Offshore Wind Energy for Florida: Resource, Development, and Policy Challenges

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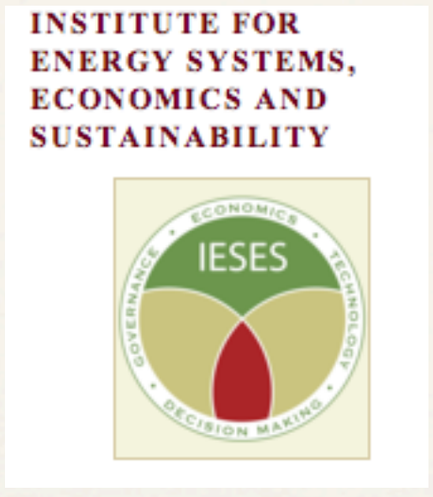


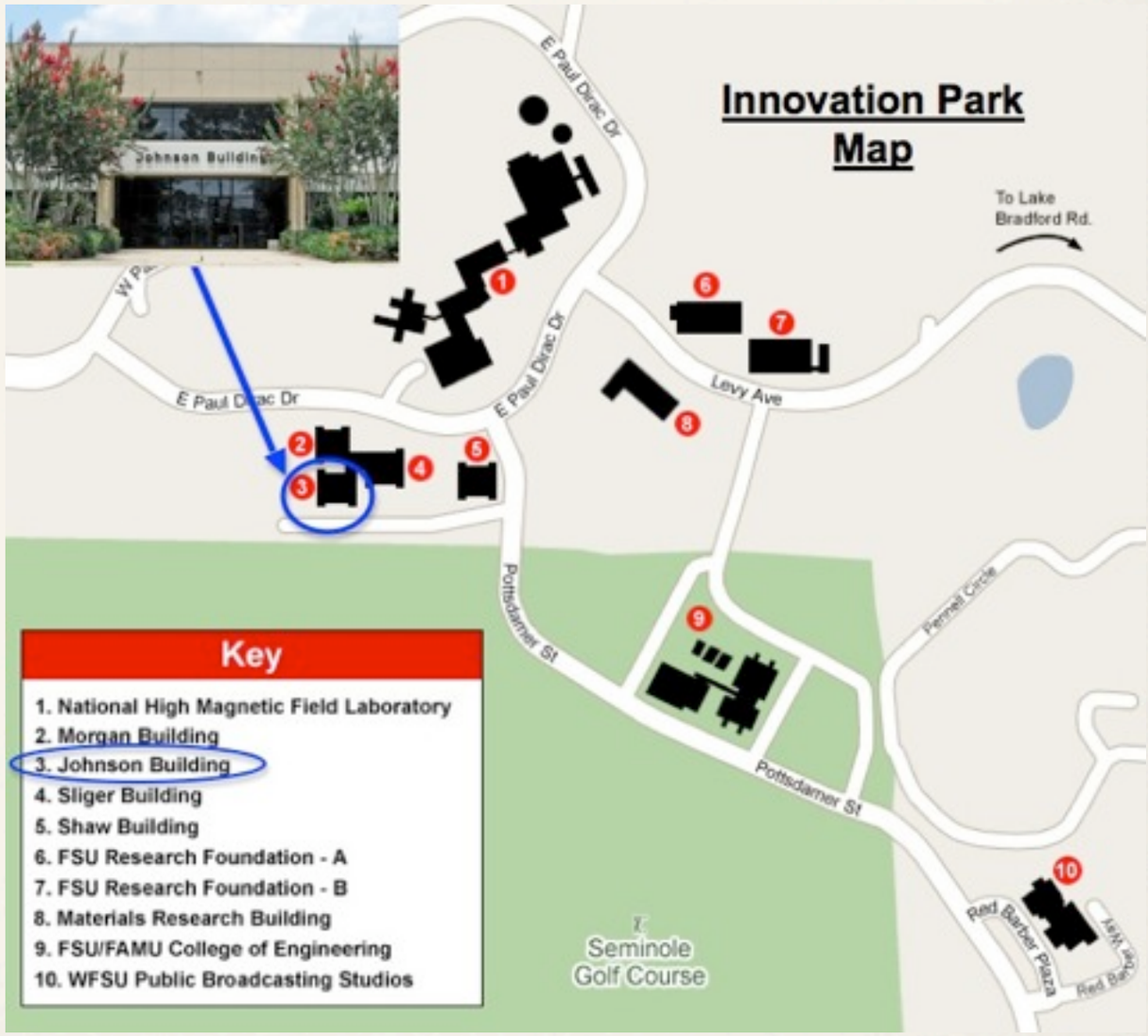
AOML

THE FLORIDA STATE UNIVERSITY

COAPS

Center for Ocean-Atmospheric Prediction Studies

- Founded by Jim O'brien in 1996
- Current Director: Eric Chassignet
- Interdisciplinary research in air-sea interaction, the coupled ocean-atmosphere-land-ice earth system, and climate prediction
- NOAA Applied Research Center, Member of CIMAS, NGI.
- Florida Climate Institute, SECC, State Climatologist, HYCOM Consortium, Research Vessel Data Center



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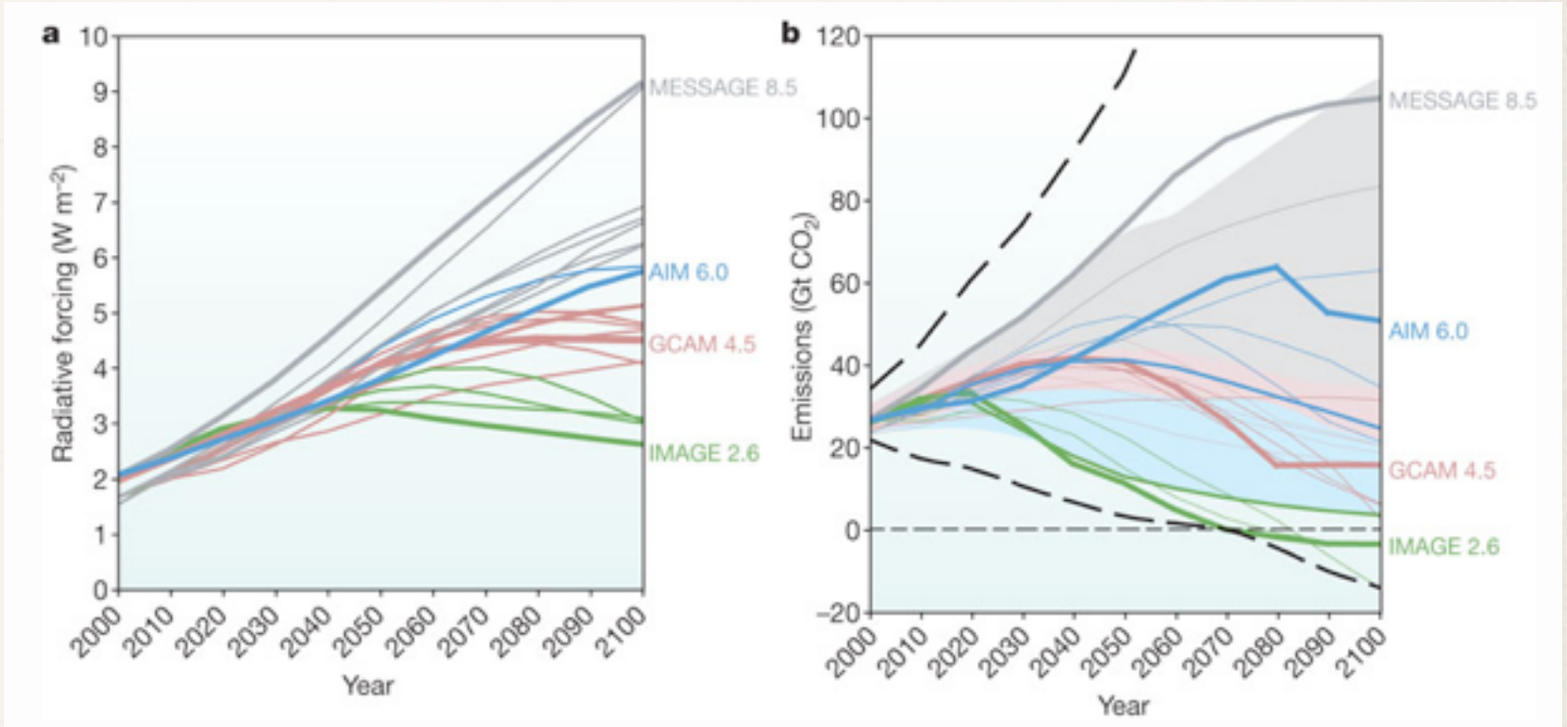
Global climate change scenarios

- IPCC AR5 representative concentration pathways
- Reduced GHG emissions needed to stabilize climate response
- Increase in renewables over next several decades
- Offshore wind one part of an overall strategy



From Moss et al., *Nature* 2010

Perceived Cost Obstacle

Crossover in 2020 if DOE meets Offshore Wind Goals of FOA

Coal and natural gas comprise about 70% of the electricity sources in the U.S, with coal contributing about 50%. Hidden costs of fossil fuels (NAS 2009) are based on damages

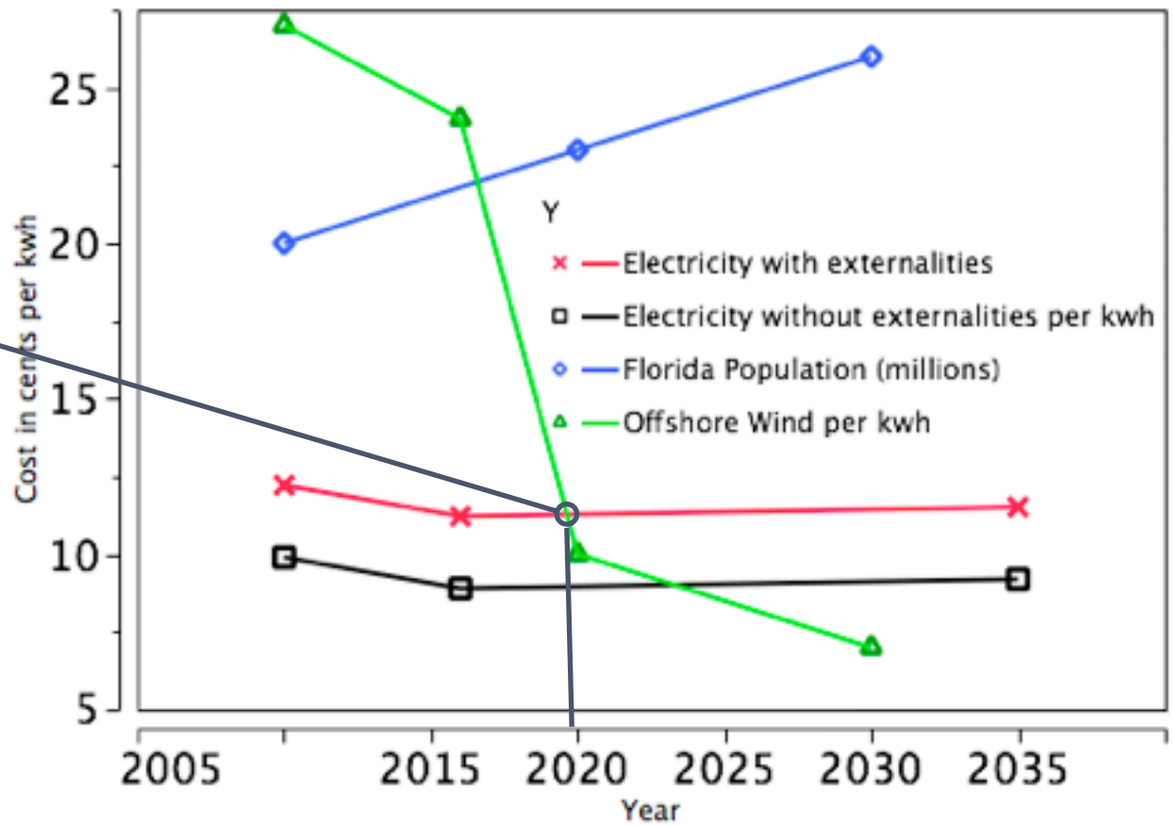


Fig. 5 Projected cost trends of fossil fuel electricity (black, EIA), fossil fuel electricity with limited pollution costs added (red, NAS), and offshore wind (green, DOE). Blue line represents projected Florida population growth from the Florida 2060 report.

in the form of human health (premature death and and chronic disease), lower grain and timber yields, and outdoor life quality (degraded visibility and recreation), but do not include costs associated with ecosystem degradation, non-grain crop losses, cancer causing toxic air pollutants, or green house gases. Limited pollution damages of coal are estimated at a mean of 3.2 c/kwh, but the highest 5% can reach 12c/kwh for the most polluting plants while mean

National Goals

- **President Obama:**
  - 80% of Energy from clean sources by 2035
  - One million electric cars on the road by 2015
  - 21st century electric grid
  - ARRA PTC incentives, efficiency standards, retrofits
- **Congress:**
  - No comprehensive climate and energy bill passed
  - Renewable production incentives short lived
  - Conventional electricity has hidden costs
- Carbon pricing and/or a national RPS needed for a level playing field

National Ocean Policy

- Executive order issued by President Obama July 2010
- Close and regular collaboration among 27 federal agencies:
- Use the best available science to: inform decisions, respond and adapt to changing global environment, support sustainable and safe access and use of the ocean
- NOP strategic objectives undergoing 30 day public review this month
- *Key element:* Coastal and Marine Spatial Planning to promote multiple sustainable uses while protecting ecosystems
- Renewables mentioned in several priority objectives
- Priorities affected by lack of energy policy (imho)

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NOAA-BOEMRE MOA, May 23 2011

- **Regulation and DOI/DOC Agency Authorities:**

1. Outer Continental Shelf Lands Act (OCSLA), 43 U.S.C. §§ 1331 et seq.;
2. National Marine Sanctuaries Act (NMSA) 16 U.S.C. §§ 1431 et seq.;
3. Magnuson-Stevens Fishery Conservation and Management Act (MSA), 16 U.S.C. §§ 1801 et seq.;
4. The Marine Mammal Protection Act (MMPA), 16 U.S.C. §§ 1361 et seq.;
5. Coastal Zone Management Act (CZMA);
6. Integrated Coastal and Ocean Observing Systems Act (ICOOS);
7. The Endangered Species Act (ESA), 16 U.S.C. §§ 1531 et seq.;
8. The Oil Pollution Act (OPA), 33 U.S.C. §§2701 et seq.;
9. The National Environmental Policy Act (NEPA), 42 U.S.C. §§ 4321-4347;
10. Executive Order 13547 (July 19, 2010) -- Stewardship of the Ocean, Our Coasts, and the Great Lakes;
11. The Coast and Geodetic Survey Act, 33 U.S.C. §§883a et seq; and
12. The National Weather Service Organic Act, 15 U.S.C. §313.

