NREL
NATIONAL RENEWABLE ENERGY LABORATORY





Offshore Renewable Energy Feasibility Study for the Gulf of Mexico

Suzanne Tegen, Ph.D.

National Renewable Energy Laboratory

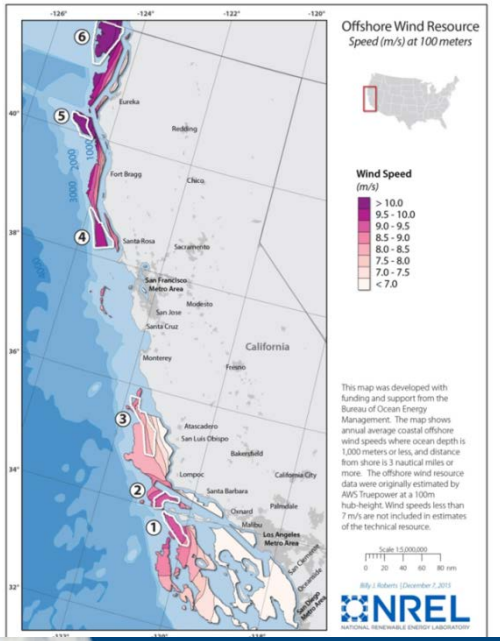
Information Transfer Meeting

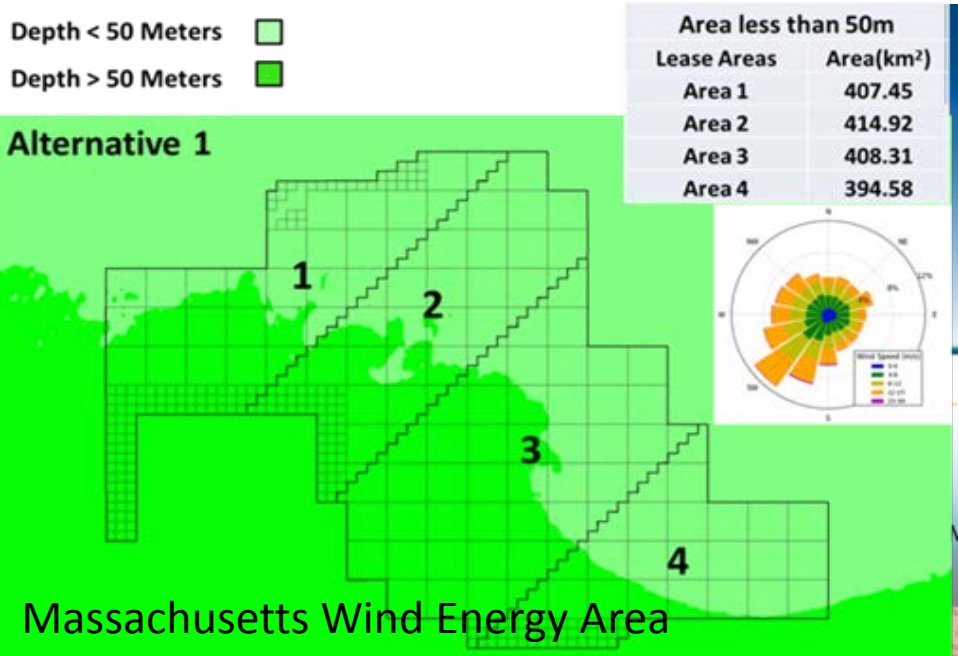
Session 1B, OFFSHORE RENEWABLE ENERGY

August 22, 2017

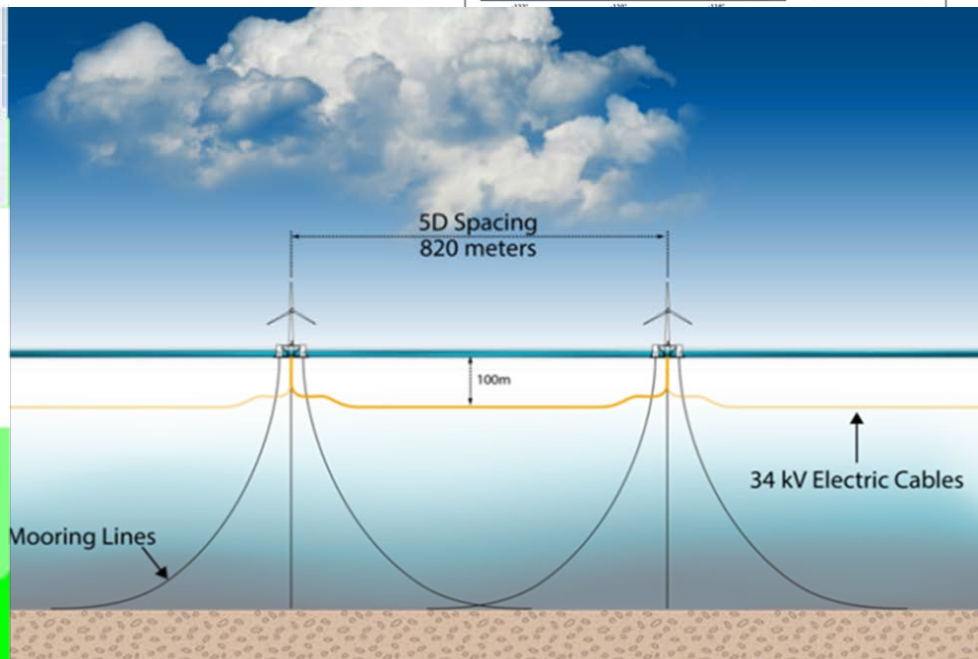
Other BOEM-NREL Work on Offshore Renewable Energy

- **Offshore wind energy cost and jobs analysis (CA, OR, HI)**
- **Marine hydrokinetic training for BOEM staff**
- **White paper to inform BOEM on offshore wind and fishing community interaction**
- **Floating wind turbine visualizations for hypothetical projects in Hawaii**
- **Technical analysis of offshore wind energy lease areas**





Area less than 50m	
Lease Areas	Area(km²)
Area 1	407.45
Area 2	414.92
Area 3	408.31
Area 4	394.58



