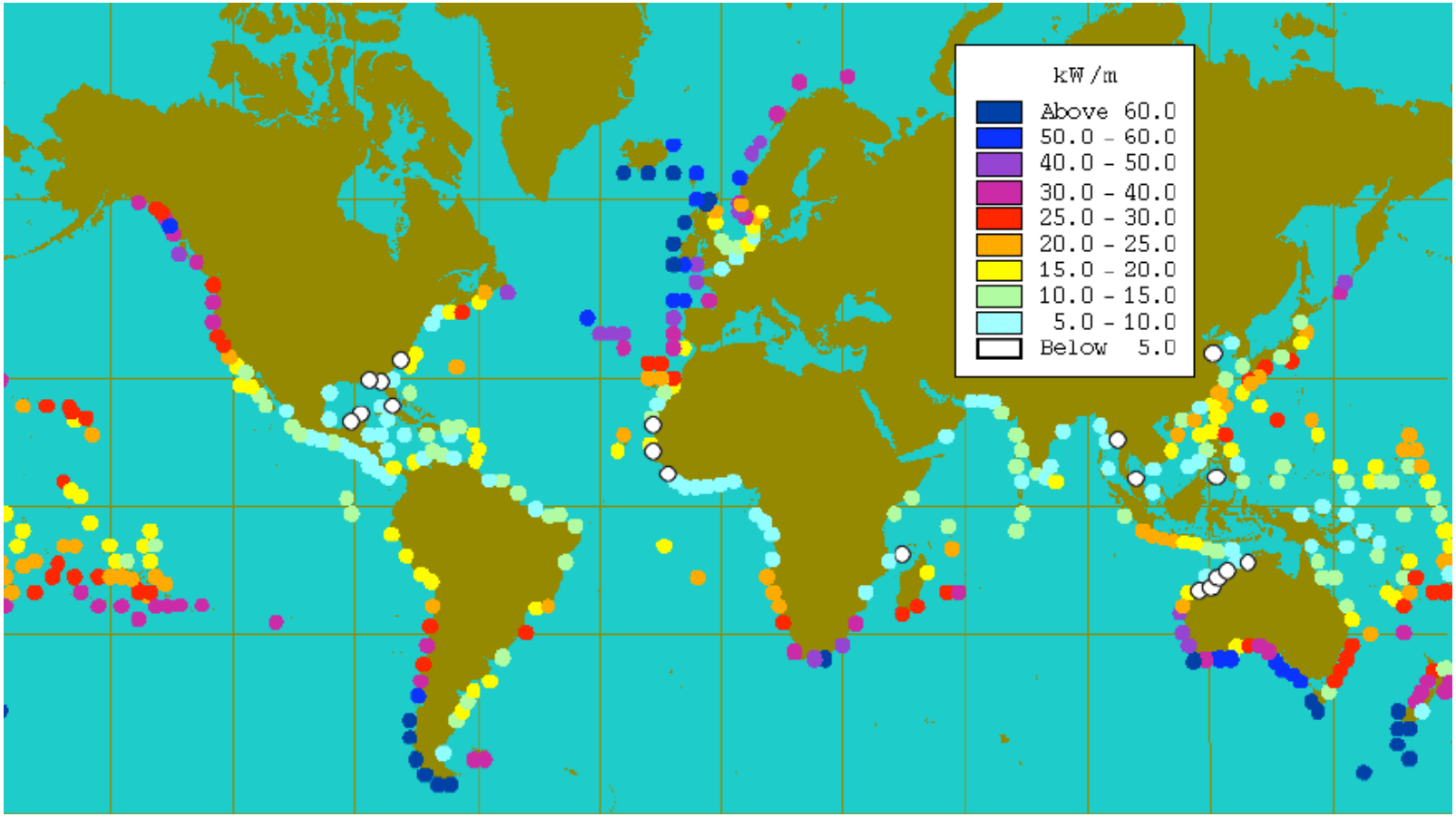
Renewable Energy Benefits

- Electricity is the leading source of US carbon emissions
- Fossil fuel-based generation produces other emissions as well
- Avoided emissions at an installed capacity of 4000 MW (California has a technical potential of > 15,000MW) of wave plants at 40% capacity factor using a proxy coal plant with emissions at NSPS limit (actual plants may be less)

Pollutant	Emissions Rate	(tons/year)
SOx	1.4 lbs/MWhr	10,000
NOx	1.0 lbs/MWhr	7,000
CO2	0.8 tons/MWhr	11,000,000
Mercury	2.1 X 10-6 lbs/MWhr	0.014
Particulates	0.2 lbs/MWhr	1,400

Wave Power Densities - Globally



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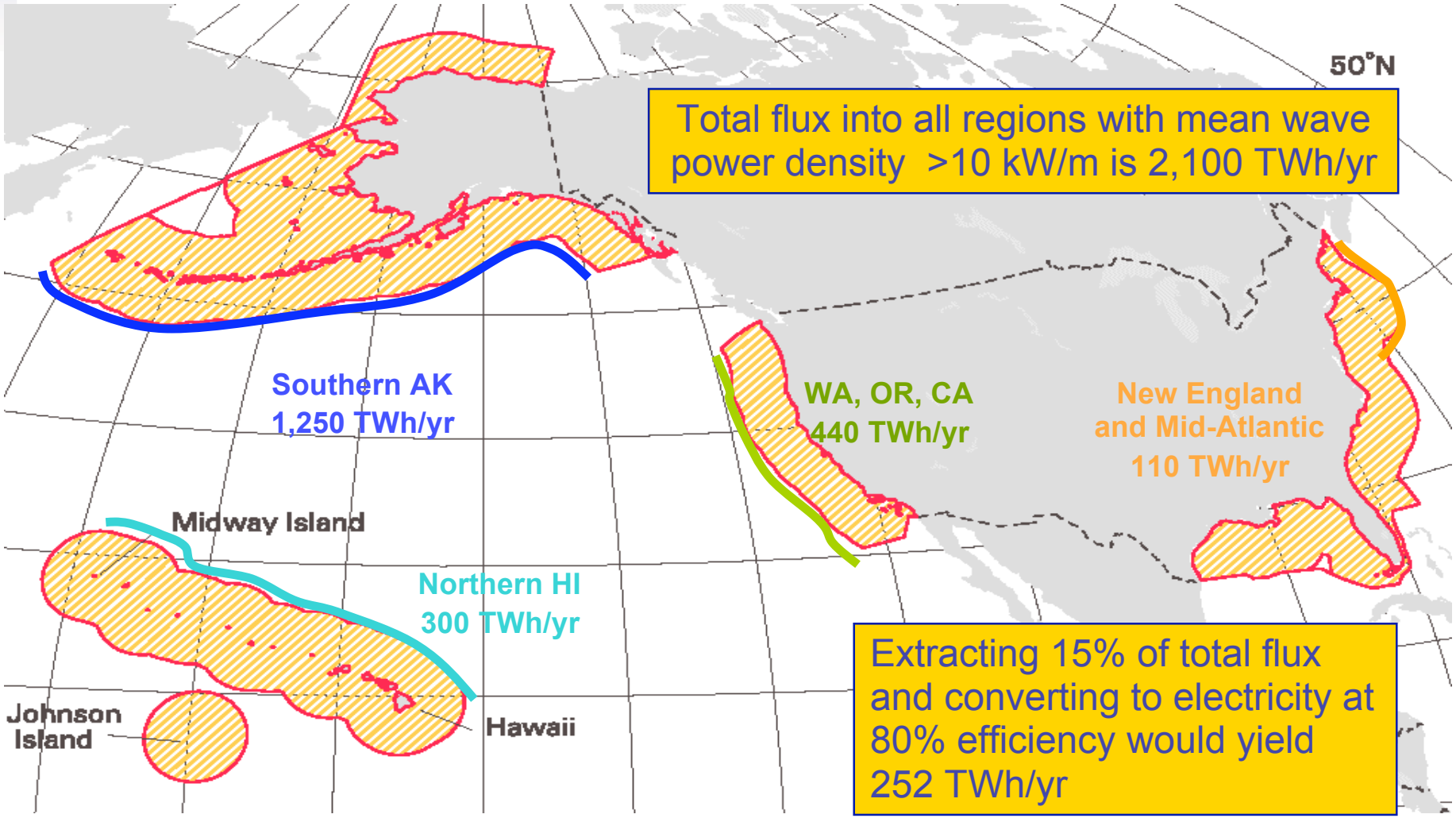
U.S. Offshore Wave Energy Resources



