U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Offshore Renewable Energy Future in the Northeast/Mid-Atlantic Region

Steve Lindenberg
Senior Advisor
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

Why Renewables?

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

- Carbon reduction and climate change
- Energy security and diversifying the domestic portfolio
- Clean energy and public health
- Reduction in water use
- Regional economic development and jobs

Marine Renewable Energy Sources

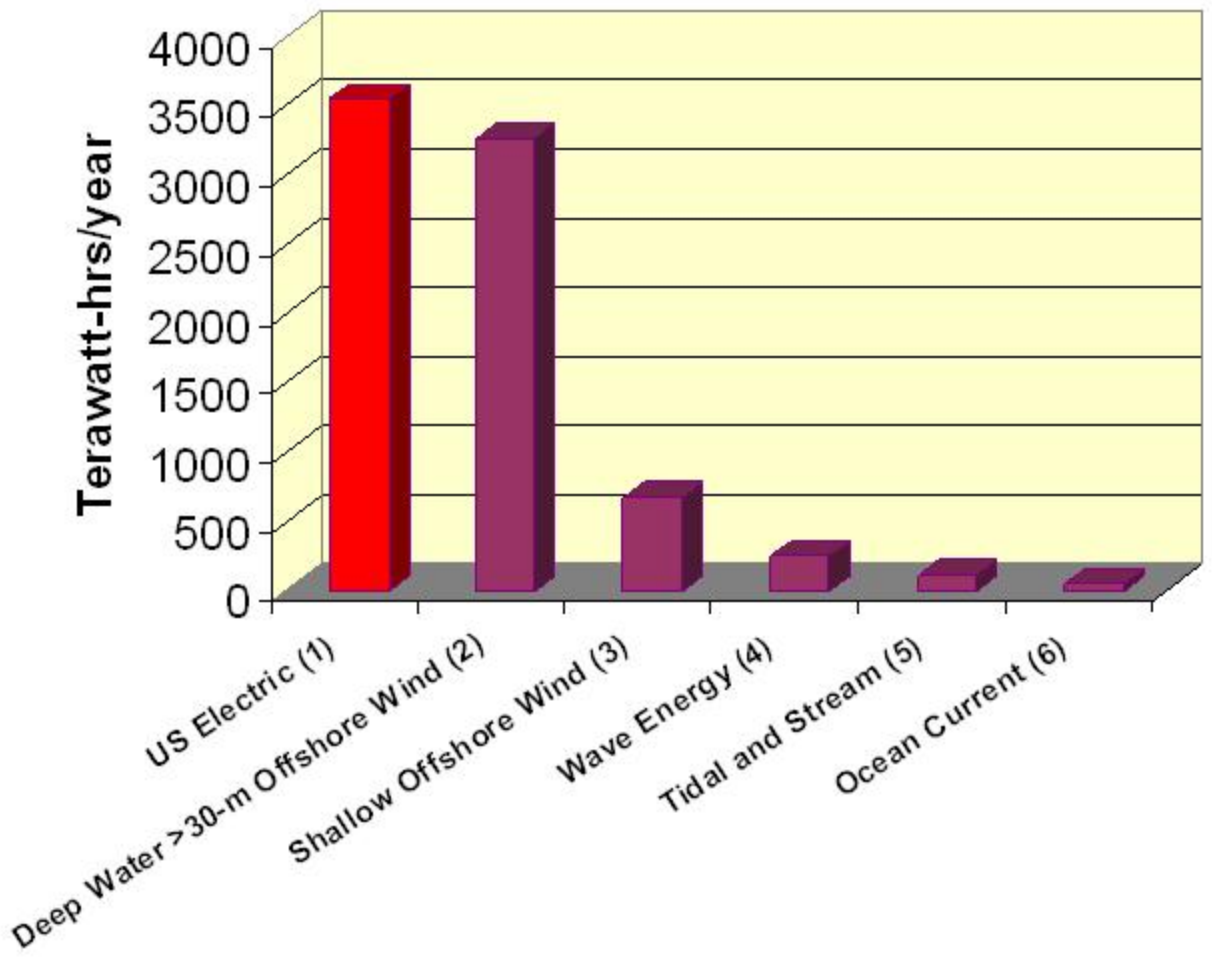
U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

- Wave energy
- Ocean current
- Tidal currents
- Offshore wind in shallow water
- Offshore wind energy in deepwater
- Ocean Thermal Power Conversion (OTEC)
- Salinity gradient
- Marine biomass

- No Silver Bullet Solution-
The Future Energy Supply Will Required a Diverse Portfolio of Clean Energy Sources

US Marine Renewable Energy Electric Potential Estimates [7]

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy



Offshore Wind

Why Offshore Wind?

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

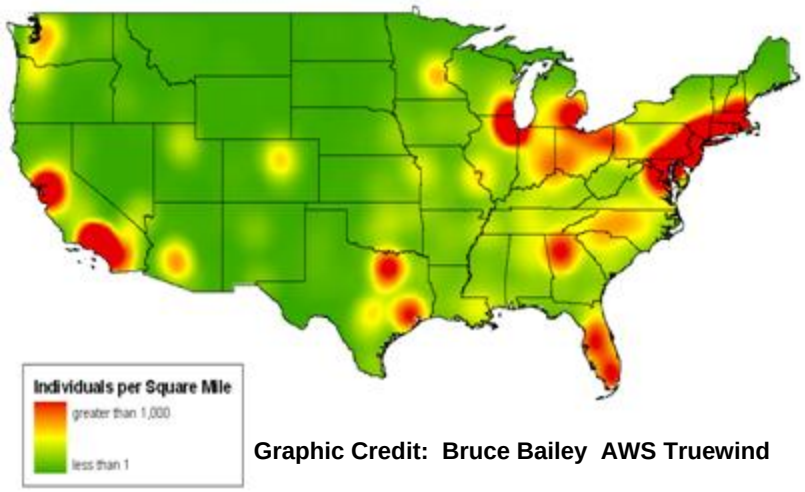
28 coastal states use 78% of the electricity in US

Many coastal load centers are difficult to serve by land-based renewable resources

Renewable energy goals cannot be achieved without offshore contributions

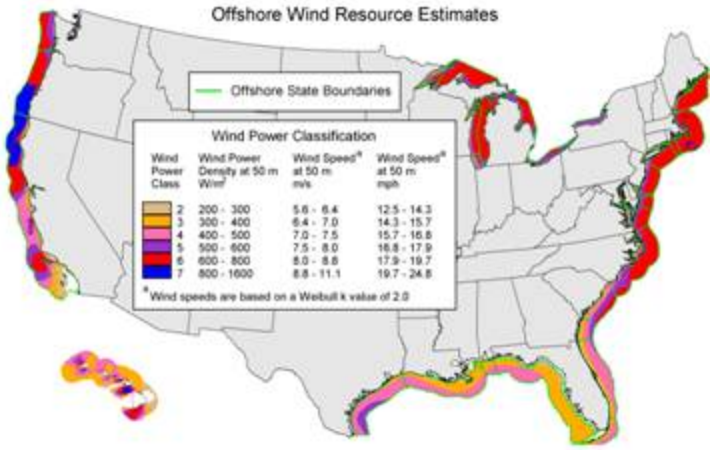
Population Density of the Counterminous United States

