



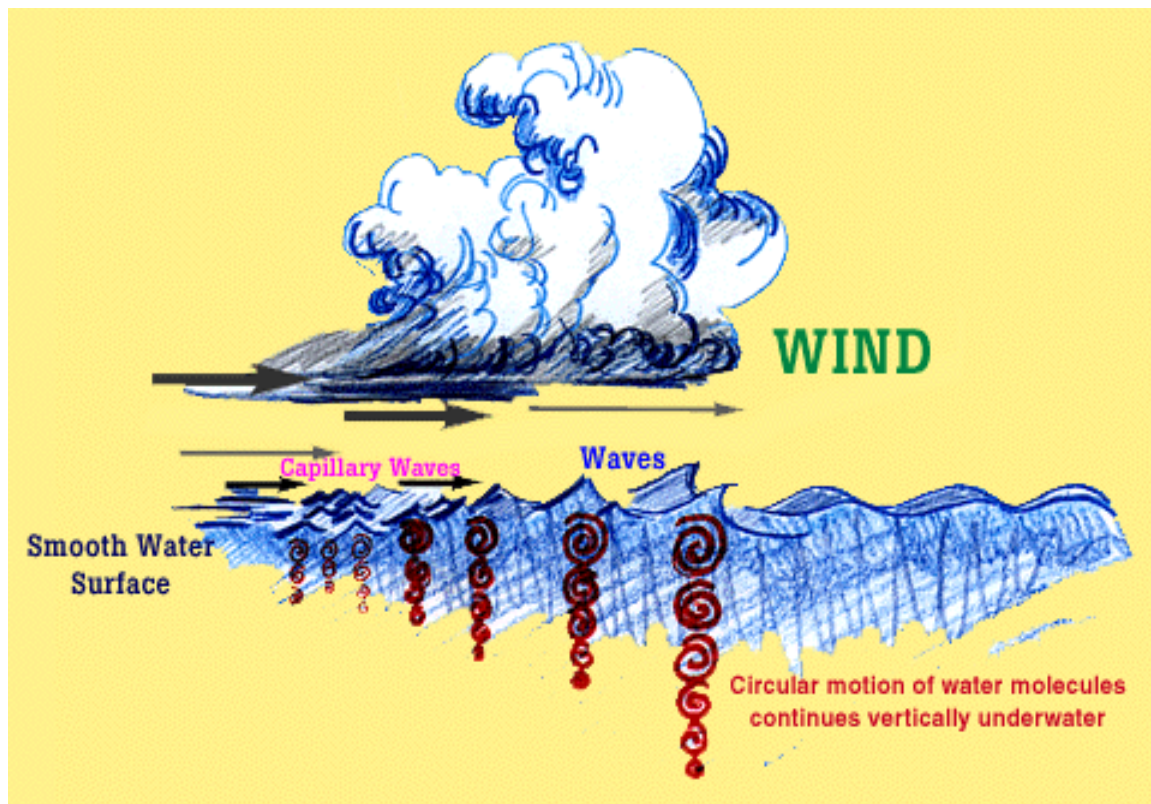
**EPRI 2004  
Wave Power Feasibility Study**

**Final Project Briefing**

**March 15, 2005**

**EPRI**

# Waves



Waves are a concentrated form of solar energy

Technology to convert wave energy to electrical energy is in its starting phase

> 1000 Patents

< 2 MW Installed

Active Gov't RD&D Program in Europe and Australia

No Gov't RD&D Program in the U.S.

