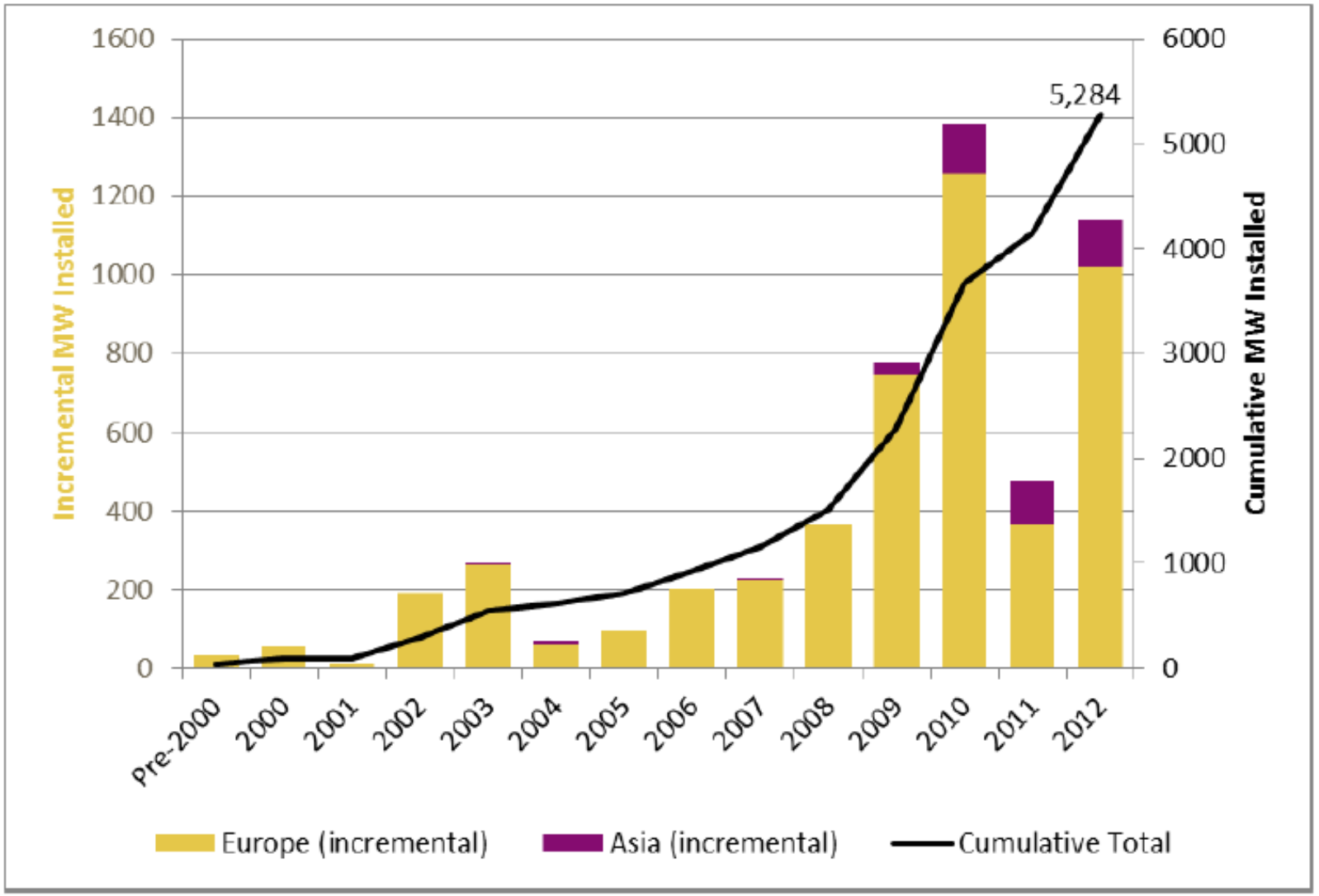
College of
ENGINEERING

Offshore Wind Development

Prof. Leonard Bohmann

Michigan Tech

Growth in Offshore Wind

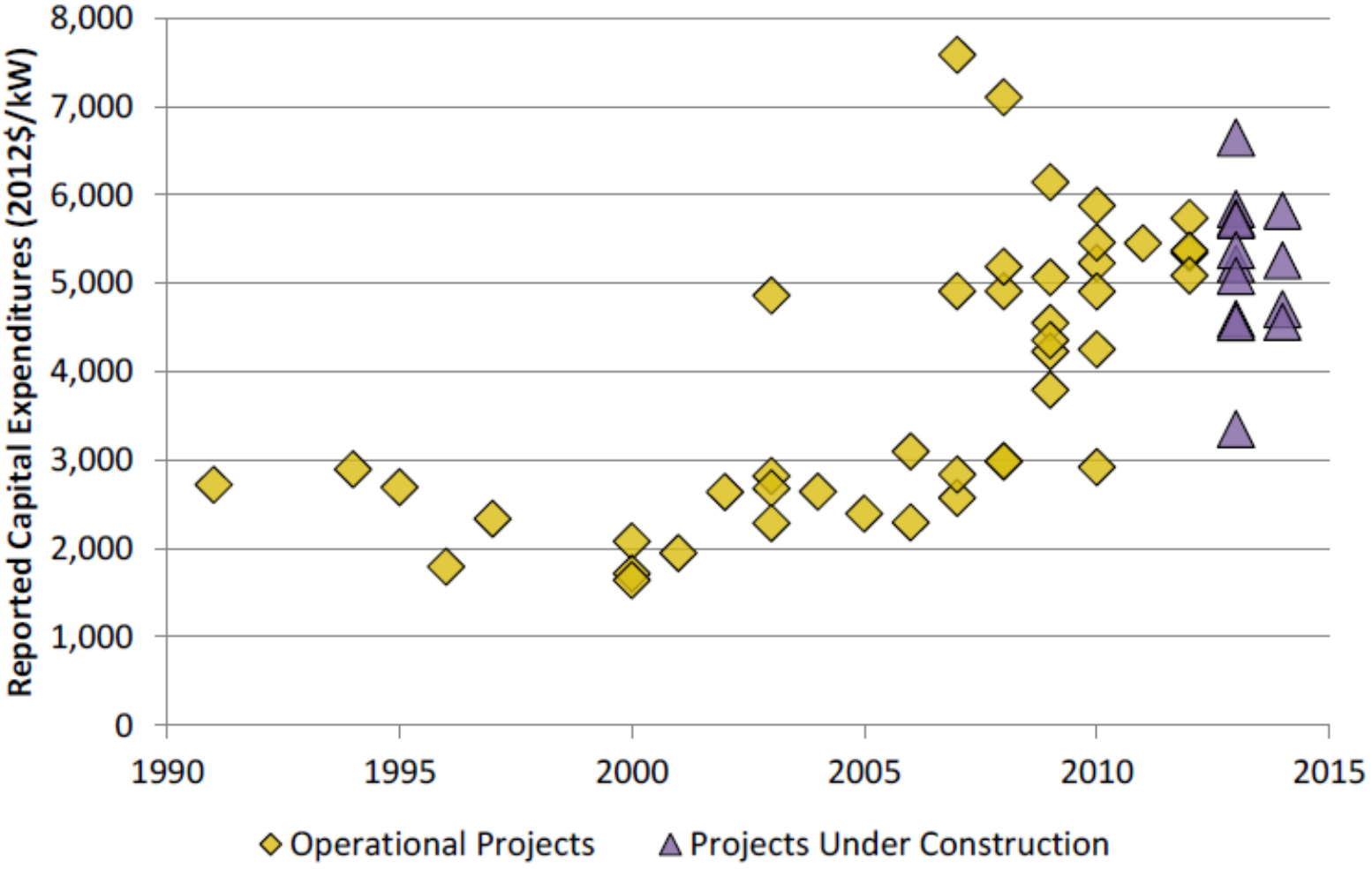


http://wind.energy.goc

Note: Shows capacity in the year it was installed but not necessarily grid-connected. Includes commercial, test, and intertidal projects.

Source: Navigant analysis of data provided by NREL and BTM

Cost trends of offshore wind

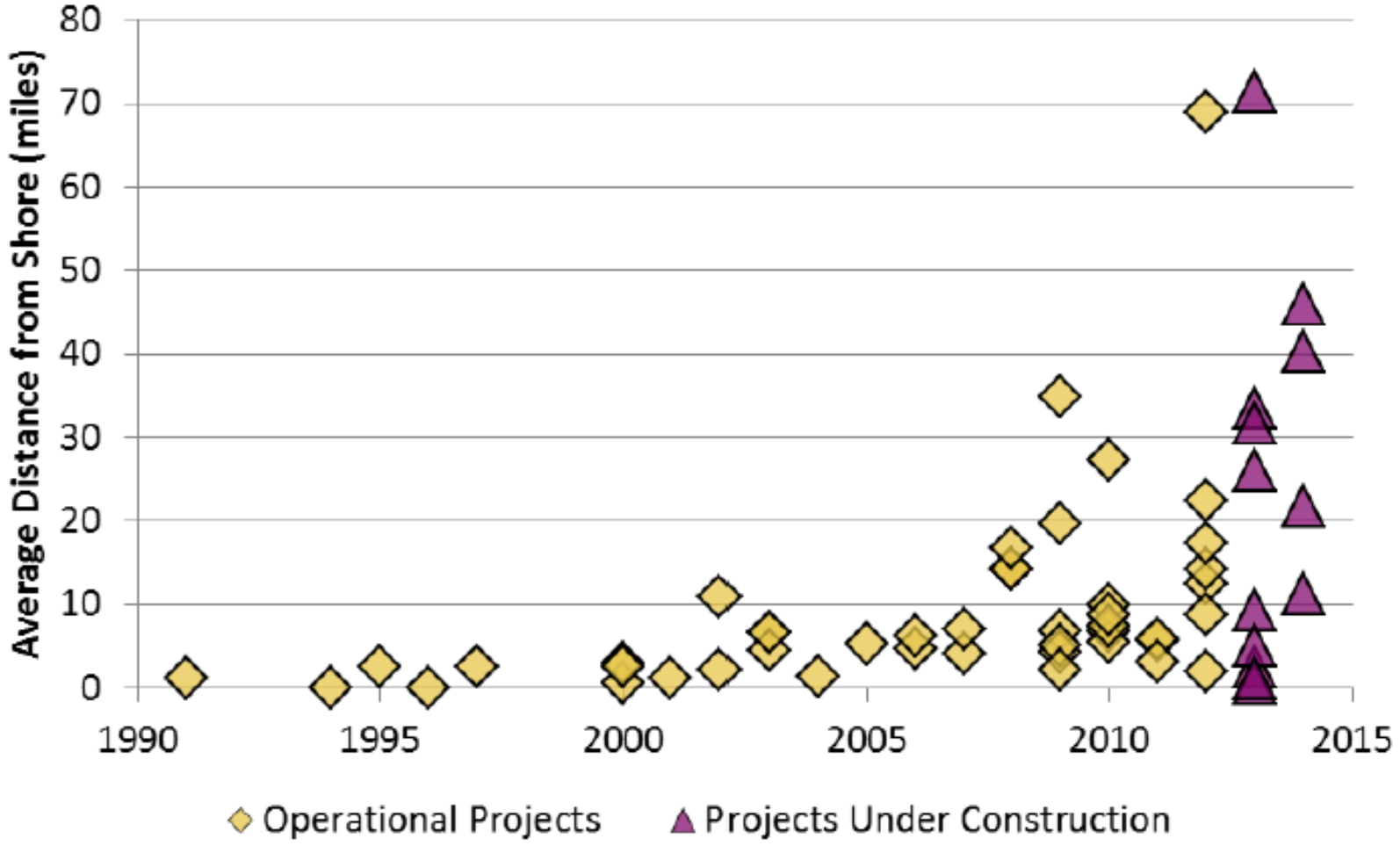


Note: Data was not available for all projects. Capital costs were inflated to 2012 currency in original currency and converted to U.S. dollars using 2012 average exchange rates. BARD Offshore I was excluded due to a cost overrun of more than 1 billion Euros.