US Population Concentration



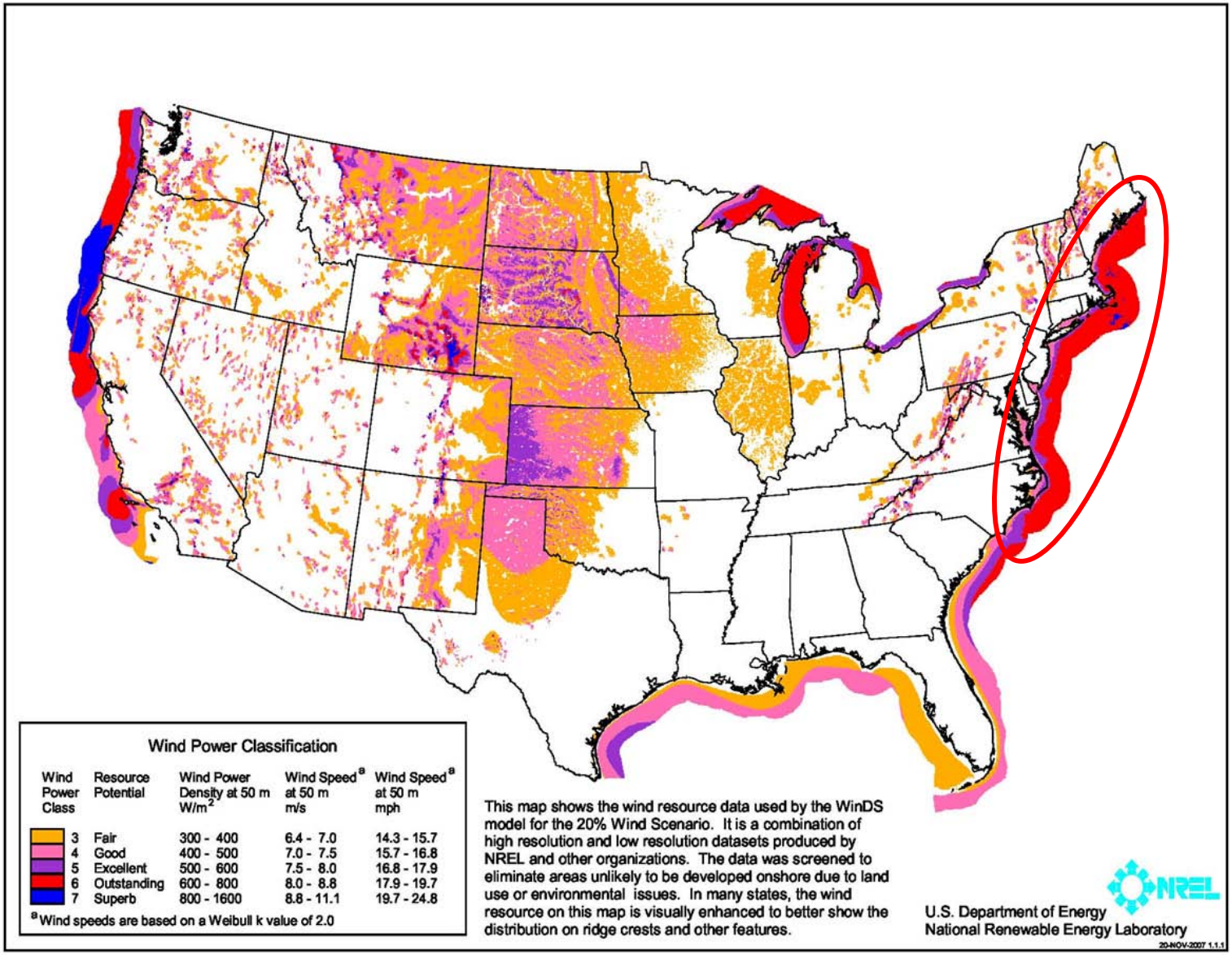
Graphic Credit: Bruce Bailey AWS Truewind

U.S. Wind Resource



U.S. Wind Resource Potential at 50 m

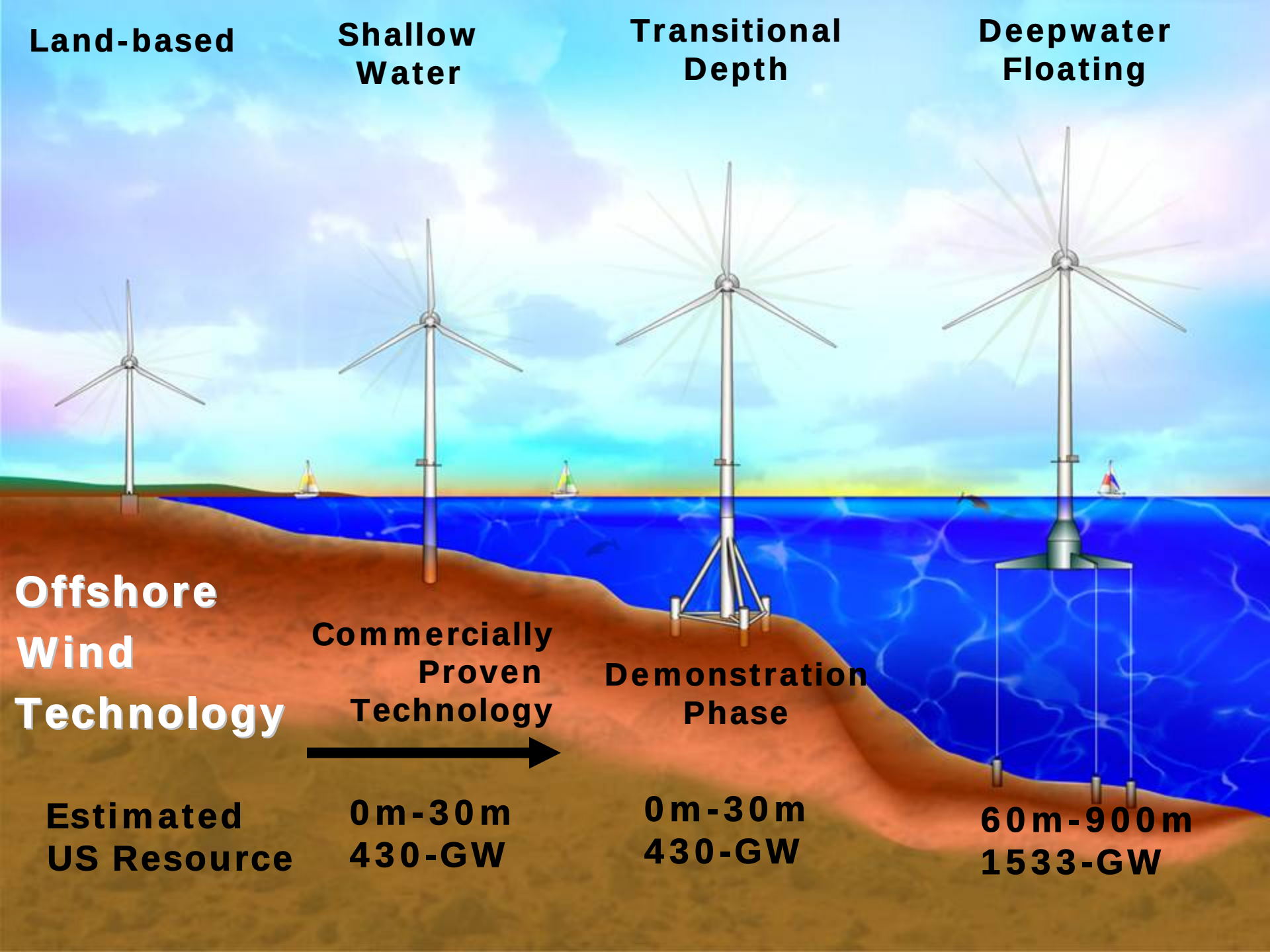
U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy



Offshore Wind Benefits

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

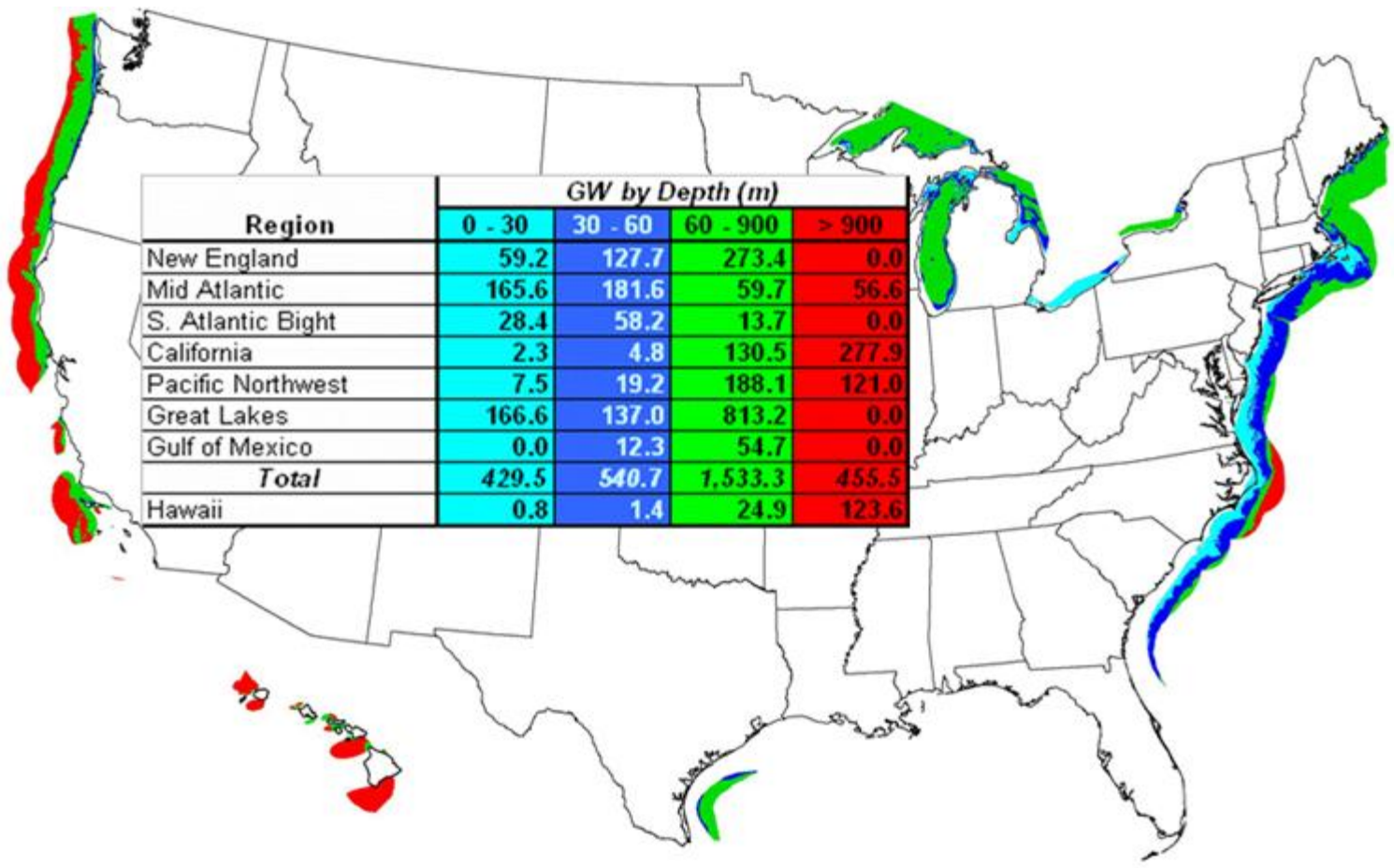
- Better wind resources
  - Reduced turbulence – steadier wind
  - Higher mean wind speed
- Aesthetics – Visual concerns will be less objectionable at greater distances.
- Increased transmission options
  - Proximity to high value load centers
  - Access to less heavily loaded lines
- Avoid constraints on turbine size
  - Larger machines may be more economical.
  - **Shipping** – onshore roadway limits
  - **Erection** – onshore crane limits


Land-based
Shallow Water
Transitional Depth
Deepwater Floating
Offshore Wind Technology
Commercially Proven Technology
Demonstration Phase
Estimated US Resource
0m-30m
430-GW
0m-30m
430-GW
60m-900m
1533-GW

Resource is Abundant

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

With no exclusions, the US offshore potential is 2500-GW
One of the largest potential renewable-electric energy sources



Region	GW by Depth (m)			
	0 - 30	30 - 60	60 - 900	> 900
New England	59.2	127.7	273.4	0.0
Mid Atlantic	165.6	181.6	59.7	56.6
S. Atlantic Bight	28.4	58.2	13.7	0.0
California	2.3	4.8	130.5	277.9
Pacific Northwest	7.5	19.2	188.1	121.0
Great Lakes	166.6	137.0	813.2	0.0
Gulf of Mexico	0.0	12.3	54.7	0.0
Total	*429.5*	*540.7*	*1,533.3*	*455.5*
Hawaii	0.8	1.4	24.9	123.6

Potential Electricity Supply from Shallow Offshore Wind by State

Class 5 or greater wind in waters less than 30 meters deep within 50 nautical miles of shore

February 12, 2007
Data Source: 200702musial_osbystate_rev3.xls

Map produced by
U.S. Department of Energy
National Renewable Energy Laboratory

NREL

Projects and Initiatives Proposed

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

No U.S. Offshore Wind Projects Installed

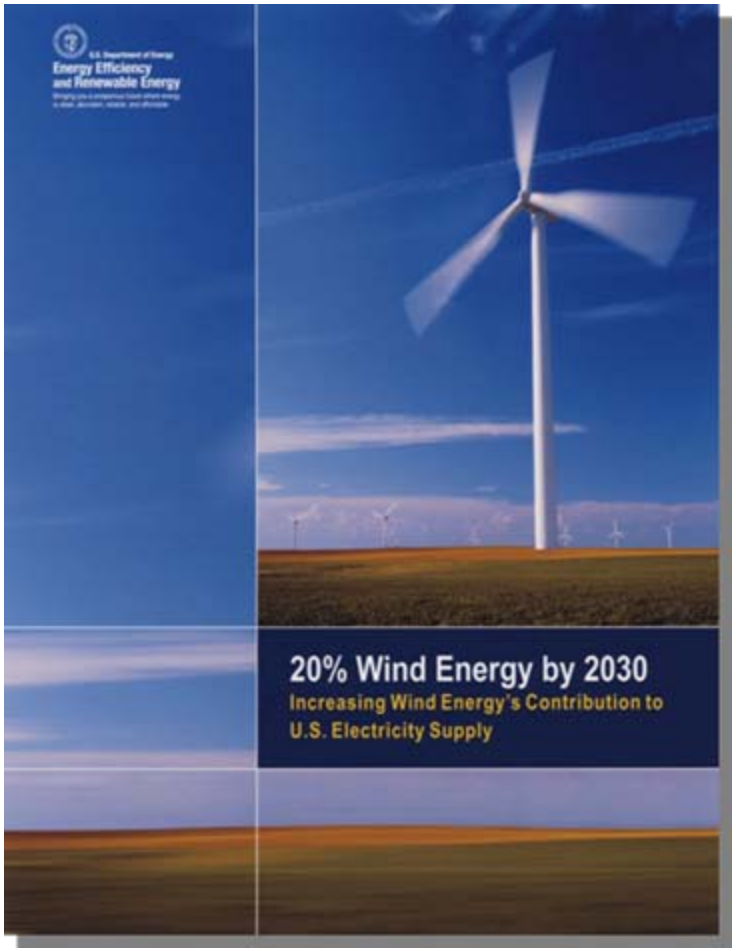
US Offshore Wind Initiatives		
Project	**State**	**MW**
Capewind	MA	420
Hull Municipal	MA	15
Buzzards Bay	MA	300
Block Island (DeepWater Wind)	RI	400
Winergy	NY	10
New Jersey (BPU)	NJ	350
Delmarva	DE	<600
Southern Company	GA	10
W.E.S.T.	TX	150
Cuyahoga County	OH	20
Total MW		2275