Offshore Renewable Energy Feasibility Study Summary

NREL is surveying the potential offshore renewable energy resources in the Gulf of Mexico and quantifying the feasibility of the technologies, to inform strategic energy planning.

- Funded by BOEM Environmental Studies Program
- Geographic region – Gulf states from Mexico to Key West

Task 1: Survey of Offshore Renewable Energy Technologies

Renewable energy types to be evaluated:

- Offshore wind
- Wave energy
- Tidal energy
- Ocean current energy (Loop Current)
- Ocean-based solar energy
- Ocean thermal energy conversion (OTEC)
- Deep water source cooling
- Hydrogen.

Evaluation based on resource, technology readiness and cost

Focus on State and Federal waters

After Task 1, there will be a down-select.

Photo: Block Island Wind Farm, August 2017 (Tegen)

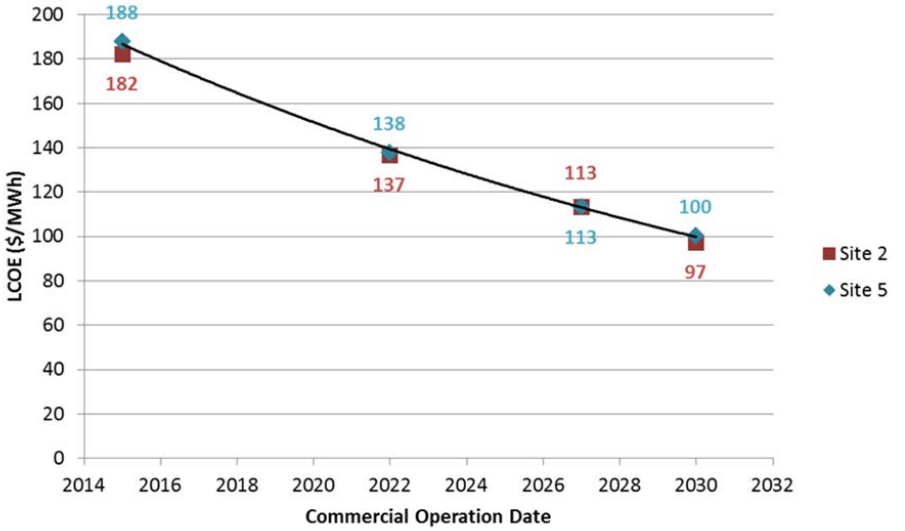
Task 2: Regional Economic Modeling for the Gulf