Source: NREL analysis[9]

http://www1.eere.energy.gov/wind/pdfs/offshore_wind_market_and_economic_analysis_10_2013.pdf

Distance to shore trends



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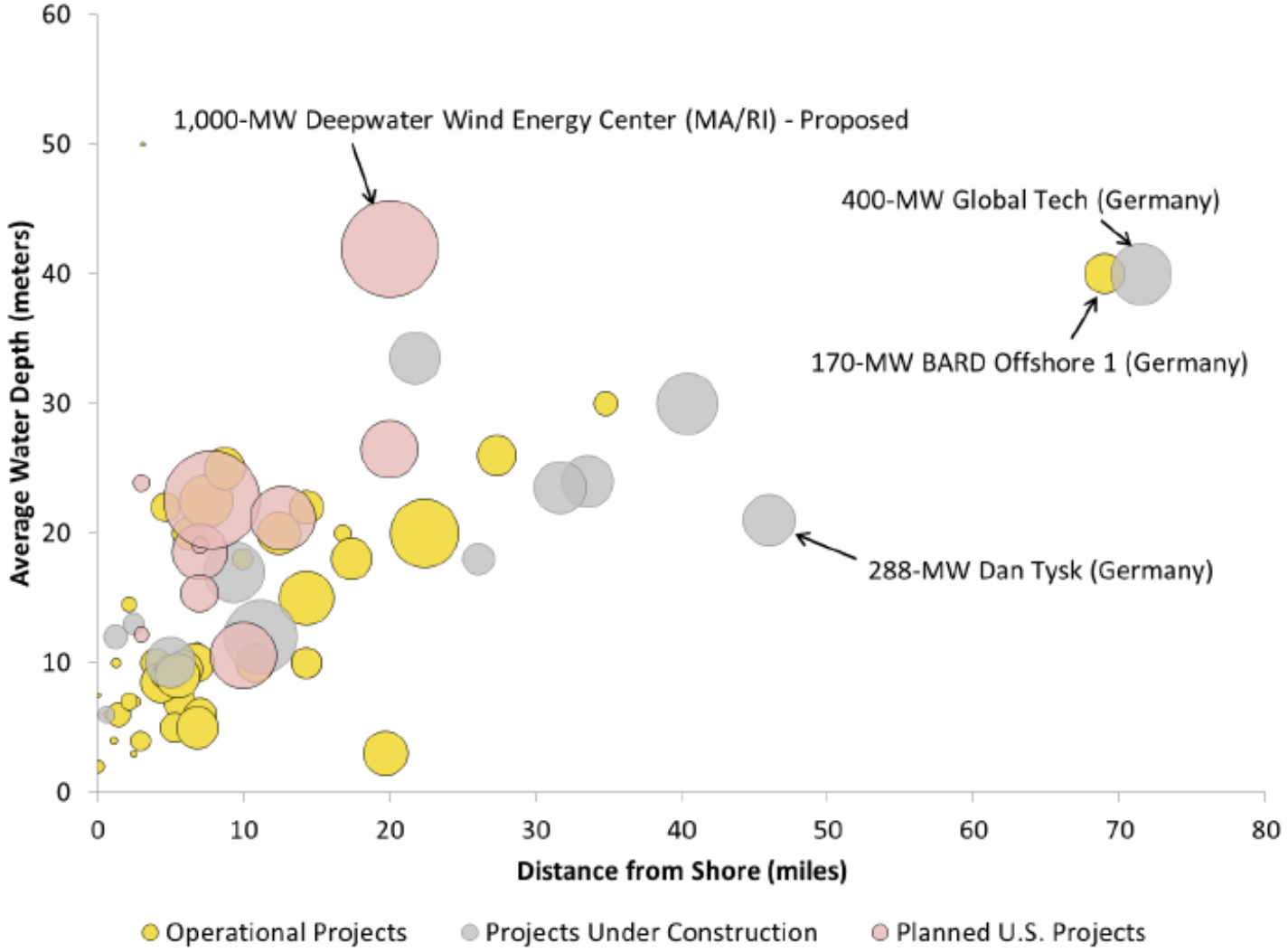
Note: Multi-phase projects were combined and are reported at the latest year when turbines were added at the project site. Expansions or phases of existing projects sites currently under construction were omitted to avoid skewing the data.

Source: Navigant analysis of data provided by NREL and BTM

Depth and distance to shore

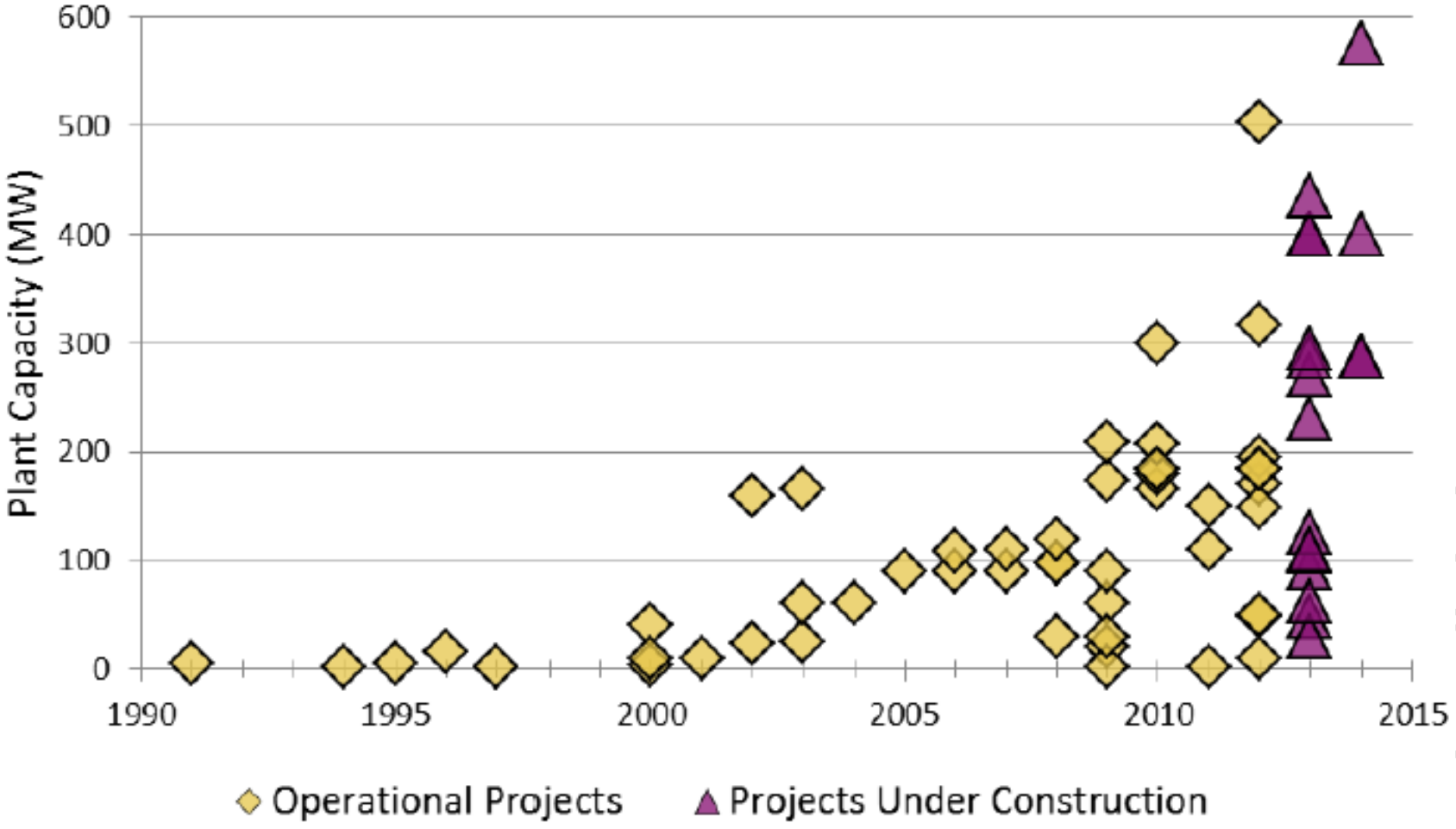


Note: Bubble size indicates projects' relative capacities; several projects are labeled for scale. Multi-phase projects were combined to show cumulative project capacity.

Source: Navigant analysis of data provided by NREL and BTM

http://www1.eere.energy.gov/wind/pdfs/offshore_wind_market_and_economic_analysis_10_2013.pdf

Plant capacity over time



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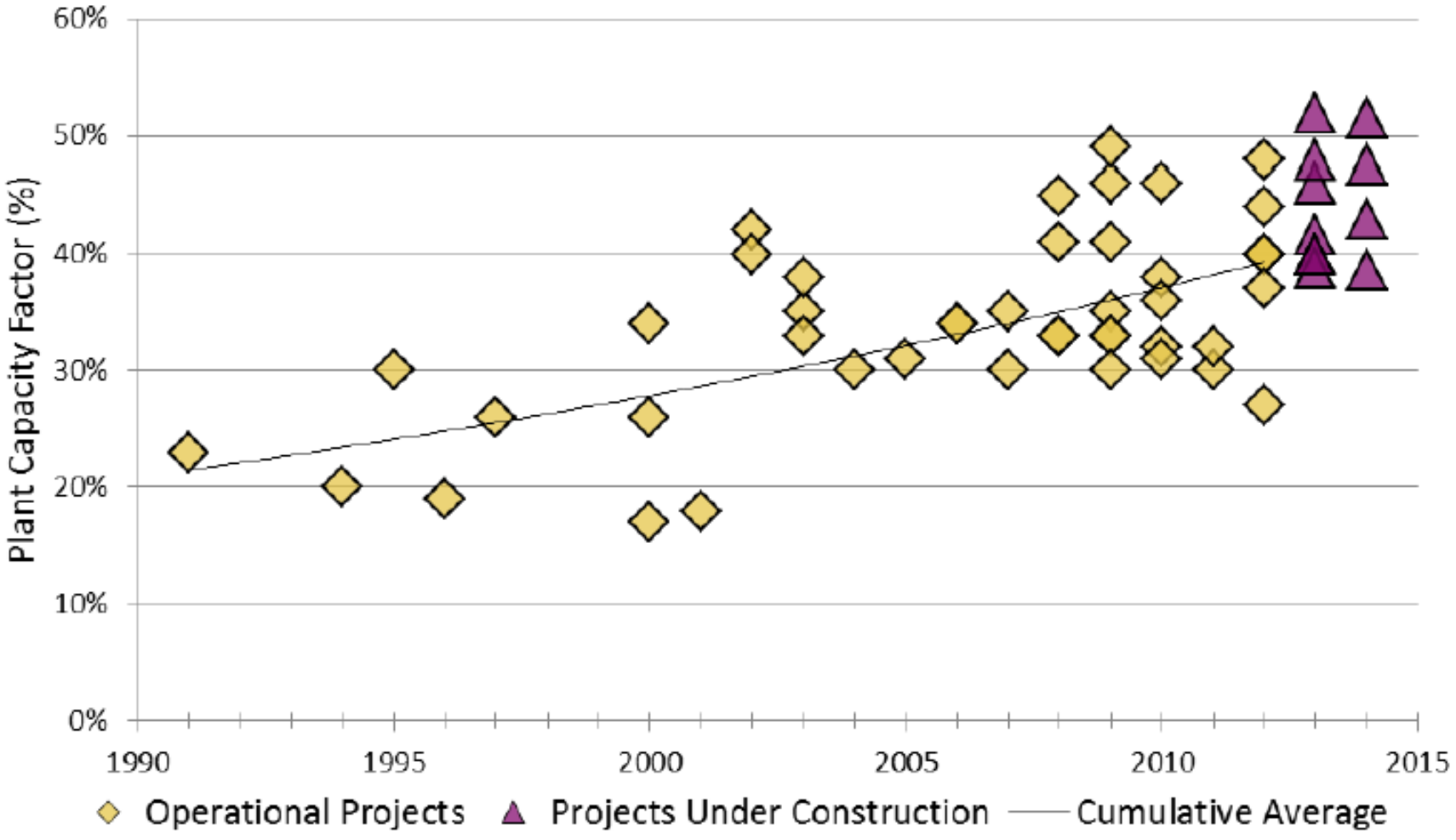
Note: Plant capacities are shown for the year each project reached completion. Multi-phase projects were combined to show cumulative project capacity and are reported at the latest year when turbines were added at the project site.