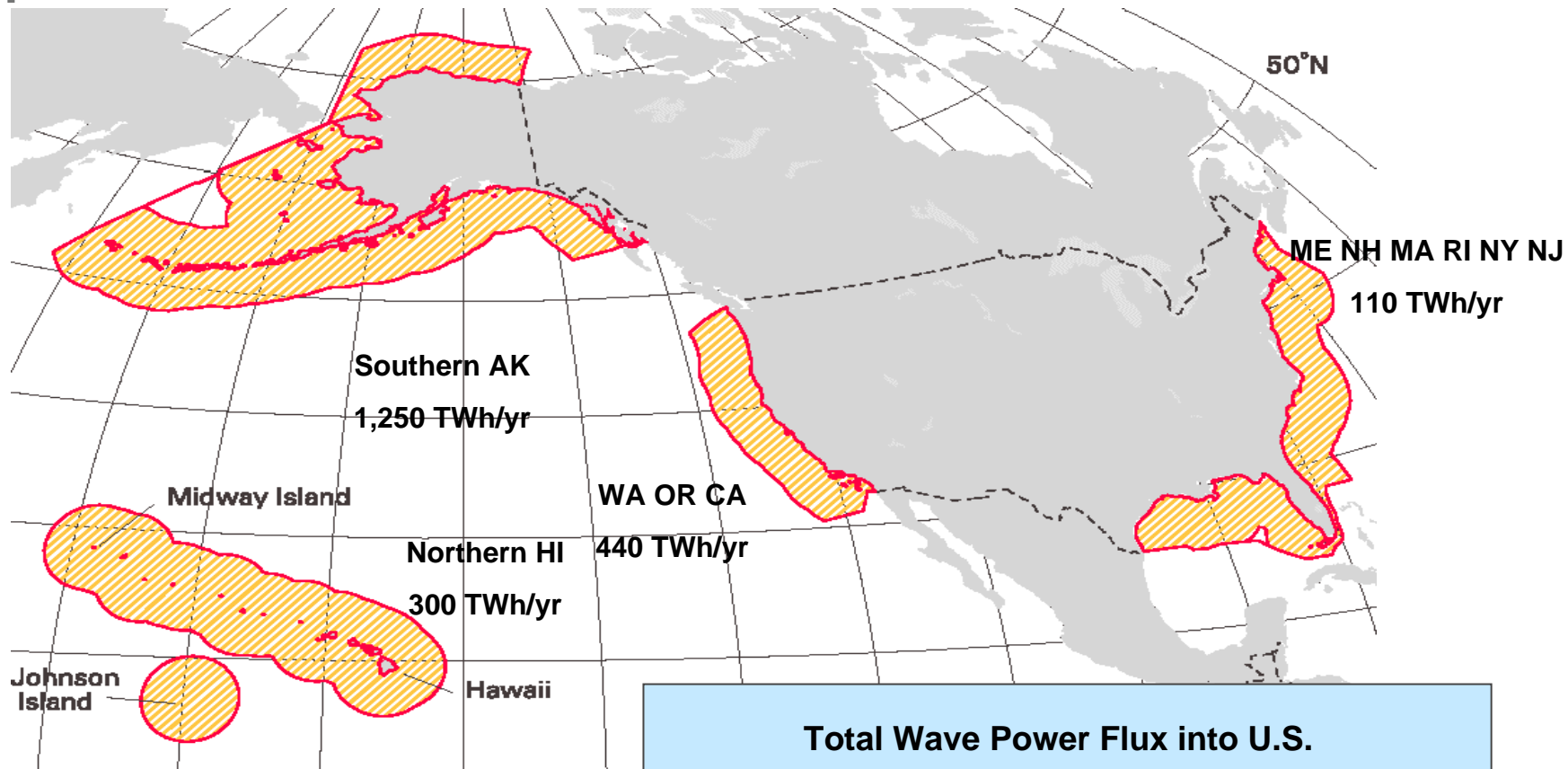
Technical and Economic Feasibility Demonstration in the U.S. is the Next Needed Step in the Technology Development Process

# EPRI 2004 Wave Energy Feasibility Study

- Techno-Economic Rationale for Investing in Wave Energy Technology is a Function of its Potential Commercial Viability
- Elements of Project Definition Study
  - ID and characterize potential sites
  - ID and assess wave energy conversion devices
  - Design and estimate performance and cost of pilot demonstration plant (500kW – 40% capacity factor)
  - Extrapolate to 90 MW – 40% capacity commercial plant
  - Assess techno-economic viability of commercial plants
  - ID and assess environmental and regulatory issues