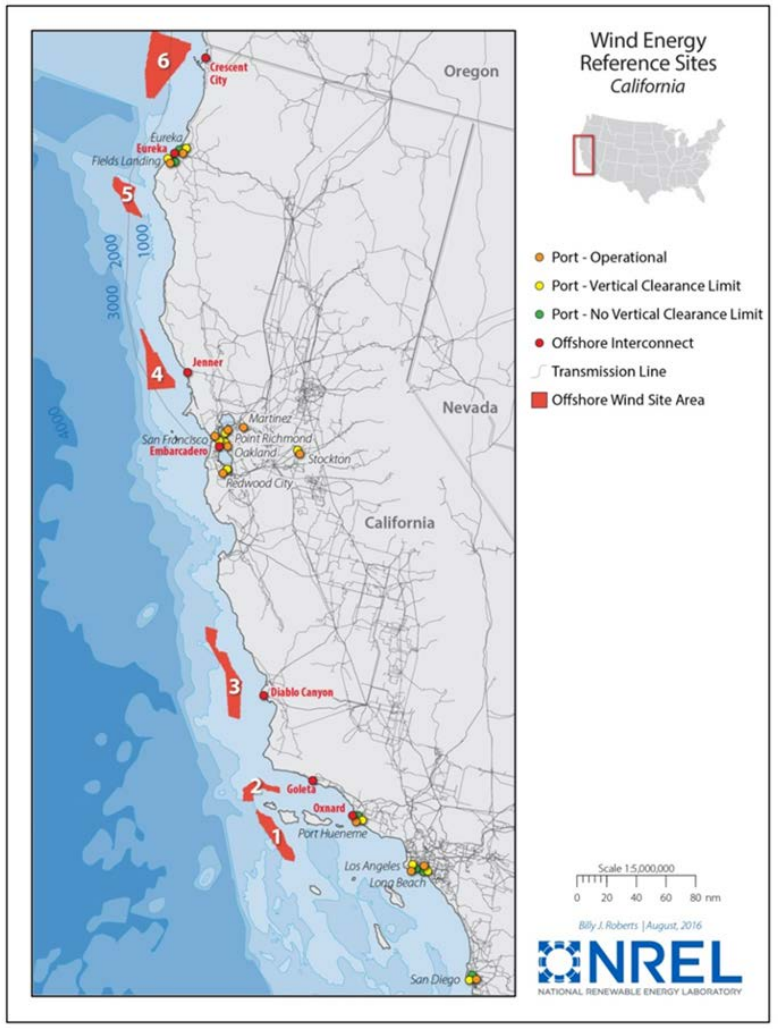
- **Part A - Geospatial Regional Economic Analysis**
  - Resource capacity and energy potential by state, distance from shore, and water depth
  - Geospatial cost variables include water depth, wind resource, sea state, substructure type, technology size, distance to port, distance to cable interconnect, and installation method
  - Regional Levelized Avoided Cost of Energy (LACE) and economic potential
- **Part B – Local Benefits and Supply Chain Advantages**
  - Integrate local benefits and challenges of deploying offshore renewable energy in the Gulf of Mexico into geo-spatial LCOE cost models
  - Perform analysis including supply chain and local content.

Task 3: Site-Specific Economic Analysis

Representative offshore sites will be selected to provide site-specific physical and economic analyses for typical projects in the Gulf of Mexico region

Cost Reduction Estimates for Two CA Sites

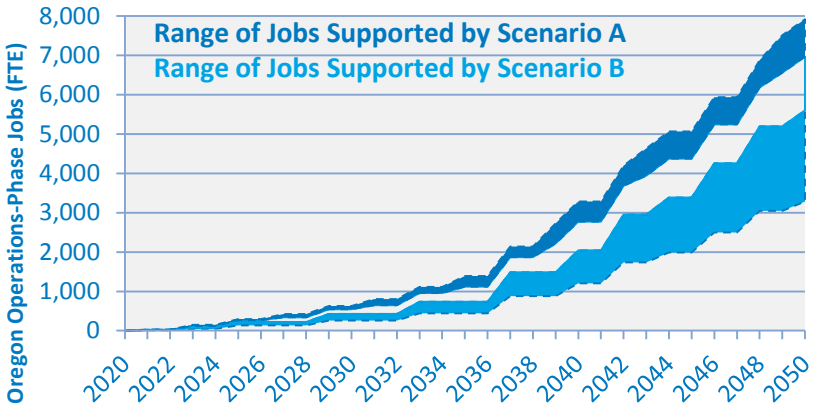




Offshore wind reference areas used for physical site and economic analysis in California.