Source: Navigant analysis of data provided by NREL and BTM

Capacity factors over time

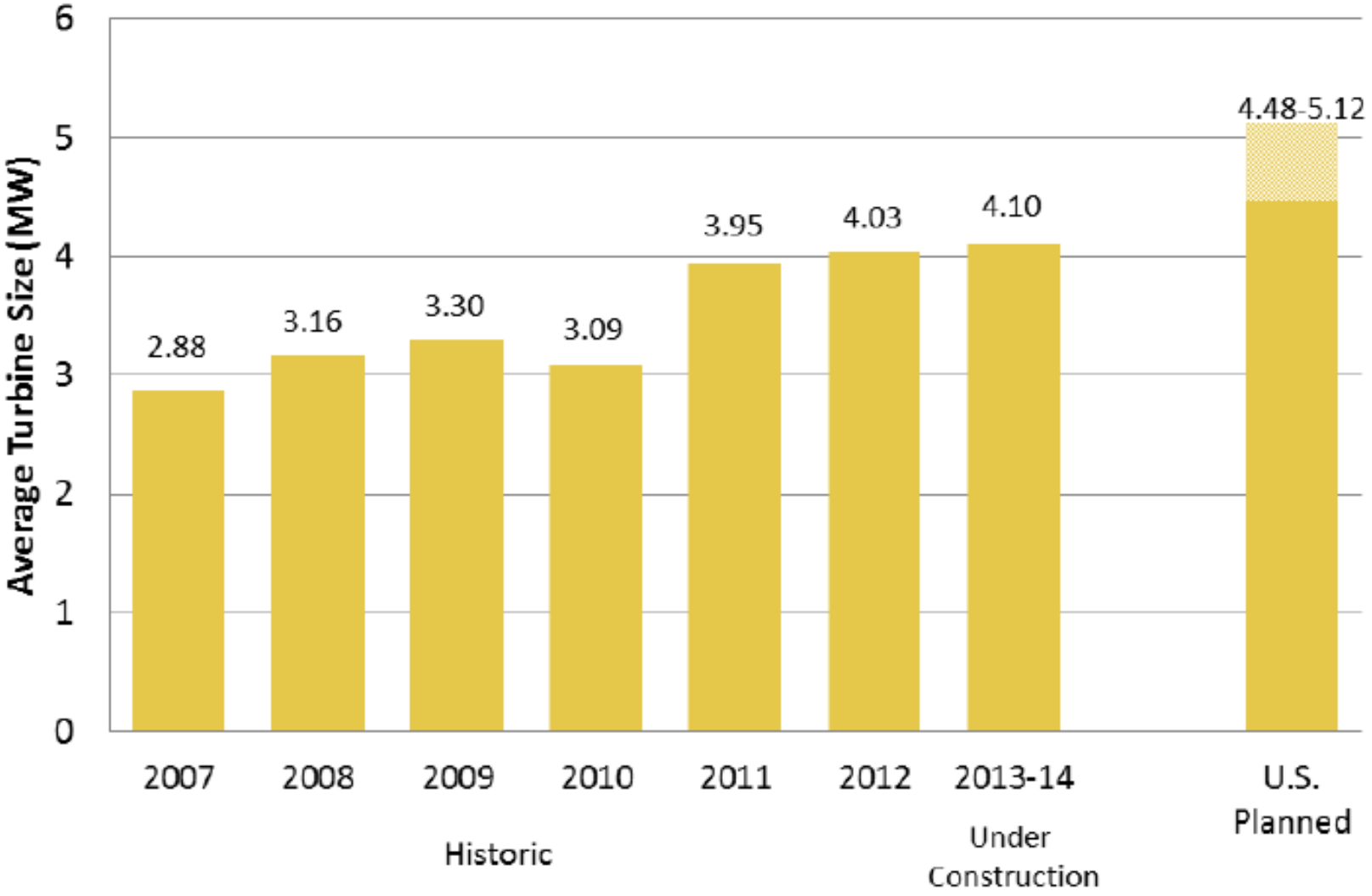


Note: Plant capacity factors are shown for the year each project reached completion. Multi-phase projects were combined to show a single capacity factor and are reported at the latest year when turbines were added at the project site.

Source: Navigant analysis of data provided by NREL and BTM

http://www1.eere.energy.gov/wind/pdfs/offshore_wind_market_and_economic_analysis_10_2013.pdf

Turbine size over time

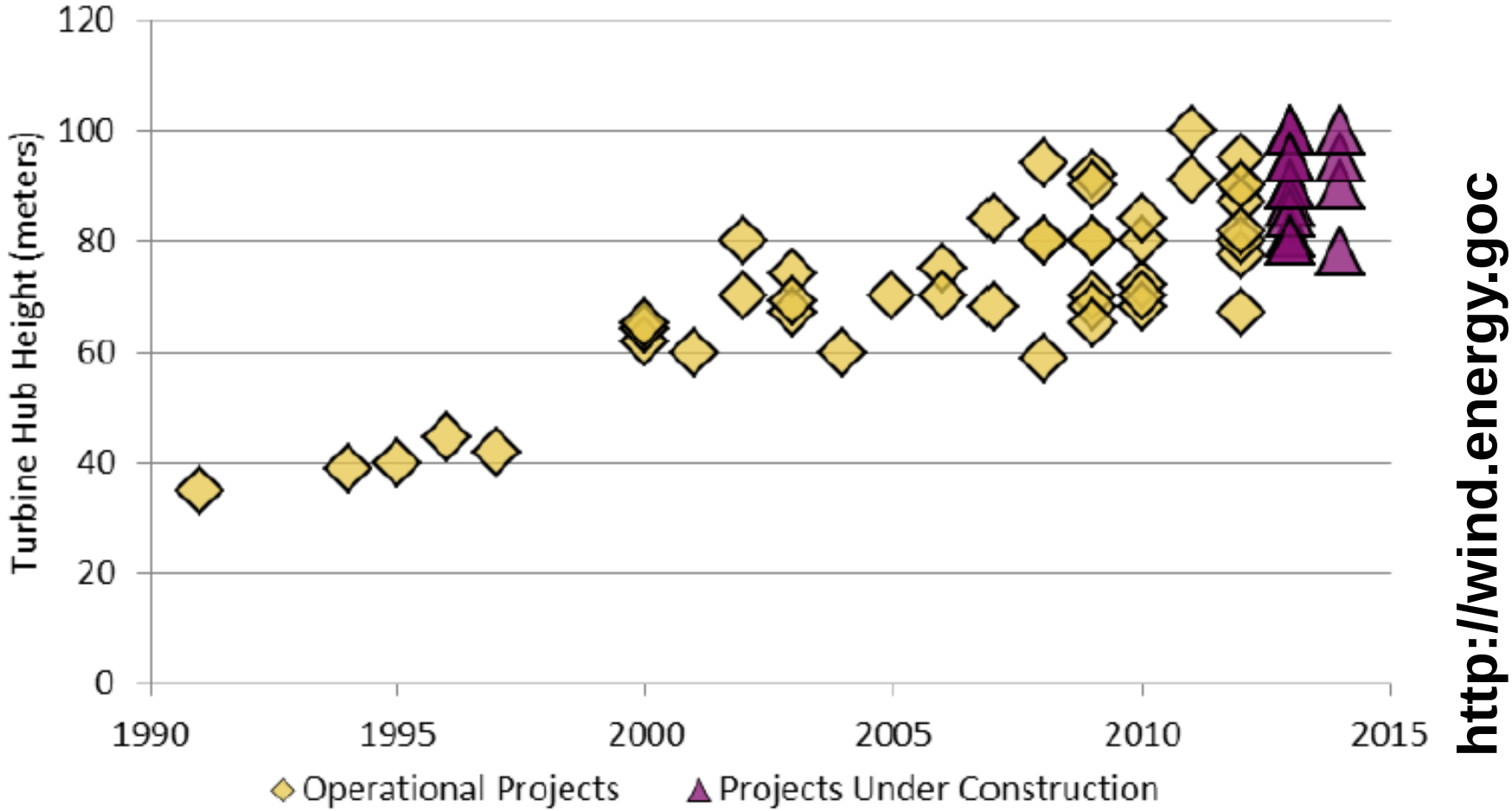


Note: Average turbine size is based on an annual capacity-weighted figure – each individual turbine installed is factored into the annual average.

Source: Navigant analysis of data provided by NREL and BTM

http://www1.eere.energy.gov/wind/pdfs/offshore_wind_market_and_economic_analysis_10_2013.pdf

Hub heights over time



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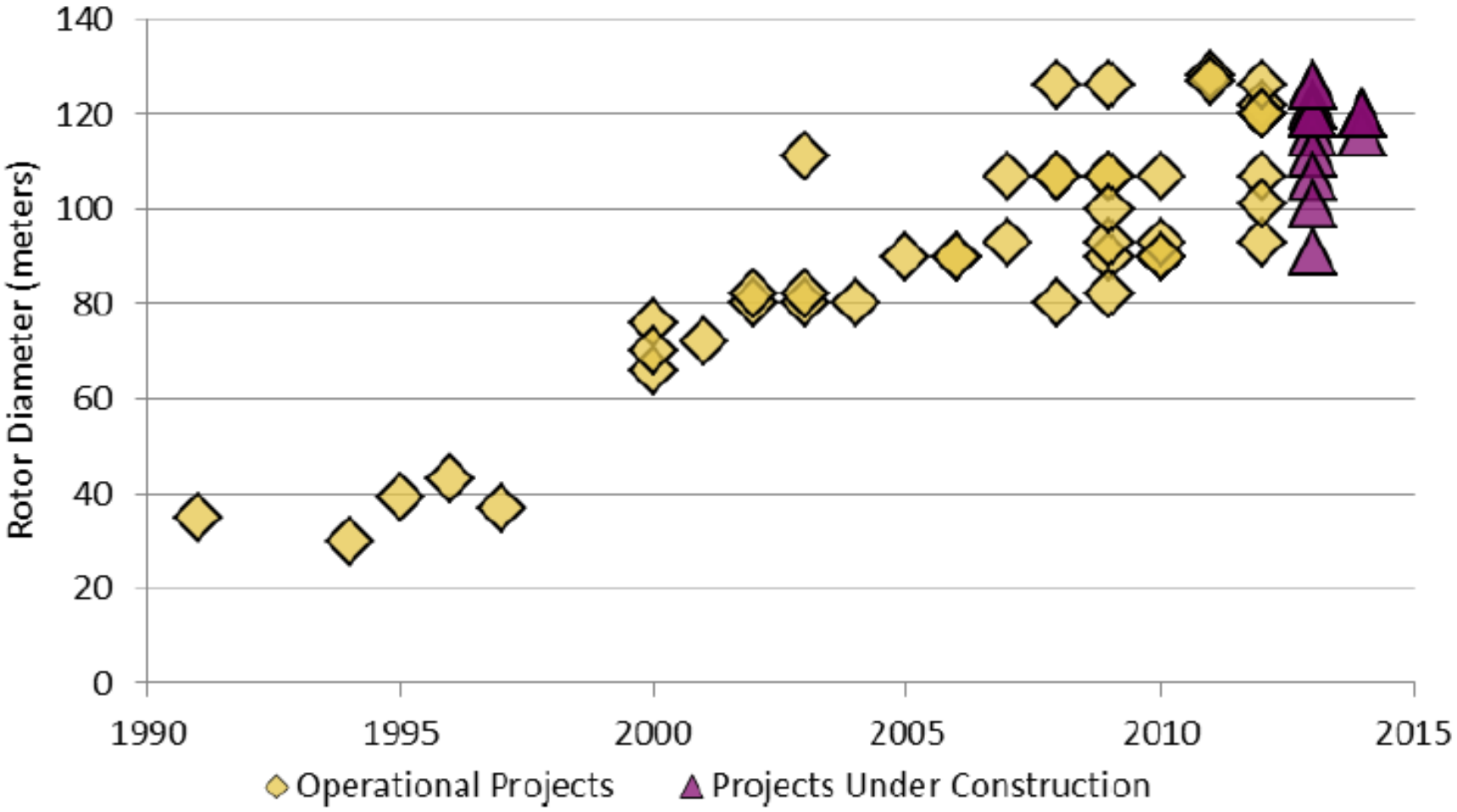
Note: Plant hub heights are shown for the year each project reached completion. Multi-phase projects were combined to show a single hub height and are reported for the latest year turbines were added.

