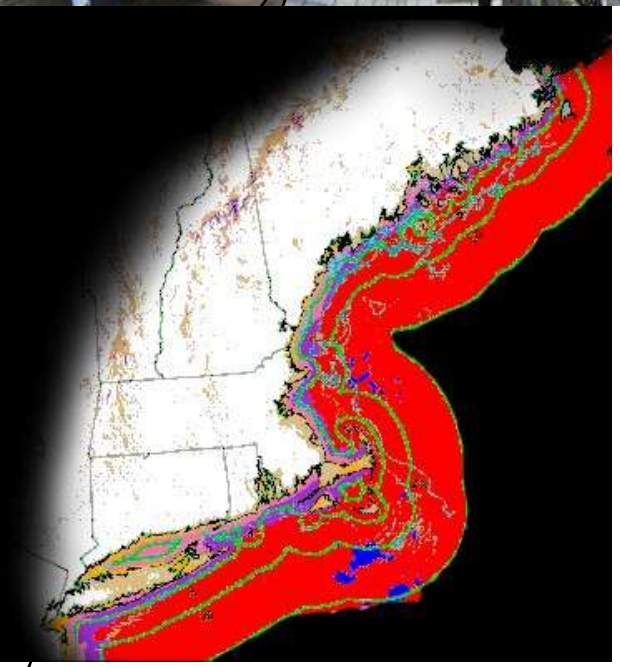
Proposed Methodology for Massachusetts Wind Energy Area Delineation



Webinar Sponsored by Bureau of Ocean Energy Management

Walt Musial

National Renewable Energy Laboratory

Manager Offshore Wind and Ocean Power Systems

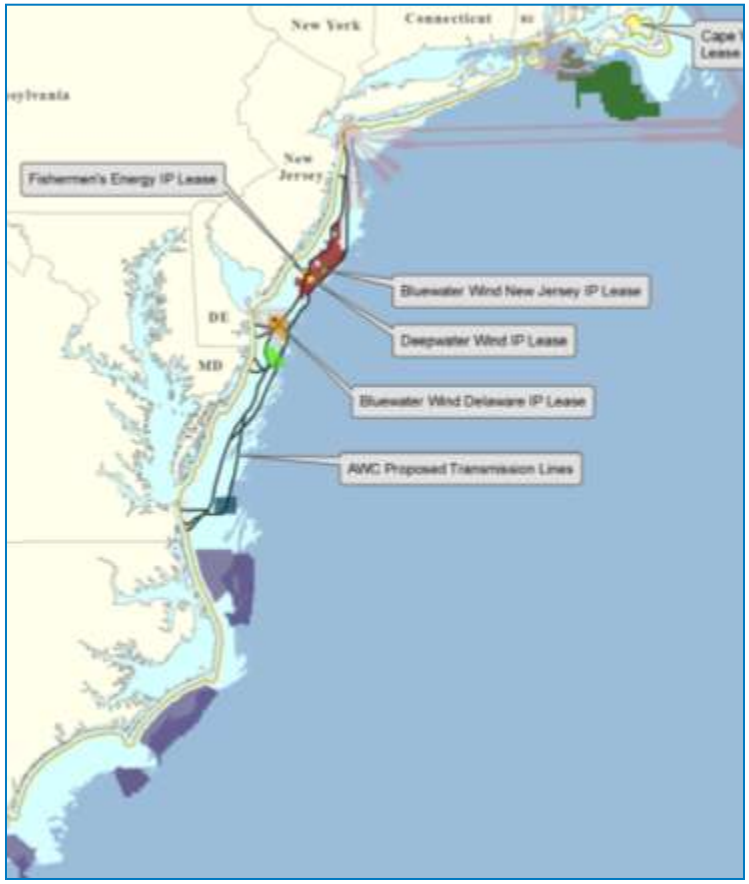
May 15, 2013

NREL Presentation Contents

- NREL offshore wind technical background
- Proposed technical approach for delineation of wind energy area into leasing areas
- Preliminary observations
- Schedule and deliverables
- Question and answers

Project Summary and Background

- Bureau of Ocean Energy Management (BOEM) requested assistance from the Department of Energy's National Renewable Energy Laboratory (NREL)
- NREL is providing technical input to help inform delineation of leasing areas within four BOEM Wind Energy Areas(WEA)
- NREL will evaluate Massachusetts' wind energy area and will make recommendations to BOEM on options to delineate the area into multiple leasing areas
- Focus will be on wind resource, energy potential, bathymetry and development challenges to to produce approximately equal development zones



BOEM Wind Energy Planning Areas

Offshore Wind Technology Status

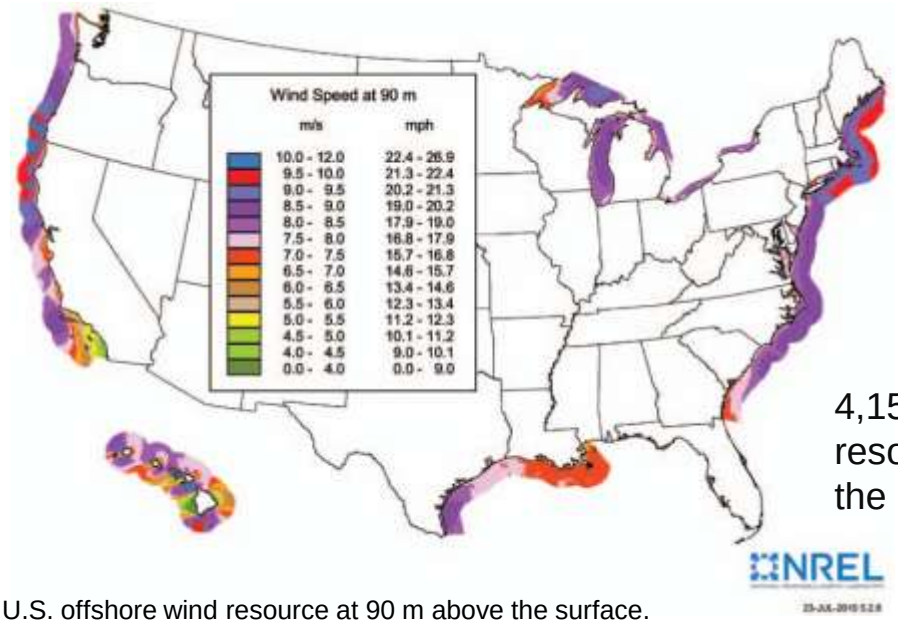
Alpha Ventus – RePower 5-MW Turbine

Siemens 2.0 MW Turbines Middlegrunden, DK

- 62 projects, 4,560 MW installed (end of 2012)
- About 59 are on fixed bottom support structures
- 2-6 MW upwind rotor configuration (Average Capacity 3.8 MW)
- 80+ meter towers
- Drive trains are modular geared systems or direct drive generators
- Marine technologies for at sea operation.
  - Submarine cable technology
  - Oil and gas experience essential
- Capacity Factors 40% or more
- Higher project cost and O&M have added project risk

NREL Offshore Wind Program Highlights

- National Offshore Wind Strategic Plan support for DOE
- Published *Assessment of Offshore Wind Energy Resources for the United States*
- Published *Large-Scale Offshore Wind Power in the United States: Assessment of Opportunities and Barriers*
- Service to National Academy of Science committee addressing Offshore Wind Energy Turbine Structural and Operating Safety
- Chaired AWEA Offshore Compliance Recommended Practices (Oct 2012)
- International Standards Development including Hurricane Design



U.S. offshore wind resource at 90 m above the surface.