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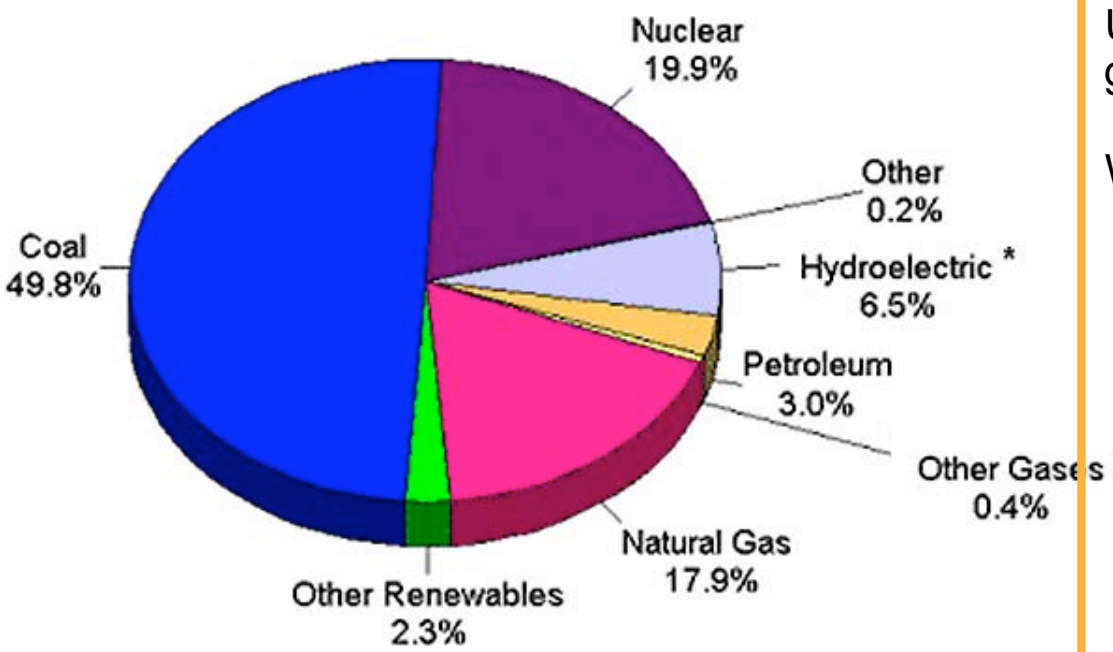
U.S. Wave and Current Energy Potential

U.S. Annual Electric Power Generation by fuel type in 2004 was 3,971 Terawatt-Hours (TWh)



* Note: Hydroelectric includes generation from pumped-storage facilities after subtracting energy used for pumping

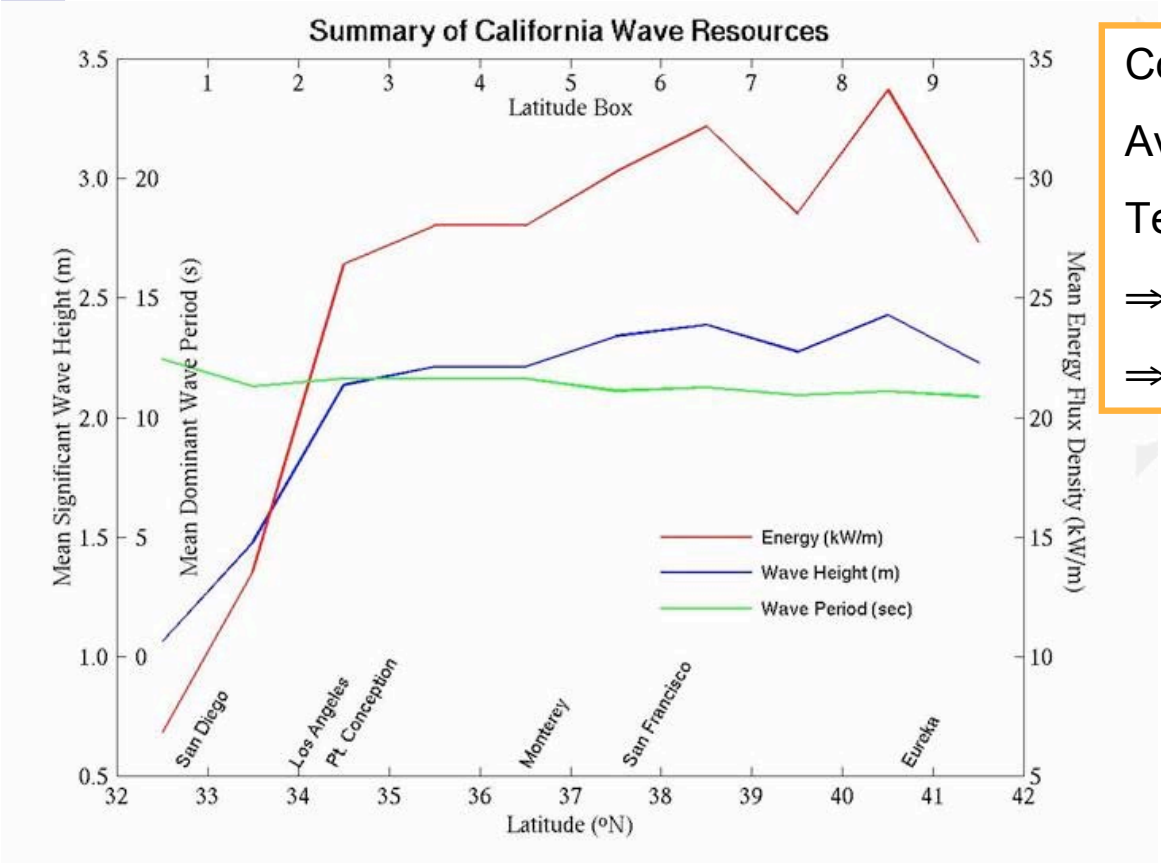
U.S. conventional hydro-electric generation in 2004 was ~260 TWh/yr

Wave and current generation potential

- Offshore wave 250-260 TWh/yr (15% of primary energy)
- Tidal, river, and ocean currents TBD but maybe half of wave

Potential to meet nearly 10% of national demand

California Wave Energy Resource



Coast Length: 1200 km

Average Power: 37,000 MW

Technical Potential: 7,460 MW

⇒65 TWh/yr =>

⇒23% of California Electricity Needs

California has a significant Wave Energy Potential, justifying moving forward with a demonstration plant in a controlled and closely monitored environment

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[redacted]

What makes a good Wave Power Site?