Task 4: Jobs and Economic Development

- Use NREL's jobs and economic development impacts (JEDI) model to estimate gross jobs and economic impacts of construction and operations associated with offshore wind build scenario.



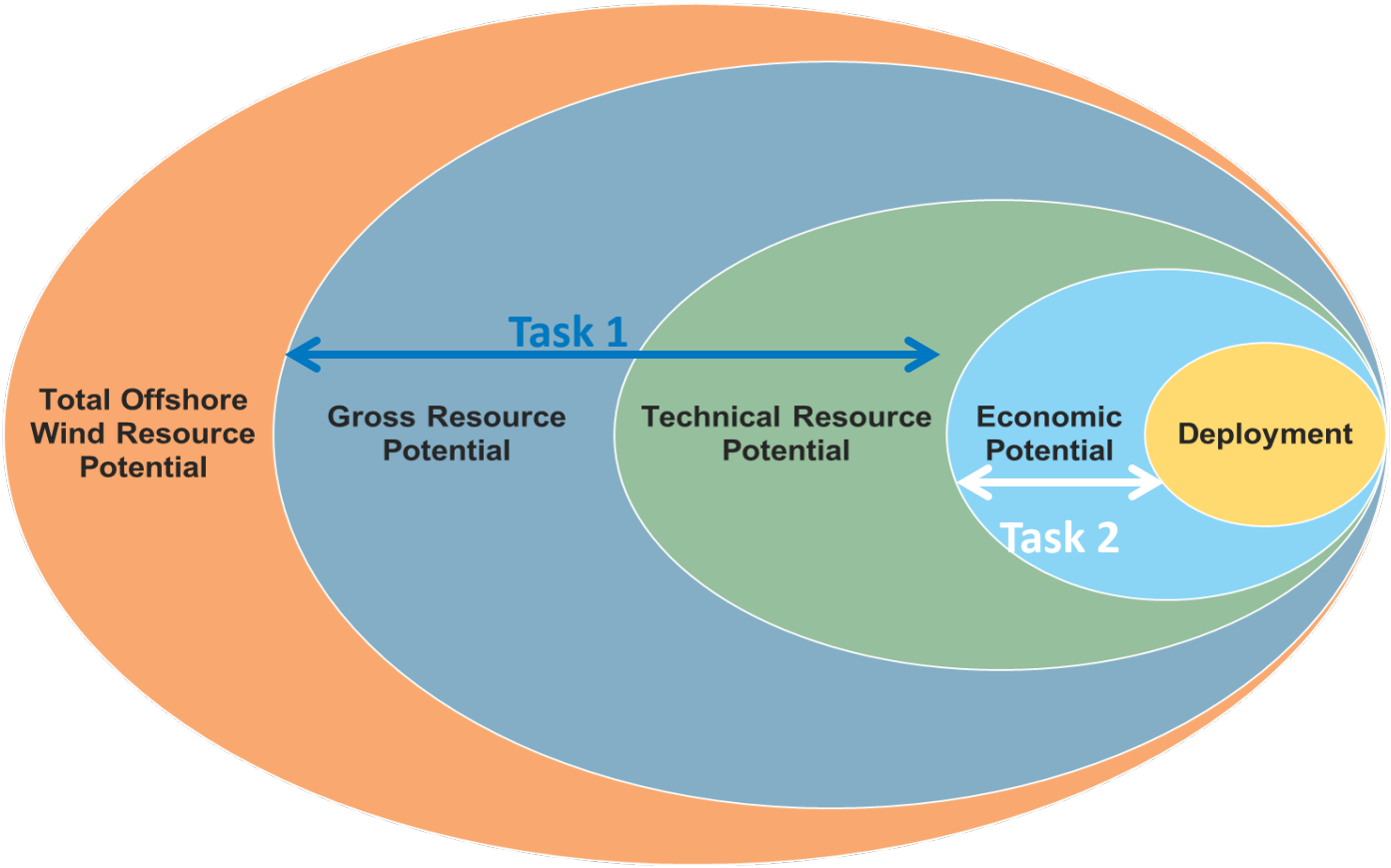
Example from Oregon report for BOEM
(Jimenez et al 2016 www.nrel.gov/docs/fy16osti/65421.pdf)

- Use assumptions on supply chain and Gulf labor from Task 2. Estimate on-site, supply chain and induced jobs and economic impacts at state or regional level.