4,150 GW of wind resource potential in the United States

NREL Tasks for Massachusetts Under Interagency Agreement with BOEM

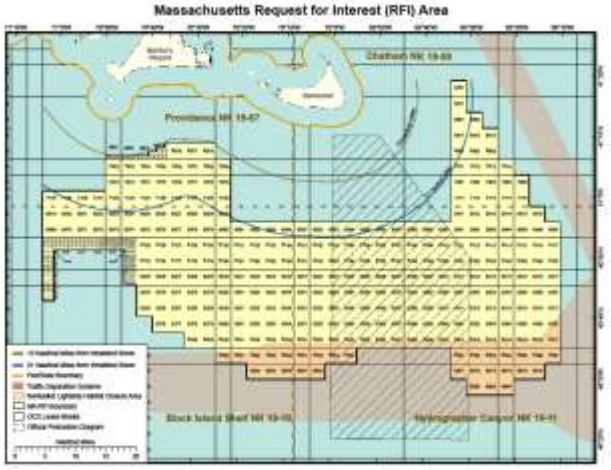
- Review nominations from RFI (2011) and Call (2012)
- Develop methodology for delineating WEA into equitable leasing areas
- Present methodology to Massachusetts Offshore Wind Task Force (May 15, 2013)
- Conduct independent analysis on WEA
- Submit draft report (June 2013)
- Publish final report (July 2013)

NREL
NATIONAL RENEWABLE ENERGY LABORATORY




Evaluation Parameters and Technical Approach for Massachusetts Wind Energy Area Delineation

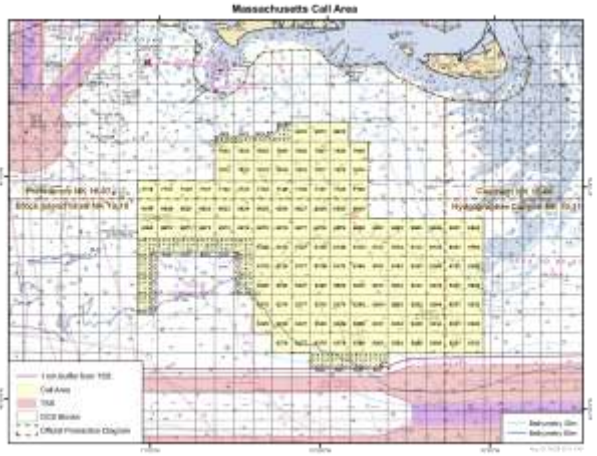
Massachusetts Wind Energy Area Evolution



Request for Interest Area (RFI)