NOAA and Renewable Energy: DOE

- MOA with DOE 1-2011
  - Interagency working group on resource characterization needs
  - Resource forecasting methods
  - Measurements to establish system designs
  - Micrositing and array challenges
- Mesoscale modeling at high spatial and temporal scales for resource characterization/ forecasts
  - Climate impacts and responses
  - ESRL/EMC funded for Wind Energy Forecast testbed with HRRR
  - Current FOA not open to NOAA scientists

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NOAA and Renewable Energy: DOI

- MOA with BOEMRE May 23
  - DOI: Manages energy activities on OCS federal lands
    - Issues timely leases, rights of way, easements, while affording environmental protection (in consultation with other agencies)
  - NOAA: Manages fisheries, coastal zone development, protected species and protecting marine areas of special significance
- Exchange info on environmental reviews and concerns (especially at early stages), "Smart from the Start"
- Align regulatory procedures and develop consistent monitoring and mitigation measures
- NOAA invited to participate in EIS and EA process for renewables
- Scientific collaboration
- AOWEC 12 states have MOAs with DOI (ME->NC), SC GA eval WEA

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Where does AOML fit in?

- Hurricane structure and risk analysis for siting, turbine design
- Improved hurricane forecast models for wind farm operations
- Boundary layer research: roughness modeling, wind extrapolations
- Inter-annual variability, Complex coastal circulations
- Marine Kinetic Energy (Ocean turbines in Gulf Stream)
- Data and studies to support environmental assessment/impacts, mitigation strategies at potential resource sites
- Ocean Thermal Conversion Energy (NOAA has regulation authority)
- 2012 Budget $2M for improved BL characterization for offshore wind (testbeds, HRRR)

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Florida Energy Policy

- Executive orders of 2006
- FECC disbanded in May
- PSC under legislature
- Biomass promoted under Sec. of Agriculture
- Investor owned utilities influential
- Difficult for 3rd party energy
- Investment difficult without long term policy
- No policy bills since 2007
- RPS off table, coal oil gas back
- Voter approved 2008 constitutional amendment still not implemented
- Fukushima and Crystal River problems leading to reassessment of Nuclear power

"Smart from the Start"

State-Fed Task Force: BOEMRE, other agencies
Atlantic WEC

Identify Wind Energy Areas
Compile/provide site assessment+NEPA data, Regional EA

1 year

Request for Interest

Response?

Lease

lease auction

Site Assessment Plan
Construction/Operations Plan

3-4 years

NEPA Environmental Assessment

Significant Impact?

Yes

NEPA Environmental Impact Study

No

1-2 years

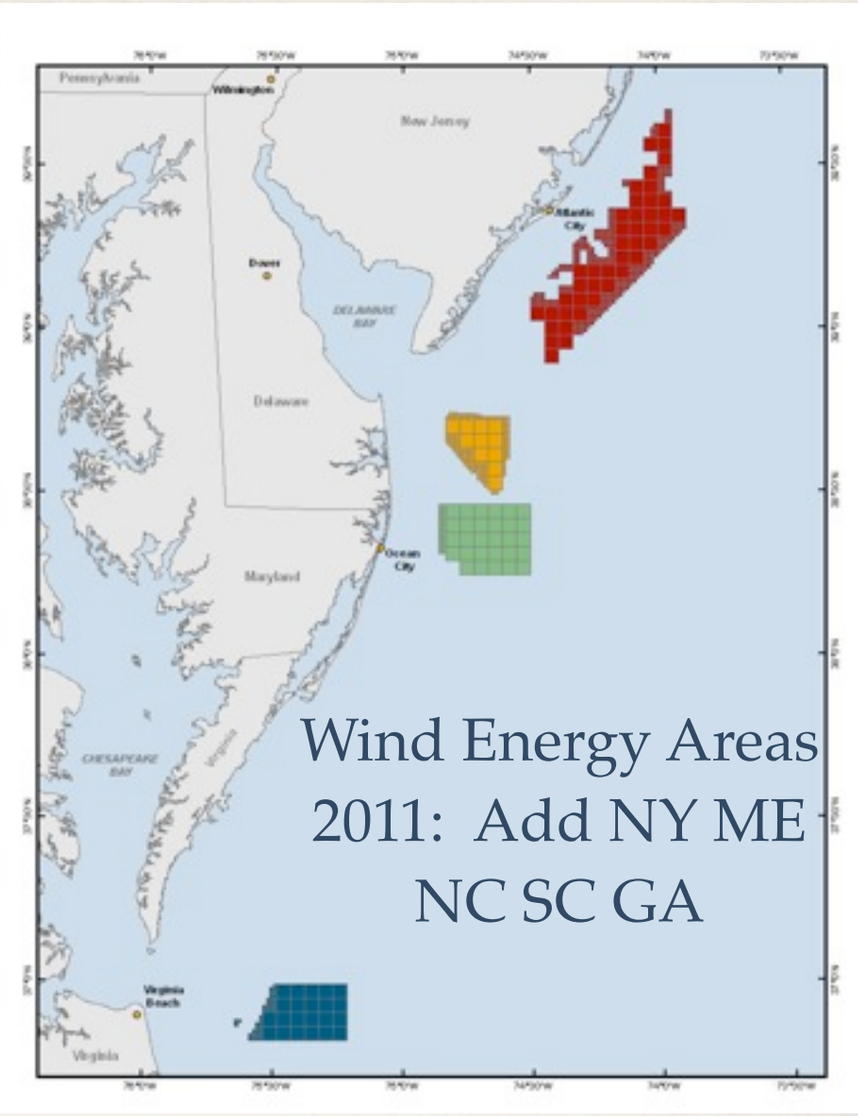
Proceed with site development

No

Significant Impact?

Yes

Mitigate or terminate



Wind Energy Areas
2011: Add NY ME
NC SC GA

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Siemens 6 MW Wind Turbine
Rotor 120 m diameter, 350 ton wt. savings, direct-drive generator, undergoing testing in Denmark

Siemens

Offshore installation

Figure 2.12. An Assembled Rotor Being Lifted onto a Nacelle at Nysted
Source: DONG Energy 2010a

BOEMRE Kaiser and Snyder 2010

How do they work?

- Wind across blades generates lift and rotation
- Wind energy converted into rotational energy of a shaft which drives a gearbox and/or generator
- Power generated depends on horizontal flux of kinetic energy which is proportional to V^3
- 1 MW can power 250 homes for a year
- A "Wind farm" may have 50-100 turbines and may take several months to a year to build

