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Beyond Oil: Powering the Carbon Free Grid

September 5, 2008

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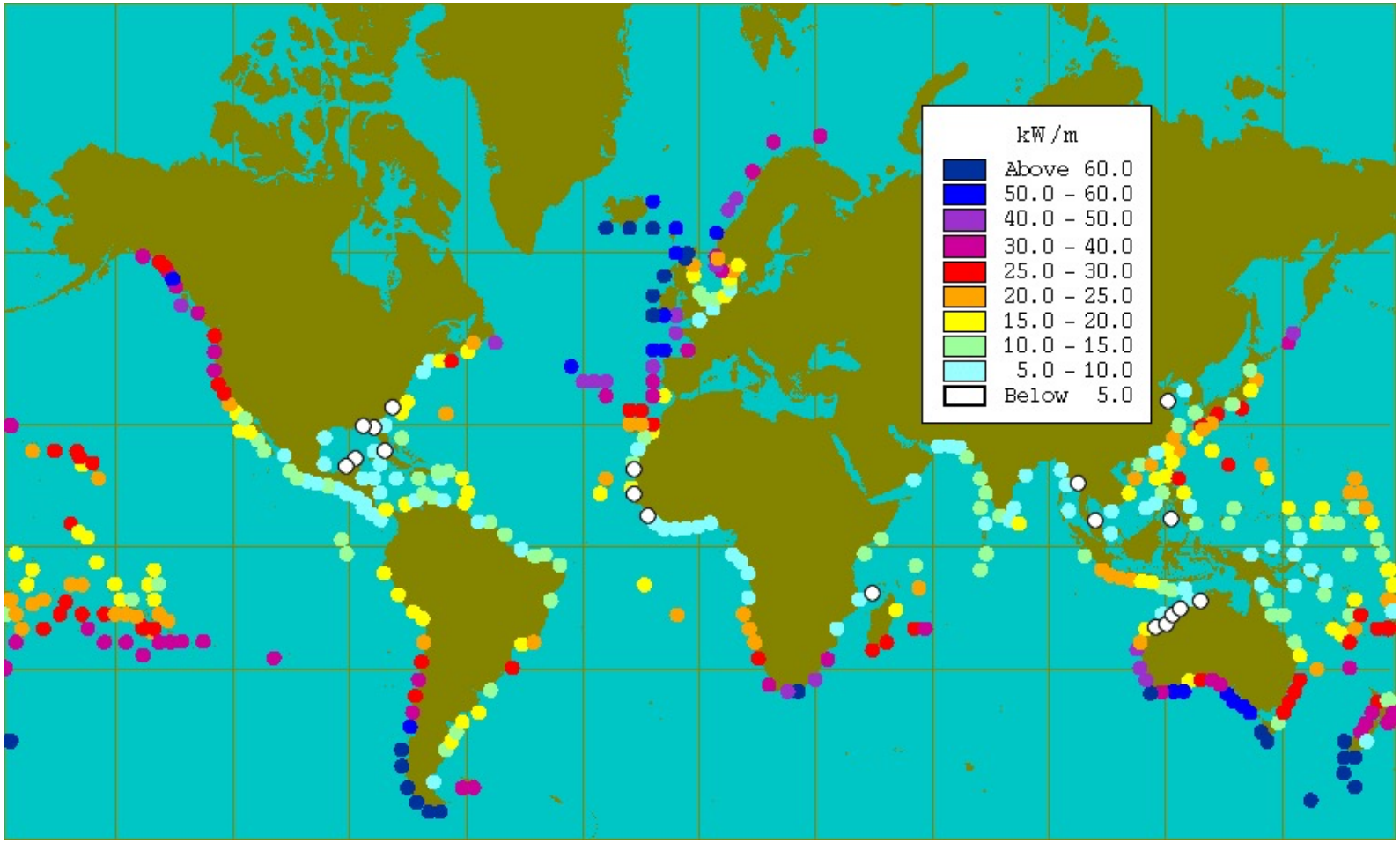
Wave Energy Density