- High Wave Power Density
- Nearby Port Infrastructure for Operational Considerations
- Nearby Grid Interconnection
- Water depth of about 50m

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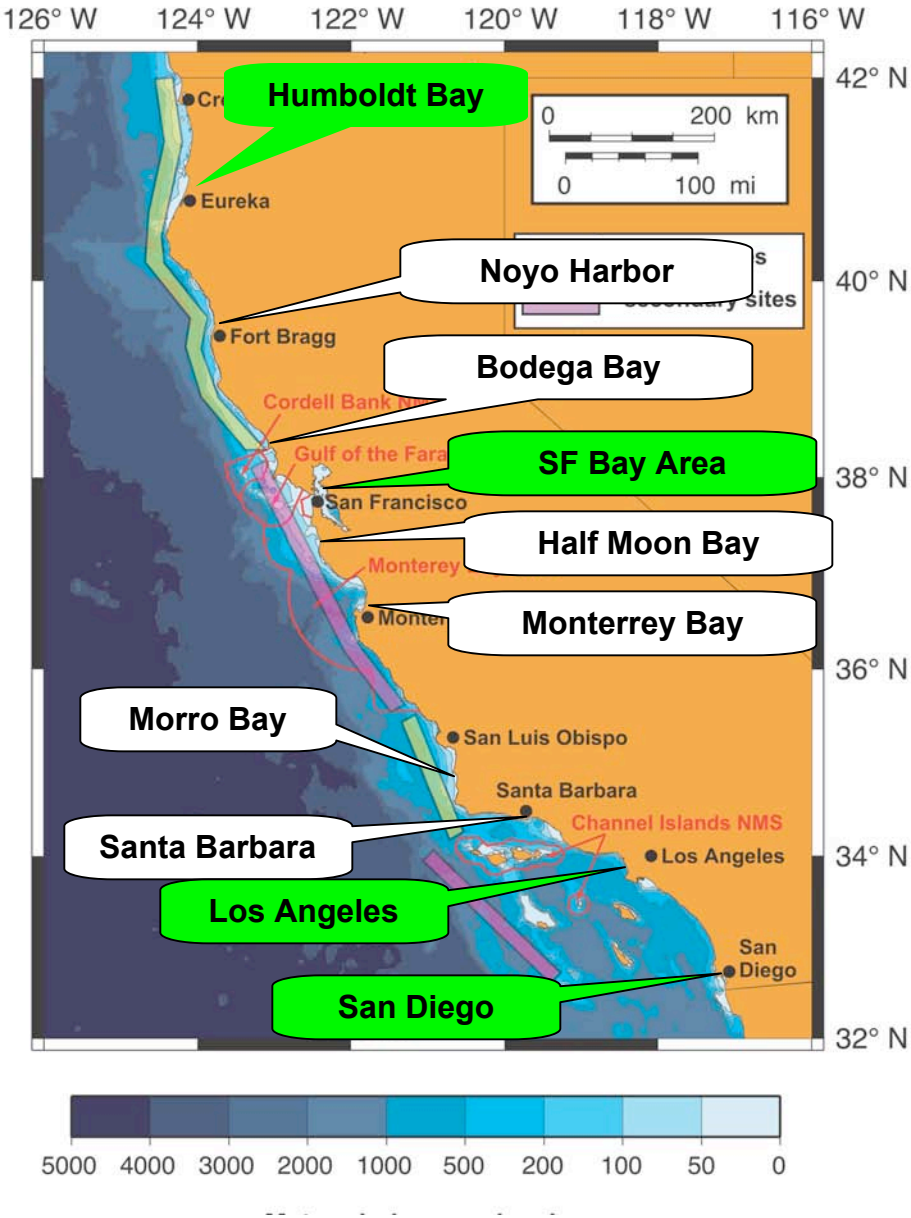
State Overview – Port Facilitites



Deepwater Ports in California

- Humboldt Bay
- SF Bay Area
- Los Angeles
- San Diego

Other ports would likely need some Modifications to carry out O&M such as dredging and building docks etc.

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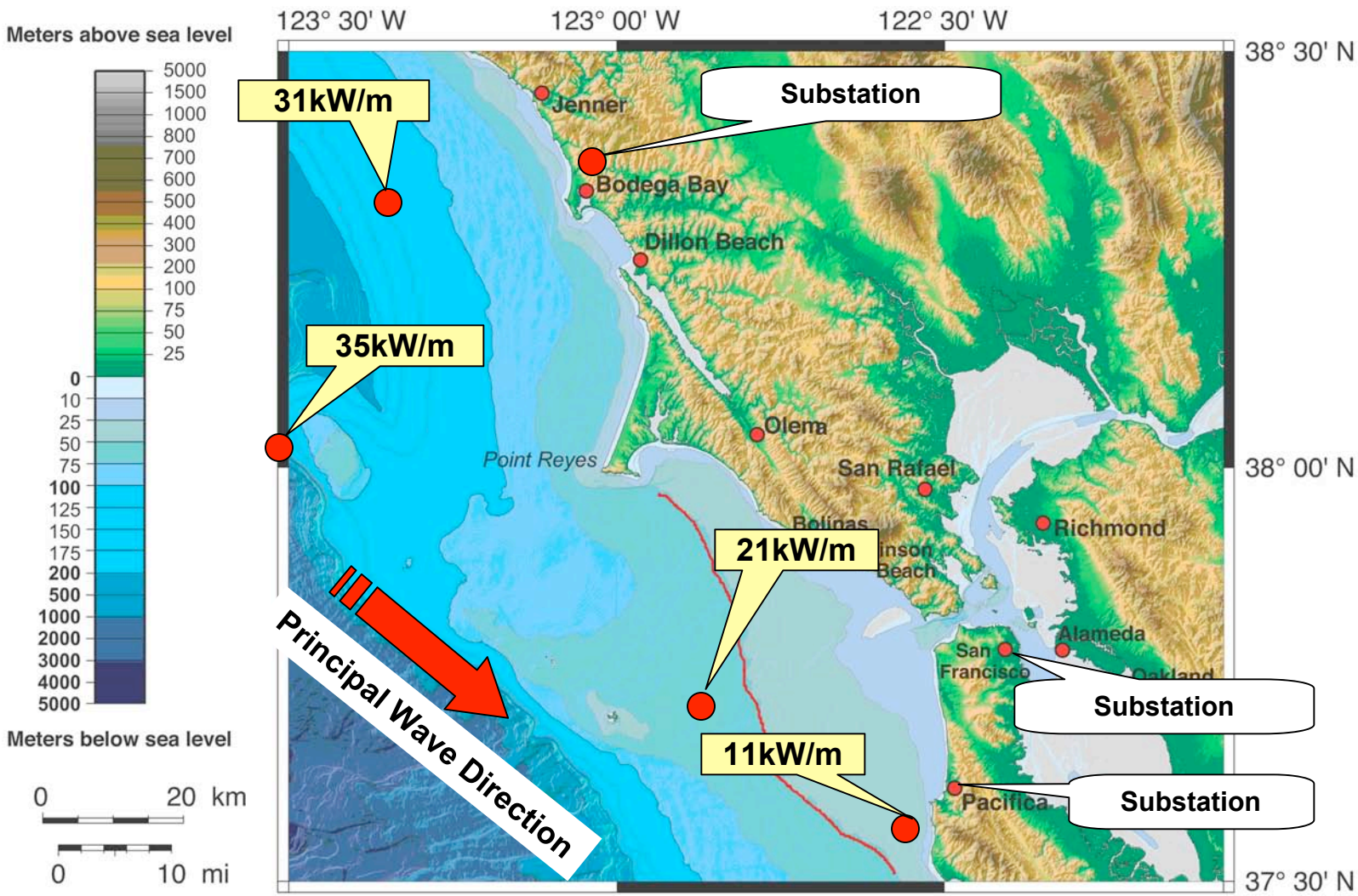
Deployment Locations – SF Area