8 responses

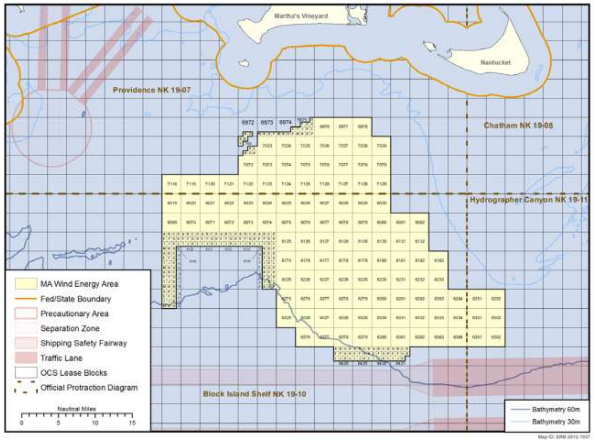
June 2011



Call for Nominations Area

11 responses

March 2012

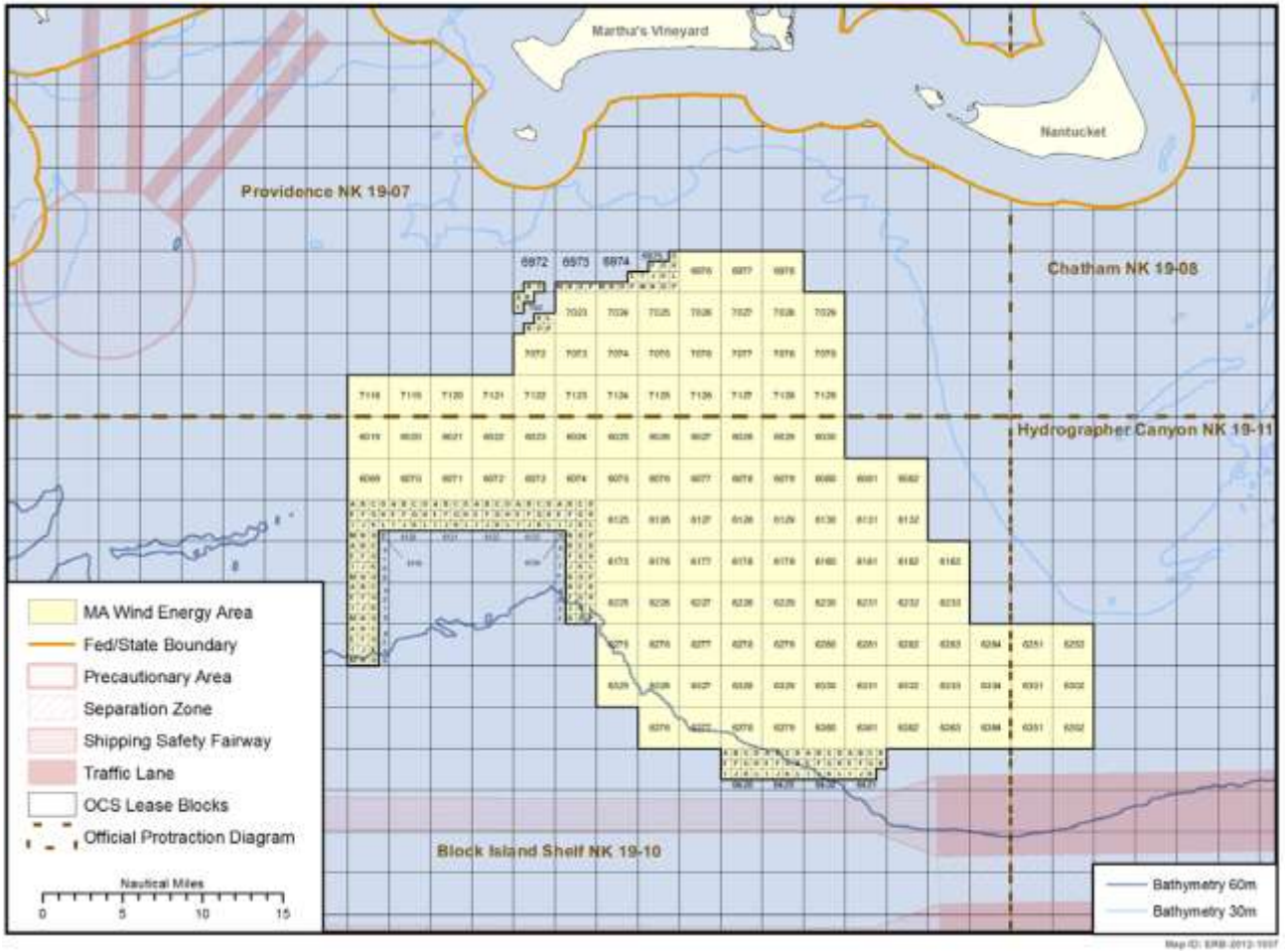


Current Wind Energy Area

May 2013

Proposed Project Description

Objective: Recommend an equitable set of delineation boundaries for the BOEM specified Massachusetts Wind Energy Area (WEA)



Massachusetts Wind Energy Area

The Massachusetts Wind Energy Area is pictured in the Figure. Its key attributes are:

2088 Aliquots
Area - 3007 km^2
Average Depth – 50m

Proposed Delineation Strategies

- Seek an approximate energy production balance and area between leasing areas
- Consider water depth and distribute water depths similarly
- Minimize wake losses among leasing areas
- Consider wake effects from RIMA and impact on RIMA
- Assess development timeline and multi-phase projects
- Maximize develop-ability for each leasing area

Assumptions for MA Leasing Area Delineation

- Investigate options for up to 5 leasing areas
- Minimum project size – 500 MW
- Baseline turbine size – 5-MW (126-m rotor NREL Reference)
- Total area is 742,974 acres (3007 km^2)
- Total maximum capacity (without buffers) is approximately 15,000 MW with about 3000 turbines.
- Baseline array spacing 8D x 8D as used for resource assessment at NREL (5 MW/km^2)
- Lower array densities: (8D x 12D) and 1000-MW project limit cases will be examined
- Developers will deploy internal buffers but 8D setbacks between areas are assumed

REpower 5M Alpha Ventus - Germany

Photo Credit: Gary Norton

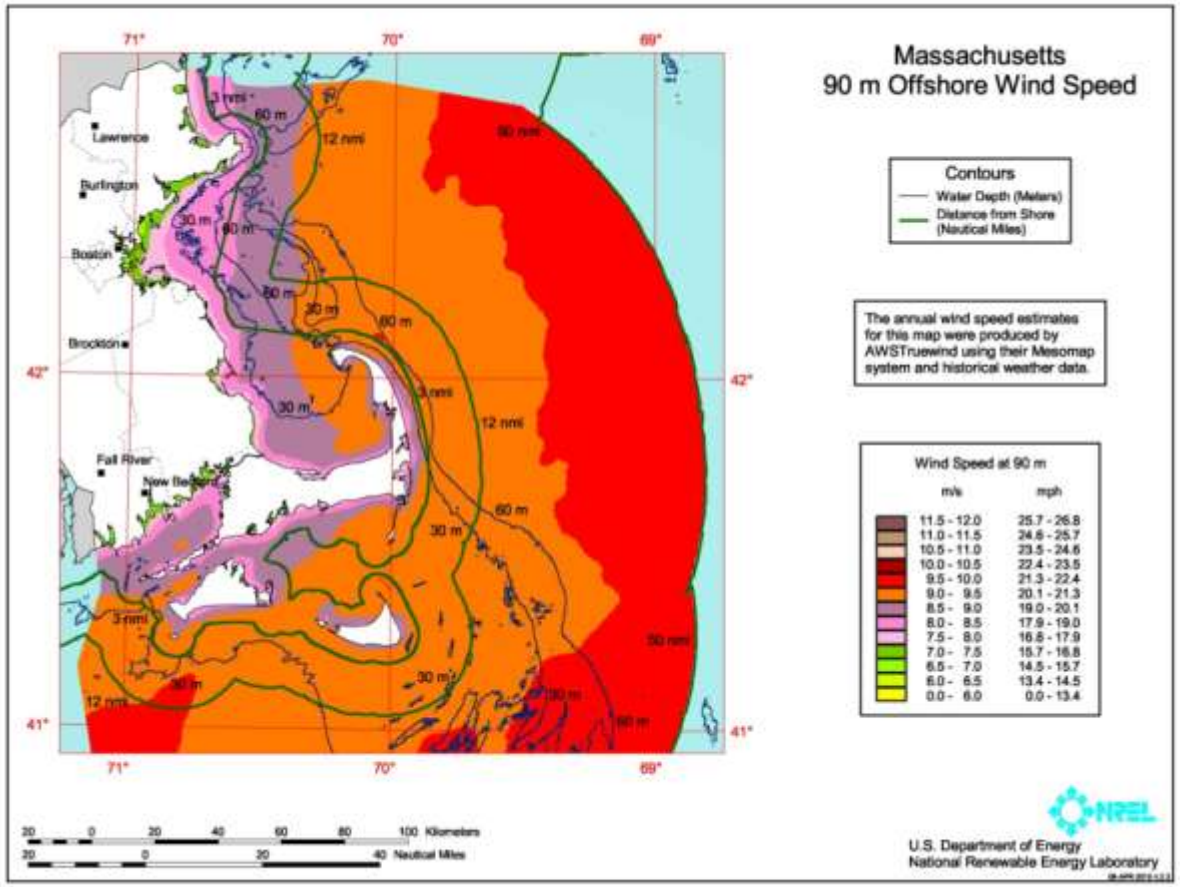
General Process for Massachusetts

1. Collect data on wind resource, bathymetry, and WEA GIS coordinates
2. Read and process RFI responses and Call nominations to gather data on ecological, conflicting use, and development strategies
3. Determine key criteria for delineation (e.g. area> bathymetry>wake losses)
4. Establish preliminary delineations for 5 leasing areas
5. Use openWind® Enterprise Program to evaluate turbine performance and wake effects for built arrays
6. Perform sensitivity analysis on turbine spacing options and buffers
7. Modify delineation boundaries if necessary
8. Make final recommendations to BOEM

NREL Criteria for Evaluation of MA WEA

Quantitative Evaluation Criteria	Qualitative Evaluation Criteria Considered
Total area (km and acres)	Distance from shore
Potential installed capacity [megawatts (MW)]	Technology challenges
Bathymetry [meters (m)]	Development cost
Annual average wind speed [meters per second (m/s)]	
Gross capacity factor (%)	
Wake losses (%)	
Potential annual energy production [MW and gigawatt-hours (GWh)]	
Development Timing	
Vessel Traffic (if required)	