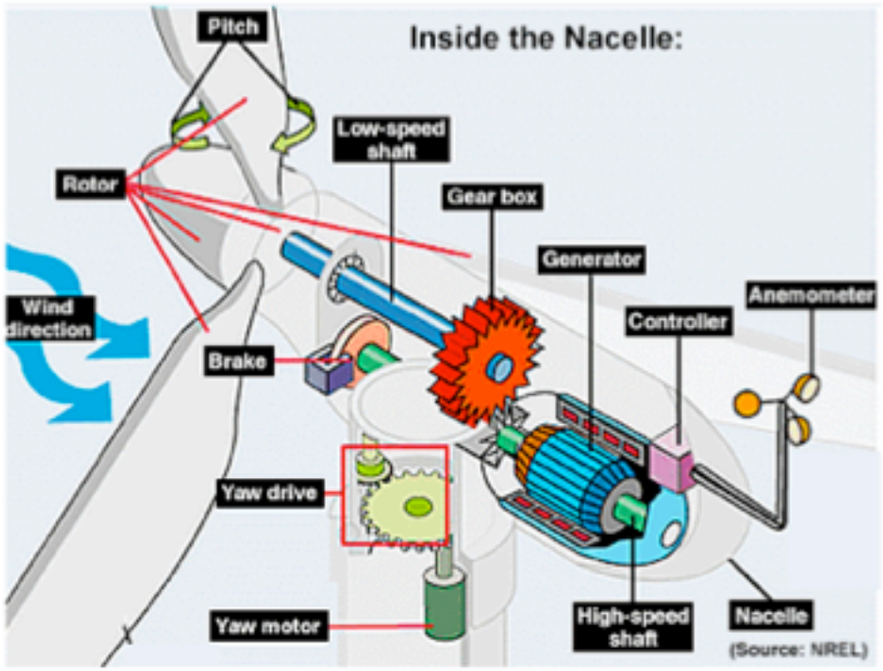


Figure 2.13. Diagram of a Nacelle
Source: DOE 2010

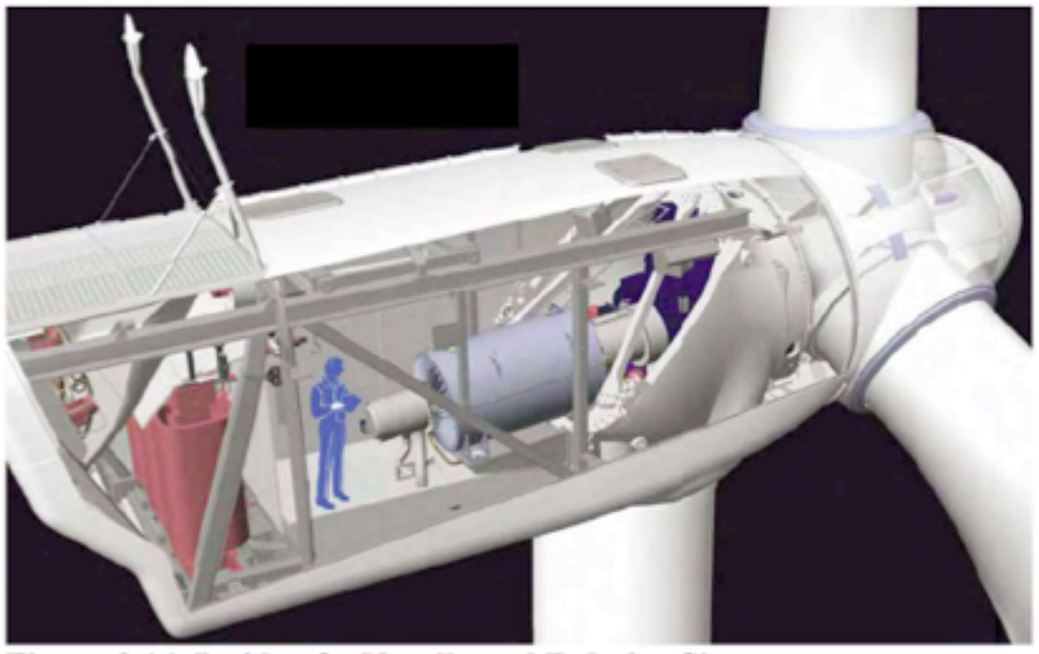


Figure 2.14. Inside of a Nacelle and Relative Size
Source: Vattenfall 2010

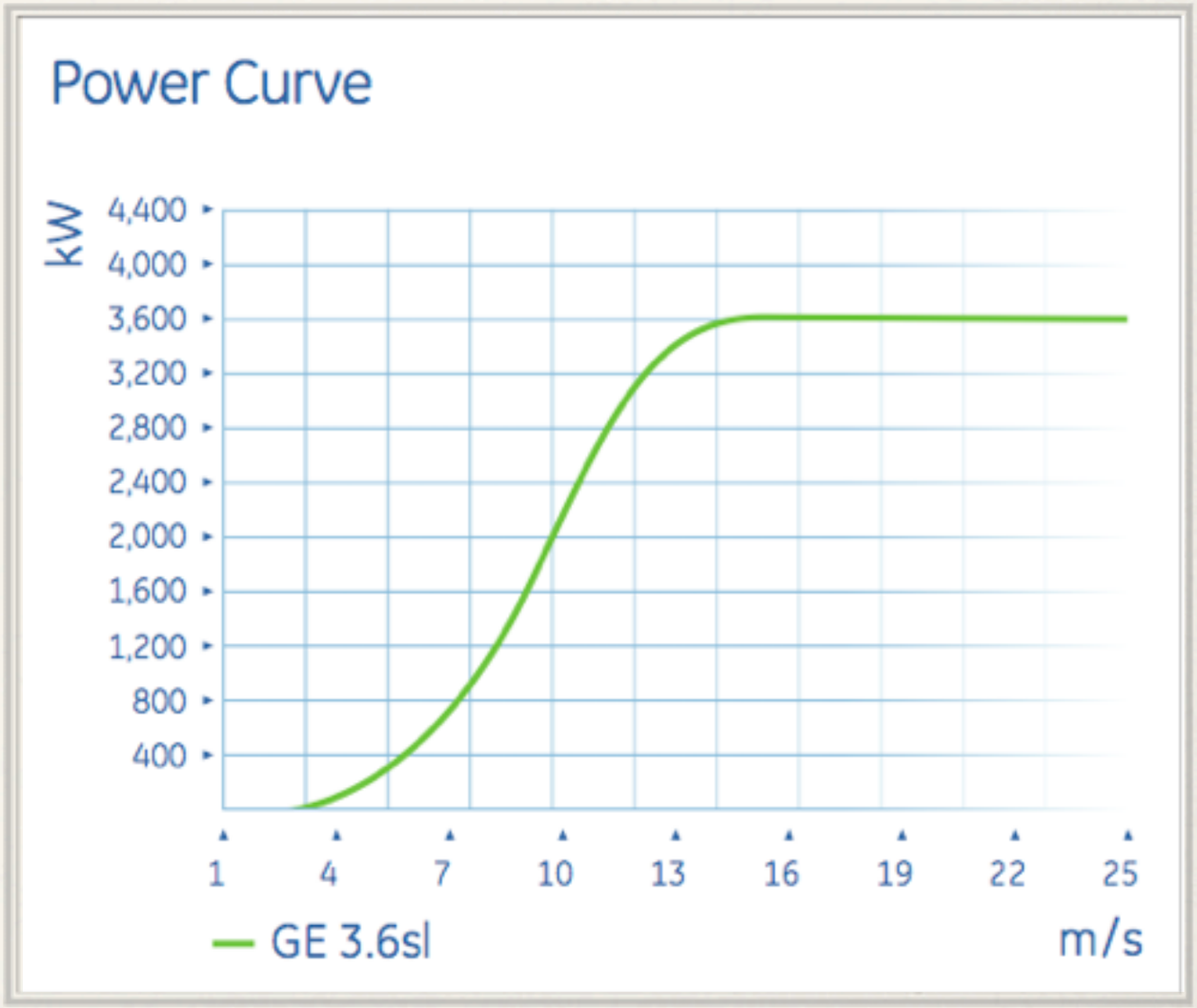
BOEMRE Kaiser and Snyder 2010

Power generated
depends on wind speed

Nominal “nameplate”
power at higher wind
speeds

Annual production
28-40% of Nominal

Wind PDF determines
annual production



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Turbine Meteorology

~ 40-50% of mean flow energy is extracted so wind decreases after passing the turbine (Betz limit 59.3%)

A meandering wake is generated

Eddies create load buffeting for downstream turbines

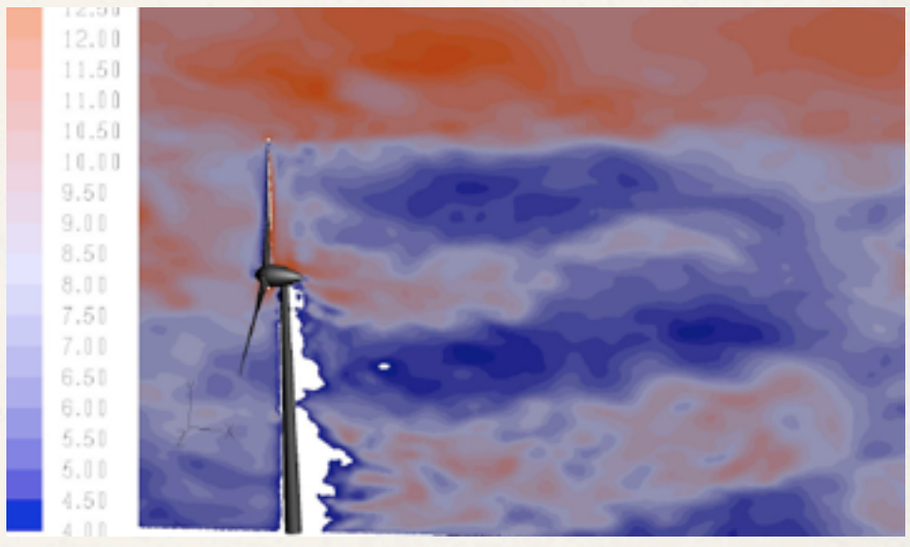
Horns Rev Wind Farm, Denmark

Wind deficit of 30% 3 rotor diameters downstream

Sfc dissipation ~ 1 w/m2

Heat, moisture fluxes enhanced

large scale roughness increased



Wubow, 2007

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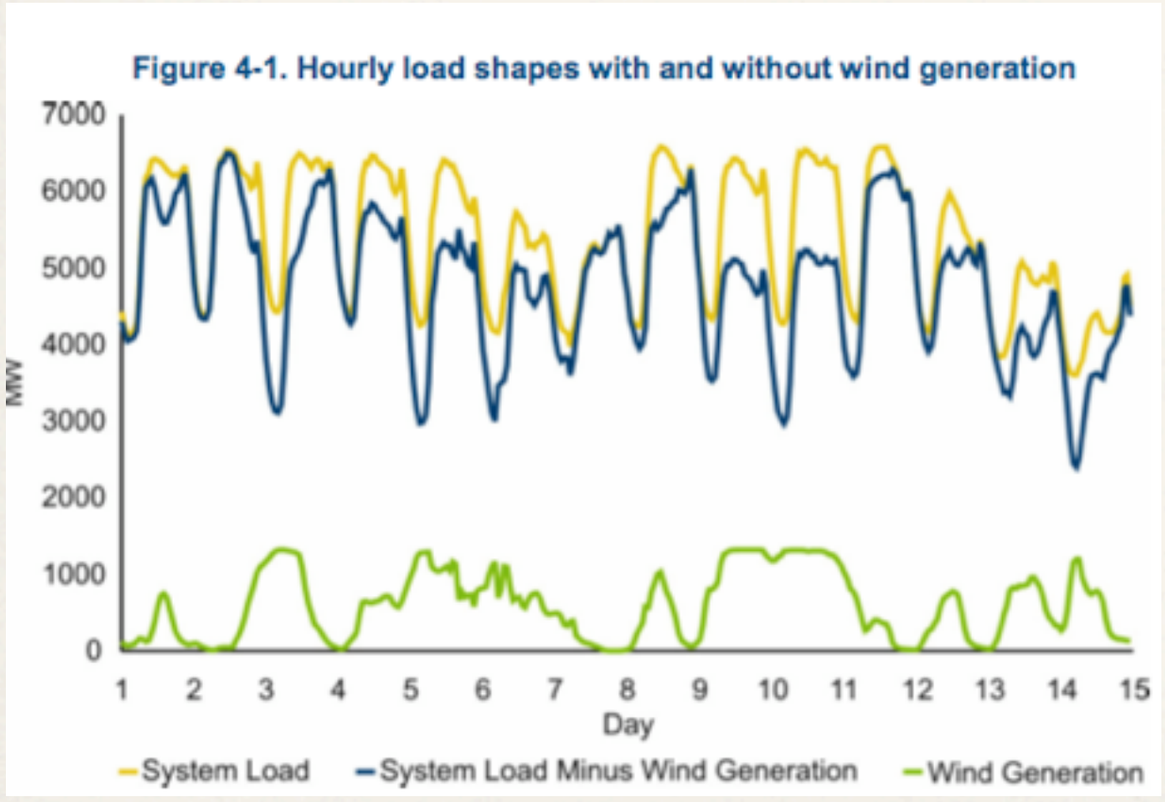
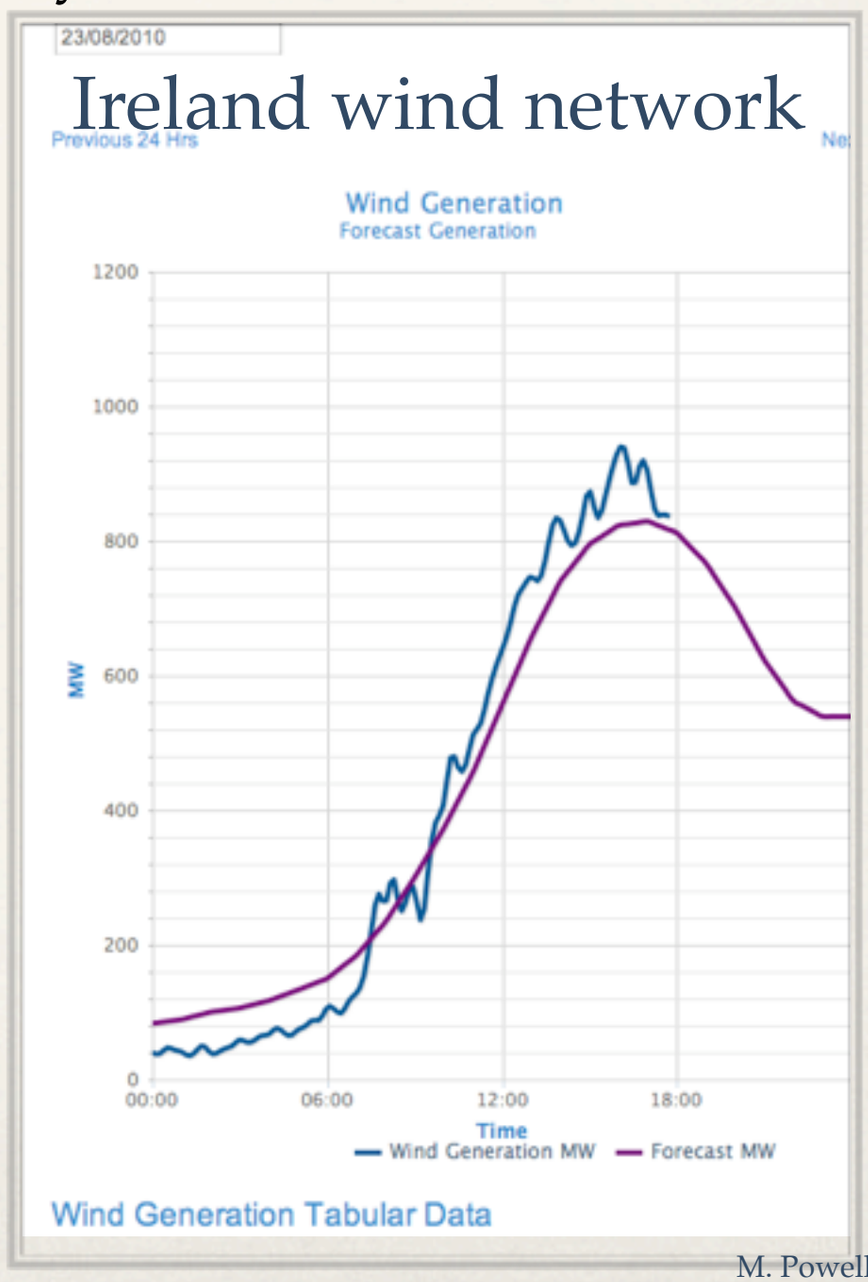
- Wind is not dispatchable (but can be on reserve)
- Load net of wind must be balanced
- Short term changes (RAMPS) can be expensive (low CF Gas turbines)

- Short term forecasts needed: 5 min, 1 h, 24 h (for day ahead market)
- HRRR and Ensemble runs used for inland US





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Florida Offshore Wind

- Demand centers close to potential wind farm locations
- Relatively shallow water and a broad shelf (except S. Florida)
- After AK, most coastline in U. S.