Source: Navigant analysis of data provided by NREL and BTM

Rotor diameter over time



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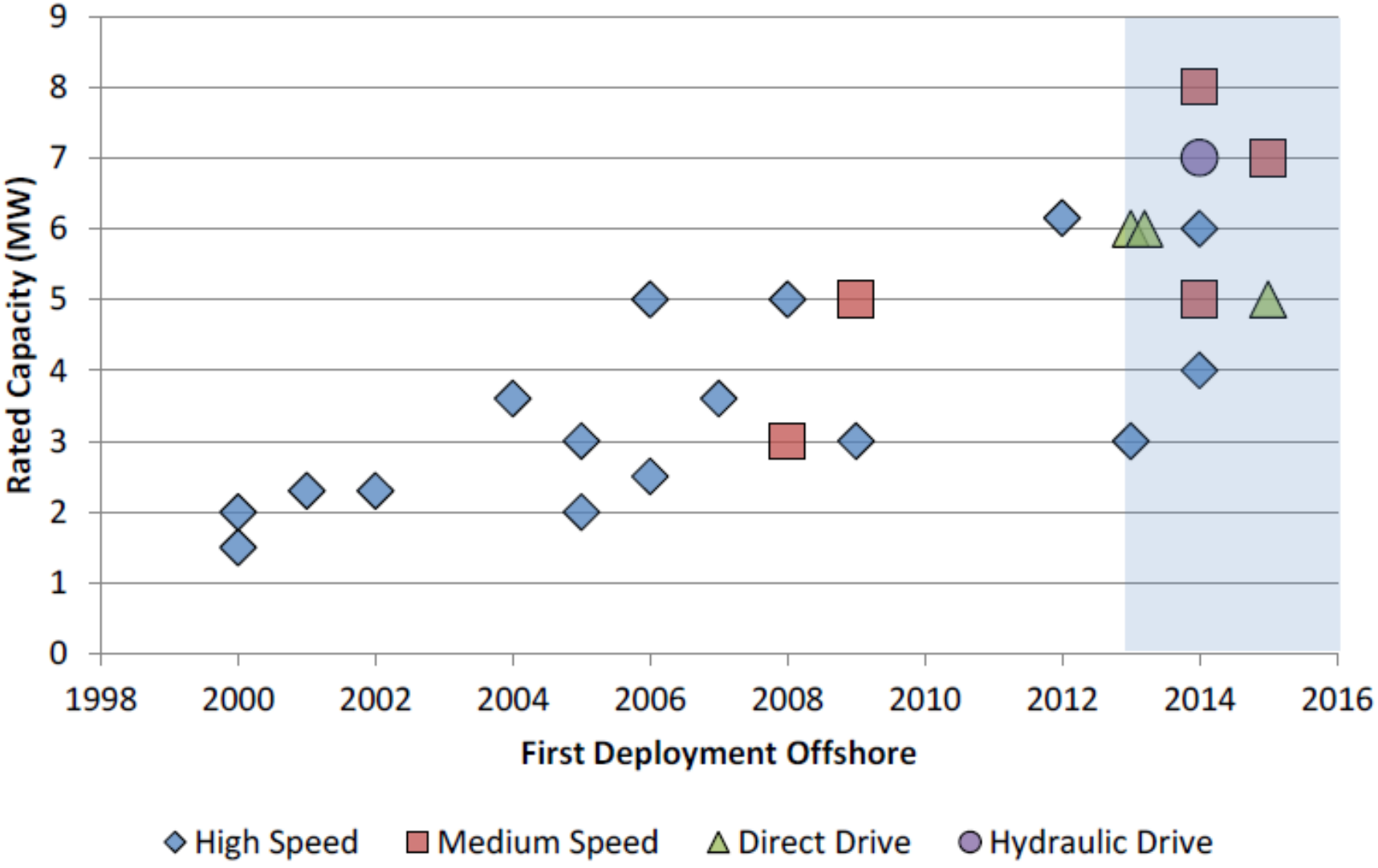
Note: Rotor diameters are shown for the year each project reached completion. Multi-phase projects were combined to show a single rotor diameter and are reported for the latest year when turbines were added.

Source: Navigant analysis of data provided by NREL and BTM

Drive train configuration prototypes

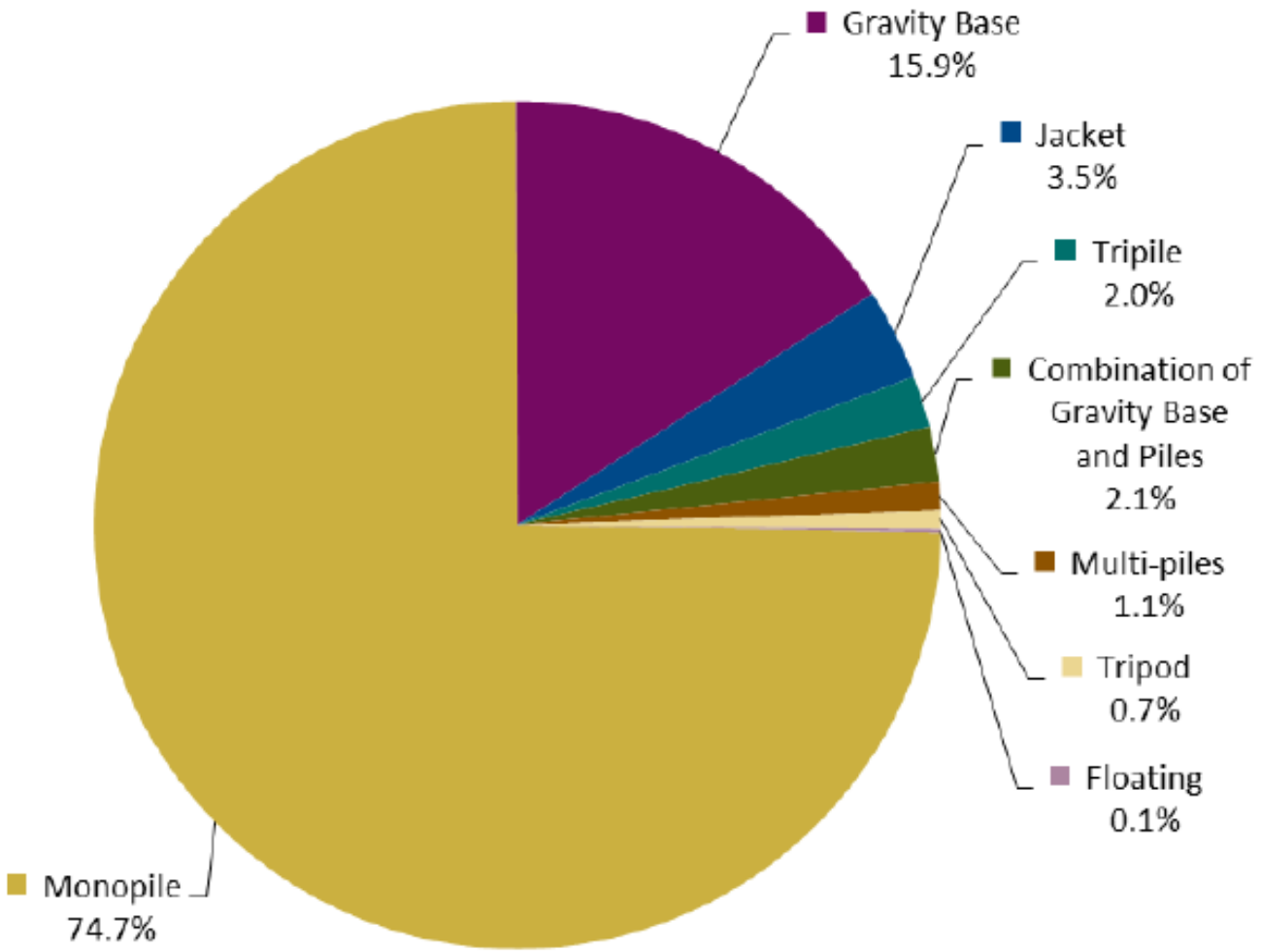


Note: Deployments after 2012 based upon wind turbine manufacturers' announced schedules.