**Study makes a compelling case for investment in wave energy RD&D**

# Wave Power into U.S.



**Total Wave Power Flux into U.S.  
~ 2,100 TWh/yr which is about  
1/10 of total US hydroelectric generation in 2003  
A SIGNIFICANT RESOURCE**

# Site Identification and Characterization

<u>State</u>	<u>County</u>	<u>Harbor</u>	<u>Grid Interconnection</u>
▪ CA	San Fran	San Fran	Ocean Beach Water Treatment Plant
▪ HI	Oahu	Honolulu	Makai Pier, Waimanalo Beach
▪ ME	Cumberland	Portland	Old Orchard
▪ MA	Boston	Boston	Wellfleet Dist Line
▪ OR	Douglas	Coos Bay	Gardiner Substation
▪ WA	Makah Bay	Neah Bay	Makah Bay Dist Line

Avg Annual Power Flux	CA	HI	ME	MA	OR	WA
(kW/m) of wave crest length	20.0	15.2	4.9	13.8	21.2	26.5

# 4 General Types of Wave Energy Devices

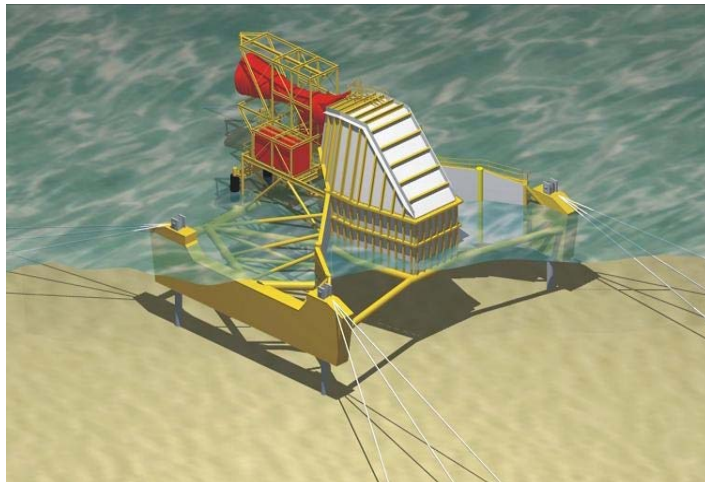
Point  
Absorber



Attenuator



Terminators  
Oscillating Water Column

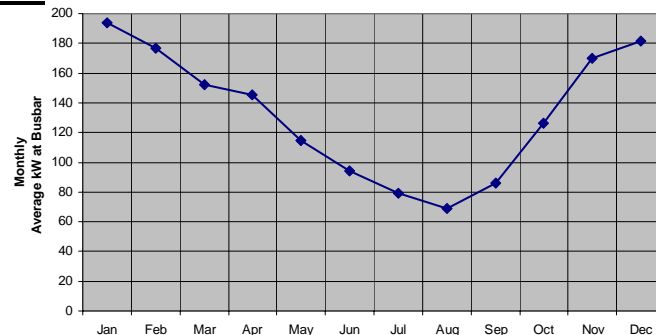
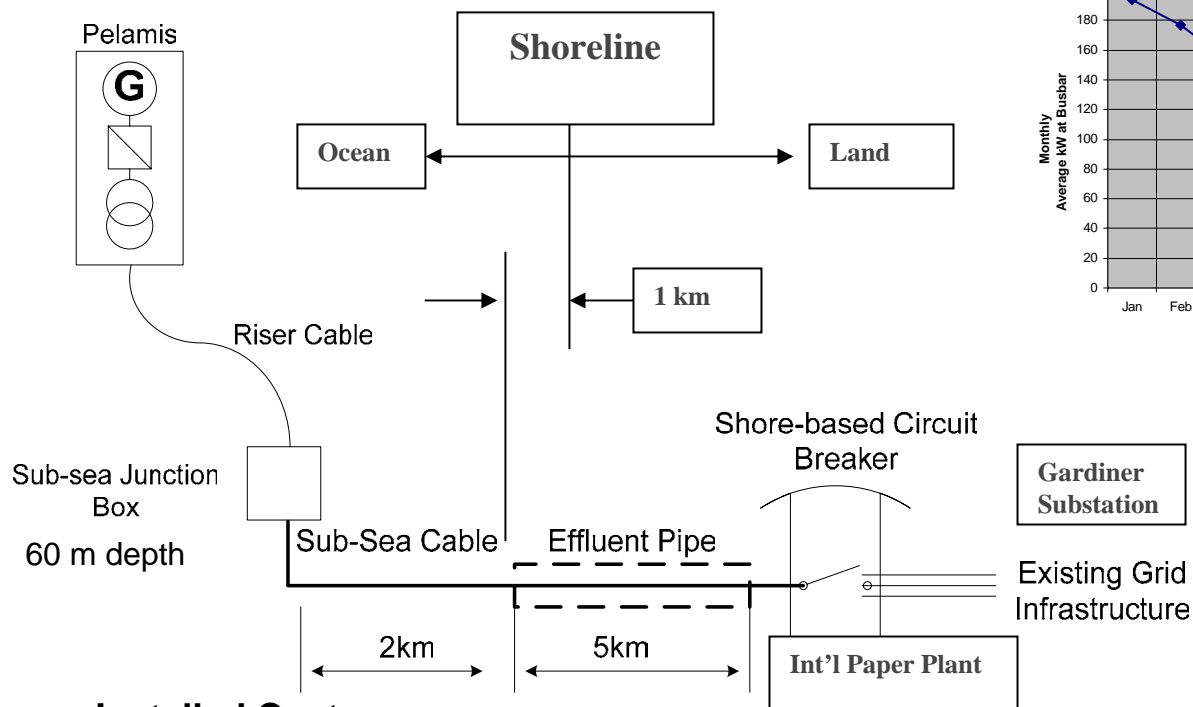