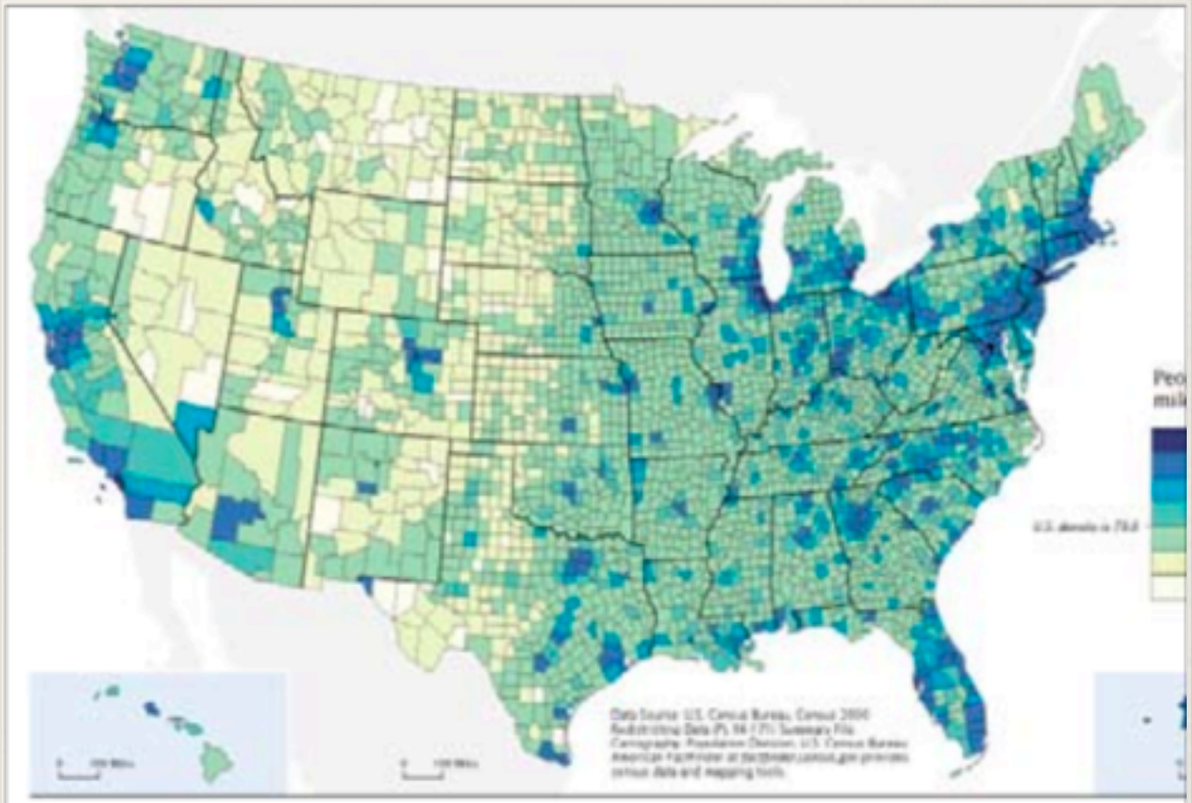

Figure 3: U.S. Population Density
Source: U.S. Census Bureau, Mapping Census 2000: The Geography of U.S. Diversity

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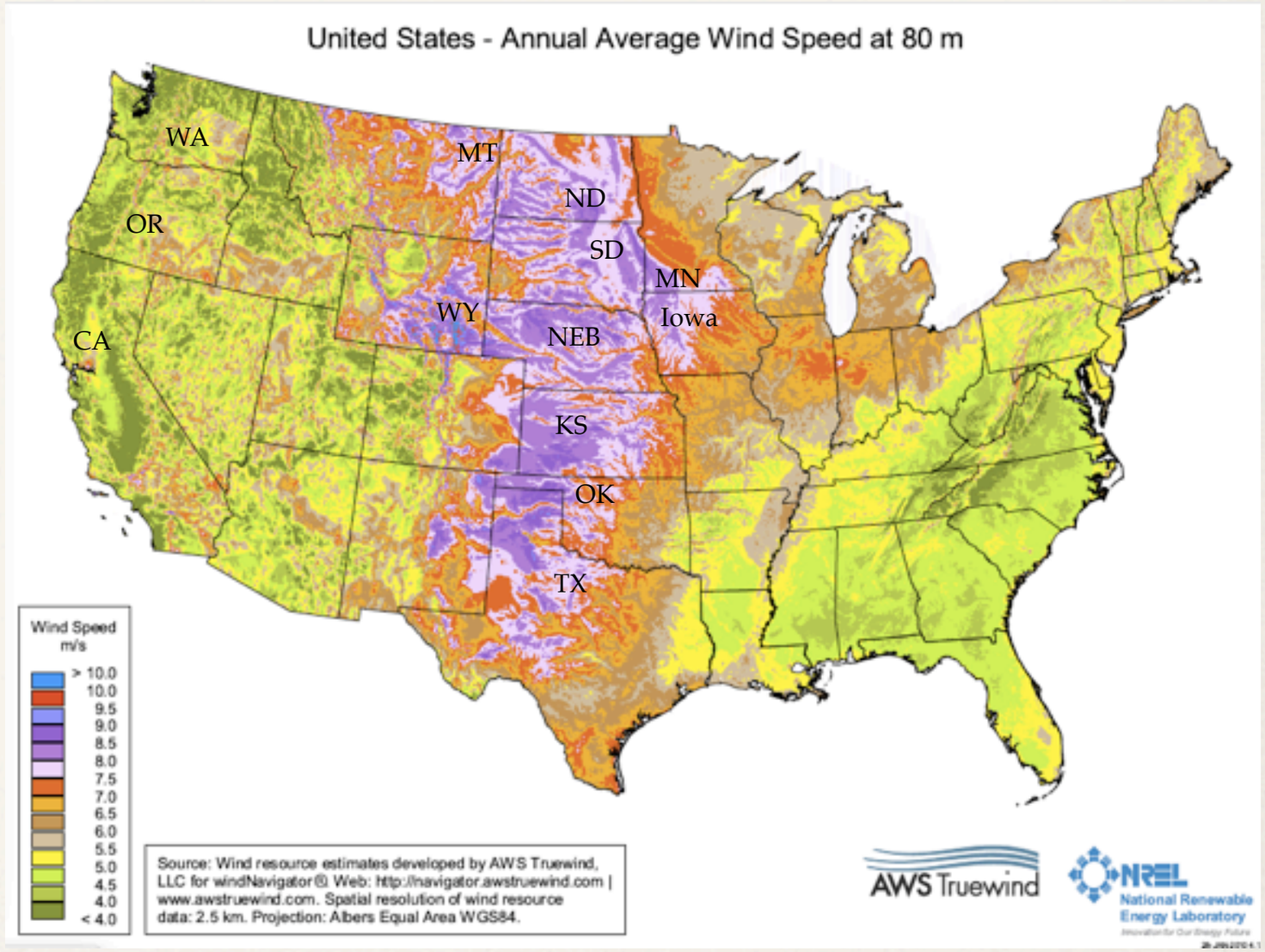
Wind Resource: US Wind farms are inland

Inland WInd

- Midwest has the best resource but far from load centers



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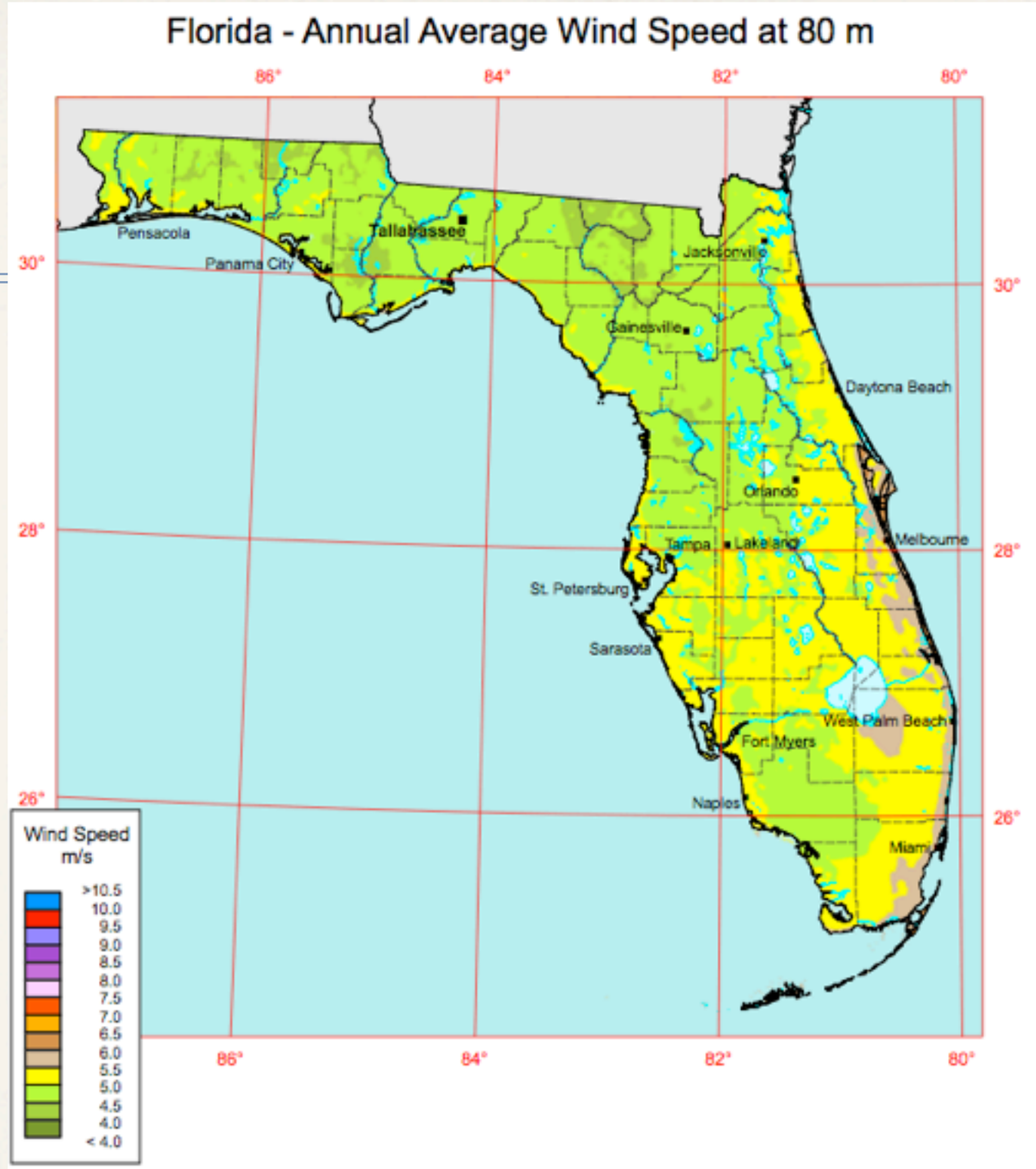
Florida Onshore Wind

- Most promising coastal areas will be difficult to develop
- Area near Lake Okeechobee has several advantages including smooth terrain upstream, proximity to demand centers, fewer NIMBY issues
- Wind Capital Group 150 MW farm proposed SE of Lake Okechobee



Wind Capital Group: 16,000 acre lease option, permitting in process, jobs and royalties, environmental review avian collision potential (surveys underway), completion timeline late 2012 (Risk factors: PTC, ITC, Natural gas prices)

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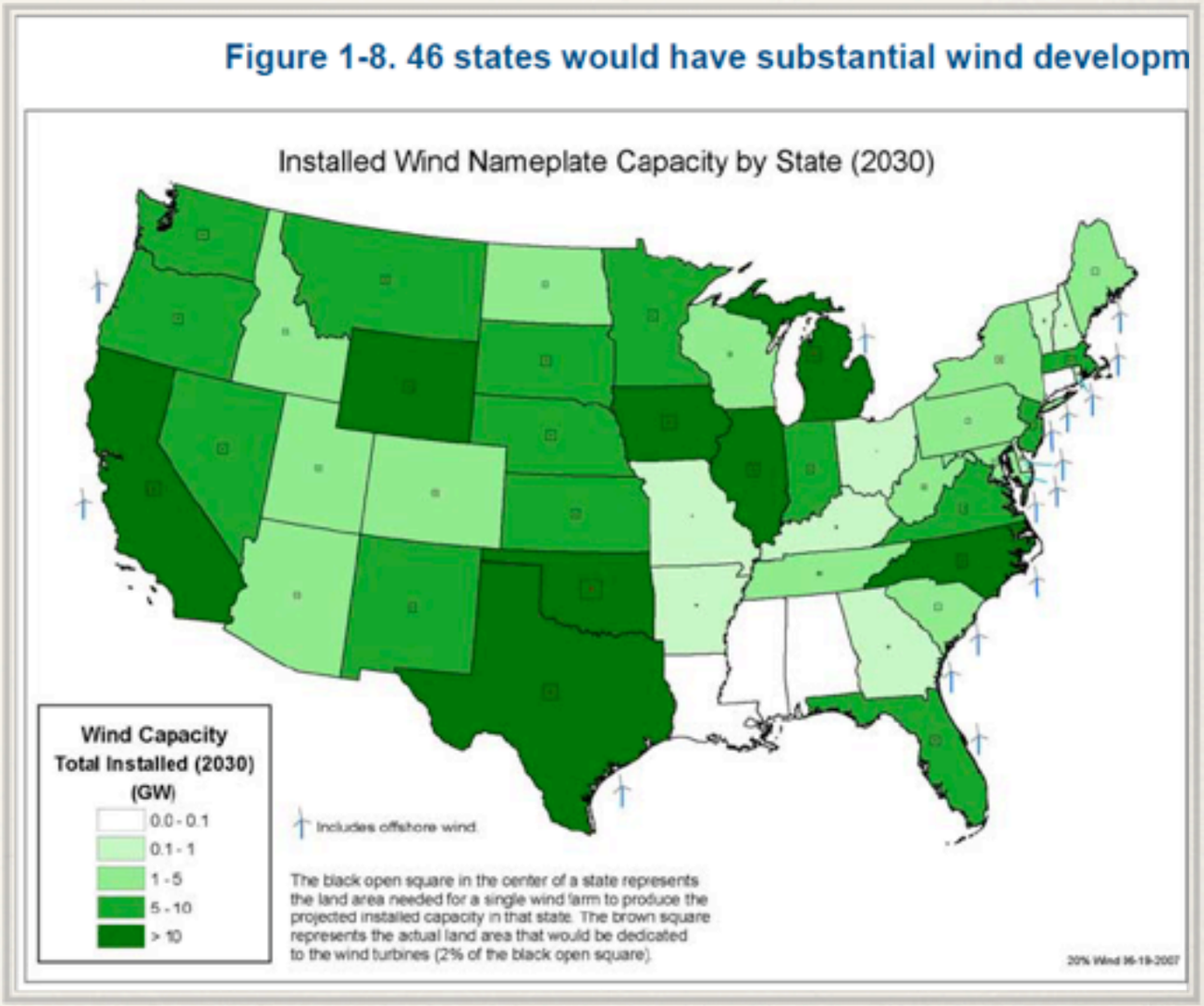
- Florida and the Gulf of Mexico shallow water