Massachusetts Wind Resources – Statewide Map



Massachusetts Wind Resource Map (Source: NREL)

Wind Data Requirements

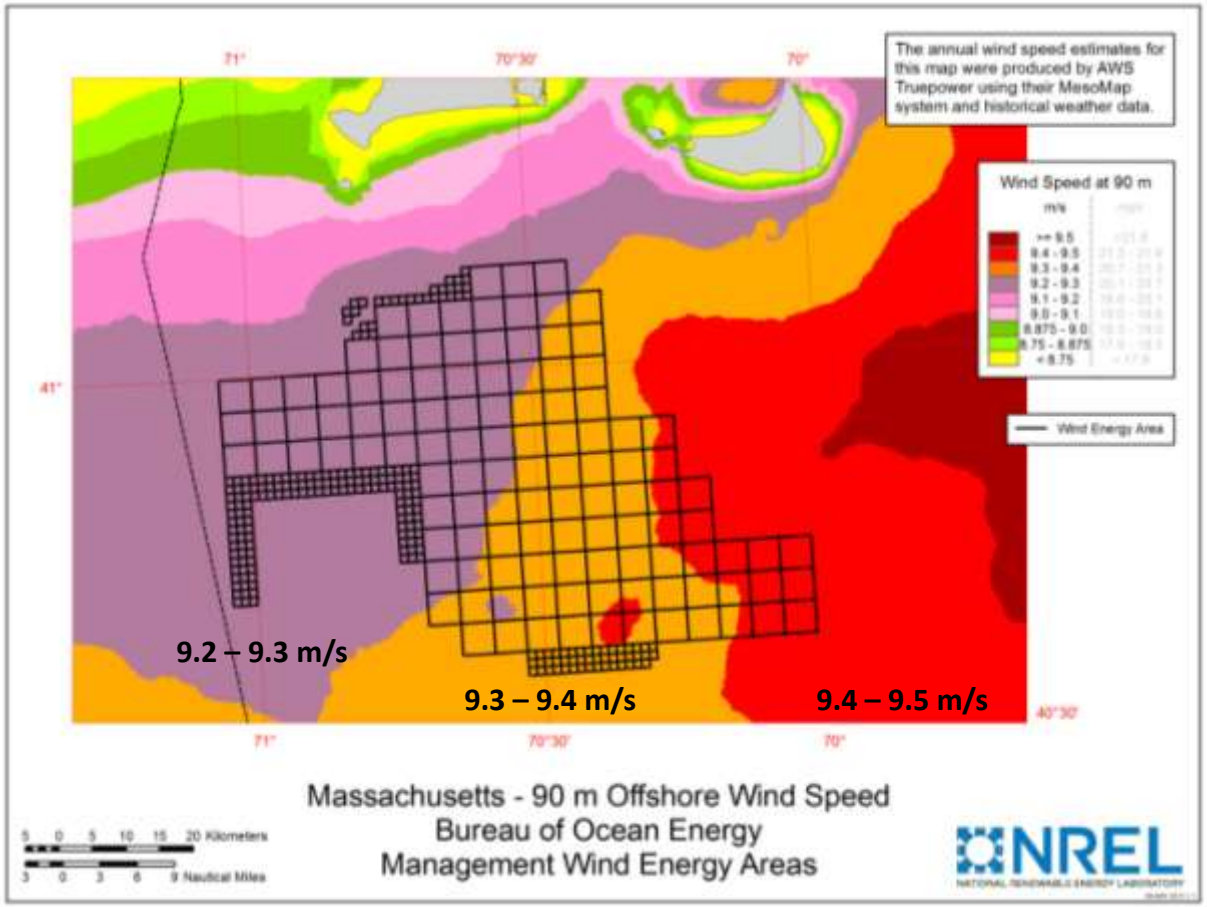
- Validated
- Long Term Record
- High resolution at wind plant scale
- Best representation

WRG/WRB Wind Data Source for MA WEA Evaluations

- WRG/WRB data was developed by AWS Truepower
- MASS mesoscale modeled data at a grid resolution of 20km and scaled to 200m grid resolution using WindMap (based on NOABL model)
- WRG/WRB wind data provide highest resolution data with long term records (14 years) of wind speed and direction
- Accuracy will be validated against local Met towers, surface NOAA buoys and REEMA data from NASA

Massachusetts Wind Resources – WEA map

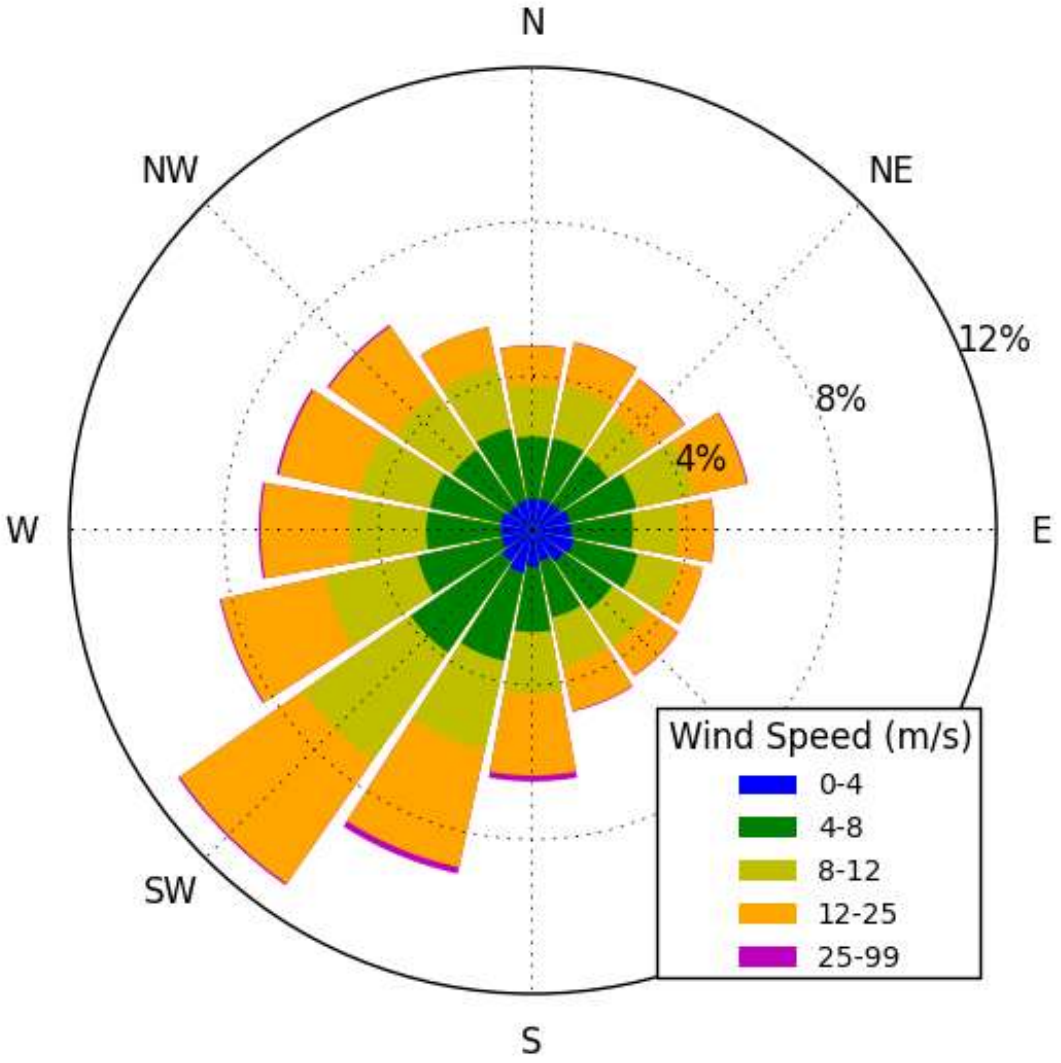
- Excellent wind resource between 9.2 m/s and 9.5 m/s across WEA
- Wind speed varies geographically with better wind in the east
- Expected Capacity Factors of 40%