Annual average wave energy flux per unit width of wave crest

(kilowatts per m)

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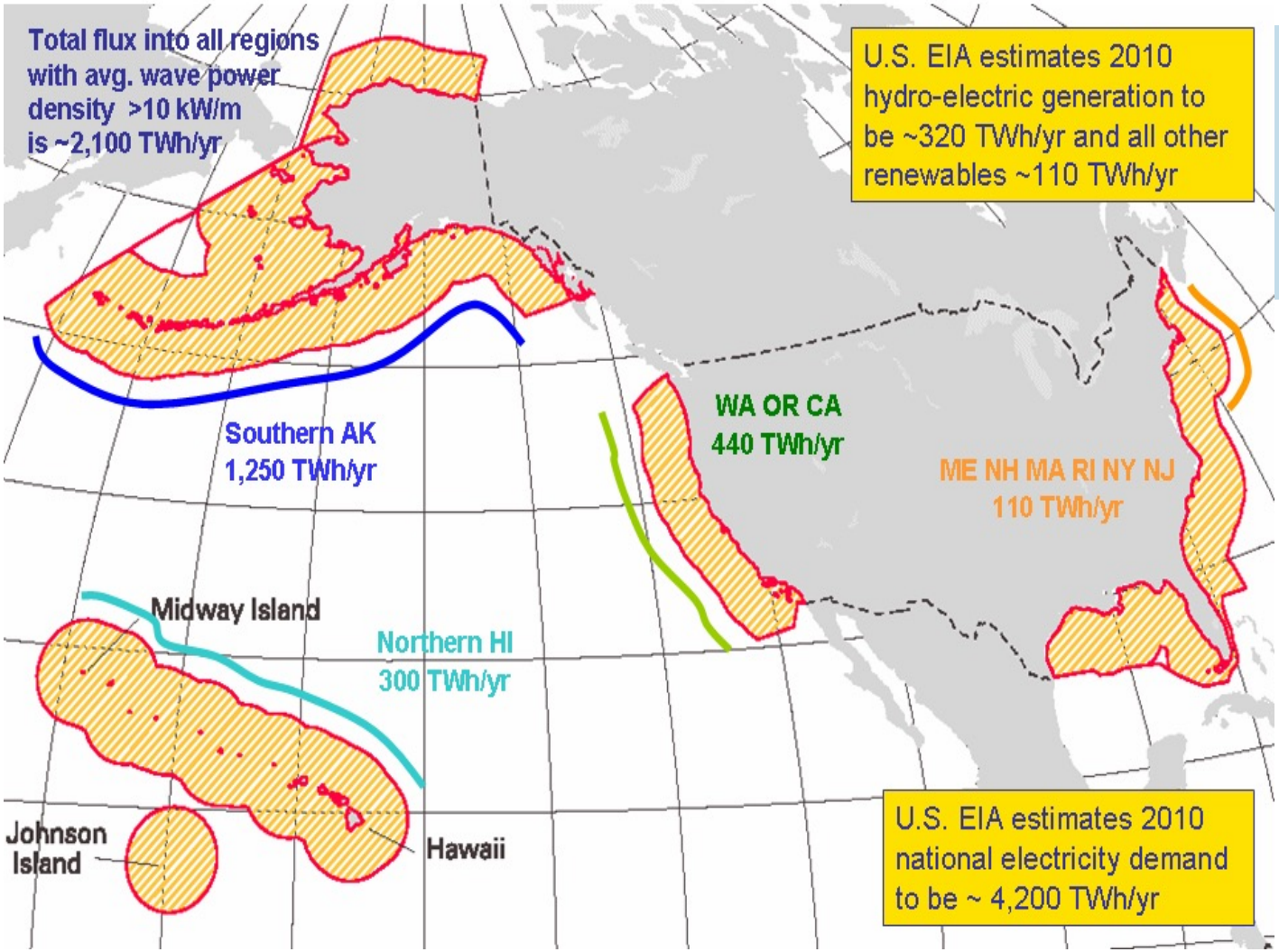
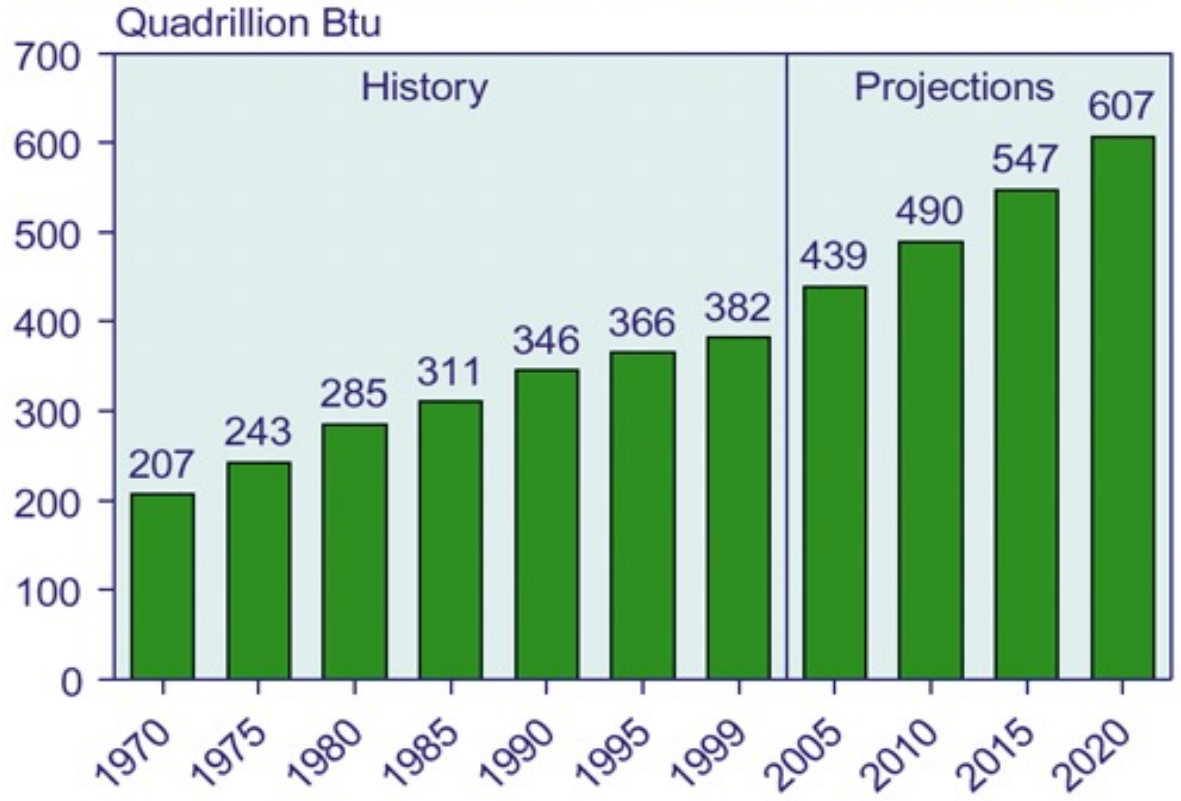