- **NREL's 20% Wind by 2030** projects 300 GW of new wind capacity (54 GW from offshore) capable of removing 25% of CO_2 emissions from electric power

- Both onshore and offshore Florida wind farms 5-10 GW; TX > 10 GW

- Oceana projects 10.3 GW off Florida Atlantic coast (10,000 jobs $24B investment)



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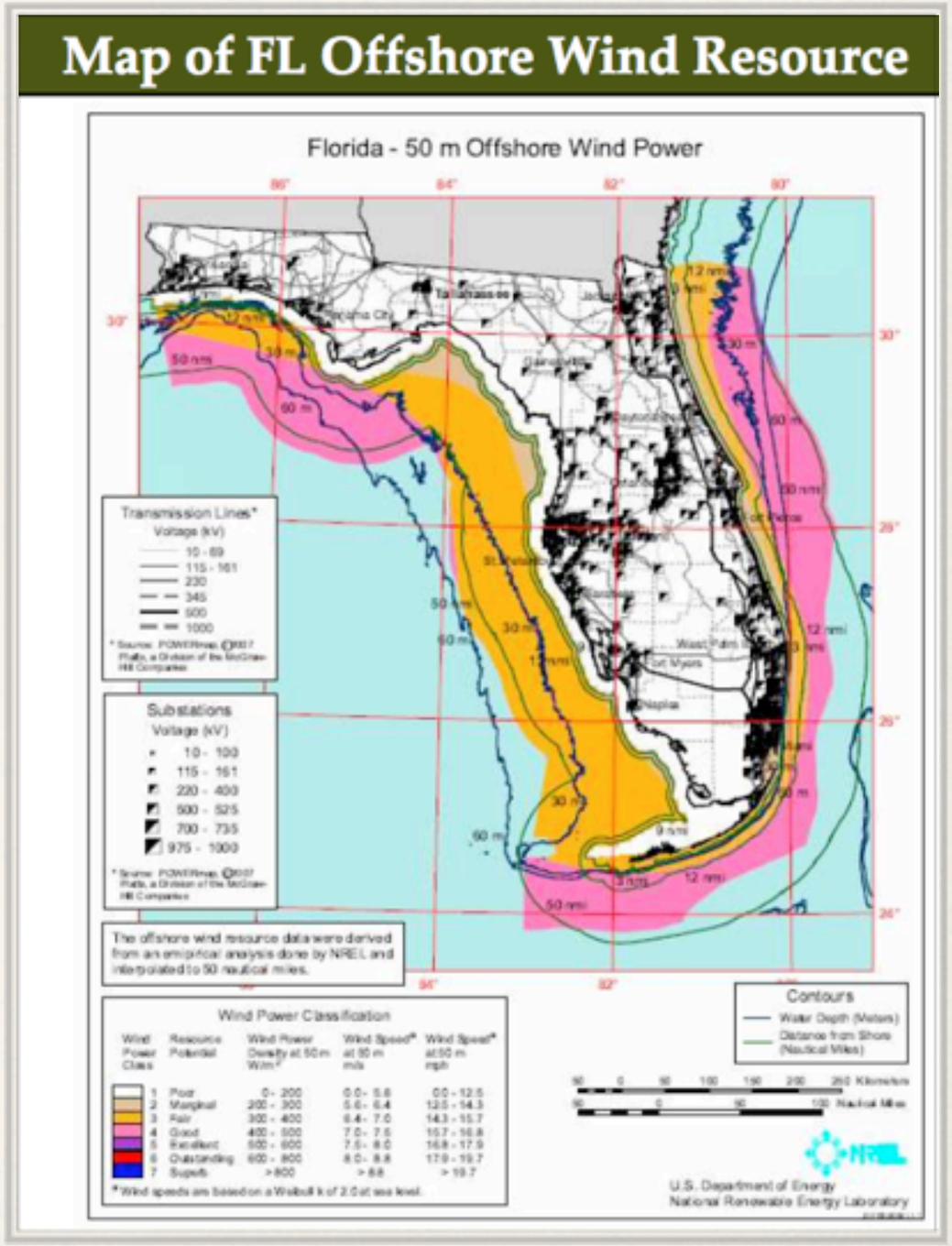
Florida Offshore Wind

- 2005 DOE FL Wind Initiative: Class 4 (pink) *"Good"* winds offshore
- 2008 Florida PSC study by Navigant ~ 130 GW available offshore
- Above studies based on very limited data



2008 NREL

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NREL Offshore wind map

- NREL and AWS TruePower July 2010
- Combination of buoy, tower and satellite wind obs, modeling up to 50 nm offshore
- ***No offshore resource mapping for FL, MS, AL due to lack of earlier preliminary maps***

The lack of shading off FL, AL, MS is being misinterpreted as no wind resource

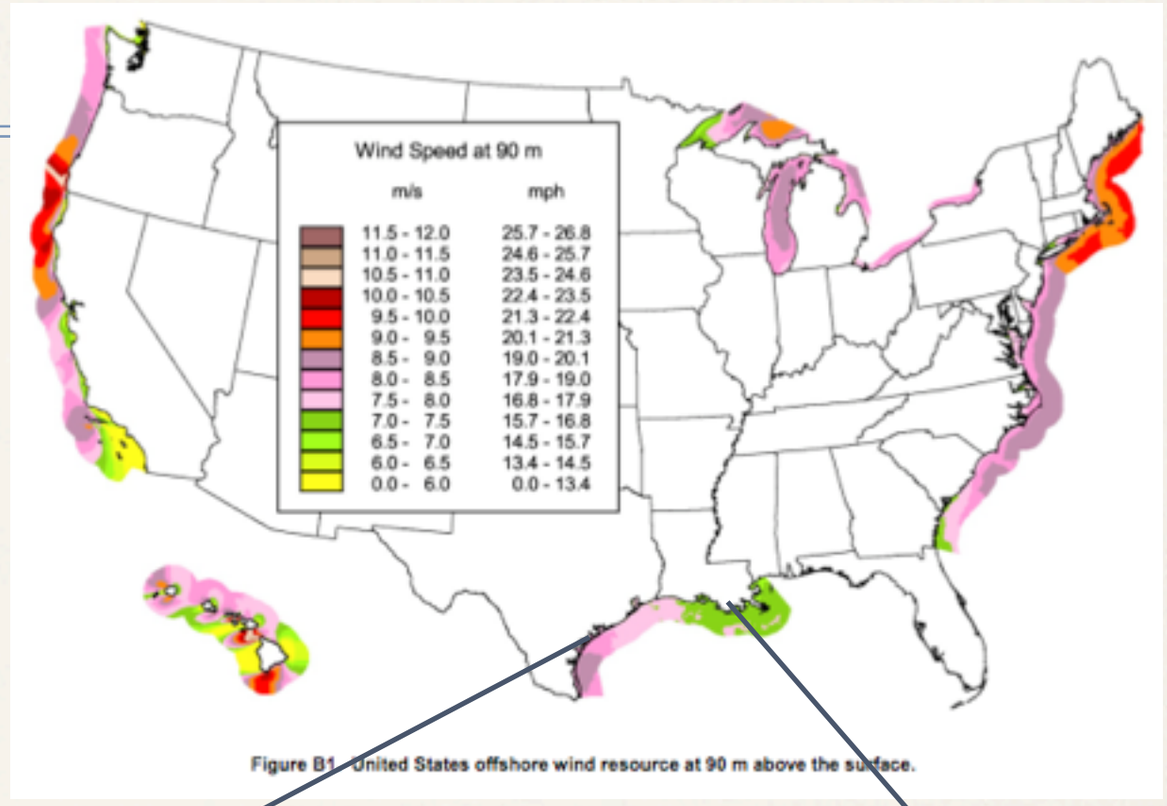
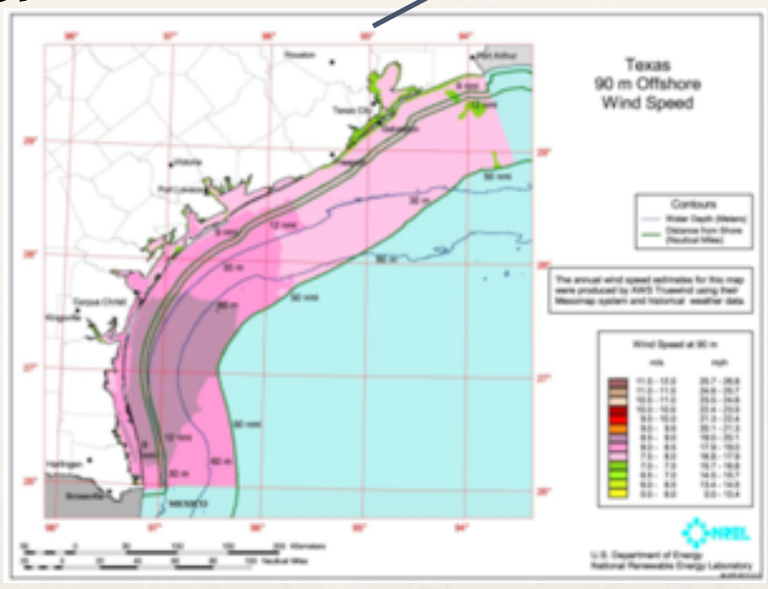
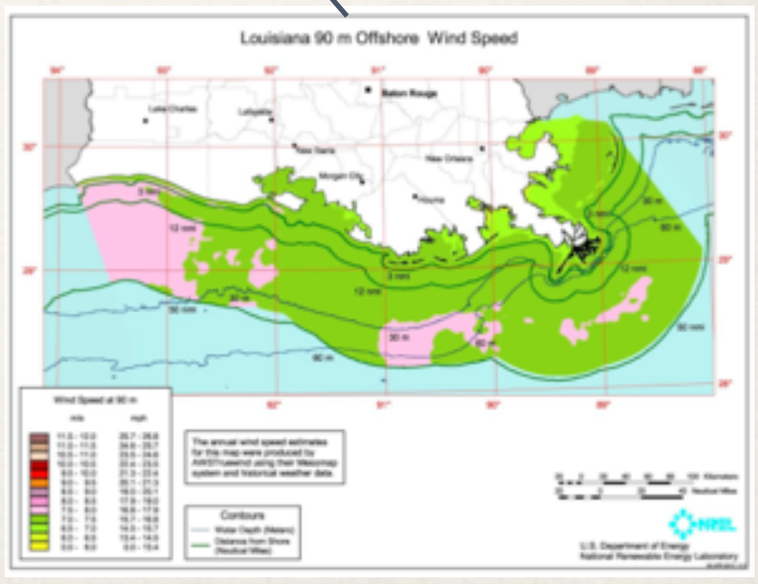


Figure B1 United States offshore wind resource at 90 m above the surface.





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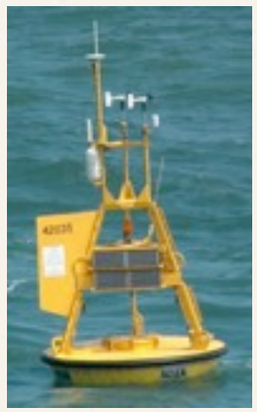
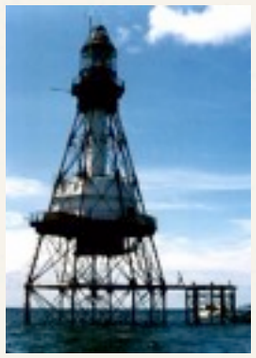
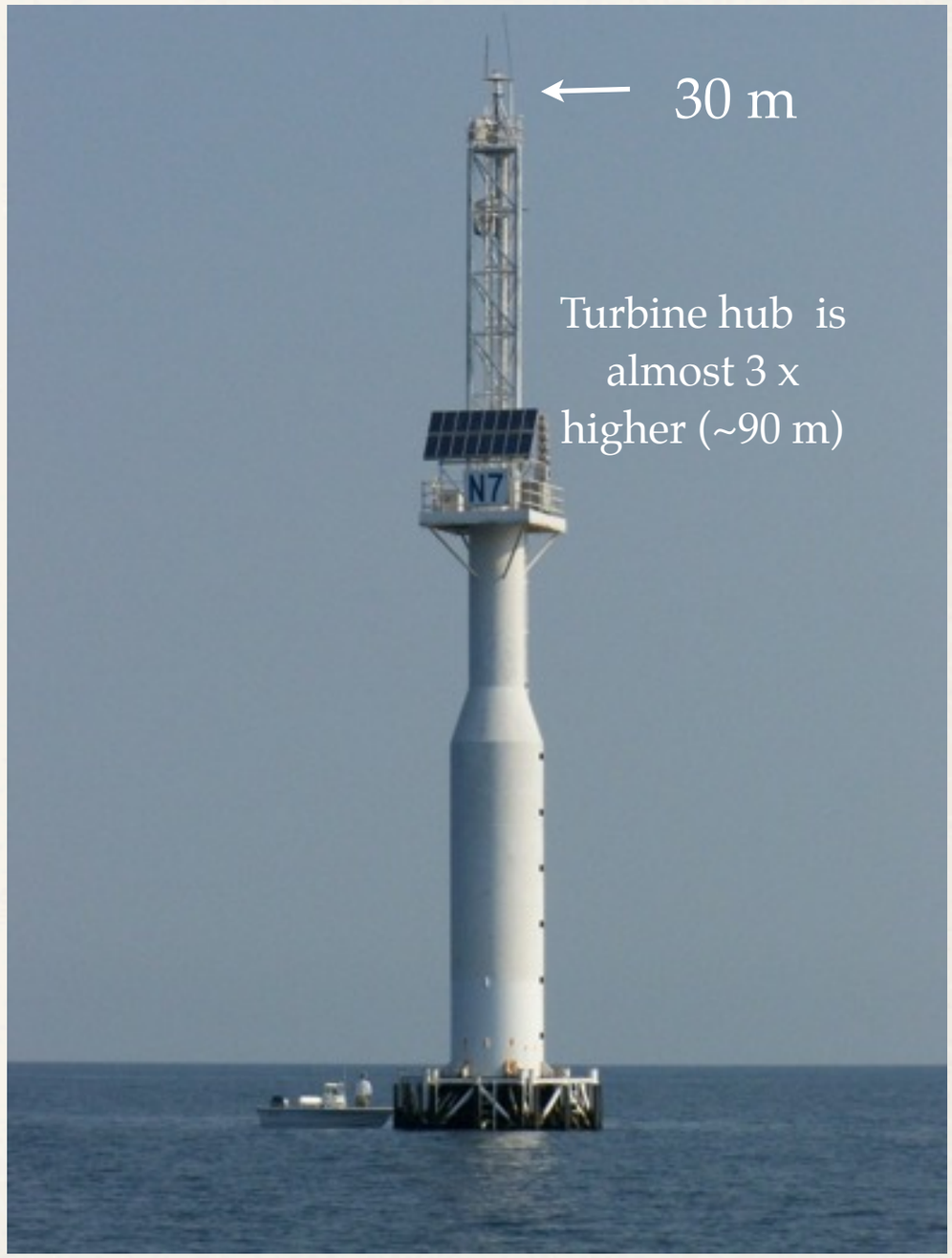
High towers are best