Overtopping



# Pilot Demonstration Wave Power Plant

## Douglas County Oregon – OPD Pelamis Device



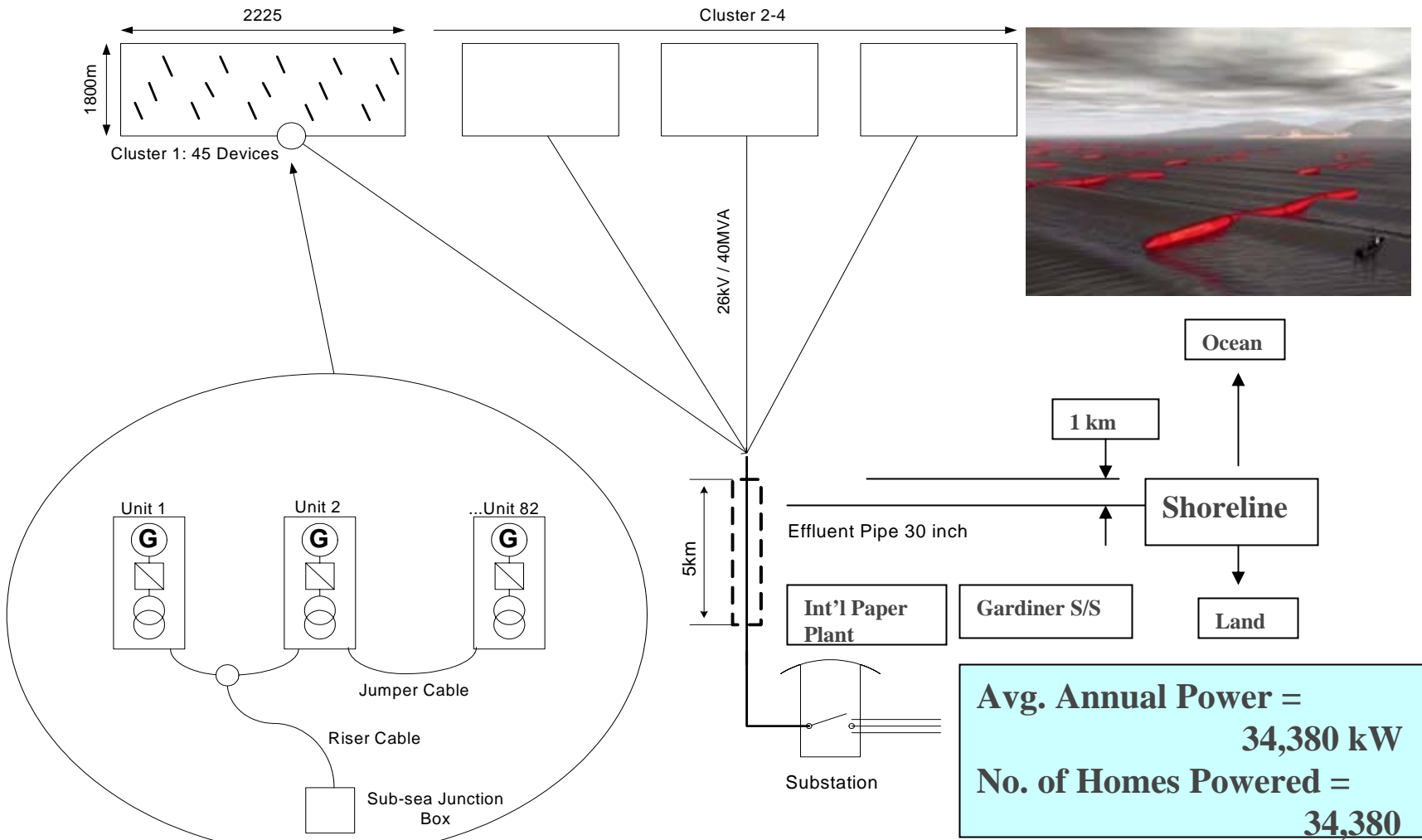
**Energy = 1101 MWh/Yr**

### Installed Cost

• Onshore Grid I/C	\$580,000	• Mooring	\$243,000
• Subsea Cables	\$300,000	• Installation	\$699,000
• Pelamis PCM	\$1,535,000	• Const Mgmt & Com	\$420,000
• Steel Sections	\$850,000	• <b>Total</b>	<b>\$4,627,000</b>

# Commercial Wave Power Plant

Douglas County Oregon Example – 300,000 MWh/yr – 90 MW Rating – 180 Pelamis Devices each rated at 500 kW