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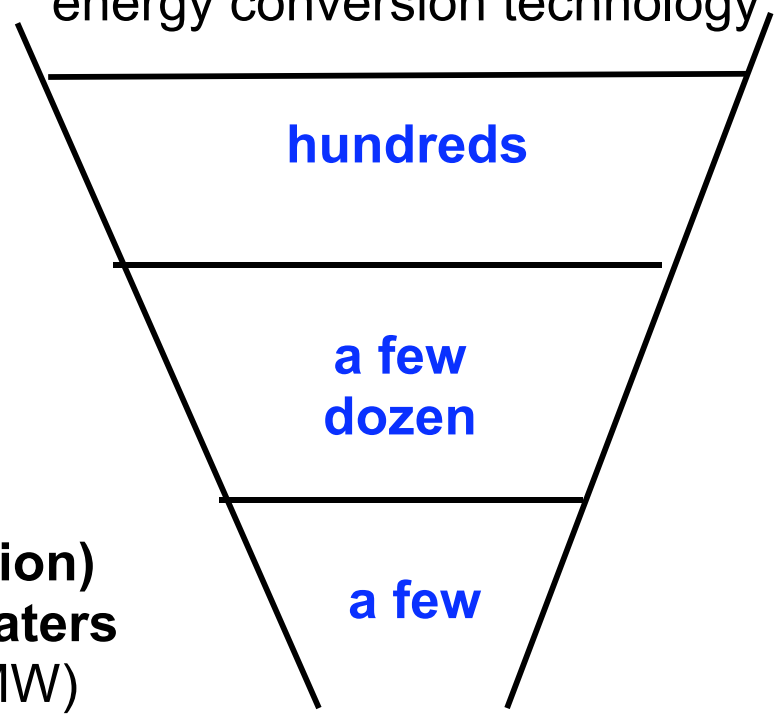
Technology Development Status

Thousand of concepts and patents on ocean energy conversion technology

Rigorous laboratory tow- or wave-tank physical model tests
(1/50- to 1/5-scale)

Short-term (days to months) tests in natural waters
(typically 10 kW to 100 kW)

Long-term (>1 yr duration) prototypes in natural waters
(typically 100 kW to 2 MW)



It typically takes 5 to 10 years for a technology to progress from concept-only to deployment of a long-term prototype

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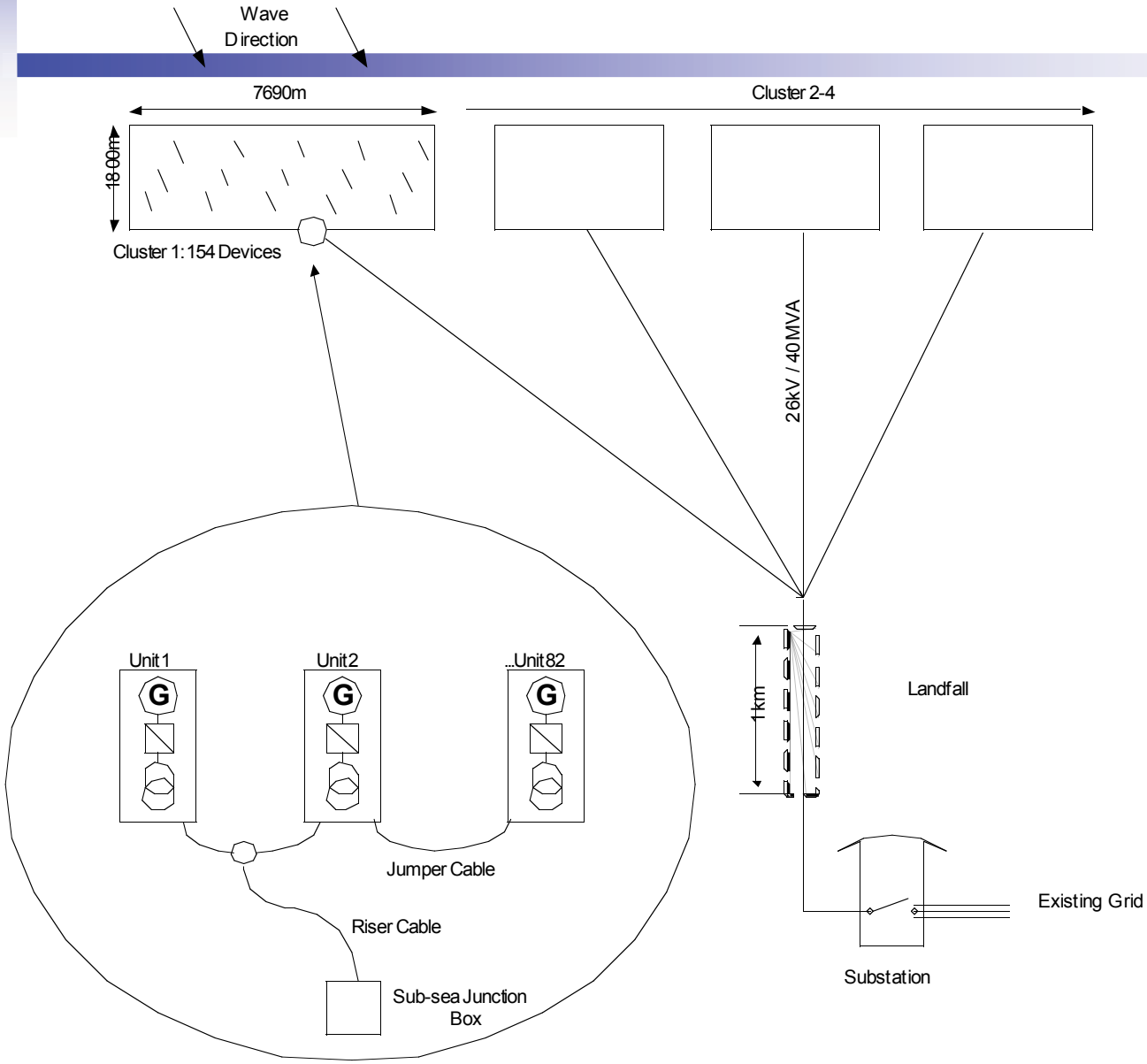
Components of a Wave Farm