HOW BIG?

Wave energy flux in the US

Figure 13. World Energy Consumption, 1970-2020



Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, World Energy Projection System (2001).

Advantages of Wave Energy

Ocean Energy has the potential to supply 10% of the world's energy needs

- Density (water 1000X as dense as air)
- Availability (a 24/7 resource)
- Predictability (lead time for utility schedulers)
- Close to sources of load
- Ability to bypass transmission constraints
- Low visual impact
- No fuel volatility (price or political)
- No emissions

"Ocean waves have tremendous potential as an energy source. The energy density in water is much higher than it is in air. We can get more power with less space, and we can know within a ten-hour window what our energy capabilities are, and we can match them to the need."

-Annette von Jouanne

Professor, School of Electrical Engineering, OSU

Competitive Advantages for Oregon

- Powerful wave resource
- Business Energy Tax Credits (BETC) for renewable energy projects
- Engaged Oregon State Government
- MOU between Oregon and FERC
- Existing metals and fabrication industry
- Renewable Energy Portfolio Standard (RPS) that includes wave energy
- Academic leader – OSU is only NSF funded wave energy research program

Energy Potential

OSU research shows a buoy about 12 feet wide and 12 feet tall, rolling up and down in the ocean swells could produce 250 kilowatts per unit.

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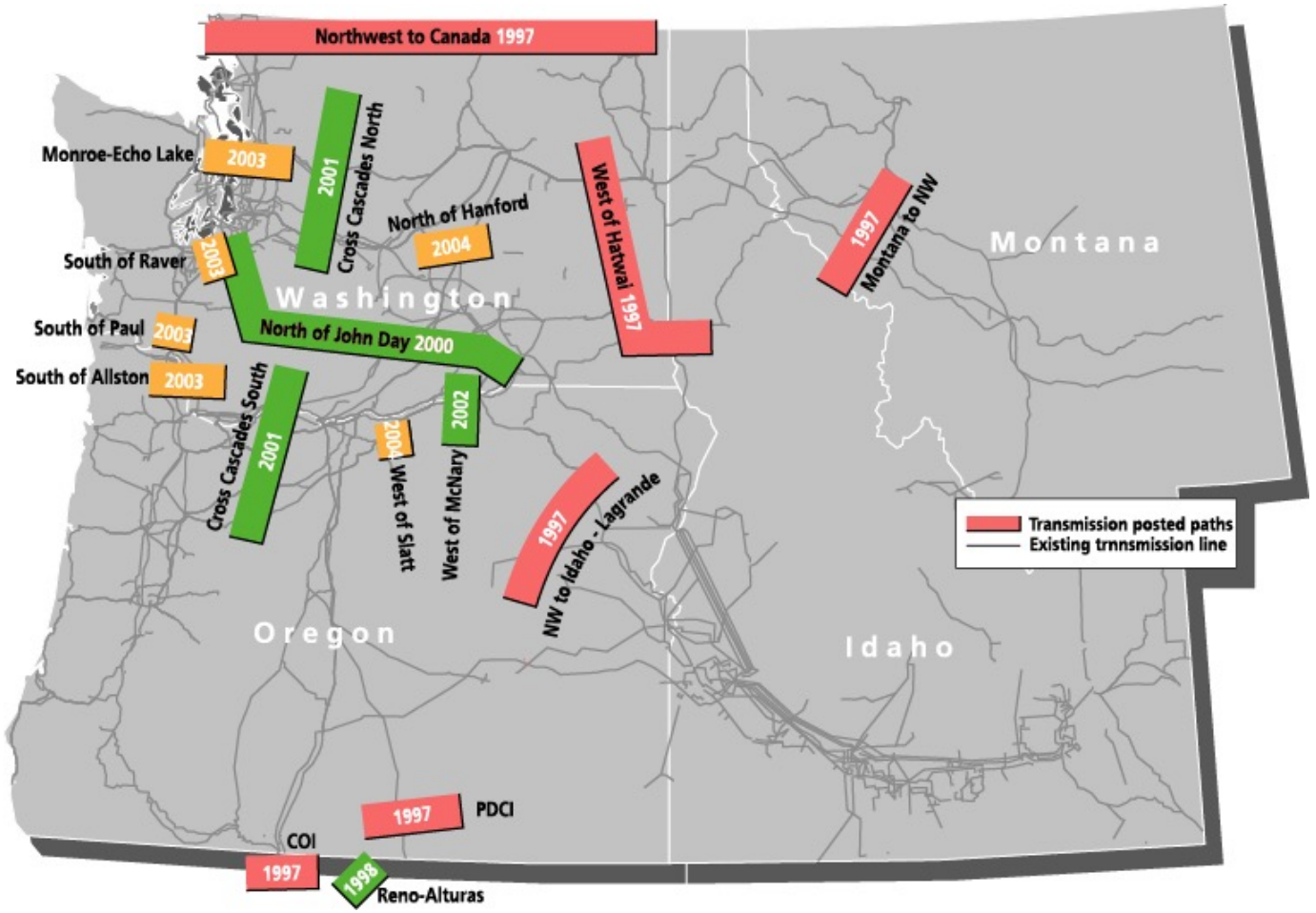
Transmission Constraints in the Northwest