Block Island Wind Turbine with Maintenance Boat

Preliminary Findings

Resource Assessment Framework

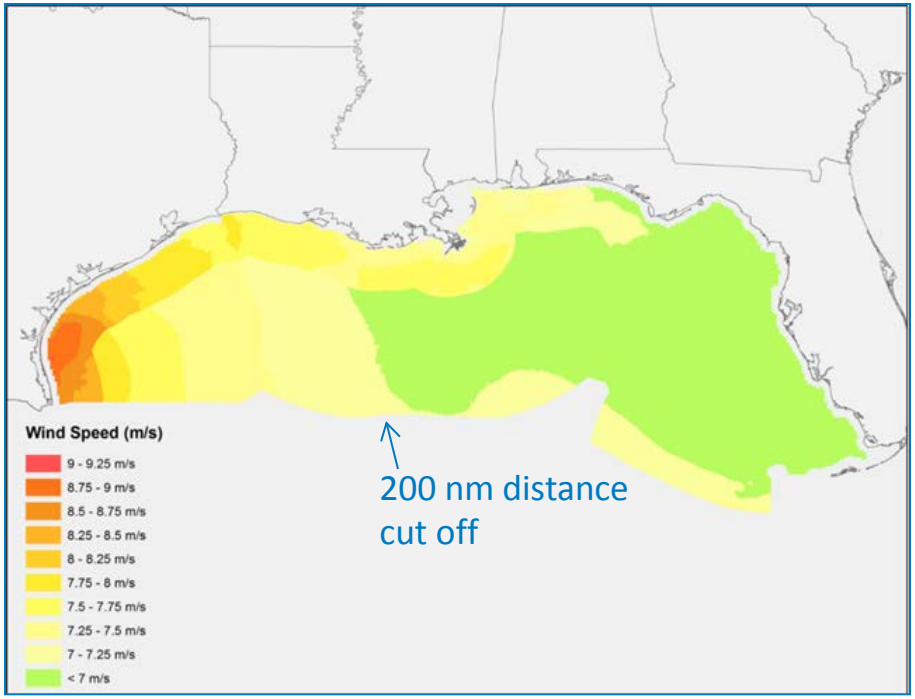


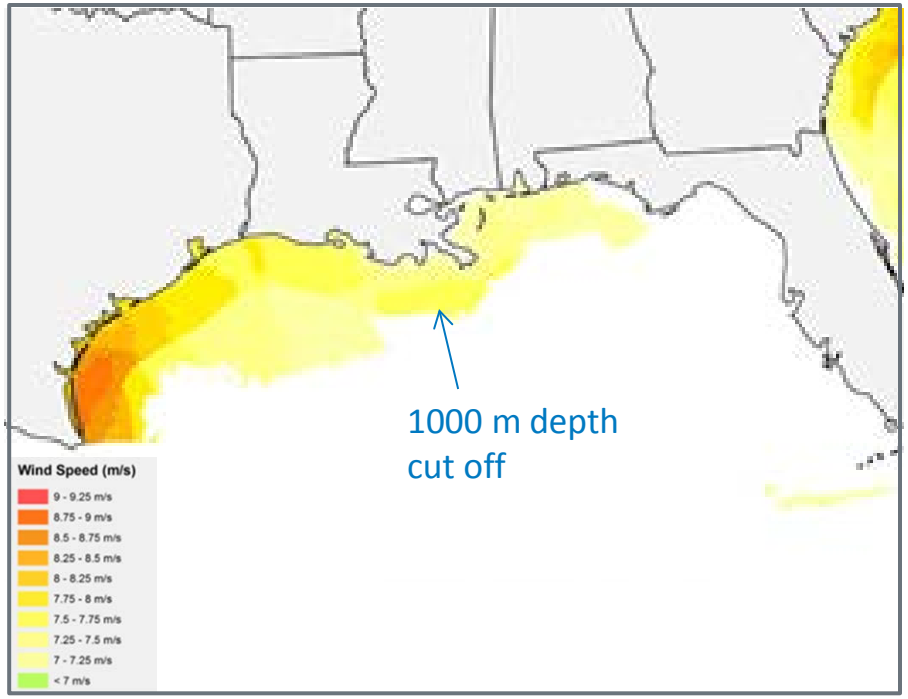
Musial, W. et al. ***2016 Offshore Wind Energy Resource Assessment for the United States***. NREL/TP-5000-66599. http://www.nrel.gov/docs/fy16osti/66599.pdf