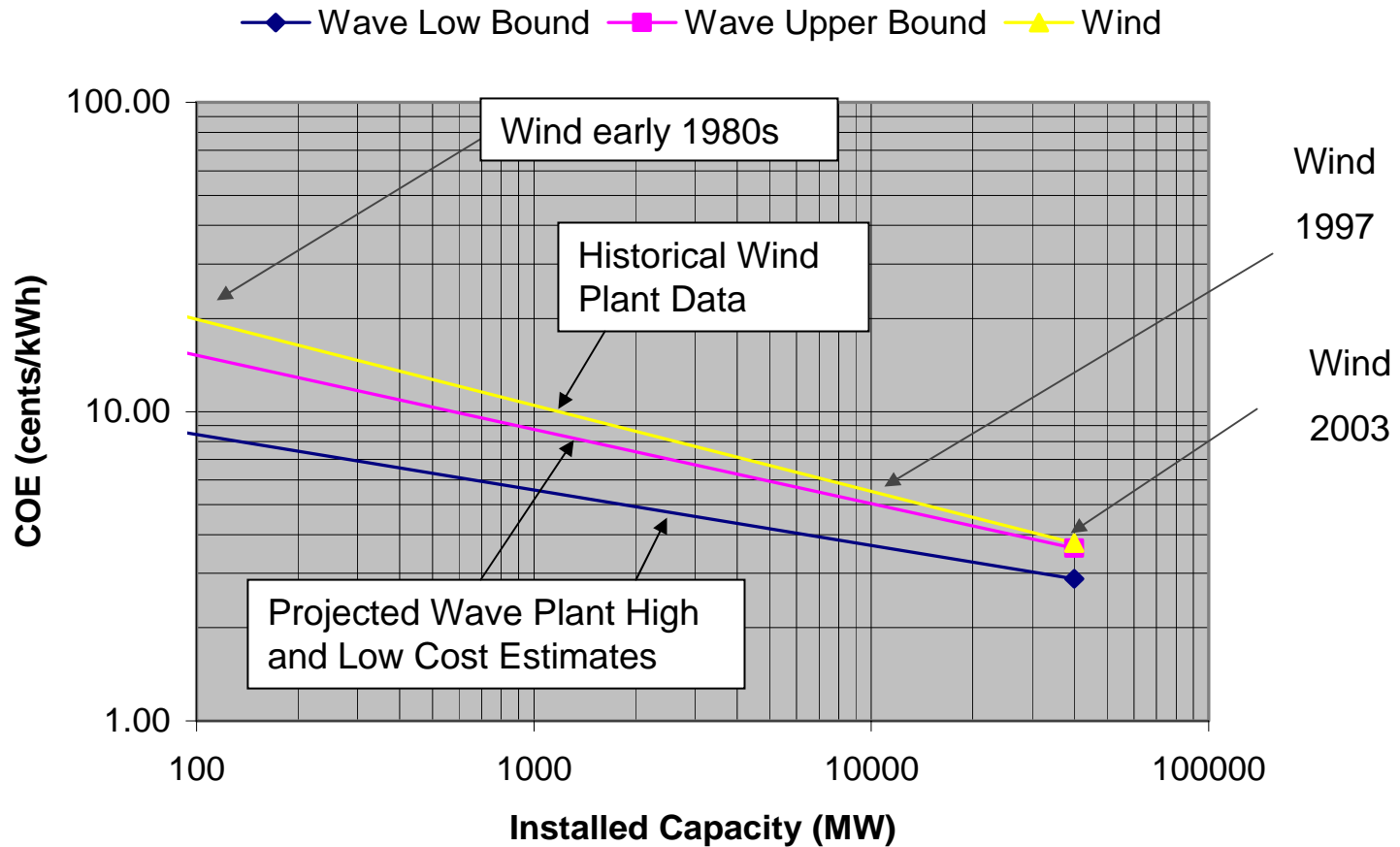


**Avg. Annual Power = 34,380 kW**

**No. of Homes Powered = 34,380**

# Cost of Electricity (COE) as a Function of Cumulative Installed Capacity (Learning)

## Oregon Commercial Scale Plant Design



# Non Economic Benefits

- Given proper siting, converting wave energy to electricity is one of the most environmentally benign ways to generate electricity
- Wave energy offers a way to minimize Not-In-My-Back-Yard (NIMBY) Issues
- Because wave energy is more predictable than direct solar insolation and wind, there is a higher probability that it may be dispatchable

# Conclusions – Techno Economic Forecasts<sup>(1)</sup>

- Northern California and Hawaii have both excellent wave climate, coastal infrastructure and high electricity prices
- Oregon has excellent wave climate and coastal infrastructure, but low electricity prices
- Washington has excellent wave climate, but poor coastal infrastructure and low electricity prices
- Massachusetts has good wave climate in the winter, but poor in the summer, high electricity prices and a REC market
- Maine has a poor wave climate – a good wind site is forecasted to be techno economically favorable to wave energy for the state of Maine

# Conclusions

- There is a compelling case for investing in wave energy RD&D to answer many application questions such as:
  - What device type and size is best?
  - What capacity factor is optimum?
  - Will the installed cost of wave energy achieve its potential of being less expensive than wind energy?
  - Will the O&M costs of wave be as high as predicted?
  - Are the performance and cost estimates accurate?
  - What is the reliability, maintainability and availability?
  - What are the effects on marine life and the coastline
  - What is its ability to survive storms?
  - What is its ability to operate over a 20 year or so life?

# Recommendations - Needed Actions

- Encourage pilot feasibility demonstration projects
- Encourage R&D at Universities
- Encourage the Federal Government to Support RD&D
  - Leadership for a national ocean energy program
  - Operate a national offshore ocean energy test facility
  - Development of standards
  - Joining the IEA Ocean Energy Program
  - Leading the streamlining of permitting processes
  - Studying provisions for incentives and subsidies
  - Ensuring that the public receives a fair return from the use of ocean energy resource
  - Ensuring that development rights are allocated through a fair and transparent process taking into account state, local and public concerns