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Activity on the West Coast

Several Permits filed
- FERC: grants development rights for 36 months
  - Ocean Power Technologies (OPT), Finavera Renewables
- FERC license granted in Makah Bay, WA (Finavera)
- PPA with PG&E in California (Finavera)

County Applications in Oregon
- Lincoln
- Douglas
- Tillamook
- Curry?
- Others?

Technology developers
- OPT
- Finavera Renewables
- OceanLinx
- Pelamis

530 total proposed MW
- Private developers 380 MW
- Less than 7 sq miles

Wave Energy

Providing 10% of the world's energy

- Various methods of harnessing the energy of waves
- Wave energy completes Oregon's renewable energy portfolio

A

B

C

D

Devices

A. Oscillating Water Column
B. Attenuator
C. Overtopping
D. Point Absorber

Oscillating Water Column

Water enters through a sub-surface opening into a chamber with air trapped above it – a pneumatic device

- Water column moves like a piston
- Air forced through an opening connected to turbines

Testing in UK, Australia, plans for UK and Spain installations

Shoreline & offshore

Attenuators

Devices oriented parallel to direction of waves - hydraulic

- Changes in wave height causes flexing
- Flexing connected to hydraulic pumps or converters

Commercially operating off Portugal

Shoreline, offshore & deepwater

Overtopping

Waves elevated to a reservoir above sea level

- Water is released through of turbines
- Turbines transform energy into electricity

Testing off UK and Denmark

Offshore

Point Absorber

Buoy floats above or below the water surface - hydraulic

- Buoy inside a fixed cylinder and moves relative to wave action
- Motion drives energy converters