Source: NREL data

http://www1.eere.energy.gov/wind/pdfs/offshore_wind_market_and_economic_analysis_10_2013.pdf

Substructures of installed turbines



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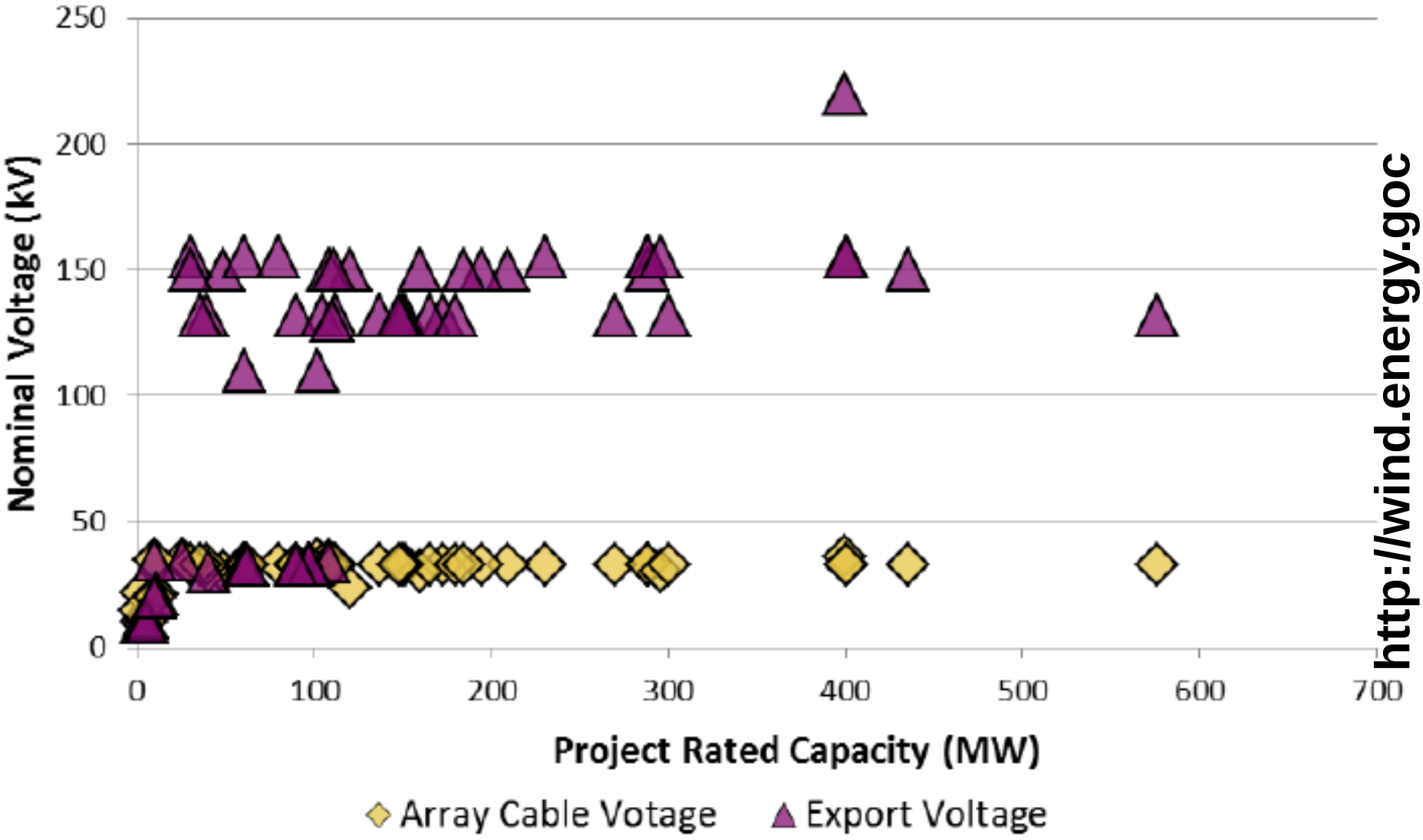
Note: Percentages are based on the number of turbines using each substructure technology.
Source: Navigant analysis of data provided by NREL and BTM

Array cable and export voltages



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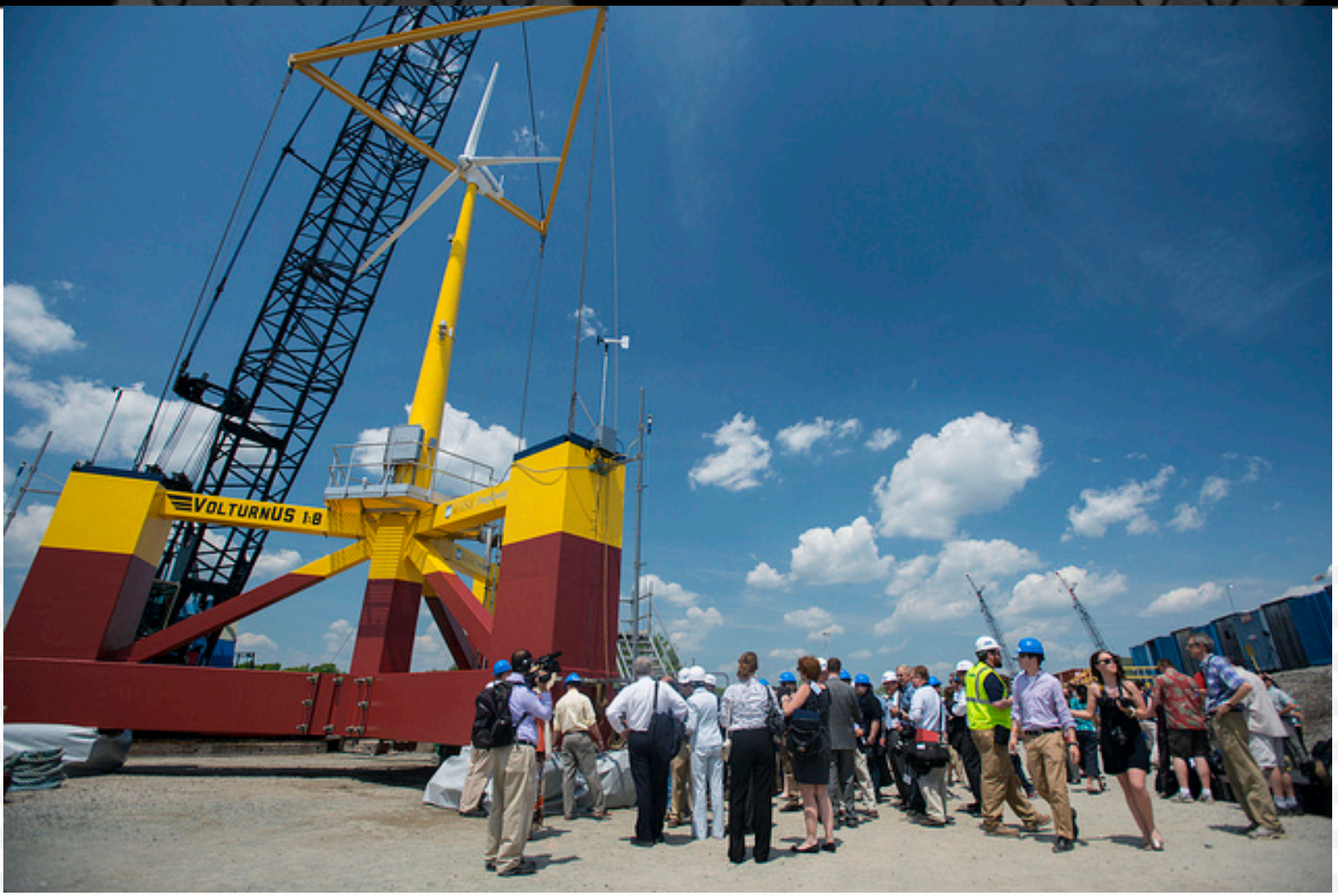
Source: NREL data

US Offshore Wind Projects

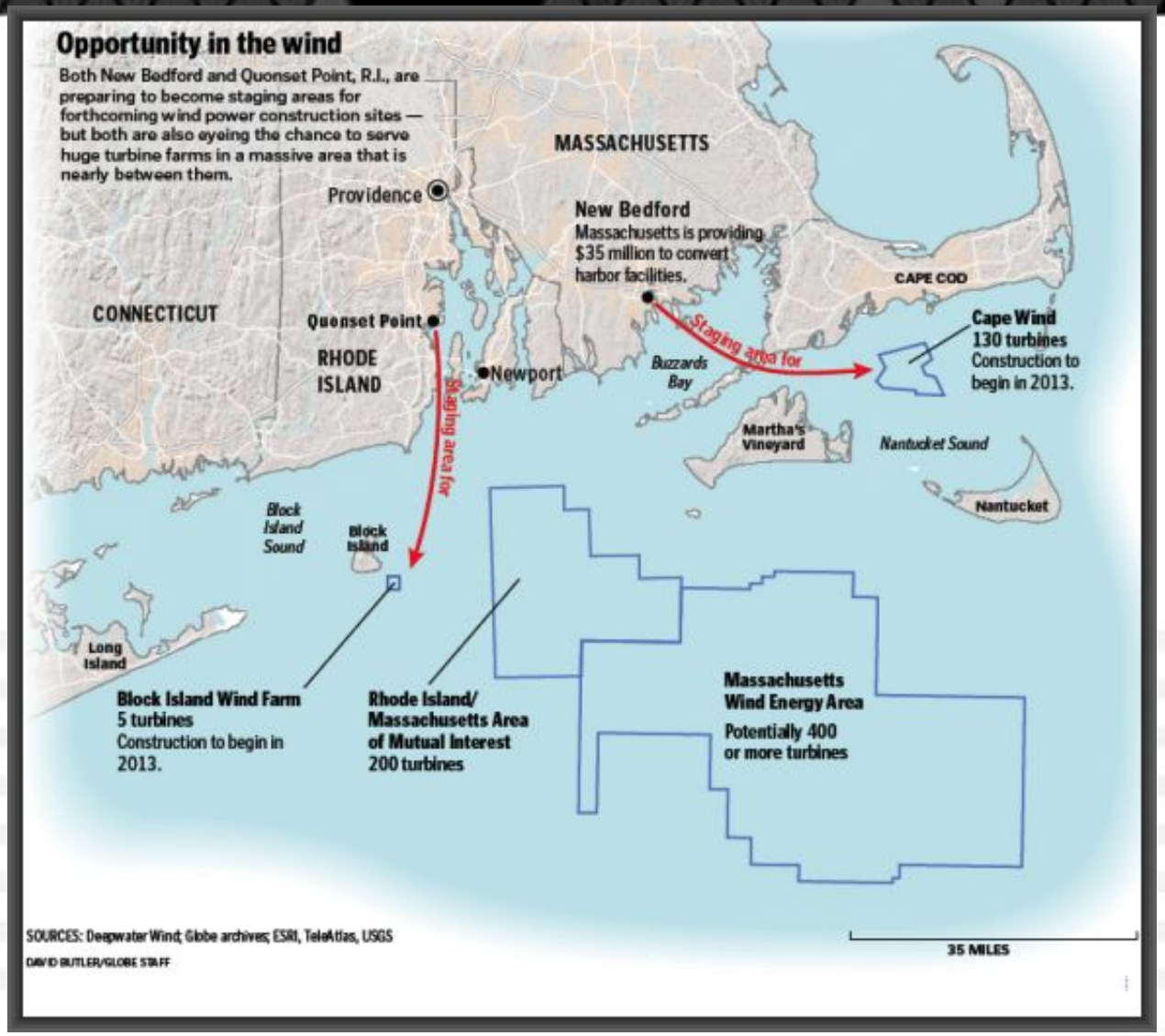
http://www1.eere.energy.gov/wind/pdfs/offshore_wind_market_and_economic_analysis_10_2013.pdf