W.E.S.T. LLC

The 20% Wind Energy Scenario

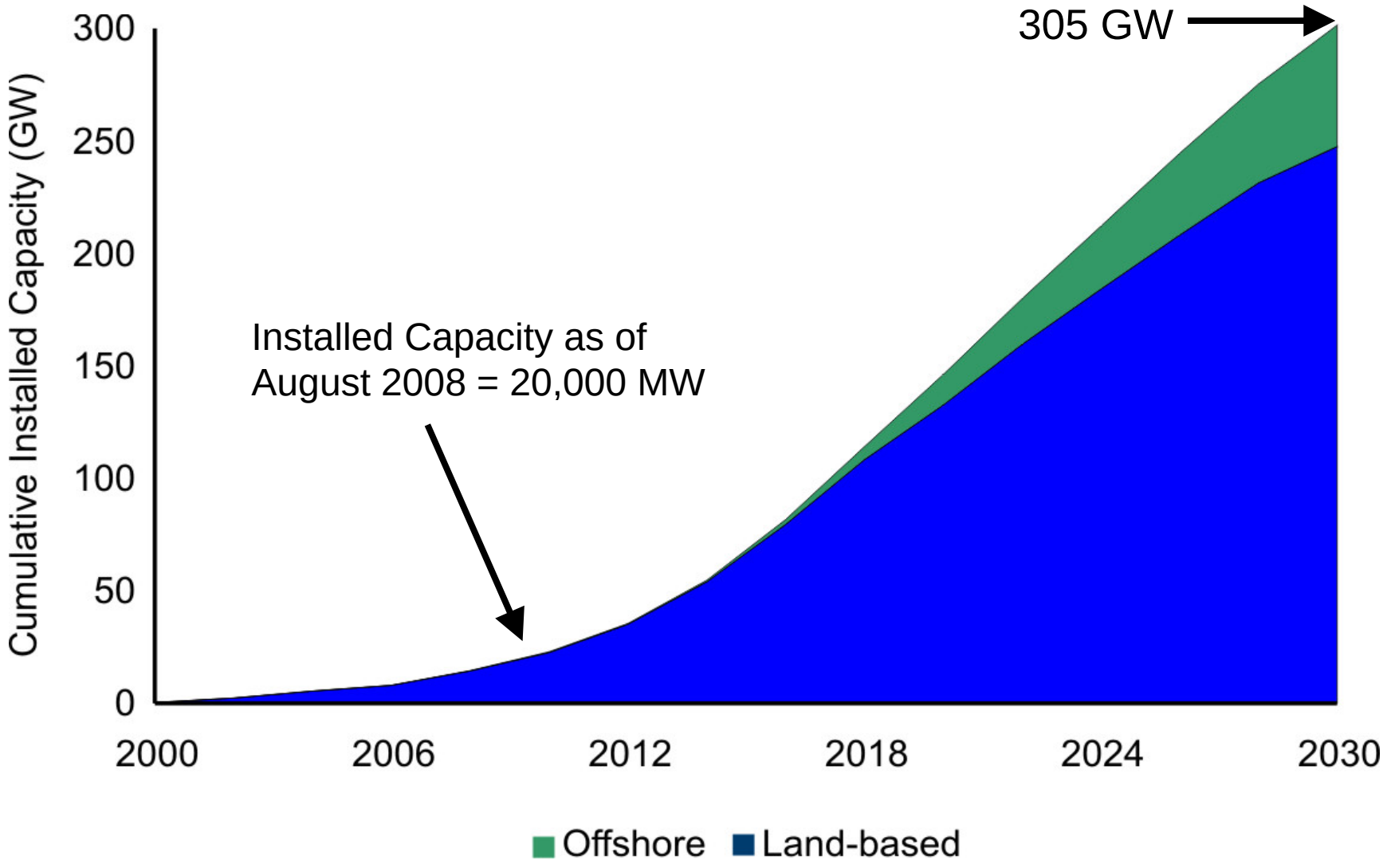
U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

- U.S. electricity consumption will grow 39% from 2005 to 2030 -- to 5.8 billion MWh (Source: EIA)
- No major breakthroughs in technology needed
- 20% electricity would require 300 GW (300,000 MW) of wind
- Affordable, accessible wind resources available across the nation
- Cost to integrate wind modest
- Emissions reductions and water savings
- Transmission a challenge
- Environmental risks and human dimensions



DOE's 20% Wind Scenario: 54 GW Offshore Wind

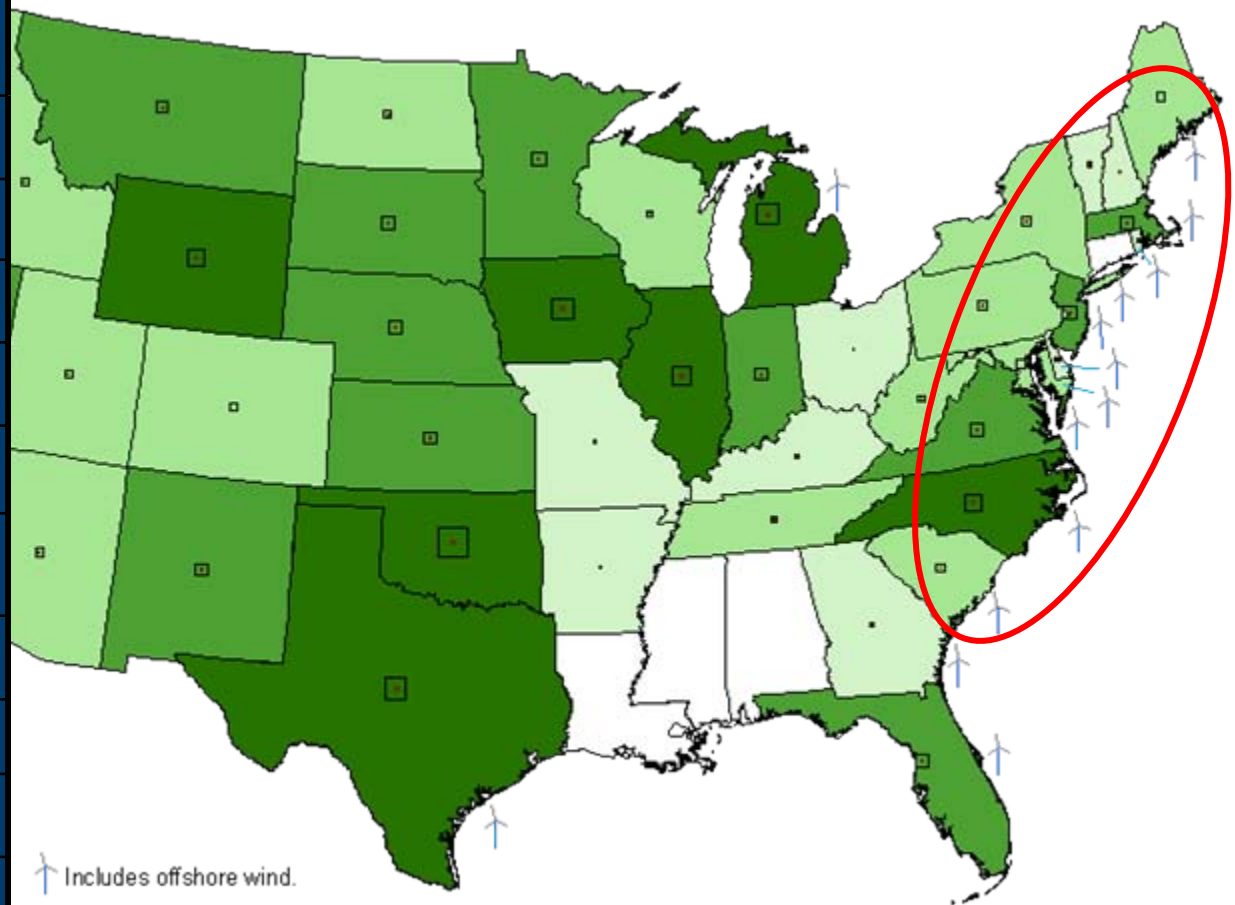
U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy



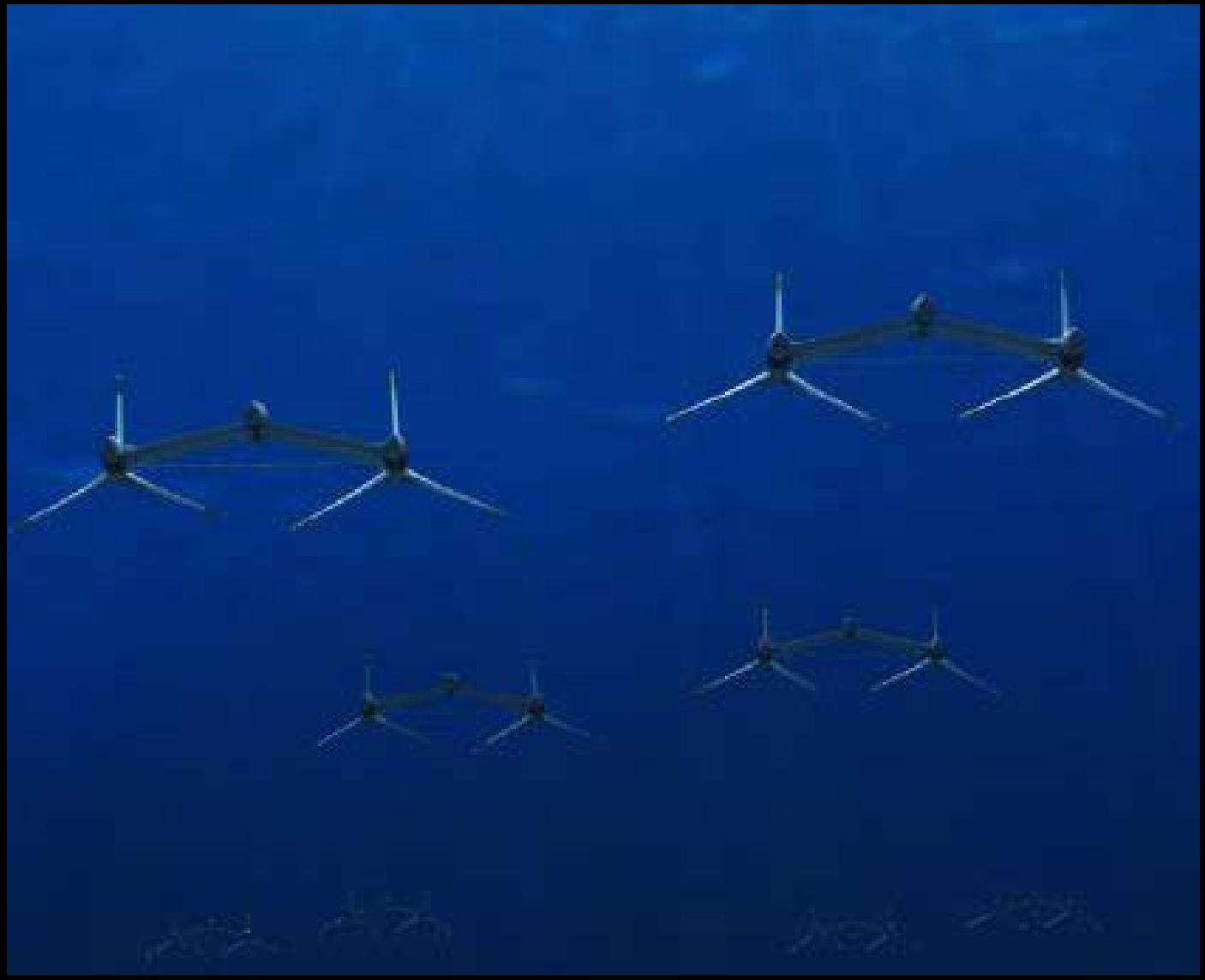
20% Scenario: Shallow Offshore Installed Capacity

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

State	20% Installed Capacity (GW)
DE	0.66
MA	7.53
MD	1.27
ME	2.01
NC	10.44
NJ	9.85
NY	2.69
RI	0.97
SC	3.13
VA	6.57
Total	45.12 GW