- Tower data analysis
  - K tower 1 year fall 2008-2009
  - C tower 2 years 2008, 2009
- NDBC Platforms





  - 12 buoys
  - Also Shell platform (122m), Chlv2 43 m, Fwyf1 (44m), Plsf1 (18 m)



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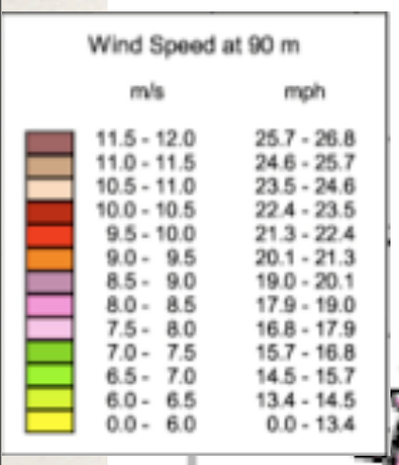
MET Towers for collecting data at lease locations

Figure 2.1. Cape Wind (Left) and Coastal Point Energy Meteorological Towers
Source: Cape Wind 2010; Coastal Point Energy 2010

BOEMRE Kaiser and Snyder 2010

Wind resource based on buoy data extrapolated to 90 m with log law, neutral conditions, wind speed dependent roughness



6.7m/s
27%

6.7m/s
27%

6.8m/s
27%

7.1m/s
31%*

6.6m/s
25%

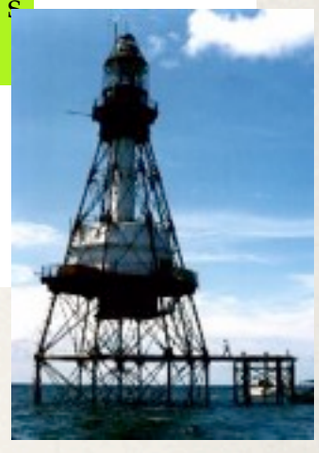
7.1 m/s
30%

6.9 m/s
29%

* C tower missing 4 mon of summer data

6.6m/s
28%

6.7m/s
27%



7.5 m/s
33%

8.0 m/s
38%

6.6m/s
27%

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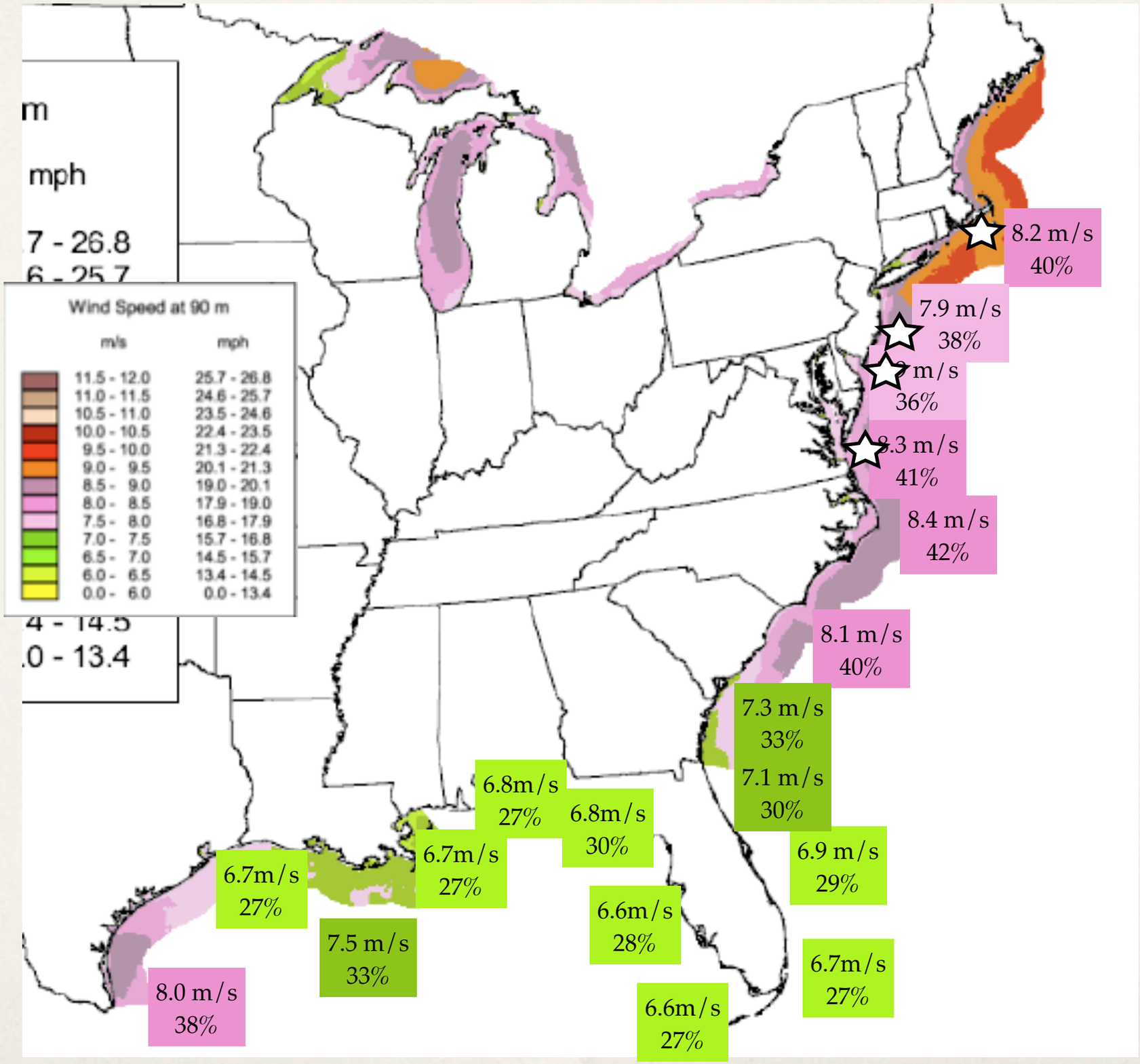
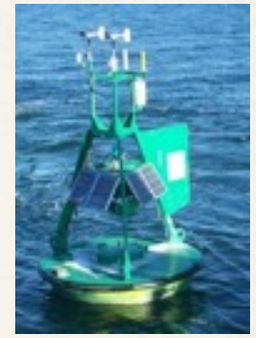
comparison to NREL map and to proposed wind farms





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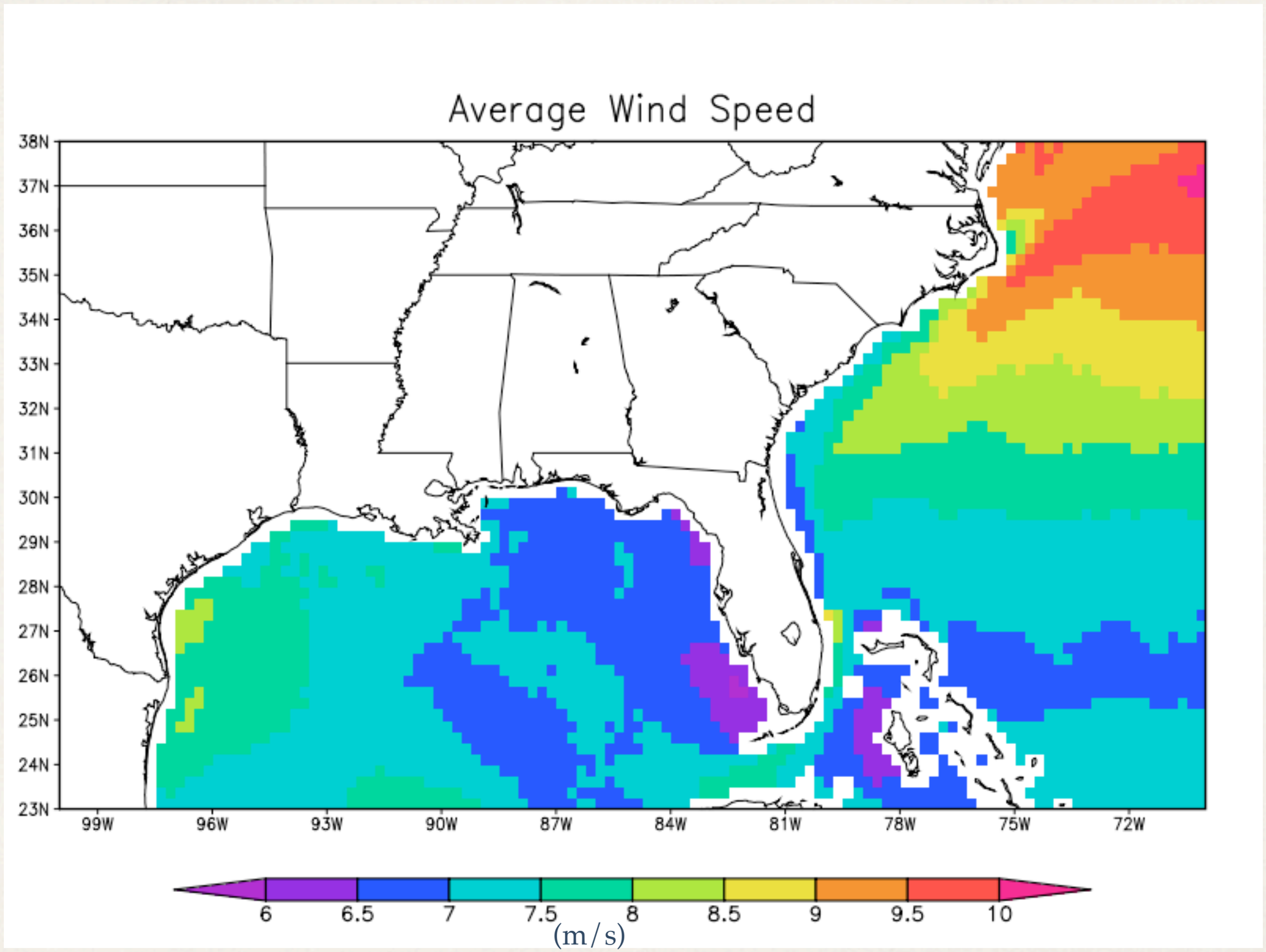
Qscat-based winds extrapolated to 90 m level (Capps 2009)