Aqua Ventus, Monhegan Island, Maine



https://umaine.edu/news/blog/2013/05/30/the-launch-of-volturnus-18/

Commercial Offshore Wind Development

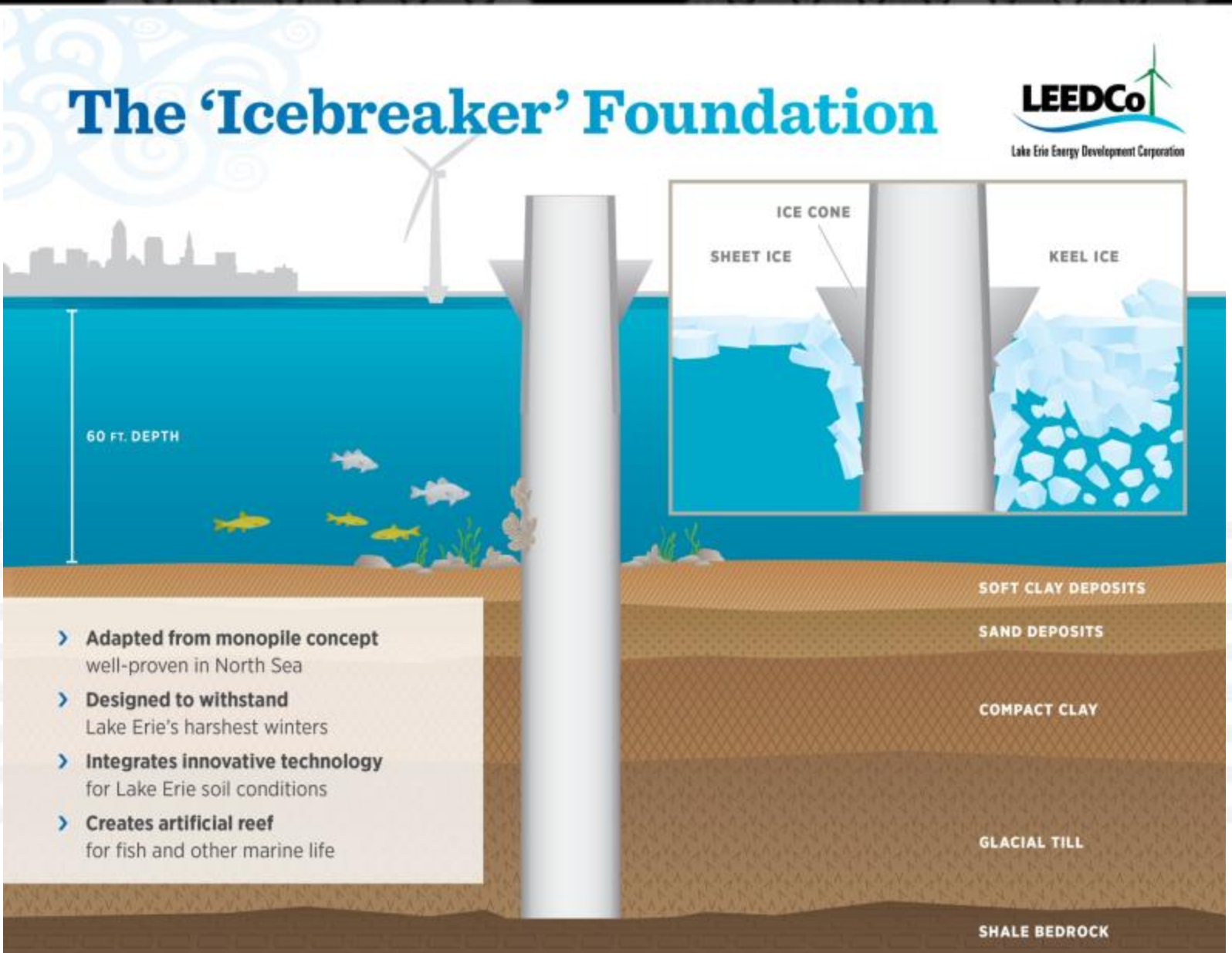


http://www.fishingunited.com/forum/viewtopic.php?t=12516

Atlantic Wind Connection

- **HVDC network using VSC**
- **To be built in 3 stages**
- **Has FERC approval**

Project Icebreaker, Lake Eire



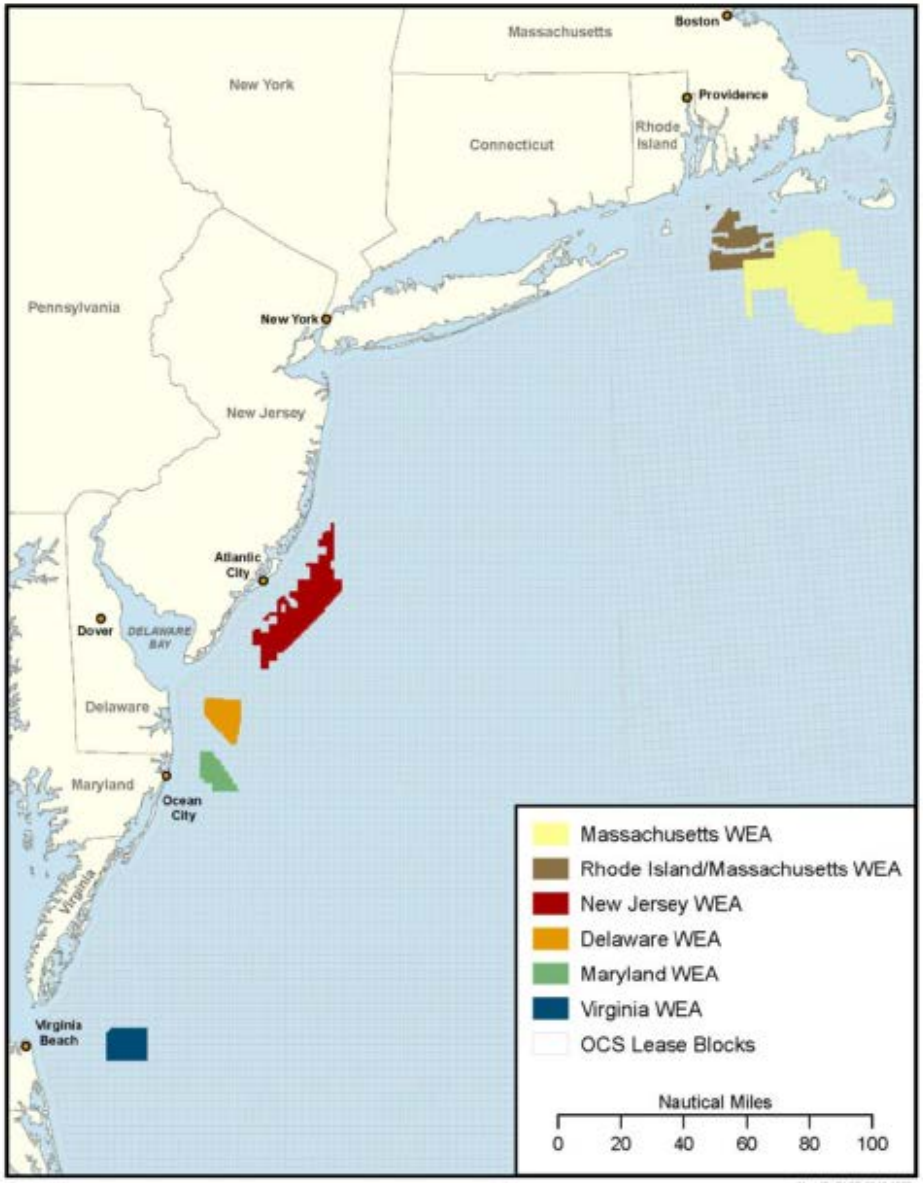
http://www.leedco.org/

US Gulf Coast natural gas price

Source: EIA

Questions?

Mid-Atlantic wind lease areas

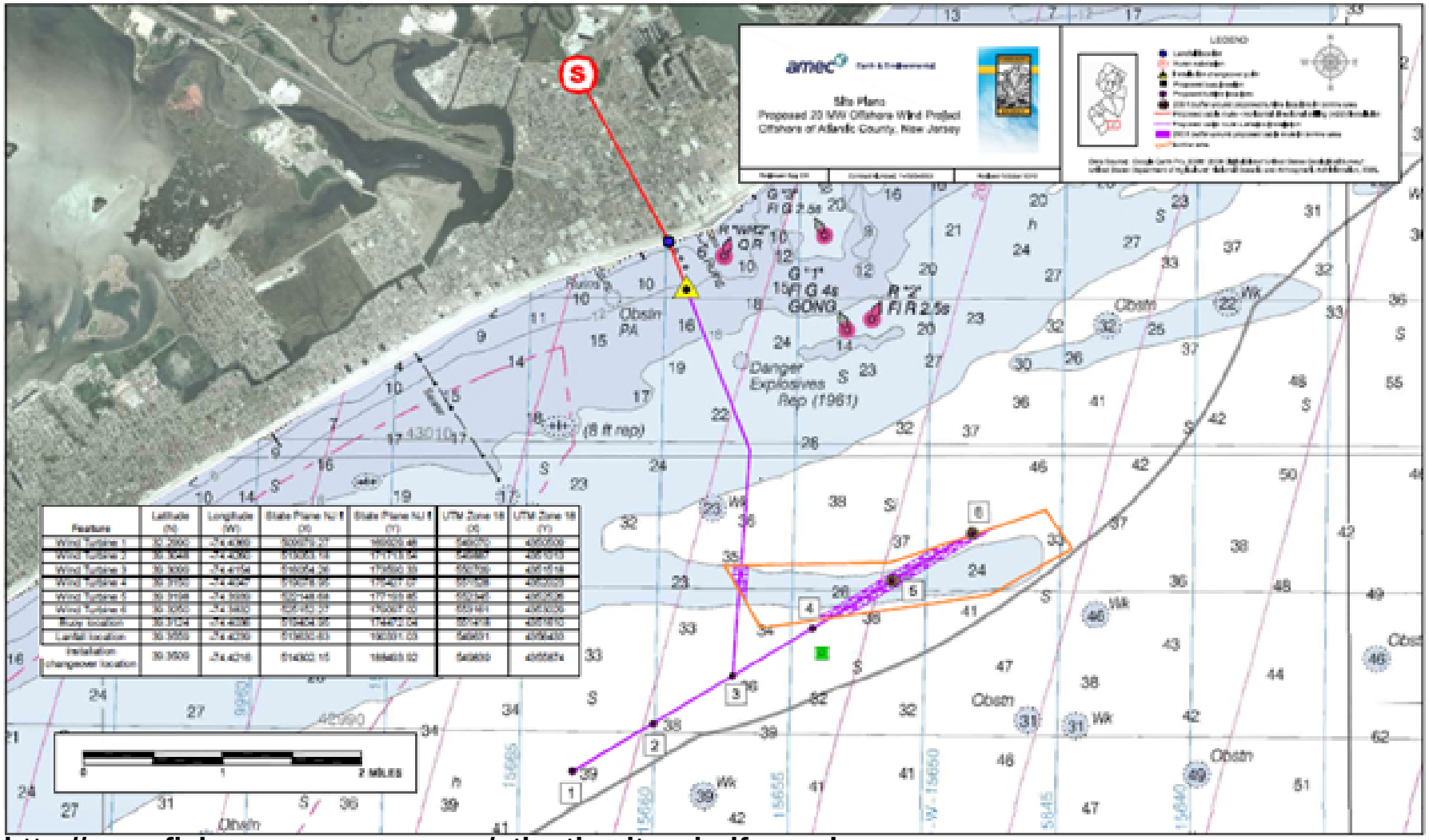


- Bureau of Ocean Energy Management lease areas
- Deapwater Wind leased 2 tracts in brown area
- Dominion Power leased 1 tract in blue area.