Massachusetts Wind Energy Area Resource Map in 0.1 m/s increments (source: NREL)

Strong Prevailing Wind Component

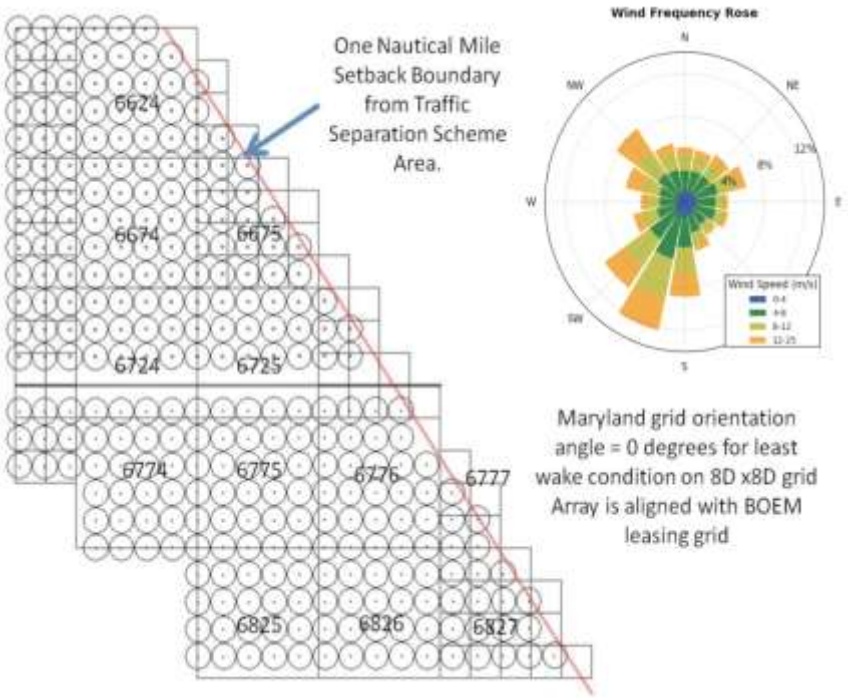
- Wind rose shows strong Southwest component



Wind Frequency Rose for Massachusetts WEA (Source: NREL)

Description of openWind® Enterprise Program

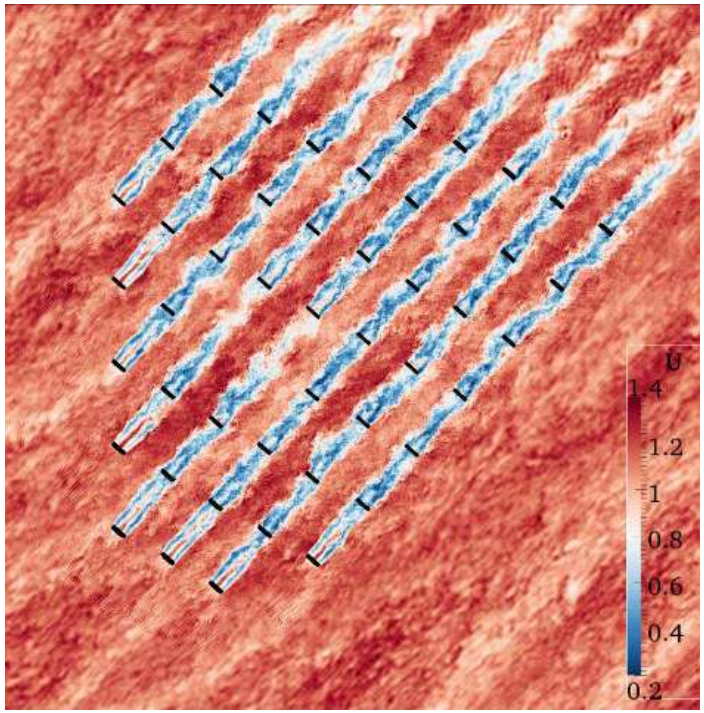
- Energy and wake effects will be studied with openWind.
- Wind power facility design software program
- Open source software with NREL licensed options for deep array wake losses and other features
- Energy computations using typical wind farm design practices
- GIS based architecture
  - GIS file compatibility
  - Spatial logic with hierarchical structure
- Default to deep array offshore wake model for higher fidelity



Example: OpenWind Enterprise Tool arranges turbines inside Maryland WEA and computes energy, wake losses and power performance (Source NREL)

Wake Losses and Inter-project Buffers - Background

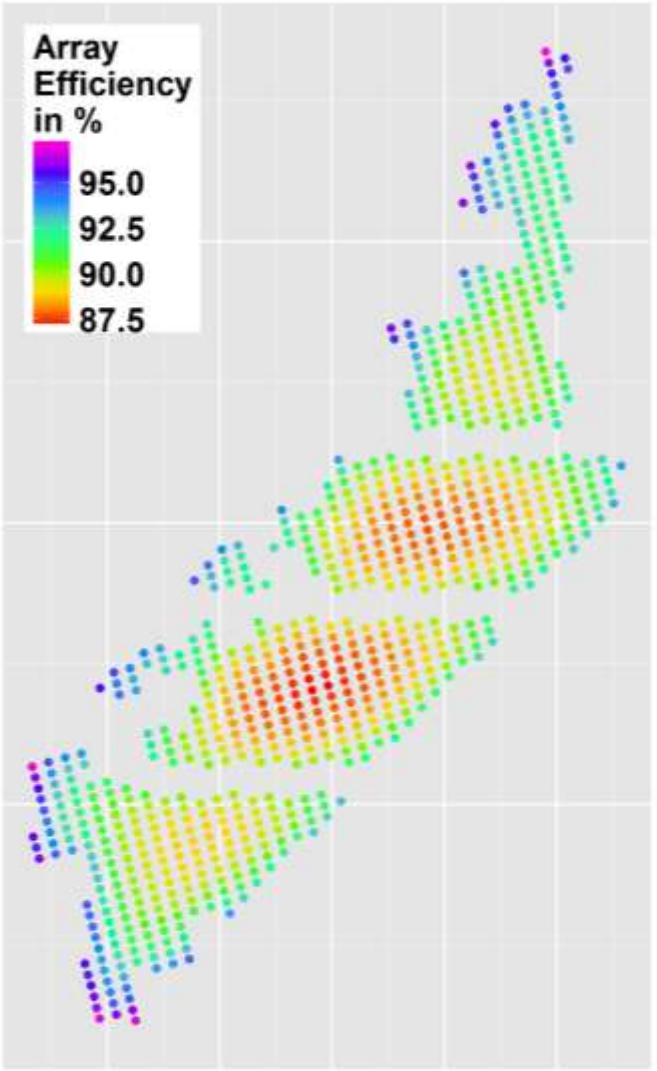
- Wind turbines wakes have lower energy available, higher turbulence, and need to be replenished by natural atmospheric mixing
- Atmospheric stability conditions dominate the rate of mixing and replenishment
- Stable atmospheres are stratified and allow turbulence to persist
- Unstable atmospheres replenish energy in the wind more quickly