Prototypes operating in Hawaii, New Jersey, deployed off Oregon

Offshore

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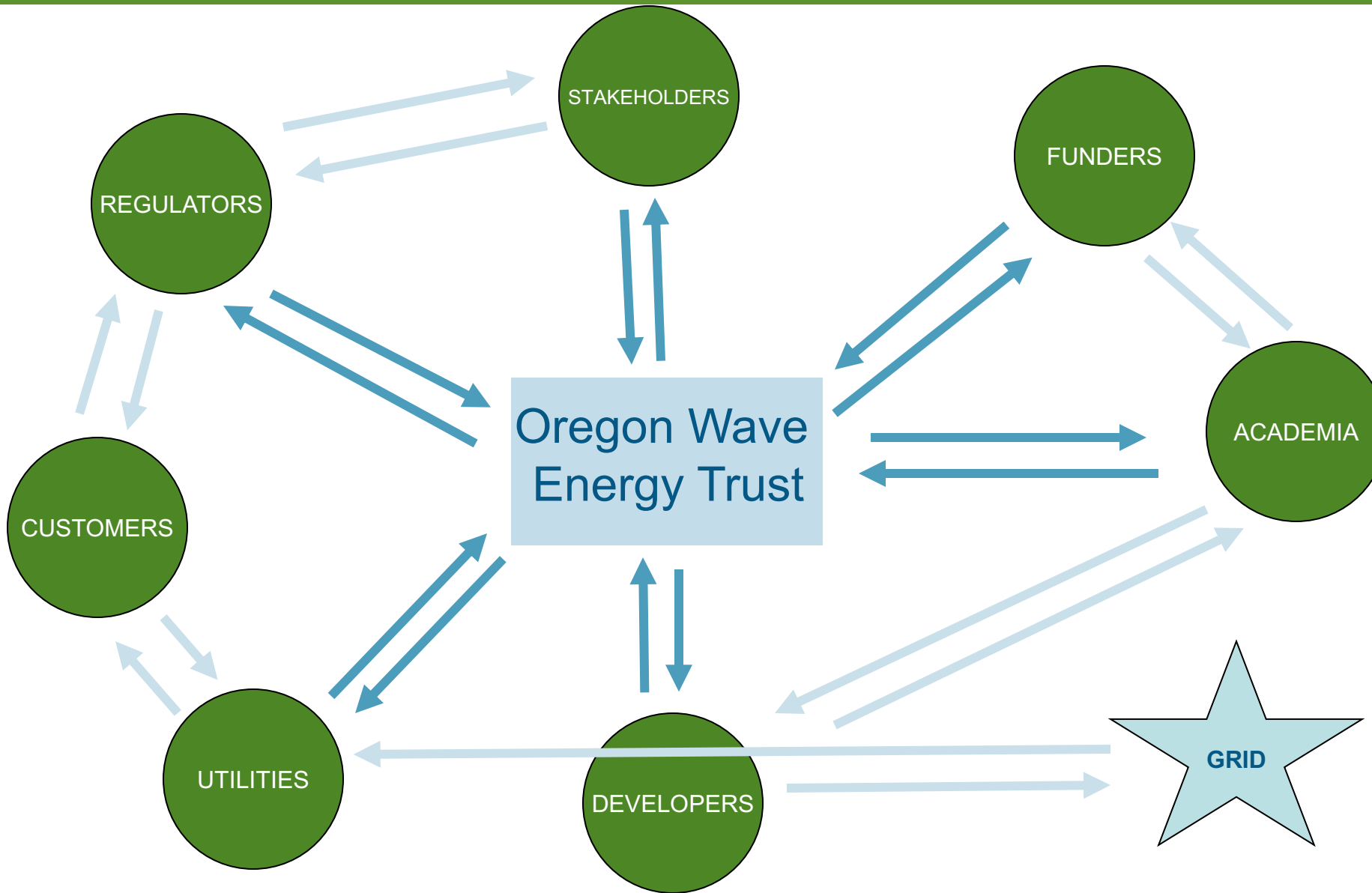
The Hub of an Industry



Industry Imperatives

- Balance new and existing ocean uses
- Establish consistent and appropriate regulatory process
- Understand project effects – environmental and socioeconomic
- Coordinate industry needs and prioritize research and development
- Identify resource gaps – workforce and maritime infrastructure
- Develop market support

Blue Power

The ocean is the largest, most concentrated source of renewable energy on Earth

Outcomes from Funding

- ✓**Increase public awareness** of the benefits of wave energy and align stakeholder efforts.
- ✓**Direct environmental, economic, and social impact studies** and projects to support regulatory streamlining of two commercial projects.
- ✓**Demonstrate new wave energy technologies** by assisting with funding to support activities at Oregon State University's Wave Energy Center and other research activities.
- ✓**Provide clean, renewable energy resources for Oregonians** by assisting in siting of one 2-megawatt commercial project by 2009 (grid connected).
- ✓**New job growth opportunities** by facilitating the installation of 500 megawatts capacity off the Oregon coast by 2025.