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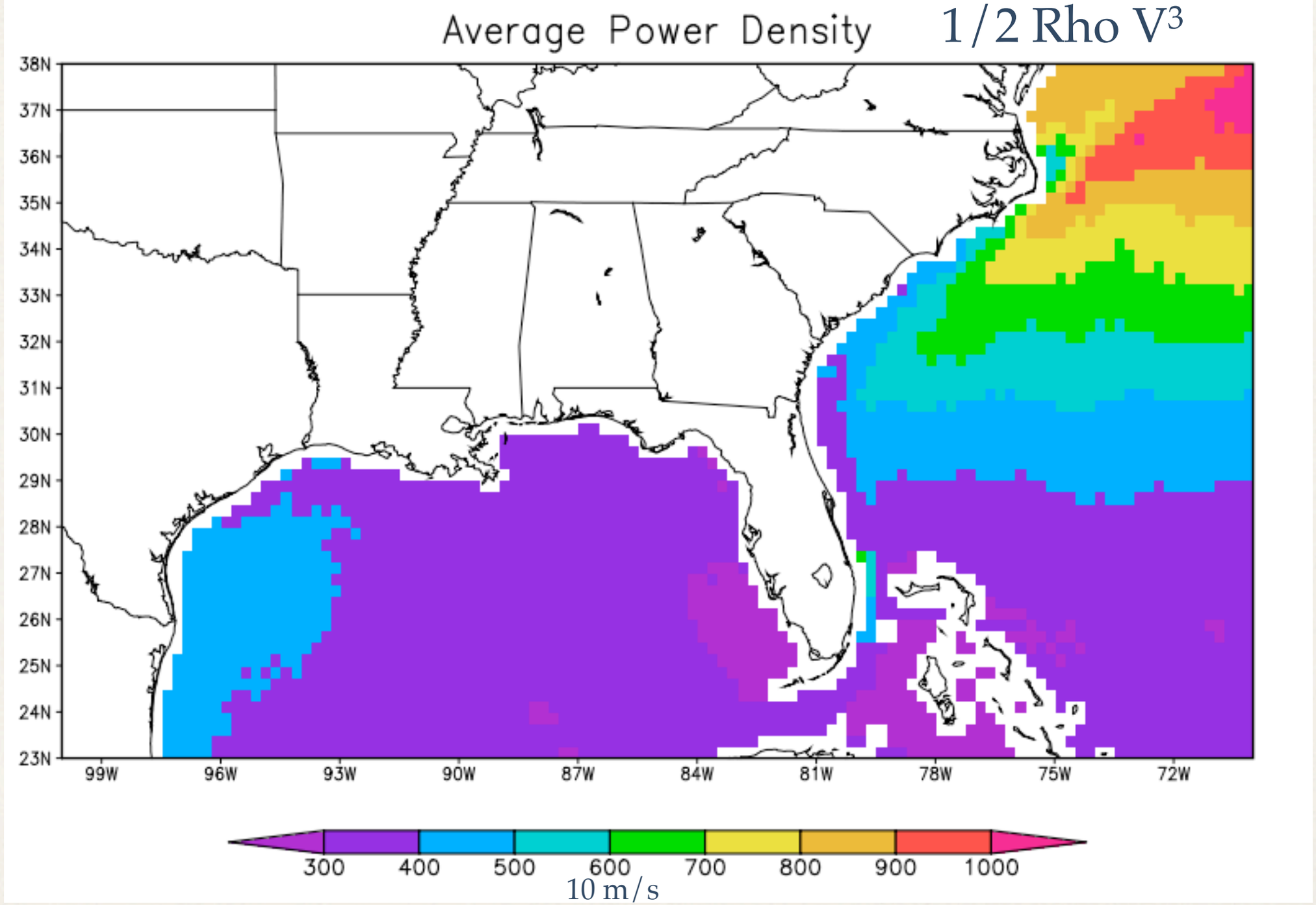

WHAT ABOUT WIND FARM INTEGRATION AND BASE LOAD?

- NREL: Wind farms reduce net base load
  - Existing base capacity can integrate 15-20% wind penetration
  - Regional transmission and load balancing needed
- Google Energy Backbone:
  - Synoptic scale transmission and load balancing
  - Reduce the sensitivity to calm or strong wind periods

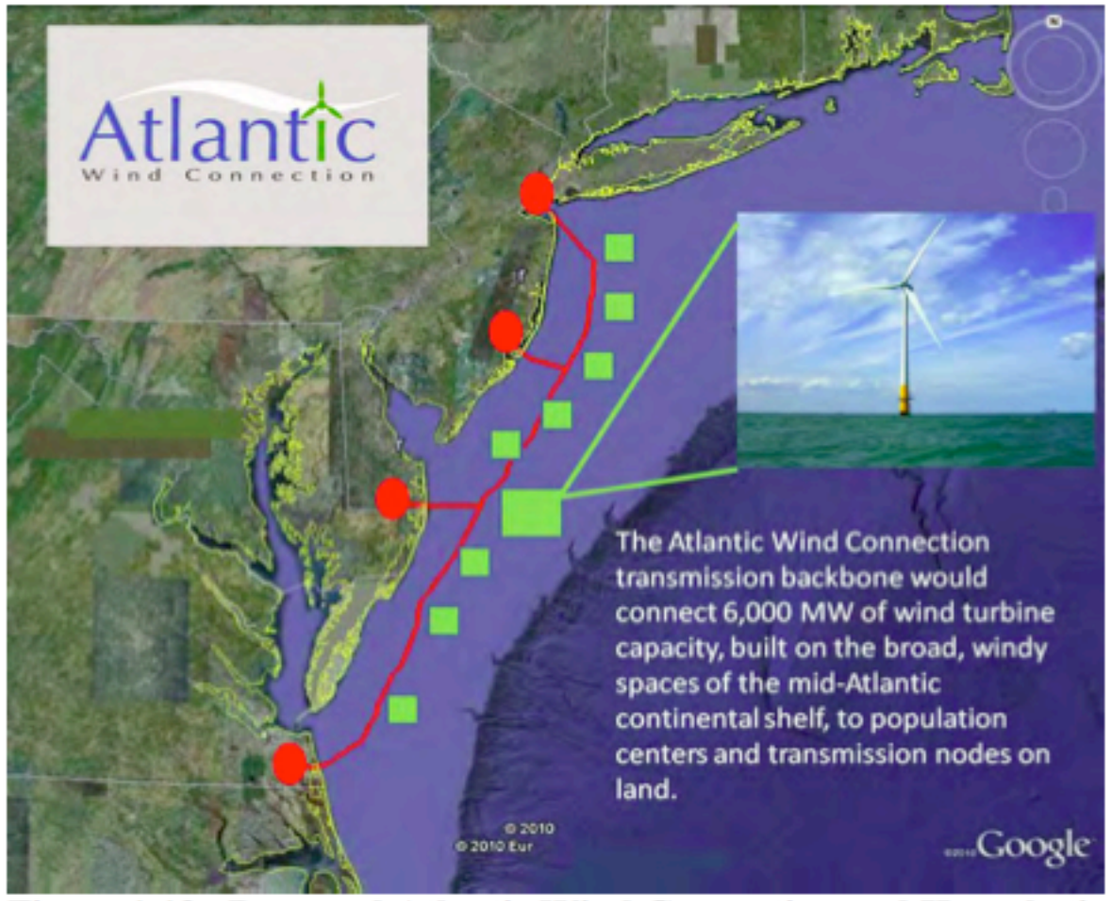

Figure 1.12. Proposed Atlantic Wind Connection and Hypothetical Wind Farms

Source: Atlantic Wind Connection 2010 BOEMRE Kaiser and Snyder 2010

What about Hurricanes?

- Entire Atlantic and Gulf coasts affected
- Offshore wind turbines are already designed to operate in extreme wind locations
- Risk modeling to establish extreme wind return periods (leverage Florida Public Hurricane Loss Model)
- Vertical wind profile and turbulence for design standards
- Wave and current extremes for design

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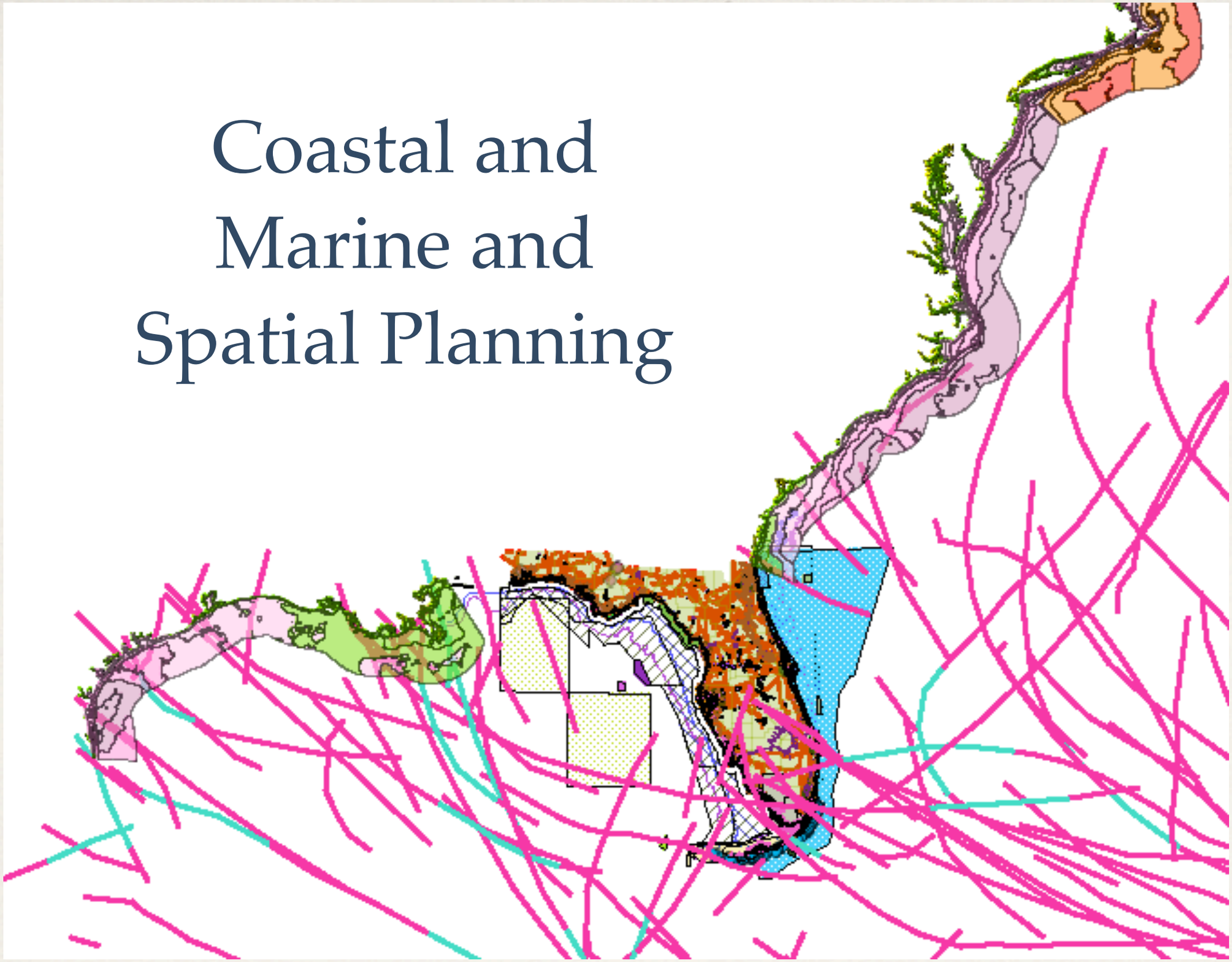
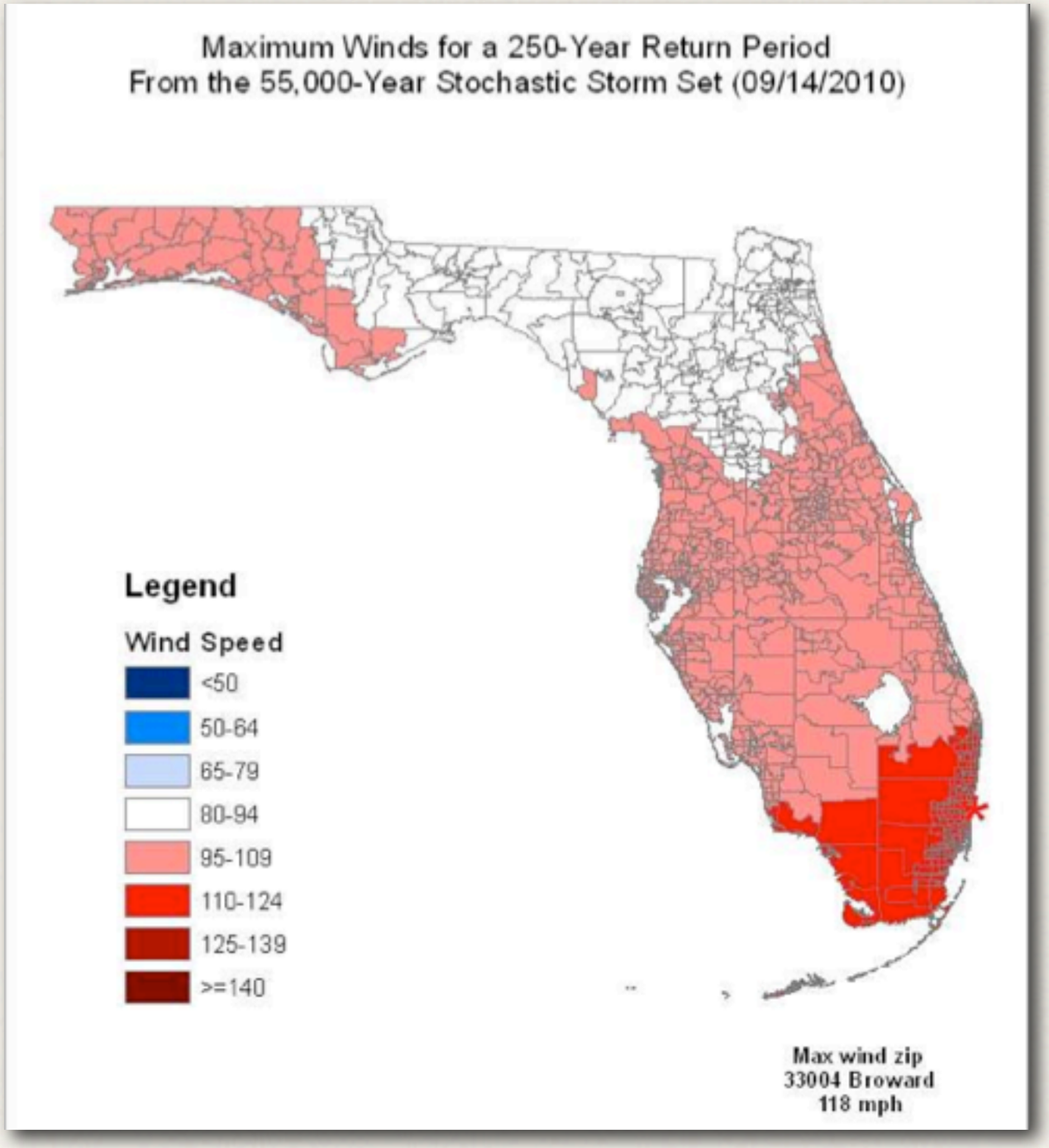
Coastal and Marine and Spatial Planning