Simulator for Wind Farm Applications showing turbine wake effects (Source: NREL)

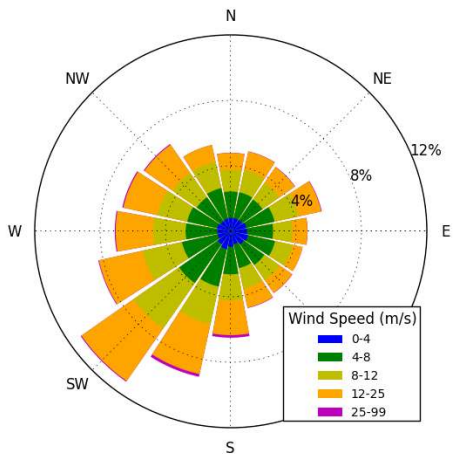
Prevailing Wind Direction Wake Effects and Buffer Requirements

- Prevailing winds are strongly from the SW
- Large leasing areas expected for projects up to 2000-MW
- Array losses can be minimized by internal developer imposed setbacks, internal buffers, and increased turbine spacing
- Buffers are not regulated by BOEM
- Developers will create buffer zones for economic purposes and in coordination with neighboring zones

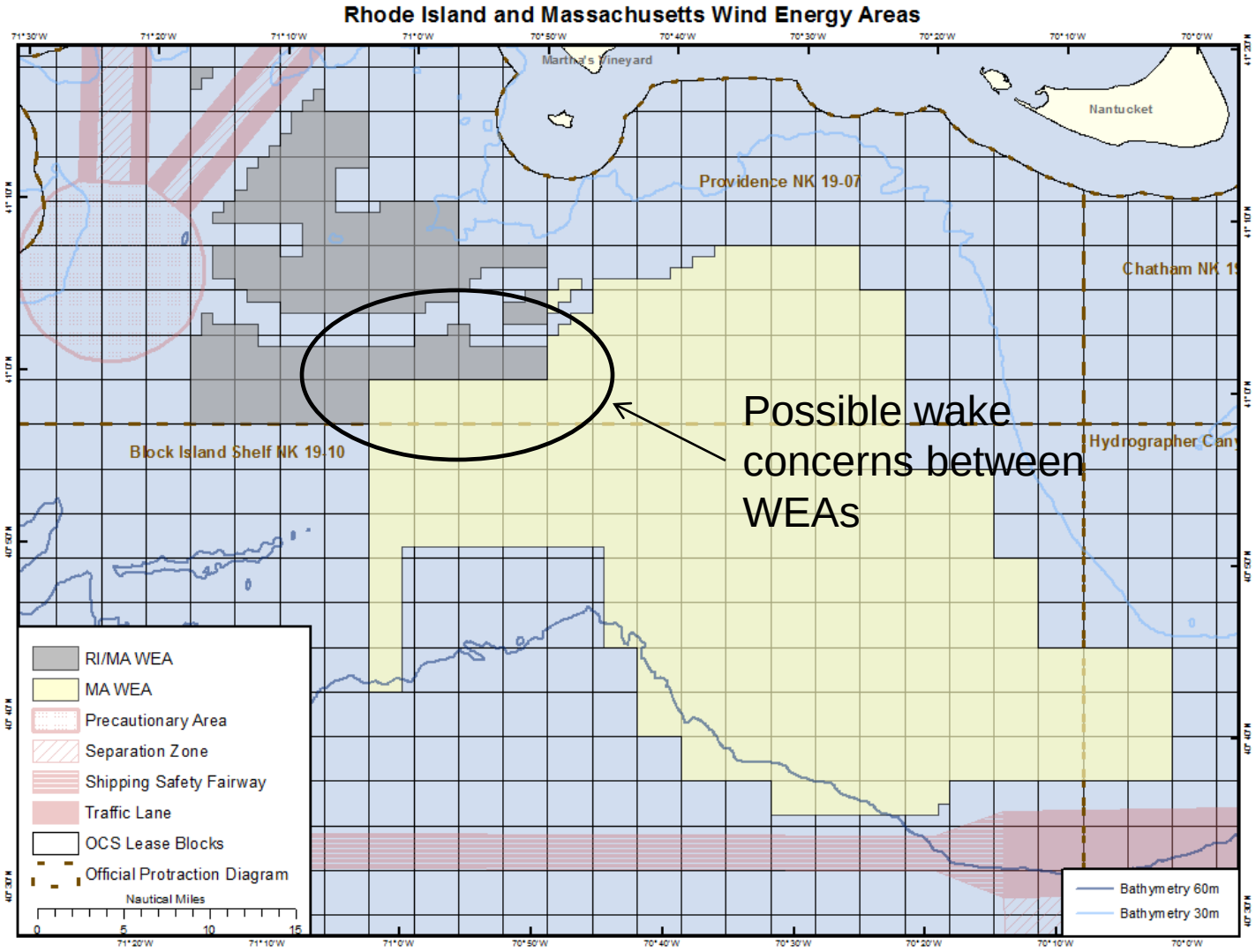


Example: array efficiency diagram for the New Jersey WEA showing array losses due to wake effects (source: NREL)