Sample Filters for Technical Potential

Renewable Energy Resource Limit Criteria for the Gulf of Mexico					
Technology	Gross Potential Limits		Technical Potential Limits		
	Distance From Shore	Water Depth	Distance From Shore	Water Depth	Resource Minimum
Offshore Wind	200 nm	unlimited	200 nm	1,000 m	Average wind speed greater than 7 m/s
Wave Energy	200 nm	unlimited	200 nm	250 m	Average wave power Greater than 10 kW/m
Offshore Solar Photovoltaics	200 nm	unlimited	200 nm	1,000 m	None – assumed adequate everywhere
Tidal Energy	200 nm	unlimited	200 nm	1,000 m	Greater than 500 W/m^2
Ocean Current	200 nm	unlimited	200 nm	1,000 m	Greater than 500 W/m^2
Ocean Thermal Energy	200 nm	unlimited	200 nm	unlimited	Annual average temperature differential greater than 18˚ C
Cold Water Source Cooling	200 nm	unlimited	10 nm	1,000 m	Annual average temperature less than 8˚C

Offshore Wind Resource - Gross and Technical Potential





Gross Resource Potential

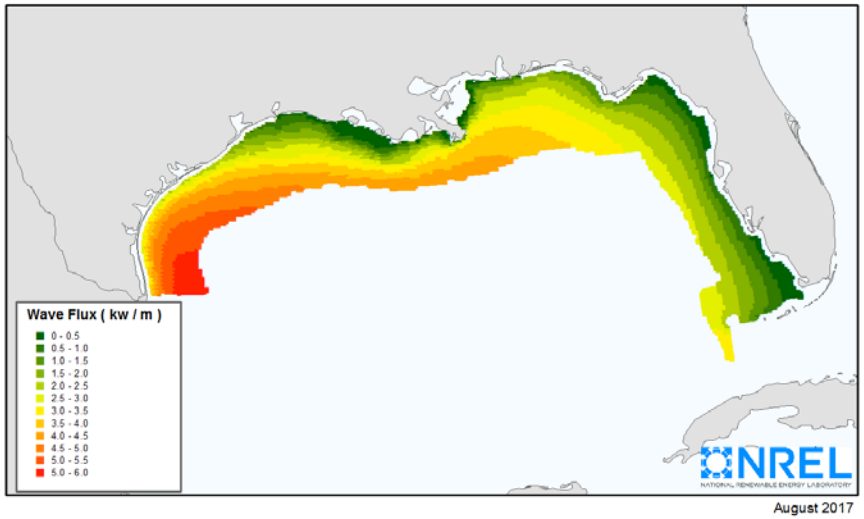
- 0 - 200 nm boundary
- No depth limit
- No wind speed filter

Technical Resource Potential

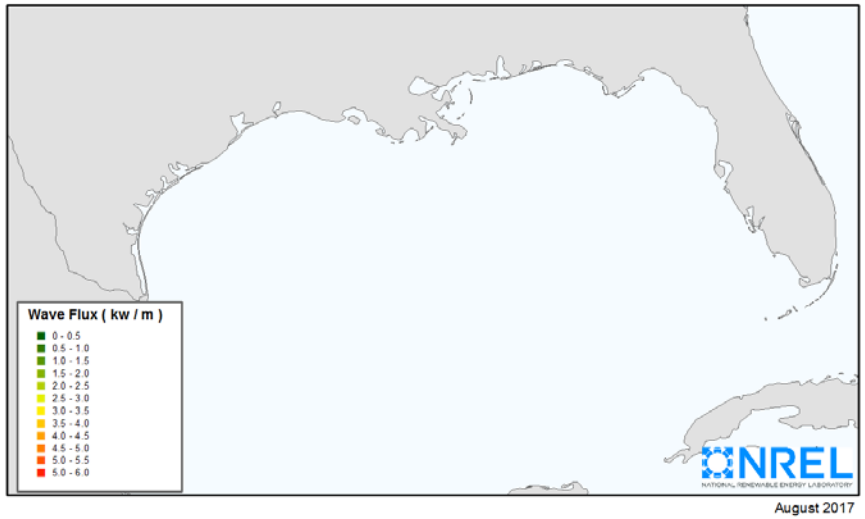
- 0 - 200 nm boundary
- Only area less than 1000 m
- Only area greater than 7 m/s