Source: BOEM 2012

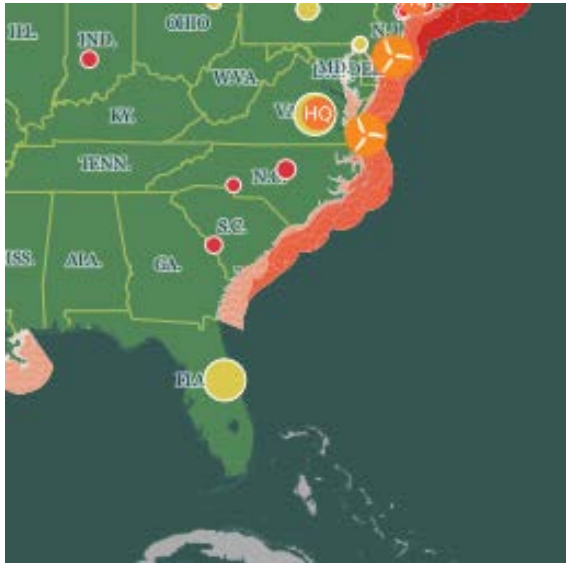
Michigan Tech

Fisherman's Energy, Atlantic City, New Jersey



http://www.fishermensenergy.com/atlantic-city-windfarm.php

Virginia Offshore Wind Technology Advancement Project

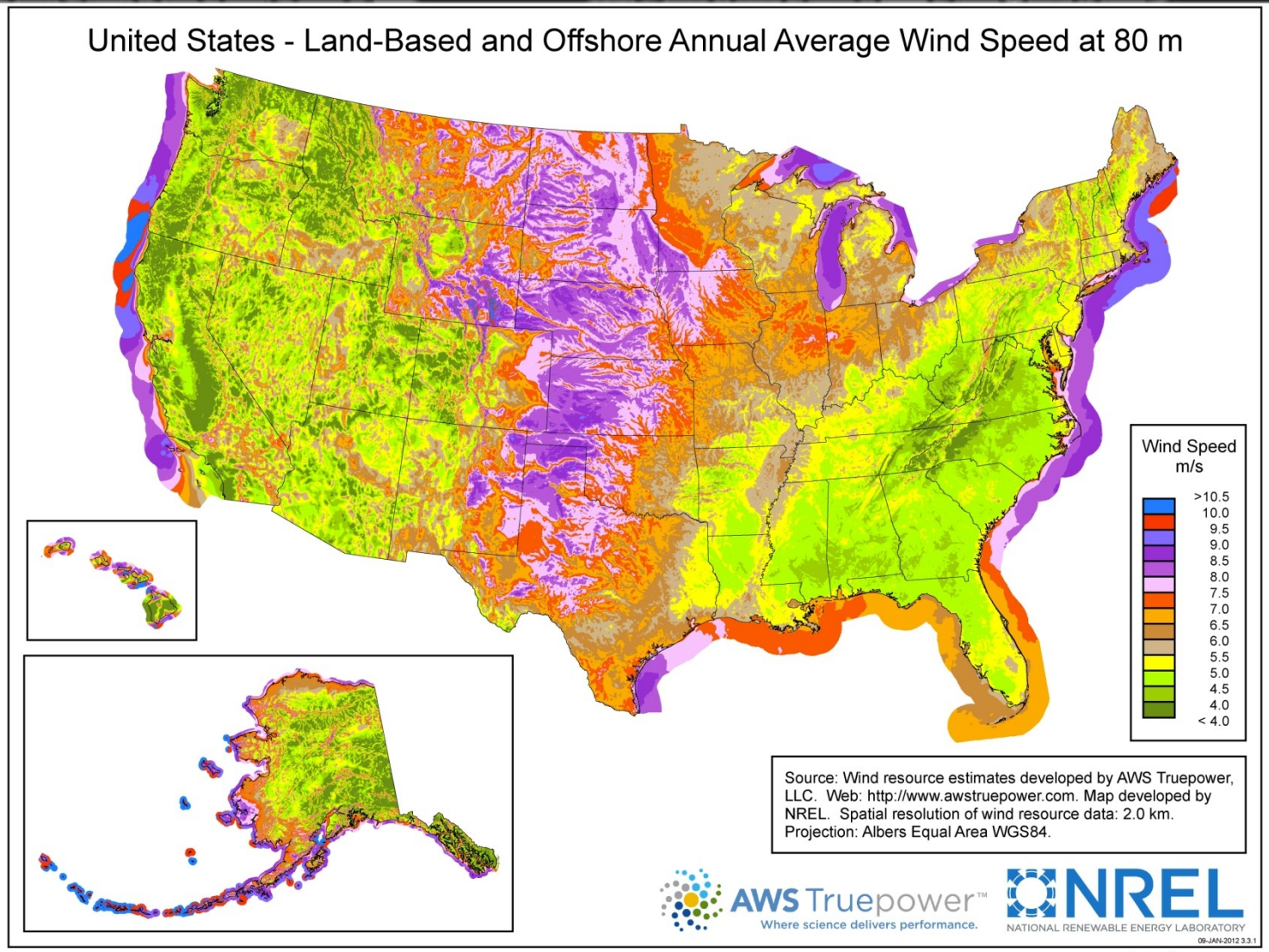


https://www.dom.com/about/stations/renewable/vowtap.jsp

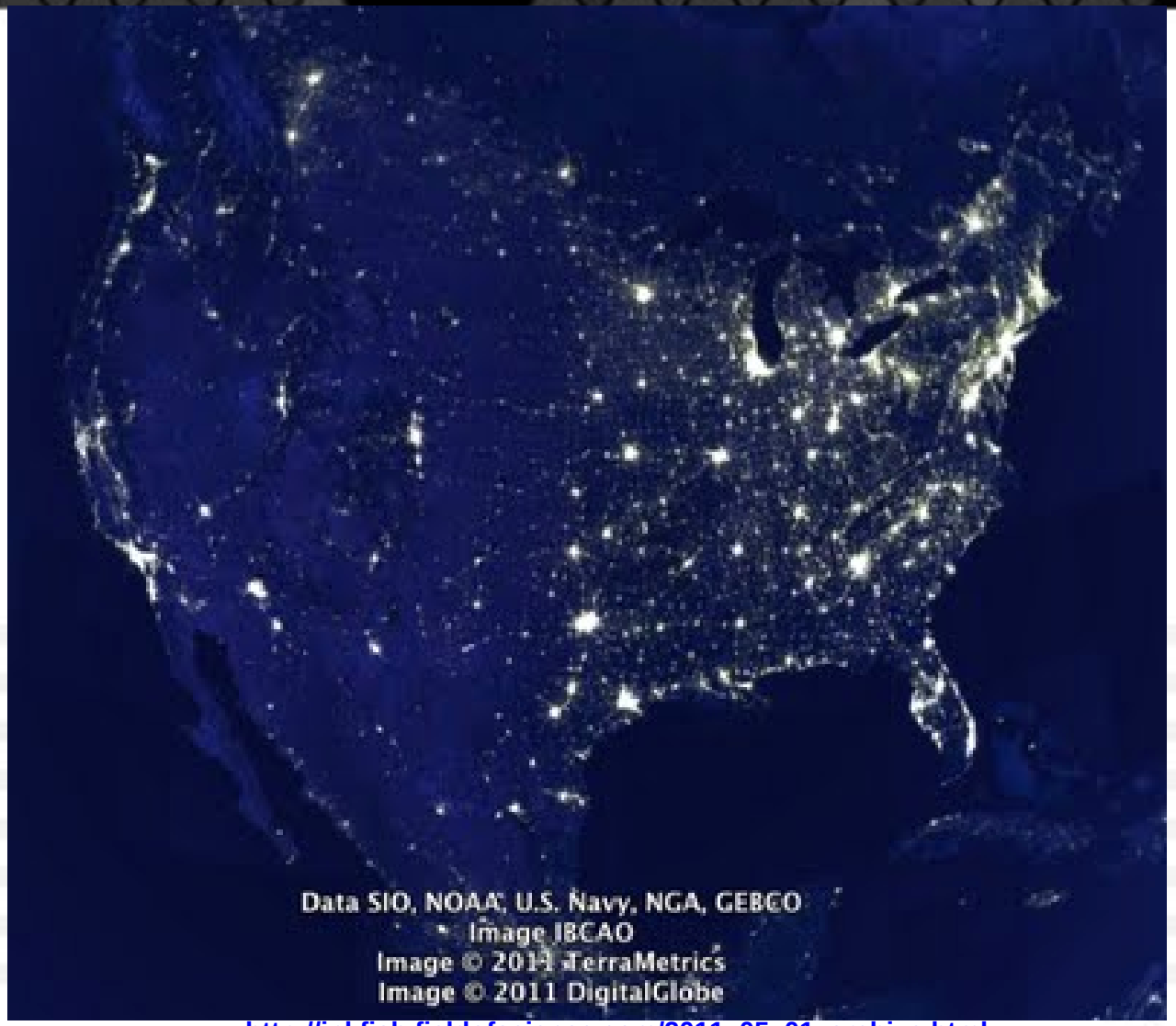
Aqua Ventus, Monhegan Island, Maine

http://www.cianbro.com/ProjectsMarkets/PowerGenerationEnergy/VolturnUS18FloatingOffshoreWindTurbine.aspx