Possible Wake Effects Between RIMA and MA WEAs

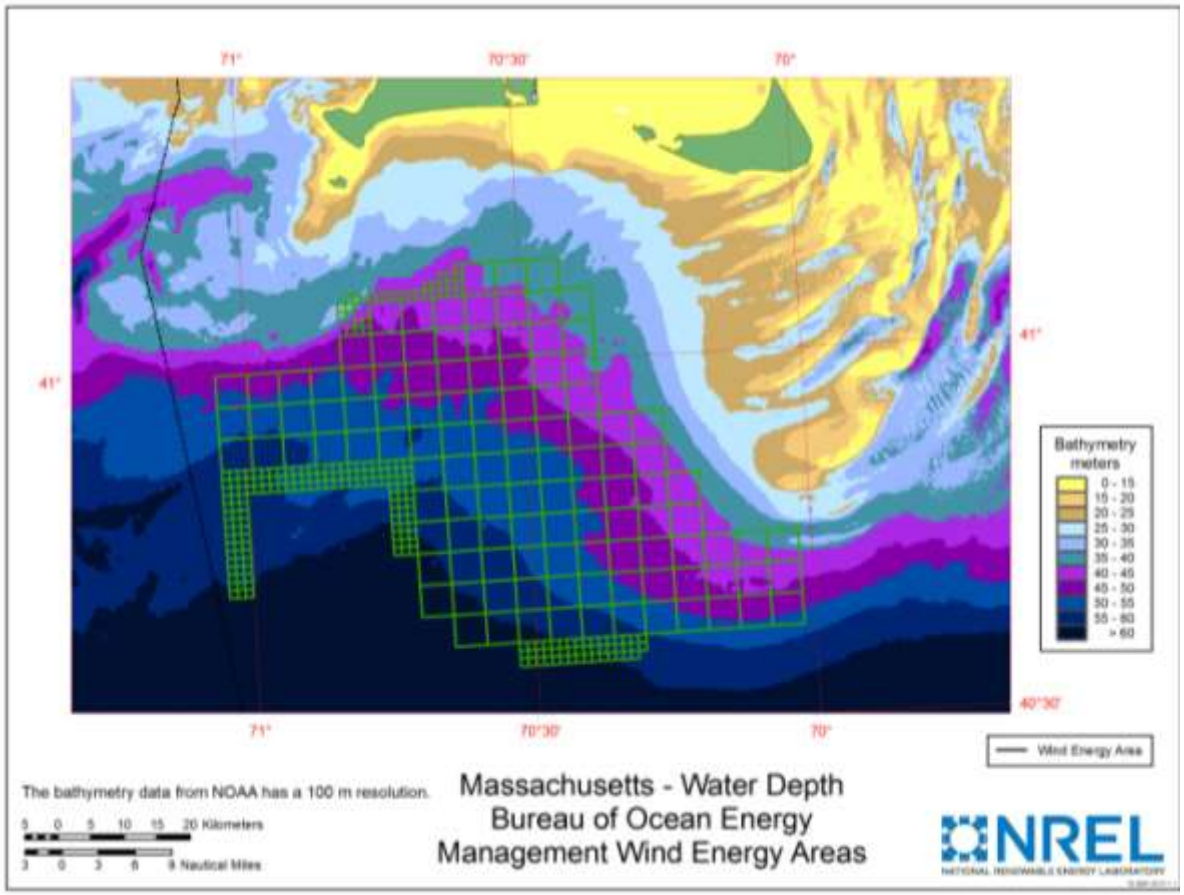


Wind Frequency Rose for Massachusetts WEA (Source : NREL)



Map showing Massachusetts Wind Energy Area with Rhode Island/Mass Area (Source BOEM)

MA WEA Bathymetry review



Map showing the bathymetry of the Massachusetts Wind Energy Area in increments of 5m (Source: NREL)

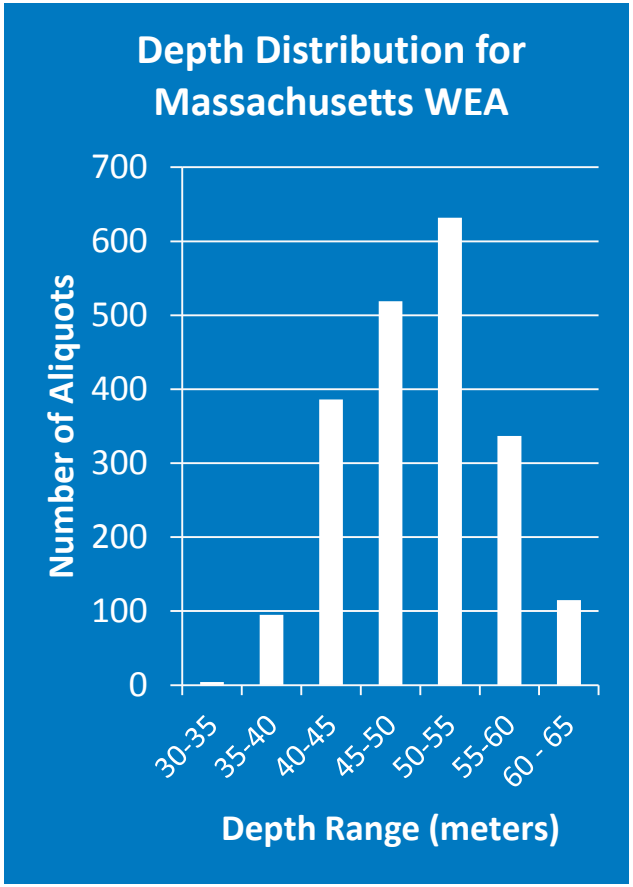
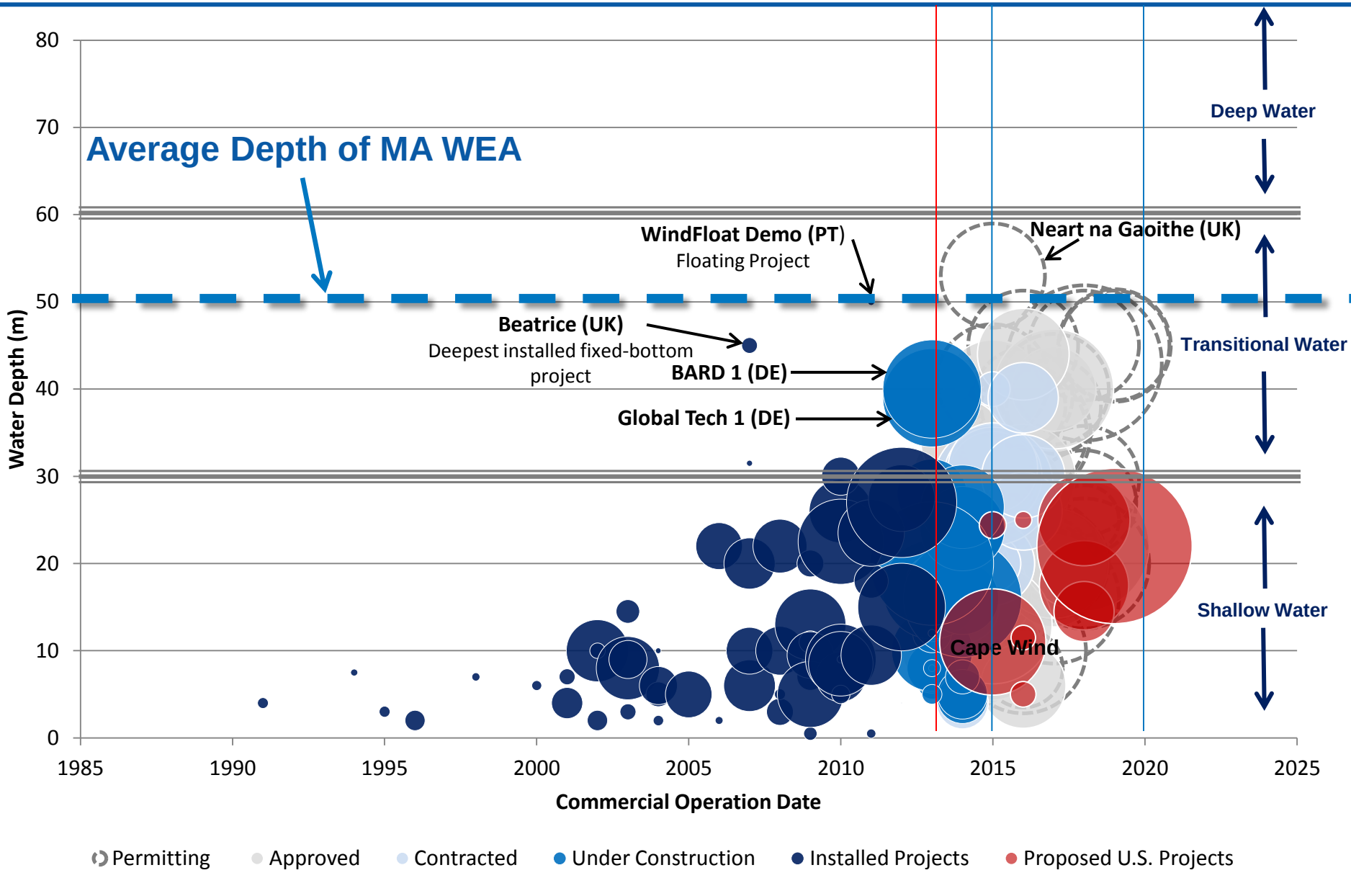