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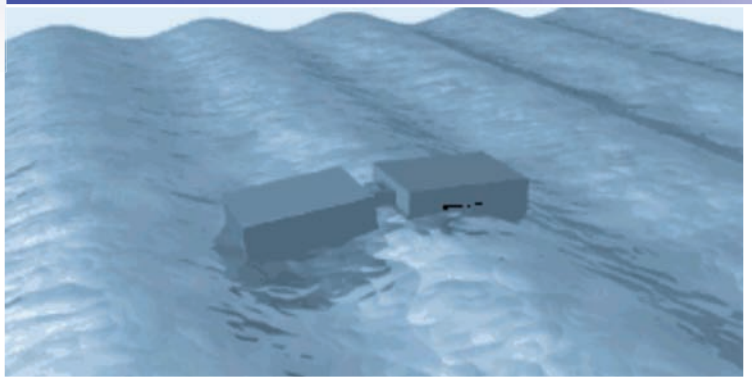
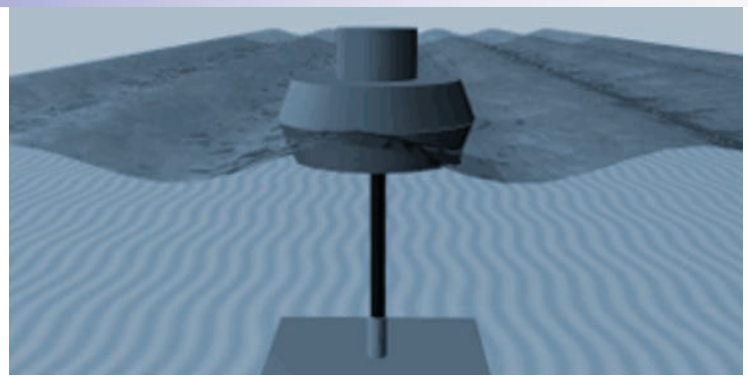
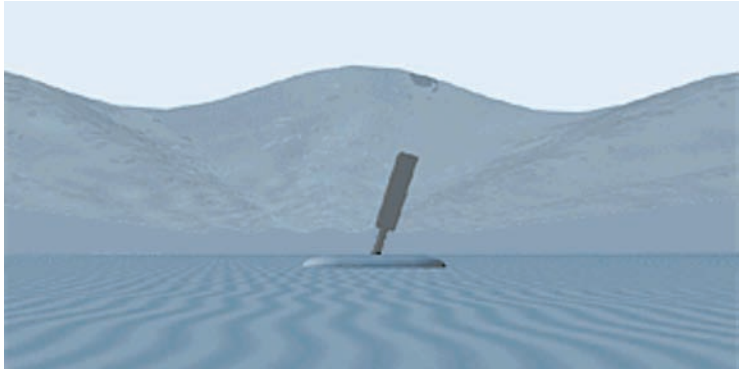
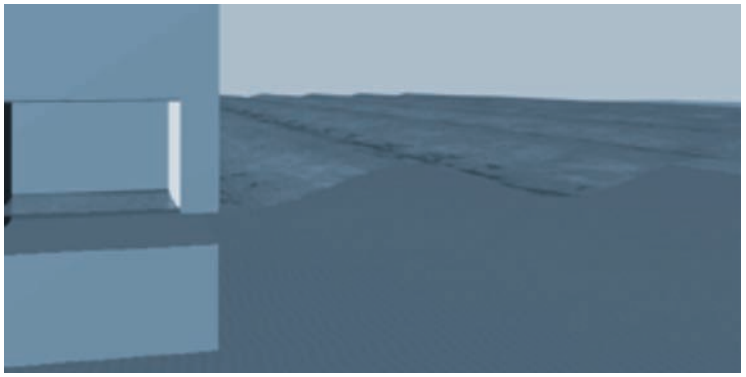
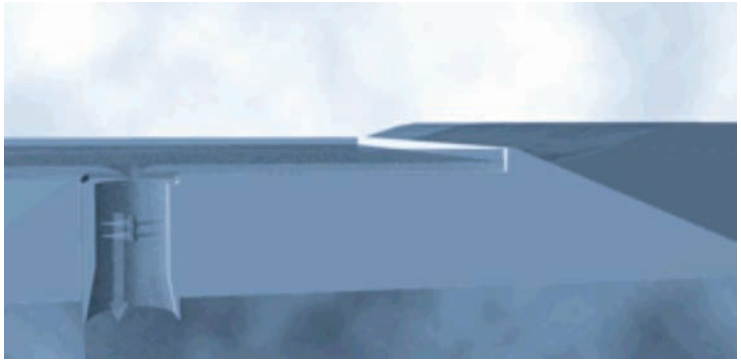
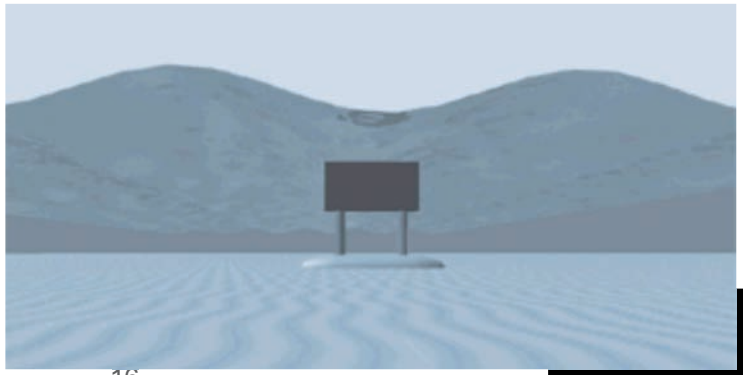
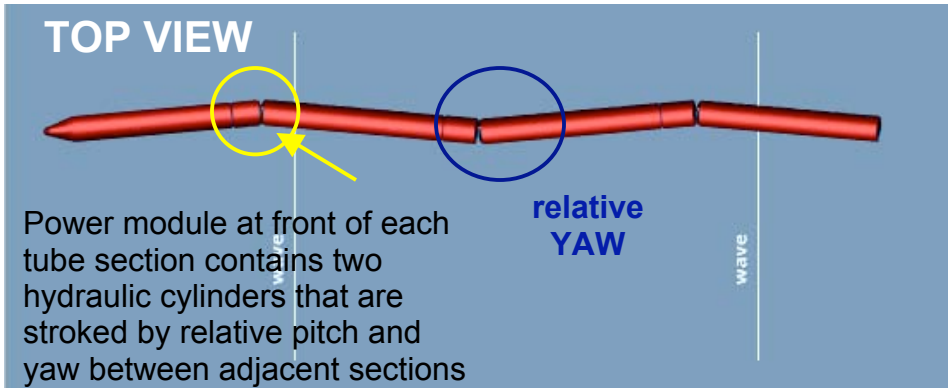
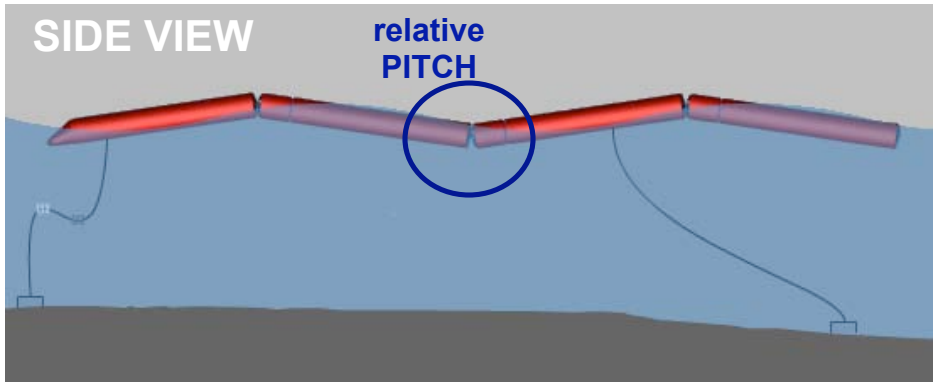
Wave Power Conversion Principles

UK Based Ocean Power Delivery Pelamis





Pelamis 750 kW prototype installed in August of 2004 in 50 m water depth, 2 km offshore the European Marine Energy Centre, Orkney, UK

Pelamis 1st commercial sale occurred 2005 – OPD Pelamis in Portugal – contains an early 3 unit qualification

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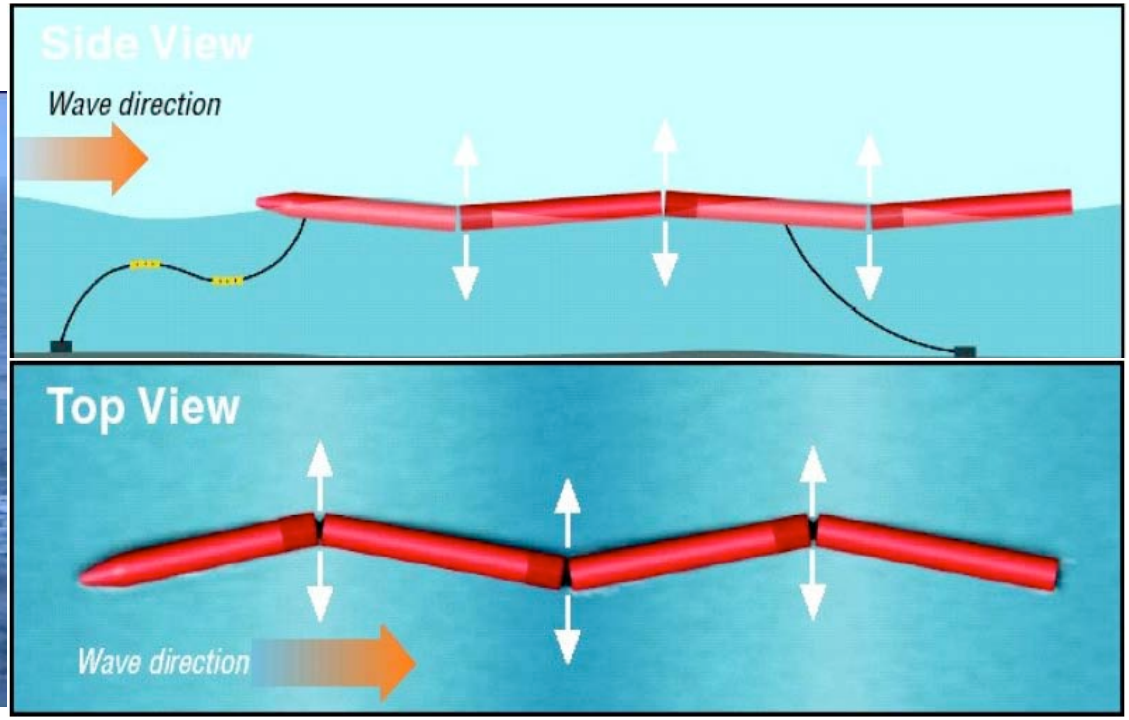
UK Based Ocean Power Delivery Pelamis