Wave Resource - Gross and Technical Potential

Wave Flux Gross Technical Potential in Gulf of Mexico



Wave Flux Above 10 kw/m in Gulf of Mexico



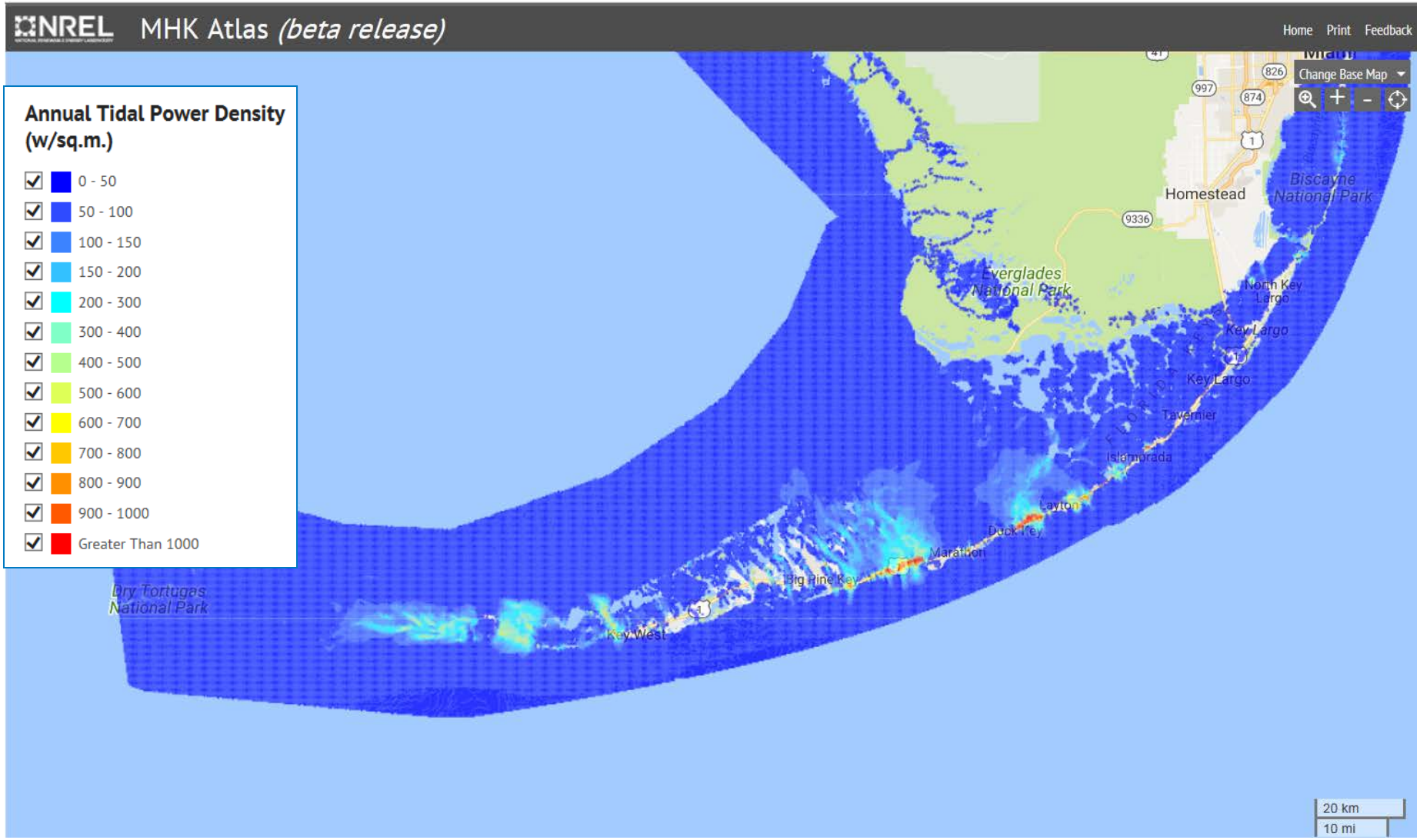
Gross Resource Potential Filters

- 0- 200 nm boundary
- No depth limit
- No wind speed filter
- Data limited to area shown

Technical Resource Potential Filters

- 0- 200 nm boundary
- Area less than 1000 m deep
- Wave power greater than 10 kW/m
- No wave energy resource within filters

Tidal Power Density – Florida Keys



Source: NREL MHK Atlas
https://maps.nrel.gov/mhk-atlas

Next Steps

- Finish feasibility analysis of RE technologies
- Down-select based on resource availability, technology readiness, and cost
- Conduct specific analysis for ~3 sites in Federal waters, on most viable technology
- Conduct supply chain, economic impact and jobs analysis
- Develop and disseminate outreach educational material
- Publish report by end of 2018/early 2019.