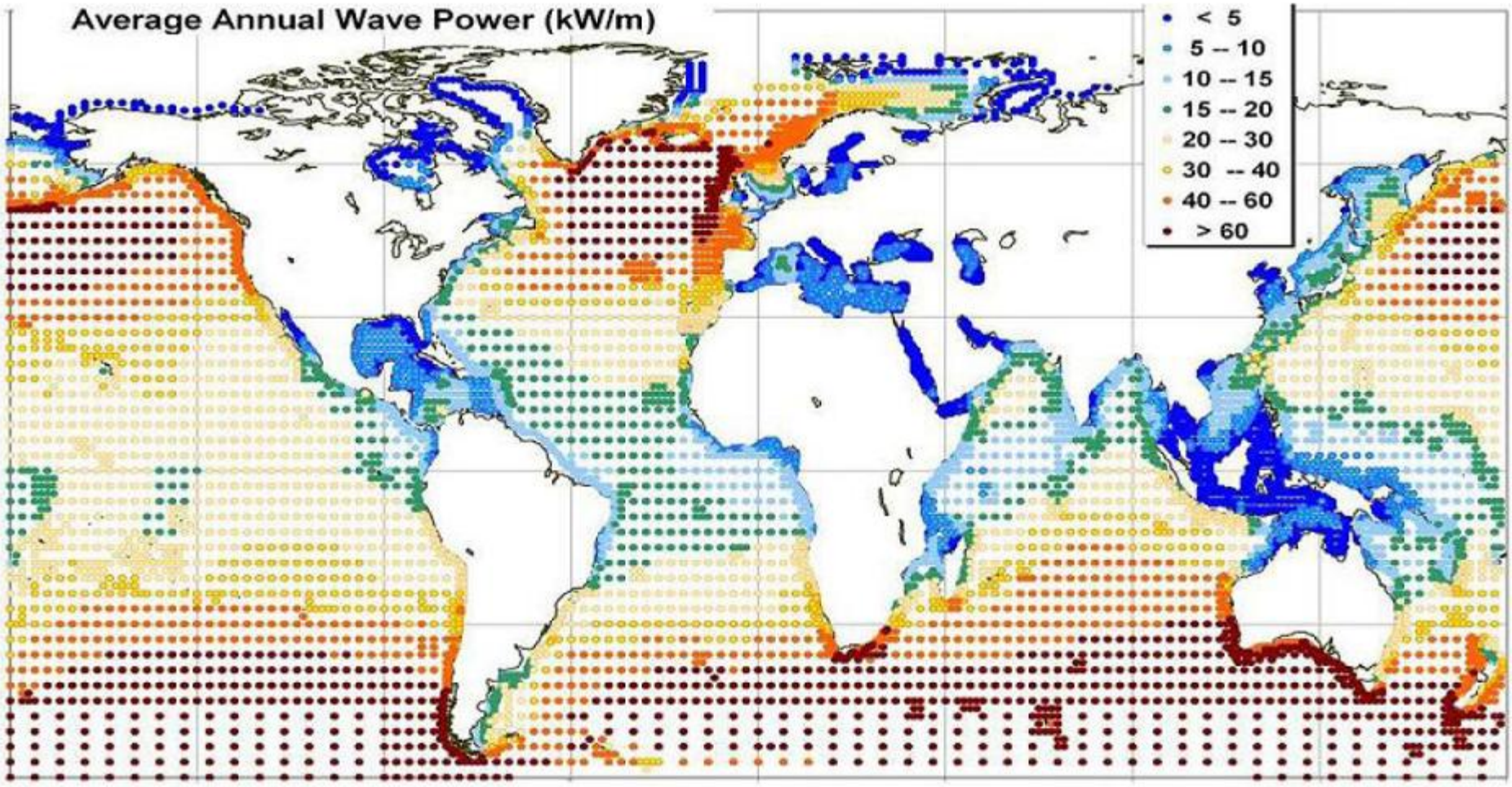


Marine Hydrokinetic Energy



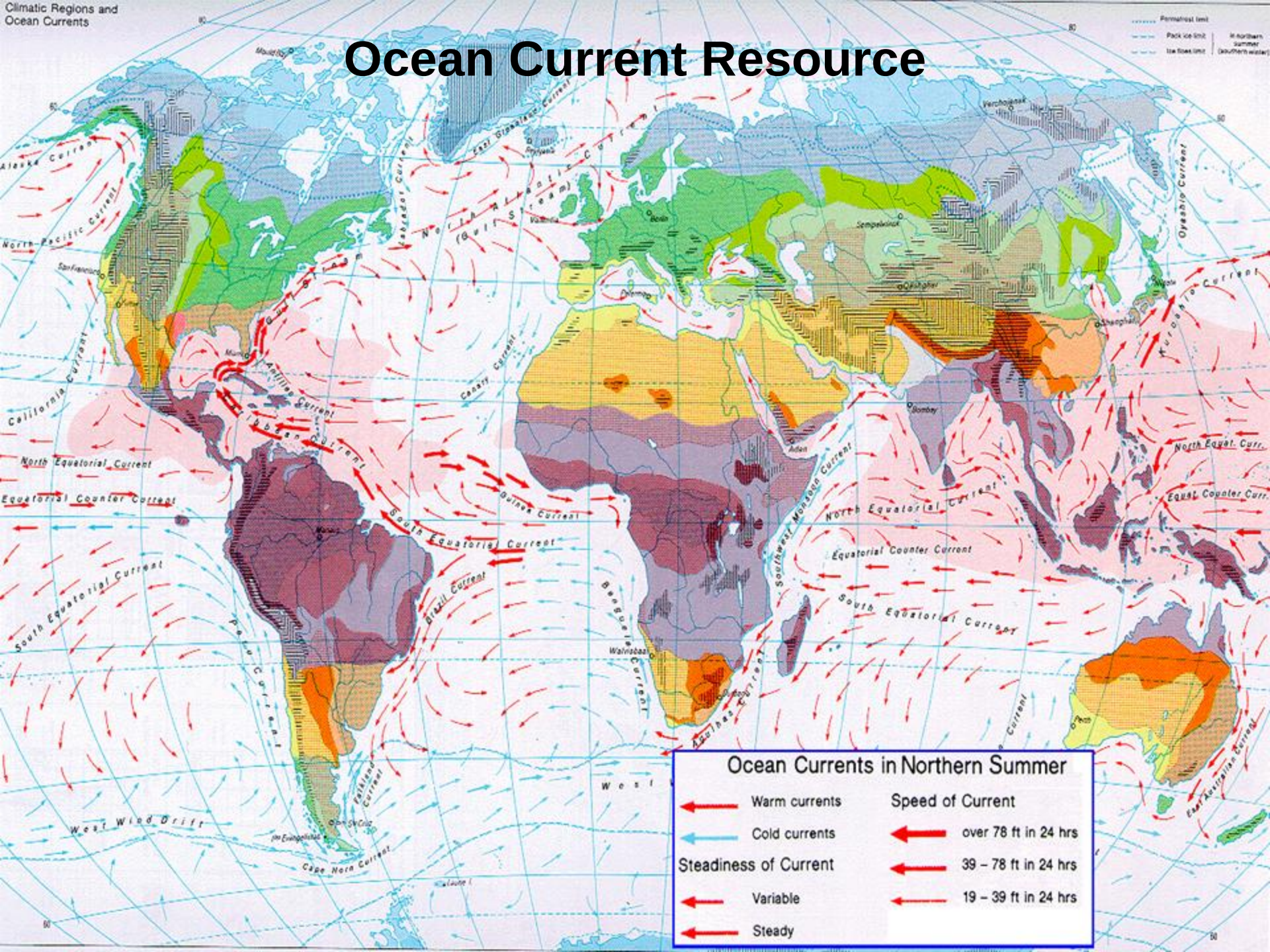
Ocean Wave Energy Distribution

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy



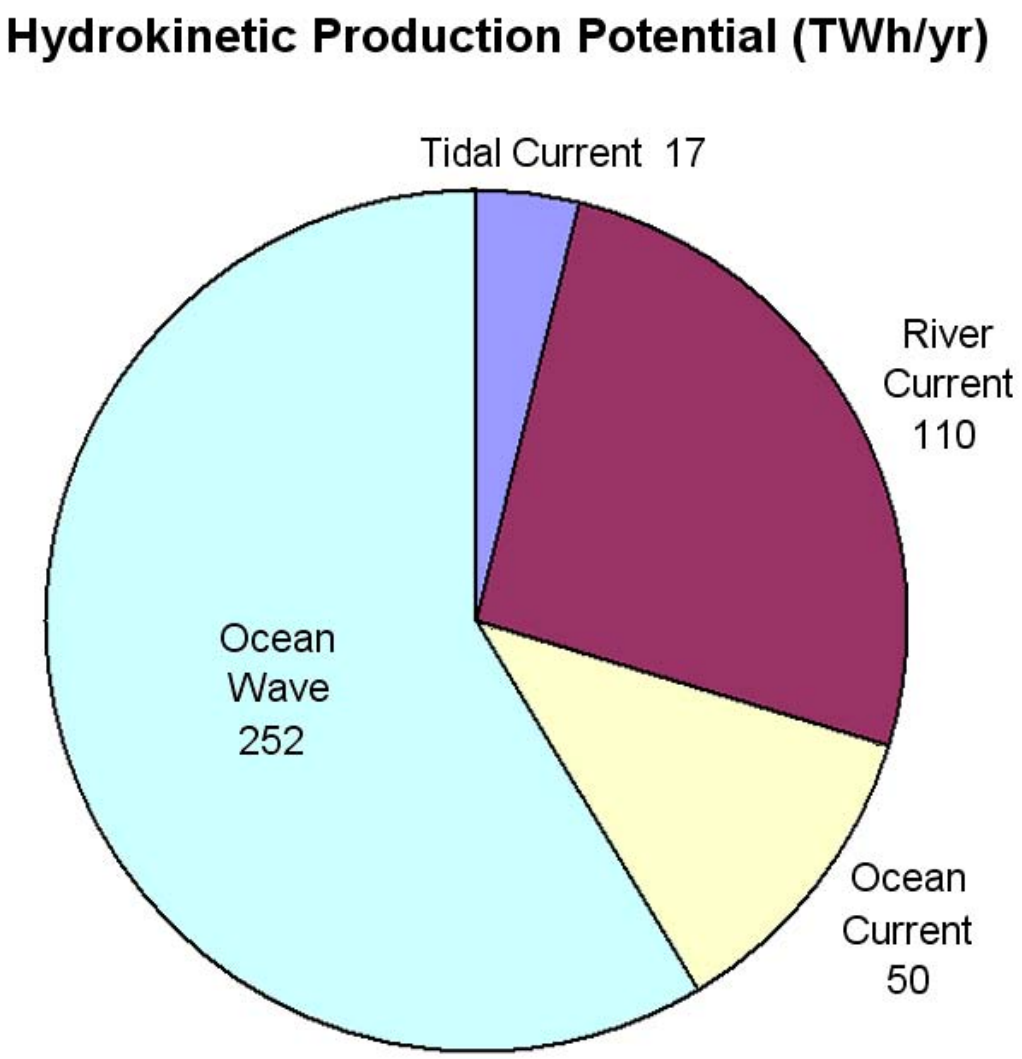
(Source: ECMWF, European Centre for Medium-Range Weather Forecasts)