Total Device Length:	150m
Device Diameter:	4.63m
Structural Steel Weight:	380tons
Average Power (24kW/m):	152kW
Water Depth:	>50m



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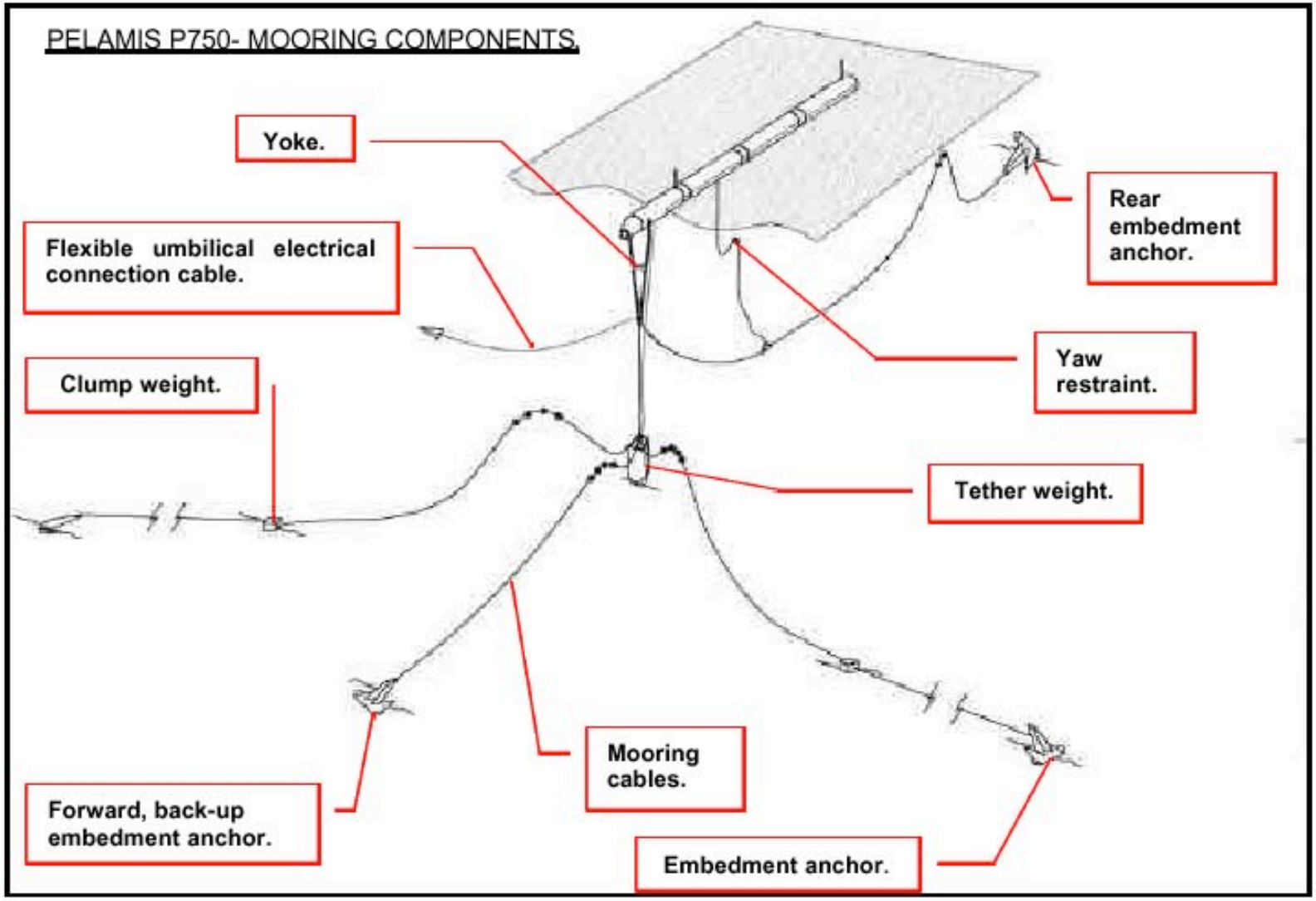
Mooring (Pelamis Example)



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Mooring Components (Pelamis Example)

Embedment anchor.

Clump weight.

Mooring cable.

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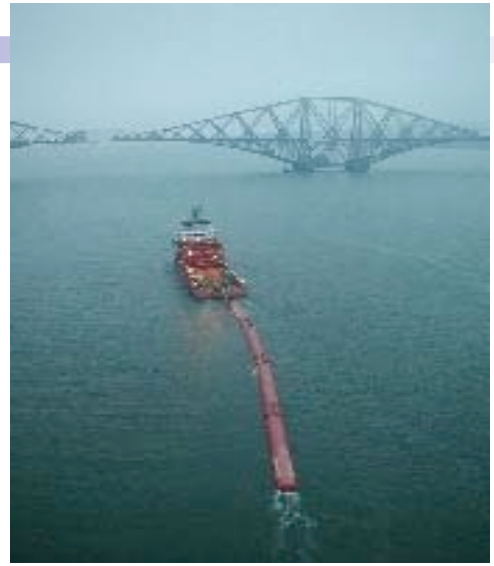
Operation



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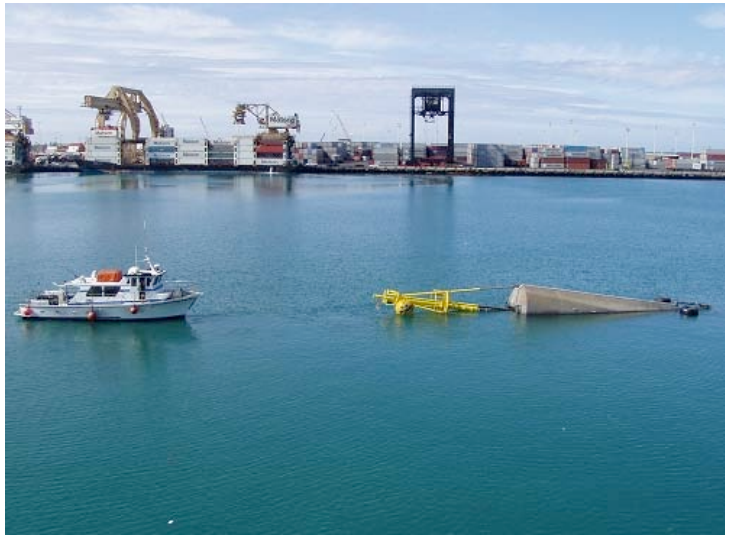
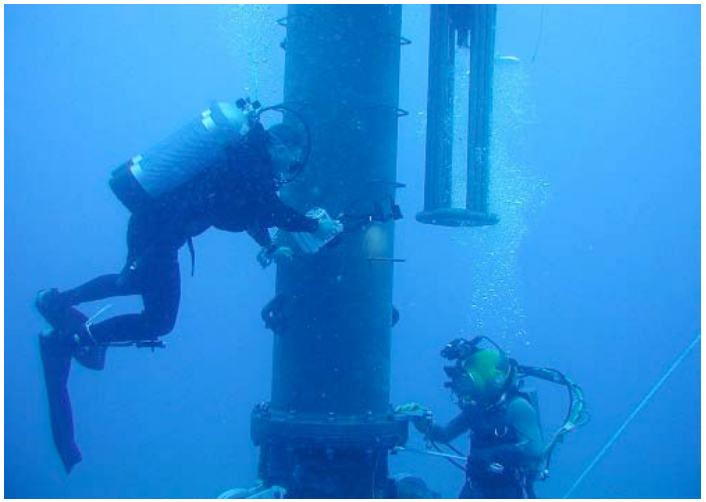
North America Wave Energy Projects
Kaneohe HI – OPT PowerBuoy