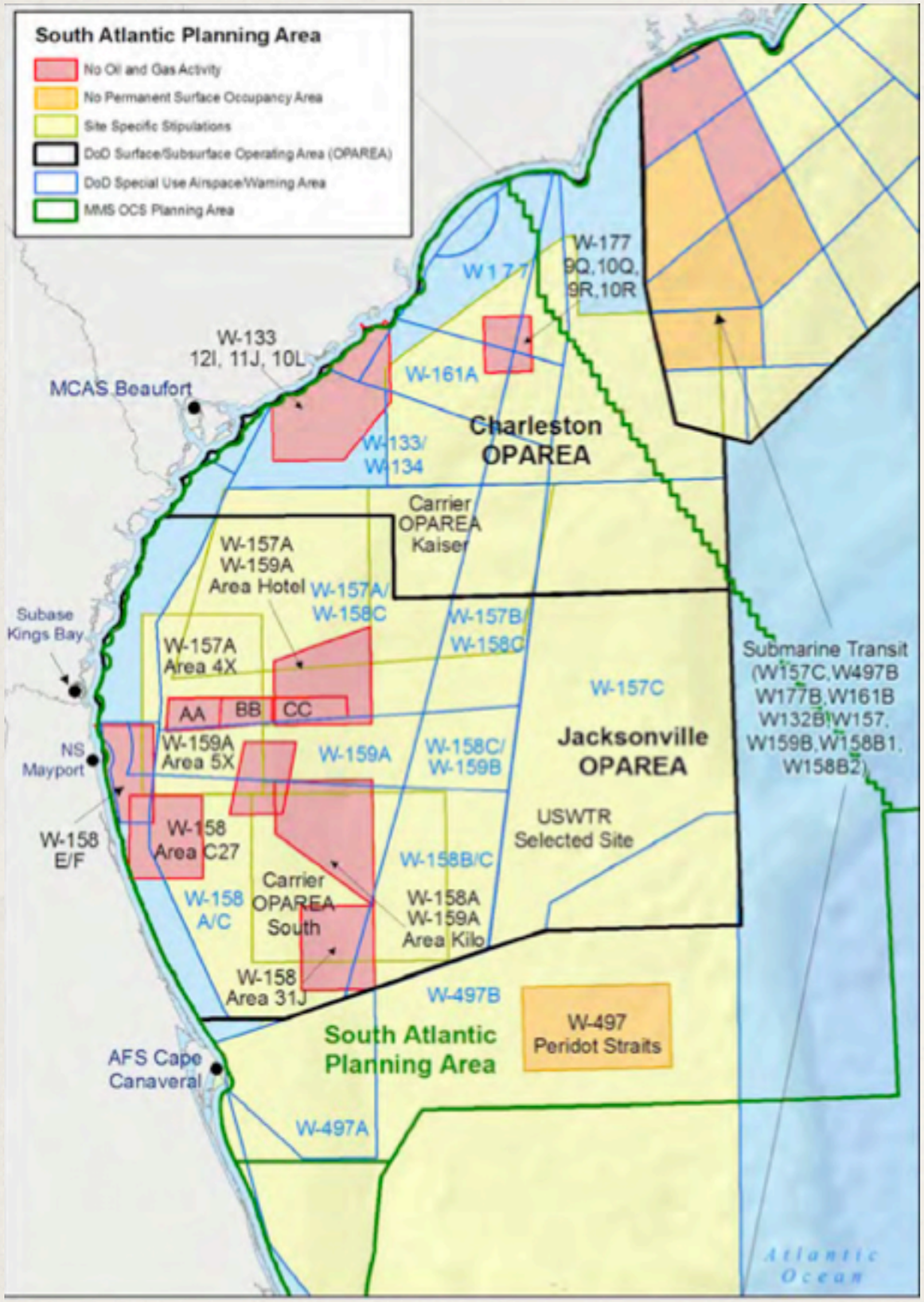


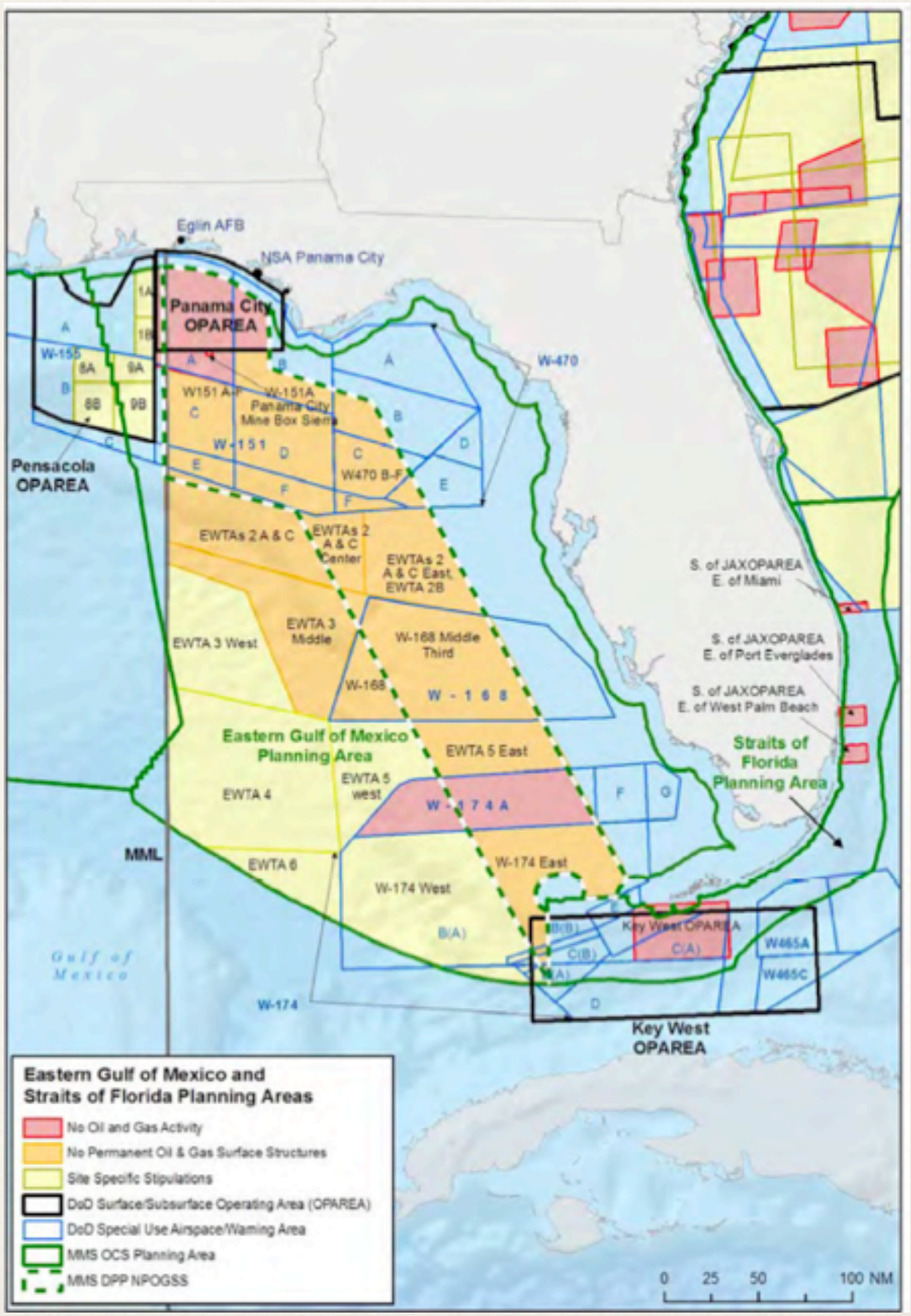
Florida Hurricane Risk



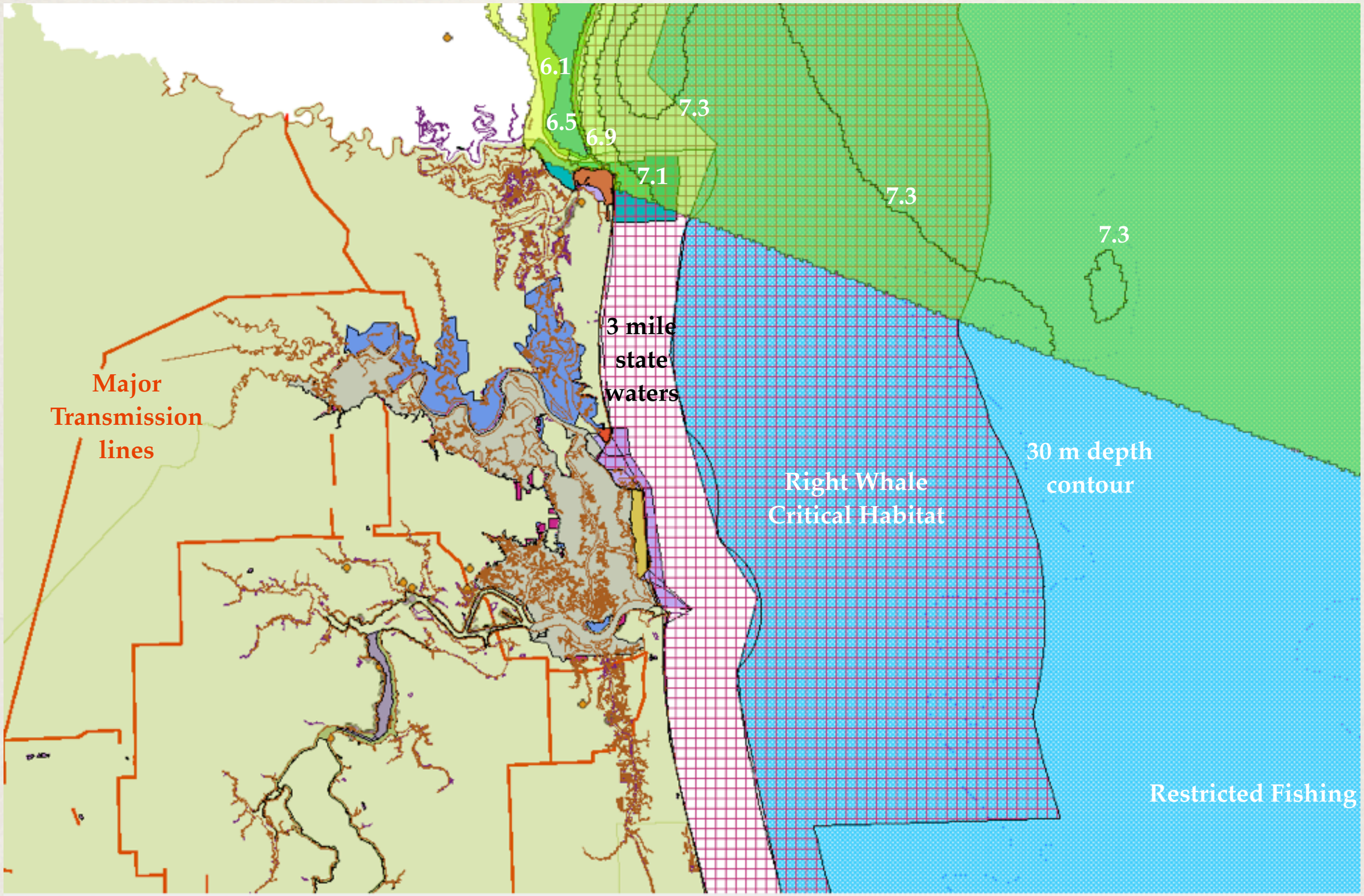
Open terrain surface winds from
the Florida Public Hurricane Loss Model

DOD Operating and Warning Areas (Oil and Gas Restrictions)





Jacksonville Vicinity Spatial Layers



Gaps and needs

- Measurements at 30-150 m to validate resource maps (towers and remote sensing)
- Resource maps needed for FL, AL, MS
- Hurricane risk needs to factor into design and operations
- Wind profile estimates need to account for air-sea stability, wind/sea state dependent roughness
- Could synoptic scale distributed networks work in the Gulf?

Is Offshore Wind Power Feasible Offshore Florida?

- Preliminary examination indicates:
  - Capacity factors off FL similar to existing inland farms but 6-15% lower than proposed E. coast offshore farms areas
  - New technology developing larger turbines with better low wind production, lower install/maintenance costs
  - Proximity to load centers, transmission infrastructure, shallow water, and economies of scale as Atlantic coast wind farms come online will help determine costs and timeline
  - Timeline also depends on energy policies and natural gas prices

Questions?