Thank you for your attention

Suzanne Tegen
Technology, Engineering and Deployment Manager
Wind and Water Power
National Renewable Energy Laboratory
suzanne.tegen@nrel.gov

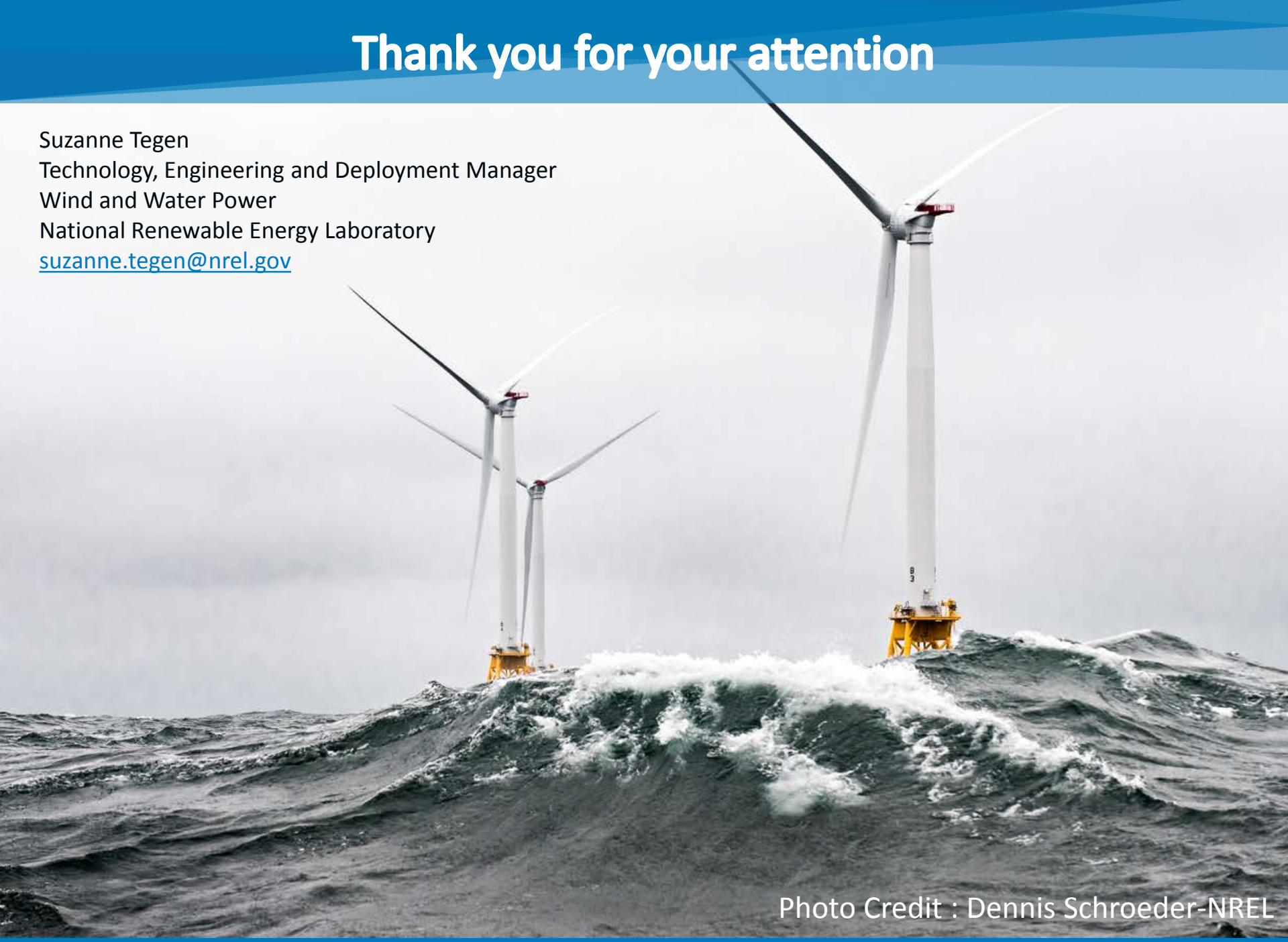


Photo Credit : Dennis Schroeder-NREL