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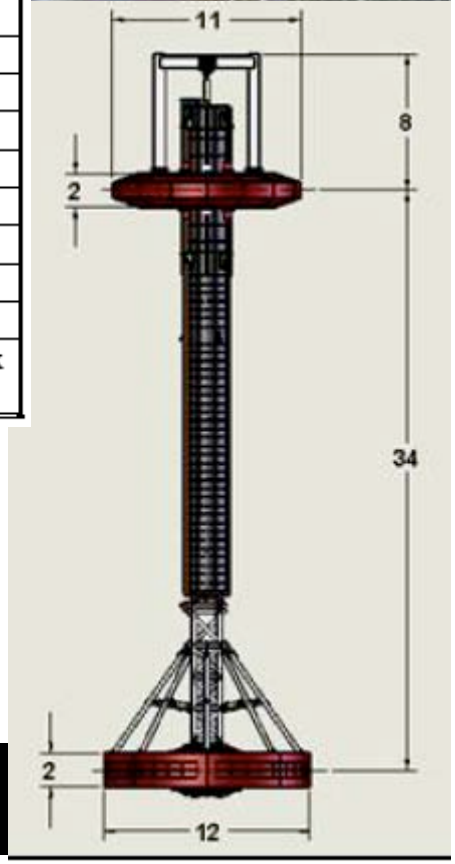
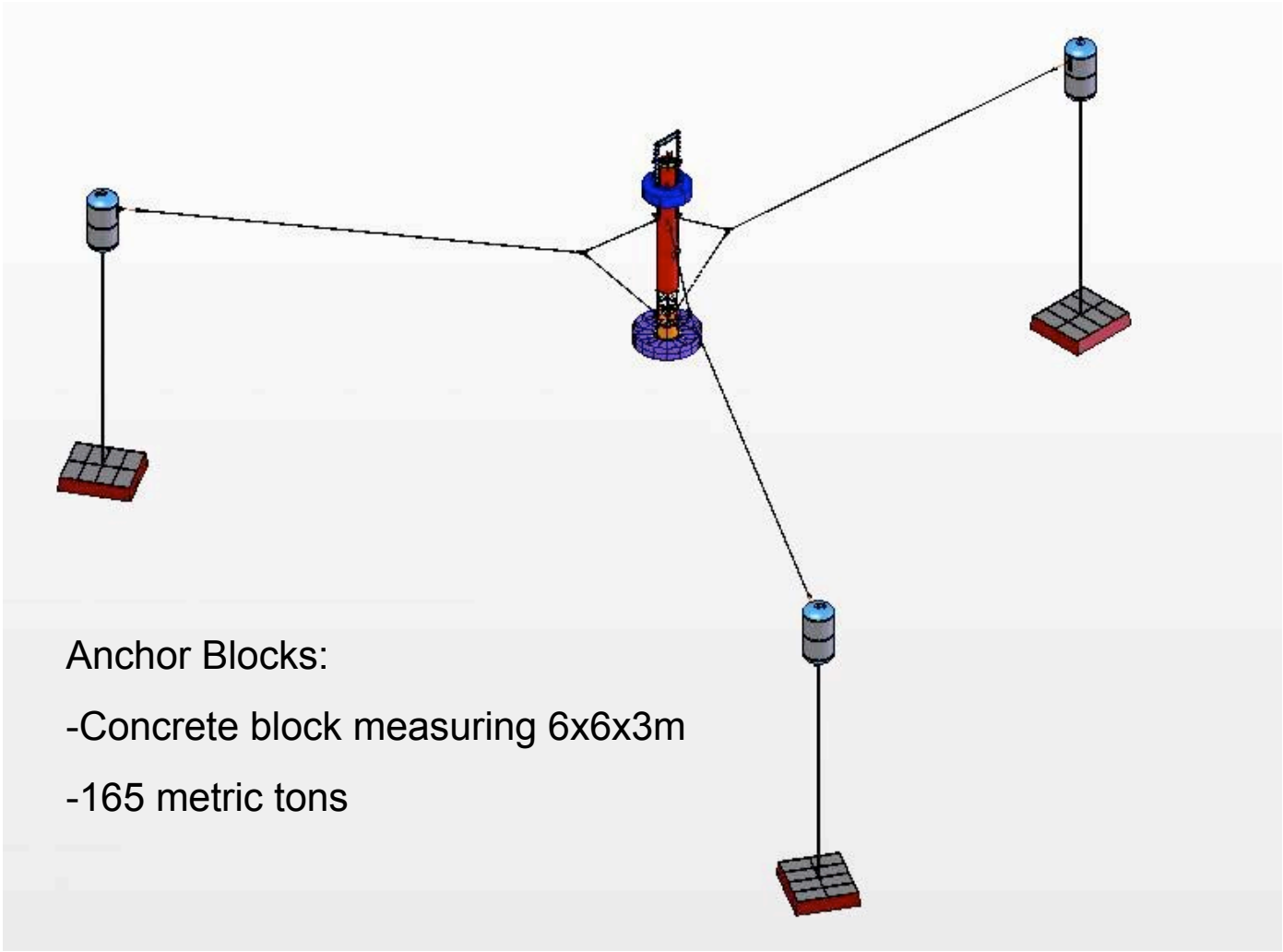
OPT PowerBuoy - Specs

Number of PowerBuoys:	14
Buoy Type:	PowerBuoy
Rated Capacity:	150 kW per PowerBuoy, 2.1 MW total
Grid Connection:	PNGC Power at Gardiner Substation
Min. Water Depth:	167-feet (28-fathoms, 50-meters)
Footprint (max):	0.25 sq mile (800-meters x 800-meters)
Configuration:	3-4 rows x 4-5 columns
Distance from Coast:	2.5 miles (4 kilometers)
Float Diameter:	37 feet (11-meters)
Float Height:	6.7 feet (2 meters)
Height Above Water:	27 feet (8 meters)
Draft:	120 feet (20 fathoms; 36 meters)
Subsea Pod:	6 feet diameter (1.9 m), 15 feet long (4.6 m)
Number of Anchors:	3 per PowerBuoy for first in each row; 2 per PowerBuoy for remaining
Anchor Type:	Mass, steel-reinforced, pre-cured concrete
Anchor Mass:	165 tons (150 metric tons)
Anchor Dimensions:	Approximately 20 feet L x 20 feet W x 10 feet H (3,941 cubic feet; 6 meters L x 6 meters W x 3.1 meters H)



Reference: PAD filed with FERC in July

OPT PowerBuoy – Mooring Configuration



Anchor Blocks:

-Concrete block measuring 6x6x3m

-165 metric tons

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Finavera - AquaBuOY

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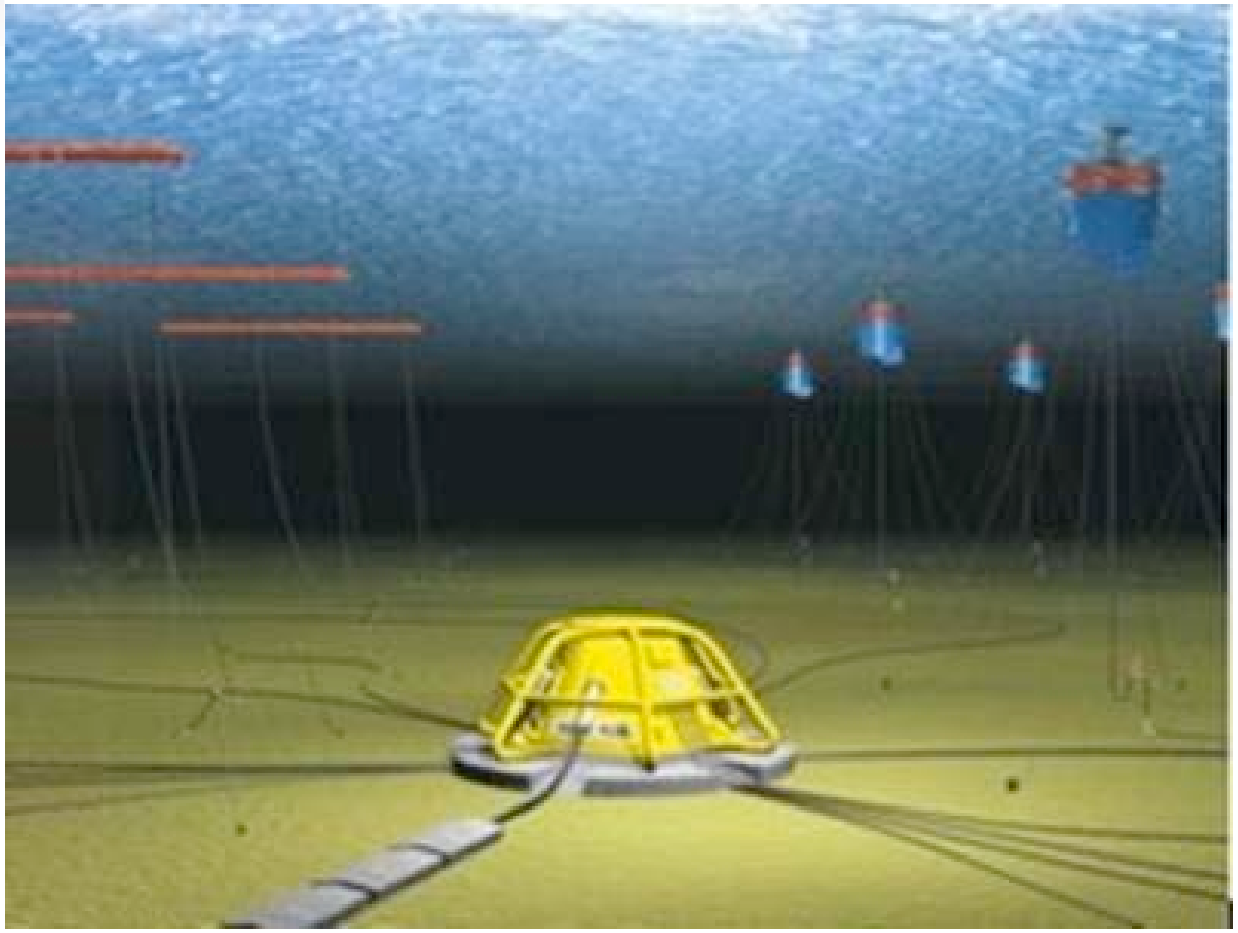
Path Forward In California



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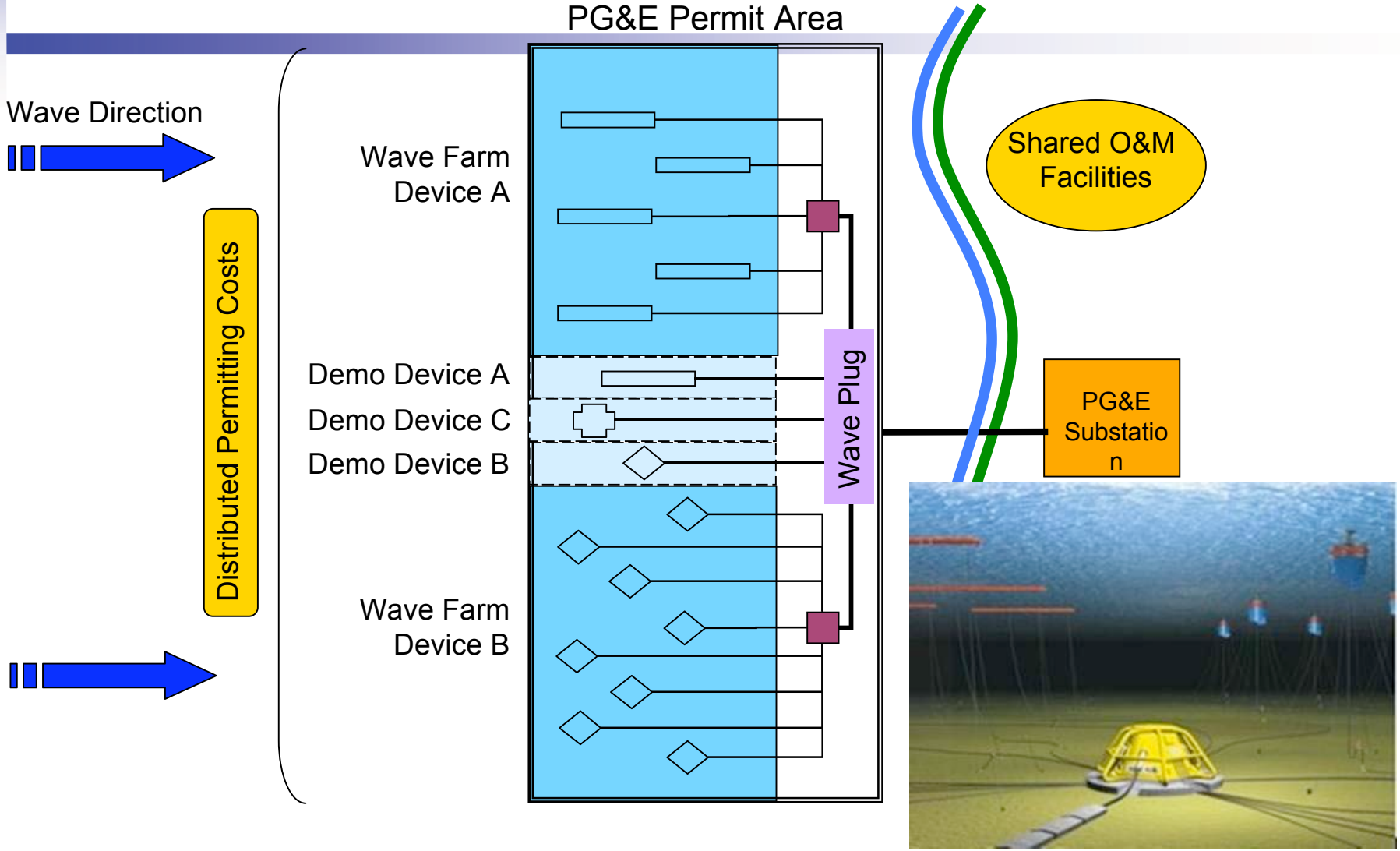
End

Need more data? EPRI has published 20 reports on wave energy conversion. Available at:
www.epri.com/oceanenergy

Any questions?

Email: mirko@re-vision.net

Wave Power – PG&E Wave Plug



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