United States Wind Resources

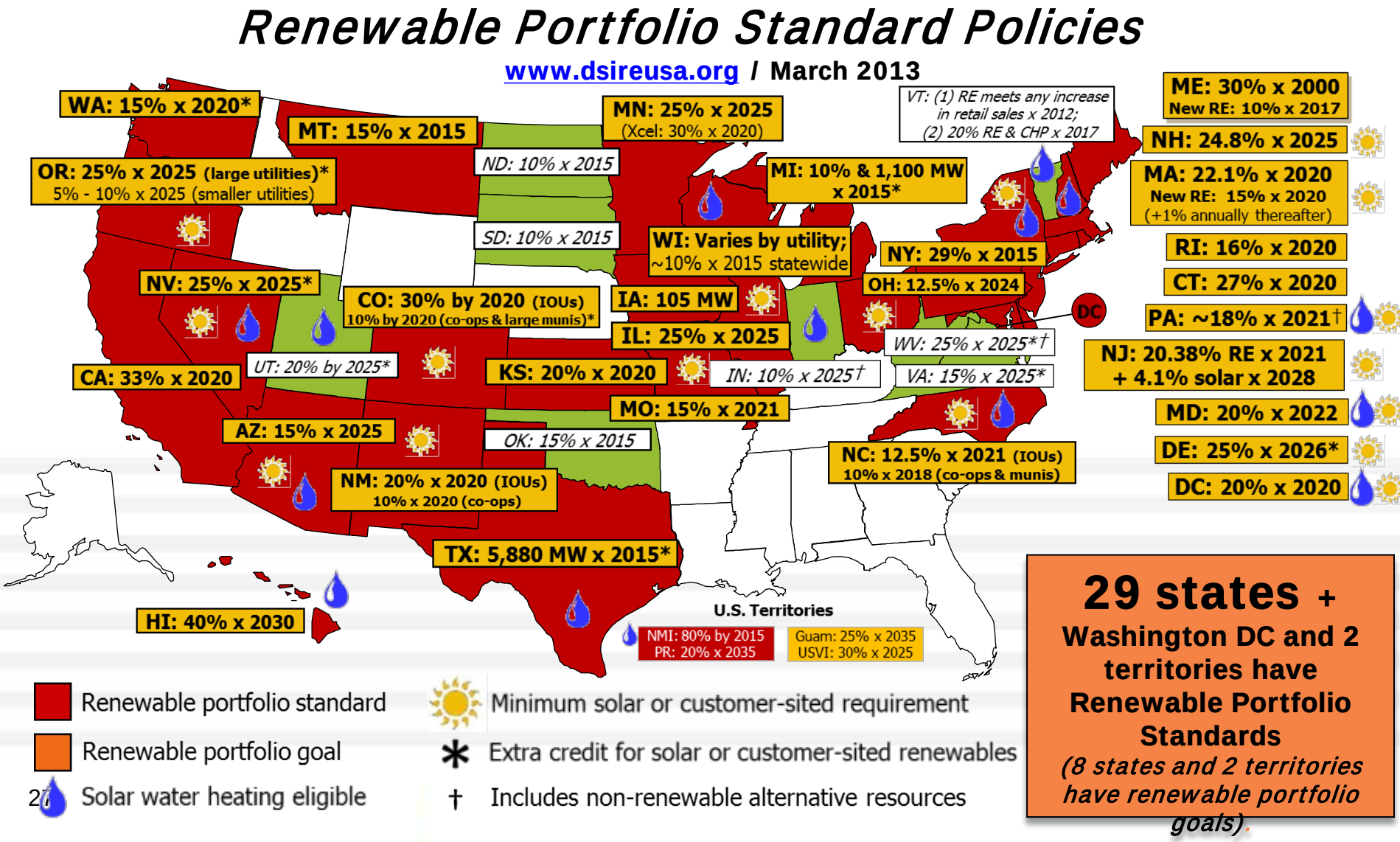


North American electric load

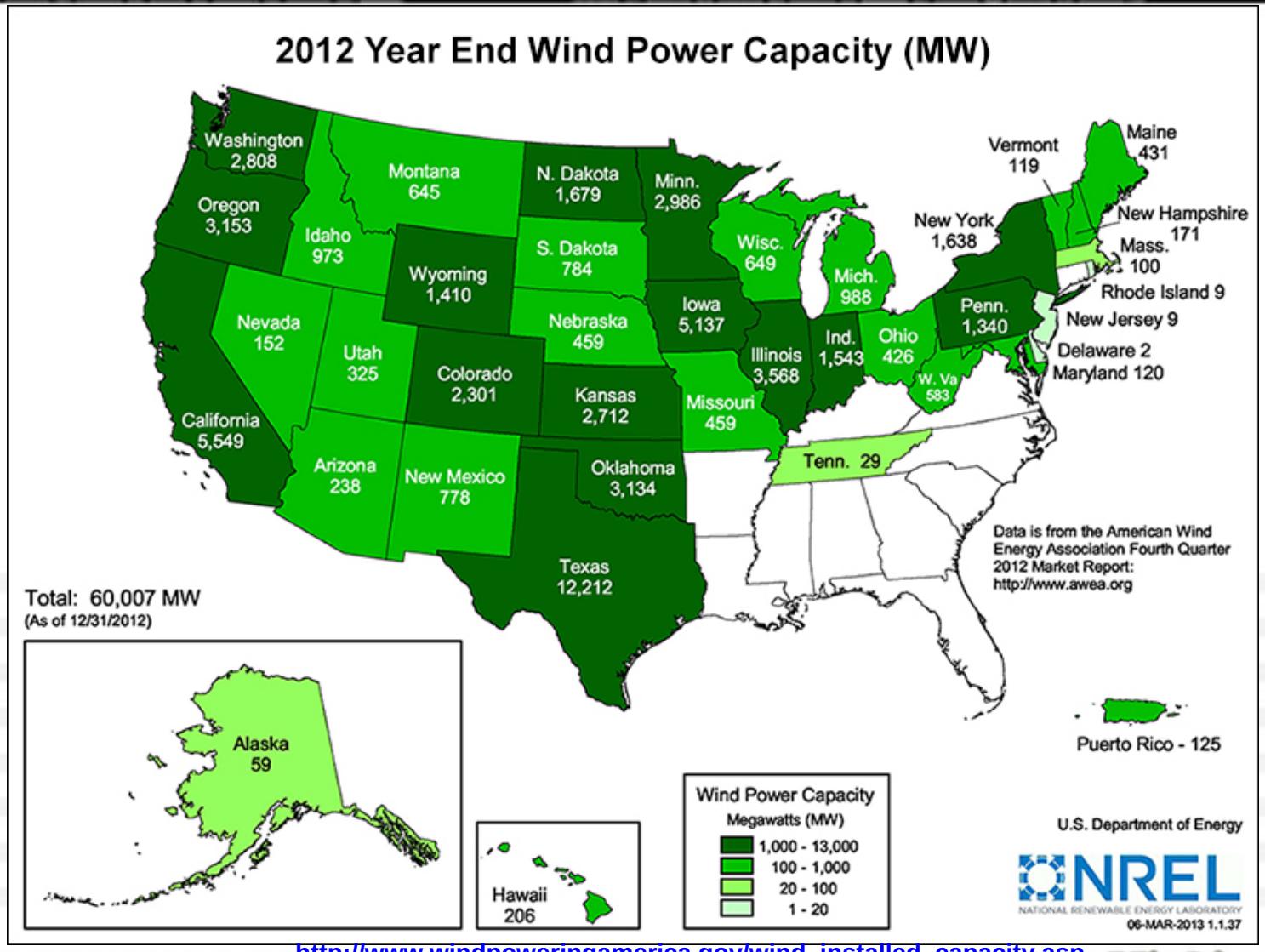


http://inkfish.fieldofscience.com/2011_05_01_archive.html

US Renewable Portfolio Standard

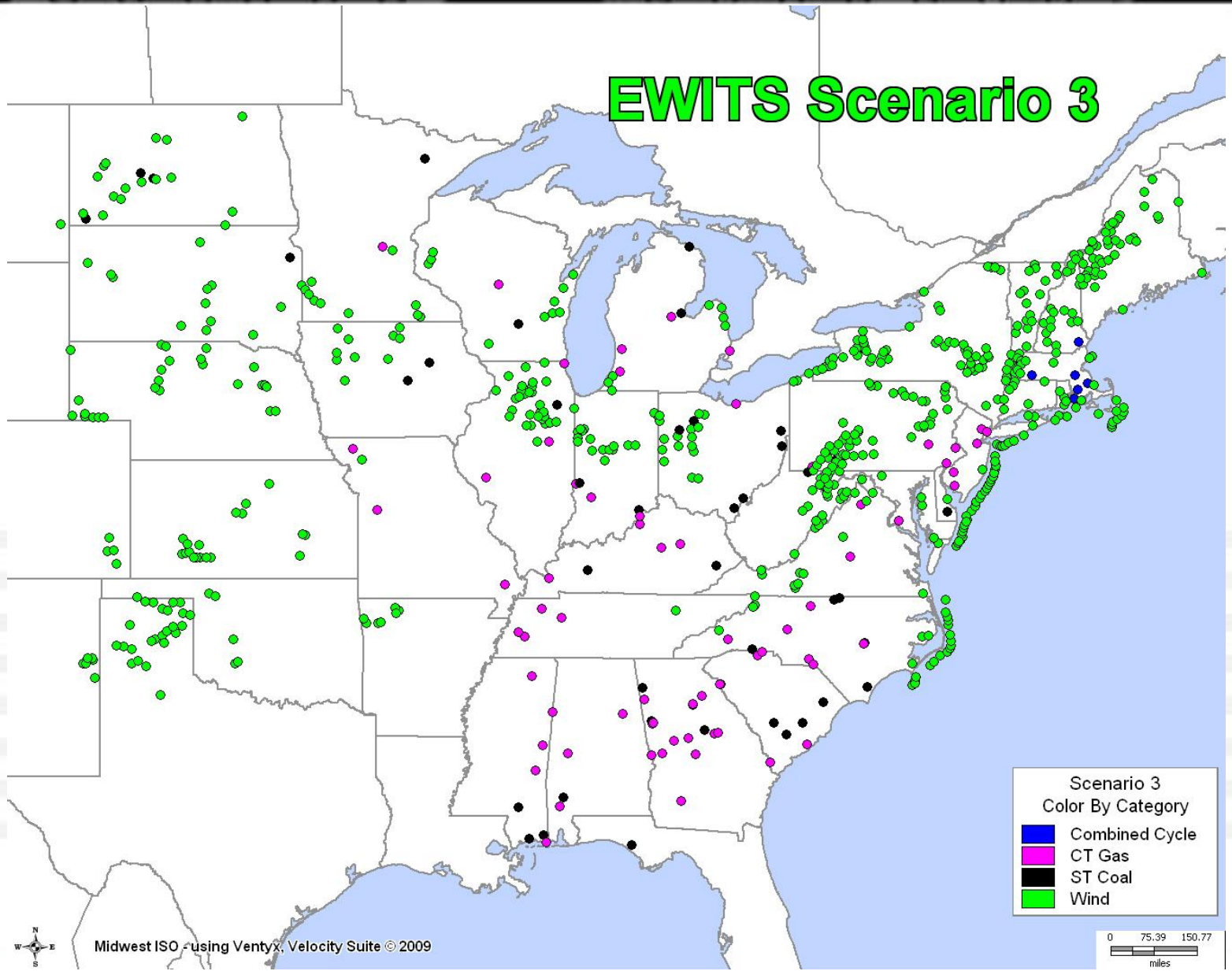


US Wind Capacity by State



http://www.windpoweringamerica.gov/wind_installed_capacity.asp

EWITS Scenario 3 Generation Siting



http://www.nrel.gov/electricity/transmission/eastern_renewable.html

Challenges

- Costs
- Regulatory process – leases, permits
- Logistics – lack of ports and ships
- Transmission infrastructure

US Department of Energy

http://www1.eere.energy.gov/wind/index.html

Off Shore Demonstration Projects

Statoil, Boothbay Harbor, Maine

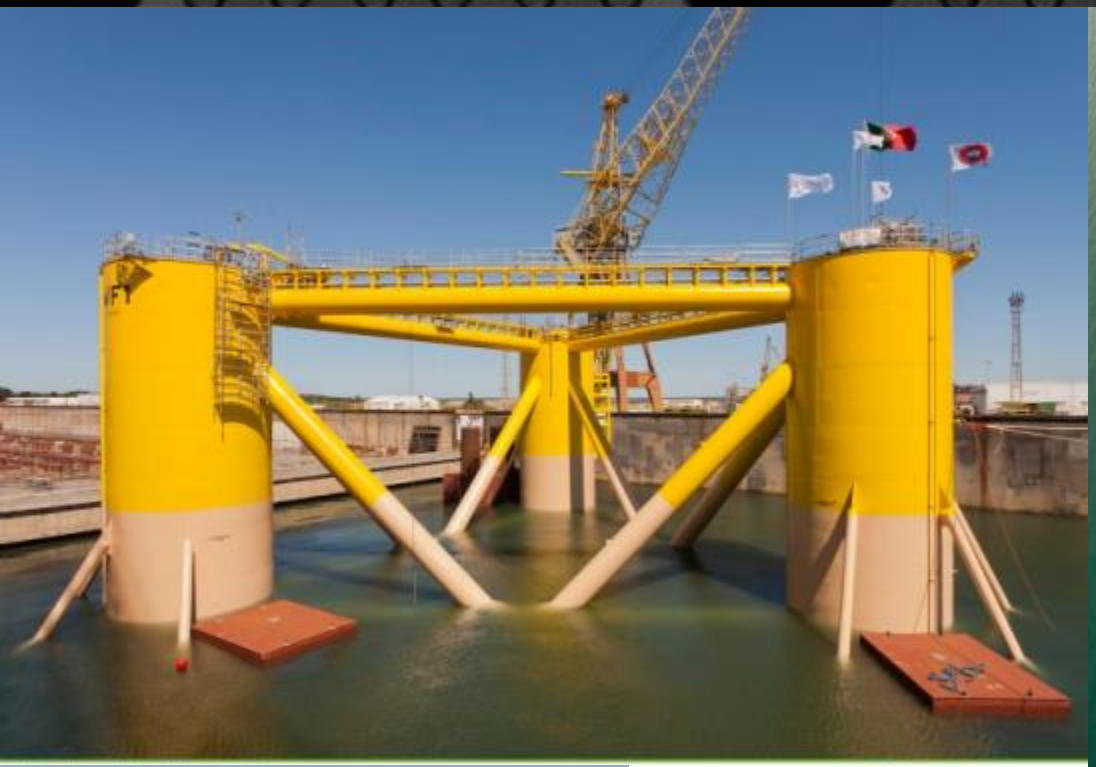
http://www.renewbl.com/2011/06/28/statoil-selling-onshore-wind-assets-in-norway-moves-focus-on-offshore-wind.html

GOWind, Gulf of Mexico, Texas

http://www.baryonyxcorp.com/

Lake Eire Project

Wind Float, Coos Bay, Oregon



https://www.facebook.com/principlepower/photos_stream

Coos Bay Project

Other Offshore Projects

Galveston Offshore Wind (Costal Energy)

Boothbay Harbor, Maine project