Issues Scoping – topical examples

Socio-economic

- System Survivability
  - Insurance, decommissioning
  - Navigation Safety
- Effects on local fishing communities
  - Productivity issues
  - Jobs associated with wave parks

Environmental

- Marine Mammal impacts
- Electro Magnetic Fields
- Alteration of seafloor habitats

Cumulative Effects (of multiple wave parks)

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The Regulatory and Legislative Framework

Industry advancement hinges on questions of public policy

- Ocean as the Commons
- Responsible agencies organized to regulate mature industries
  - Technologies evolving/is there a fit?
  - Impacts unknown
- Irresolution between agencies
  - FERC and MMS' artificial boundary at 3 NM

Lawmakers motivated but need education

- Funding at DOE for ocean energy ($10m)
- Definitions of eligible resources often excludes 'ocean energy'

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Wave Energy Policy Priorities

Wave Energy's regulatory framework should be certain and consistent

Tax provisions for wave energy should be equivalent to those for other resources

Agencies should collaborate on studies of generic interest to the industry

Rents and royalties on the seabed should be established in a way that promotes the industry

Federal authorities should identify coastal transmission deficiencies and opportunities to upgrade

States should provide timely leadership to identify preferred sites

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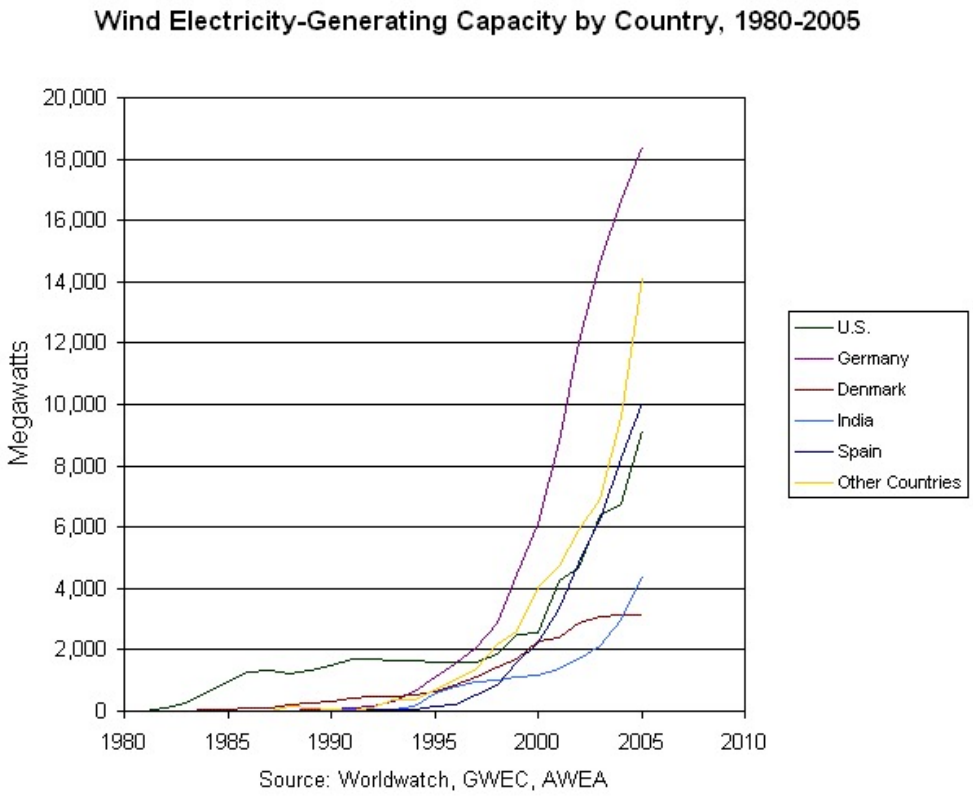
Where to from here?

Economic – the rising costs of energy around the world, tied to the rising demand

Technological – improving technologies drive *down* the cost of generating electricity from the ocean

Social/Political – increased awareness of our impact on the planet, leading to policies that promote – even mandate – 'better' energy



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www.oregonwave.org