Ocean Current Resource



U.S. Marine Hydrokinetic Energy Resource Production Potential

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy



Two Basic Forms of Marine Hydrokinetic Energy

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

CURRENTS

- Activating force flows in same direction for at least a few hours
- Tidal, river, and ocean variants
- Conversion technology is some sort of submerged turbine

WAVES

- Activating force reverses direction every 5 to 20 seconds
- Conversion technology can be floating or submerged, with a wide variety of devices still being invented and developed

US Marine Hydrokinetic Energy Resource Issues

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

- Resource estimates are incomplete
- High uncertainty
- Extraction limits are preliminary and unproven.
- Energy extraction dependent on device type, environment, and regional demand.
- Much work is needed to establish contribution to national energy strategy.
- Maximum potential approximately equal to conventional hydro (EPRI)

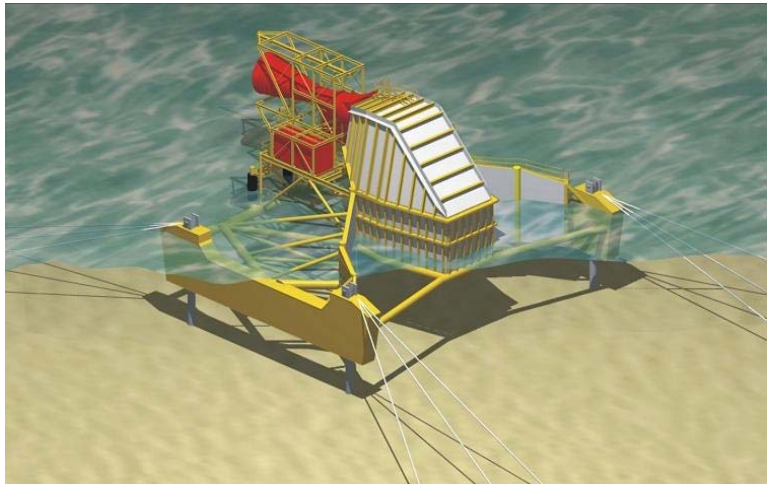
Wave Energy Devices Are Highly Diverse

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

Floating
Point Absorber
(*AquaBuOY)*

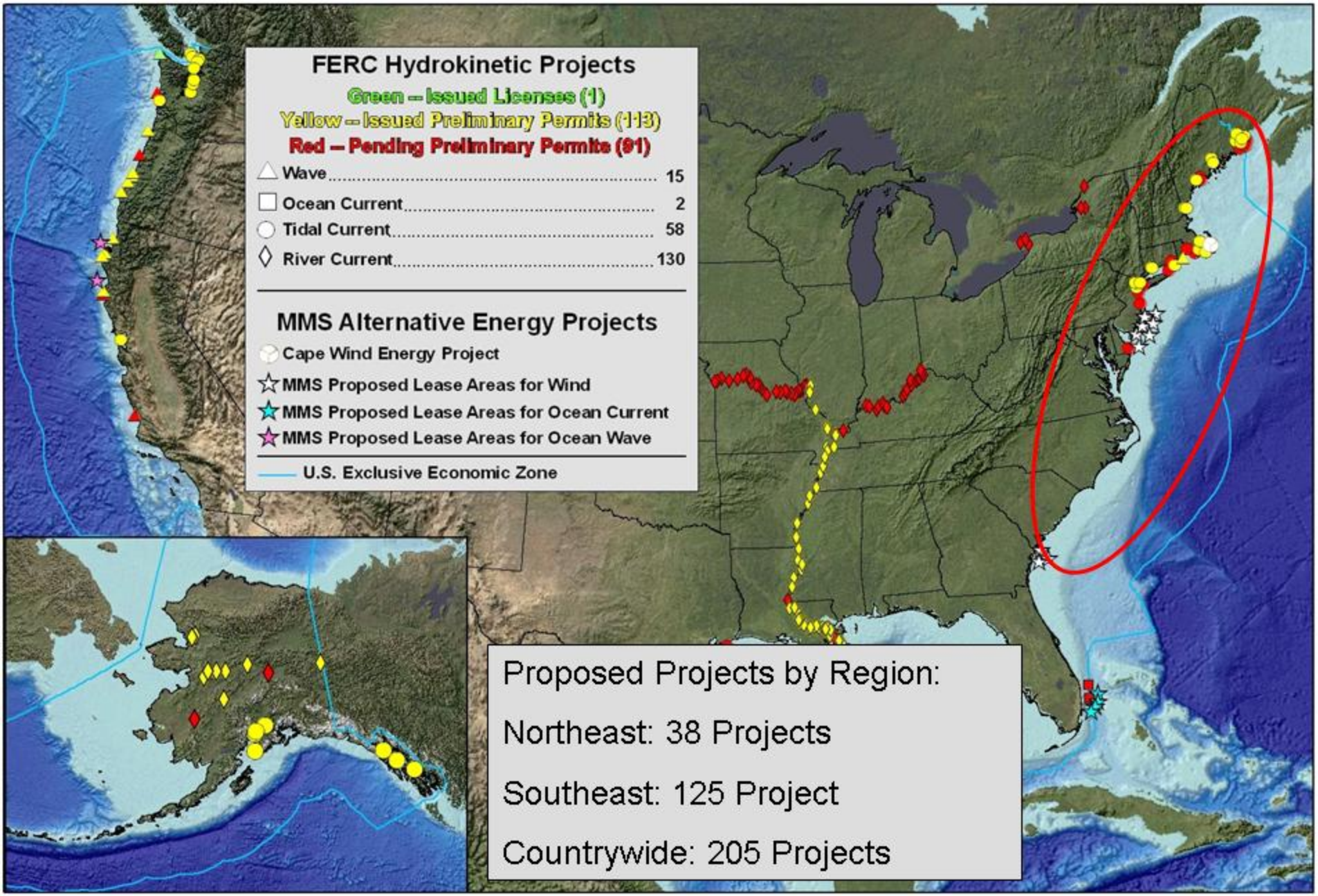
Floating
Attenuator
(*Pelamis*)

Oscillating Water Column
Terminator (*Oceanlinx*)



Floating Overtopping
Terminator (*Wave Dragon*)

FERC Hydrokinetic Projects and MMS Alternative Energy Projects in the U.S.



Produced by NOAA Fisheries Office of Habitat Conservation. Information accurate as of August 14, 2008. For reference purposes only.

Coastal Zone Impacts

Selected Offshore Wind Energy Environmental Documents from the U.S.

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

Project Name	Organization	Environmental Documentation
Cape Wind	MMS	Cape Wind Draft EIS January 2008
Long Island Power Authority	MMS	Notice of Intent to Prepare June 2006 Never completed
New Jersey	NJBPU	Blue Ribbon Panel on Development of Wind Turbine Facilities in Coastal Waters Final Report
Proposed Rule: Alternative Energy and Alternate Use of Existing Facilities on the Outer Continental Shelf	MMS	Environmental Assessment of Proposed Rule July 2008
National Program	MMS	Programmatic Environmental Impact Statement November 2007 Record of Decision January 2008

Selected Marine Hydrokinetic Energy Environmental Documents from U.S.

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

Project Name	Organization	Environmental Documentation
Oahu Kaneohe, HI Ocean Power Technologies	Department of the Navy	Environmental Assessment January 2003
Makah Bay, WA Finavera	FERC	Draft EA October 2006
Verdant Power	Verdant	Studies ongoing during test phase; To be released in FERC license application
Proposed Rule: Alternative Energy and Alternate Use of Existing Facilities on the Outer Continental Shelf	MMS	Environmental Assessment of Proposed Rule July 2008
National Program	MMS	Programmatic Environmental Impact Statement November 2007 Record of Decision January 2008

Potential Environmental Risks

- Seabed sediments
- Marine and coastal processes
- Seabed contamination
- Water quality


Photo Courtesy: FWS


Photo Courtesy: NOAA

Source: 11, 12

Potential Environmental Risks

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

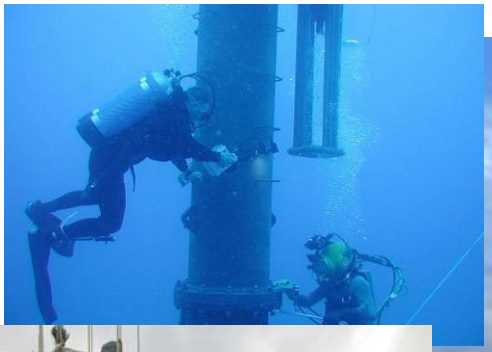
- Protected sites and species
- Benthic ecology
- Fish and shellfish/ Fisheries
- Marine birds
- Marine mammals

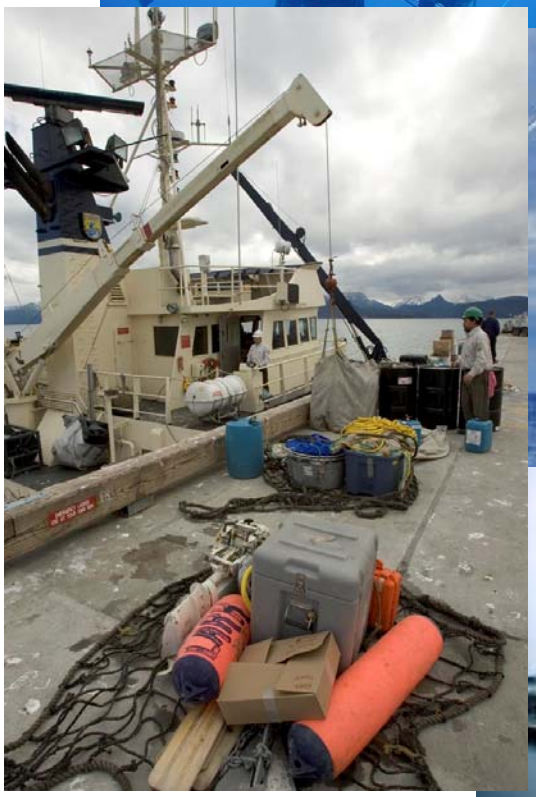
Source: 11, 12

Potential Project Risks

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

- Cables and pipelines
- Military activities
- Radar security screening
- Disposal areas
- Electronic and magnetic fields
- Onshore grid connection
- Noise and vibrations
- Decommissioning





Source: 11, 12

Community and Human Dimensions

- Worker health and safety
- Integrity of coastal communities
- Tourism and recreation
- Aesthetics
- Cultural/historic views
- Property values
- Fisheries
- Shipping and navigation
- Local community and involvement

Source: 11, 12

Visual Effects

Pre-visualization of the Horns Rev wind farm from Blåvands Huk (above) and actual post-construction photograph from Blåvands Huk (below) (Credit: DONG Energy)

DOE State and Regional Activities

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

- Core funding for initiation of the Offshore Wind Collaborative
- Proposal review in competitive solicitations (RI and NJ)
- IEA Wind and Ocean Energy Annexes
- Marine Hydrokinetic R&D funding:
  - **Verdant Power Inc. (New York, N.Y.)** Improved structure and fabrication of large, high-power kinetic hydropower systems rotors for tidal turbines.
  - **Concepts ETI, Inc (White River Junction, Vt.)** Development and demonstration of an Ocean Wave Converter (OWC) Power System.
  - **Lockheed Martin Corporation (Manassas, Va.)** Advanced Composite Ocean Thermal Energy Conversion (OTEC) cold water pipe project.
  - **PCCI, Inc. (Alexandria, Va.)** Identification of potential navigational impacts and mitigation measures to provide improved guidance to help developers understand how marine and hydrokinetic devices can be sited to minimize navigational impact and to expedite the U.S. Coast Guard review process.

Thank you!

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

Questions?

Steve Lindenberg
Department of Energy
steve.lindenberg@ee.doe.gov
202-586-2783

Resource References

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

Wave Energy Resources

Available at www.epri.com/oceanenergy/

1. **EPRI WP- 001, 003 and 006 reports**
2. **New England – "Southern New England Wave Energy resource Potential" March 2001, George Hagerman**
3. **North Carolina: "Wave Energy Resource and Technology Assessment for Coastal North Carolina" 1988, George Hagerman**
4. **Hawaii: "Wave Energy Resource and Economic Assessment for the State of Hawaii" June 1992, George Hagerman**
5. **California: California Small Hydropower and Ocean Wave Energy Resources" May 2005, Mike Kane, Asfaw Beyenne, Mirko Previsic**

Tidal Current Energy Resources

Available at www.epri.com/oceanenergy/

6. **EPRI TP- 001 Resource Estimation Methodology Report**
7. **EPRI TP- 003 Site Survey Reports**
8. **EPRI TP- 006 Feasibility Study Reports**

Ocean Current

9. **Coriolis Program: A Review of the Status of the Ocean Turbine Energy System" Lissaman & Rackey, AeroVironment, 1979**

River Current

10. **"Allocation of Kinetic Hydro Energy Conversion Systems (KHECS) in USA Drainage Basins", Miller et al. NYU, NYUDAS 86-151, Aug 1986**

Offshore Wind

11. **Faber Maunsell and Metoc PLC. 2007. Scottish Marine Renewables. Strategic Environmental Assessment: Environmental Report. http://www.seaenergyscotland.co.uk**
12. **EMEC. 2005. Environmental Impact Assessment (EIA): Guidance for Developers at the European Marine Energy Centre. http://www.emec.org.uk.**
13. **DOE. 2008. 20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply.**

Reference Continued

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

Slide 4: Assumptions

1. U.S. electric consumption based on 2005 EIA statistics.
2. Class 5 wind or better; depths between 30-m and 900-m included; 60% exclusions; HI and AK not included; 0-50nm from shore; 45% Cap factor; Source: NREL.
3. Class 5 wind or better; depths between 0-m and 30-m; included; 60% exclusions; HI and AK not included; 0-50nm from shore; 45% cap factor; Source NREL.
4. 15% of incident wave energy; 20% conversion losses; AK and HI Included; Wave climate 10kW/m or better; Source EPRI.
5. Estimated from aggregate siting studies; 15% extraction permitted; In stream river kinetic estimated by EPRI.
6. Estimated from *Coriolis Study, Aquantis,* and FAU; Miami/Gulf Stream region only, 57% capacity factor; 10-GW rated capacity.
7. OTEC, salinity gradient, marine biomass not evaluated.

Slide 19: Assumptions

Ocean Wave - 15% of incident wave energy; 20% conversion losses; AK and HI Included; Wave climate 10kW/m or better.

Tidal Current estimated from aggregate siting studies; 15% extraction permitted; Incomplete.

River Current estimated in 1986 NYU study; EPRI has estimated a few specific sites.

Ocean Current estimated from *Coriolis Study* and by *Aquantis;* Miami/Gulf Stream region only, 57% capacity factor; 10 GW rated capacity.