Chart quantifying depth of WEA (Source NREL)

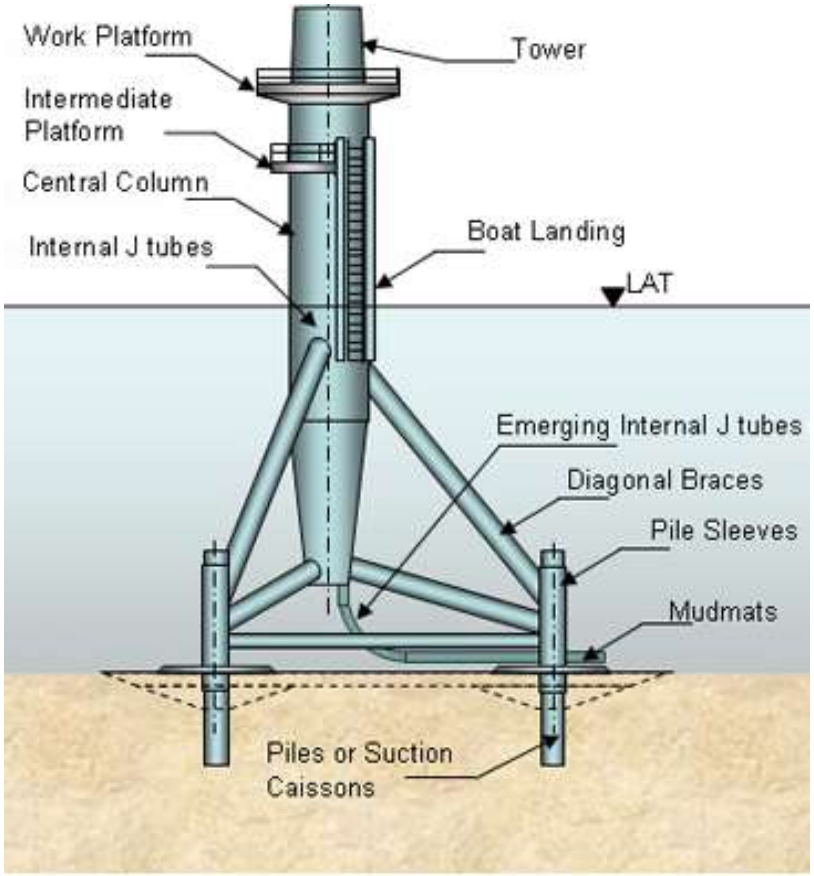
Massachusetts WEA Bathymetry

- Deep water dominates the MA WEA
- Water depth (50-m average) will be a driving factor in development cost and development timing
- Delineation methodology will treat bathymetry as a primary variable to distribute water depths among all leasing areas
- Most developers have proposed a phased development approach – deeper aliquots will likely assume a longer development time frame
- Call proposals indicate development times between 4 and 16 years with average around 8 years
- Lease rent fees may need to be structured to account for longer development timing

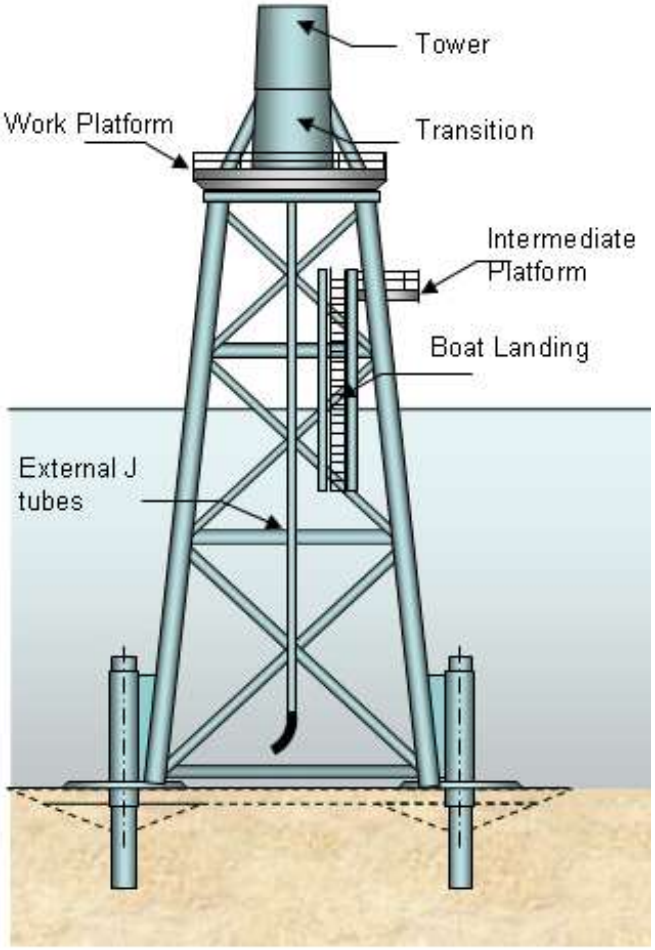
Most European Offshore Wind Projects are <50 m



Some Foundation Options (30-60m depth)

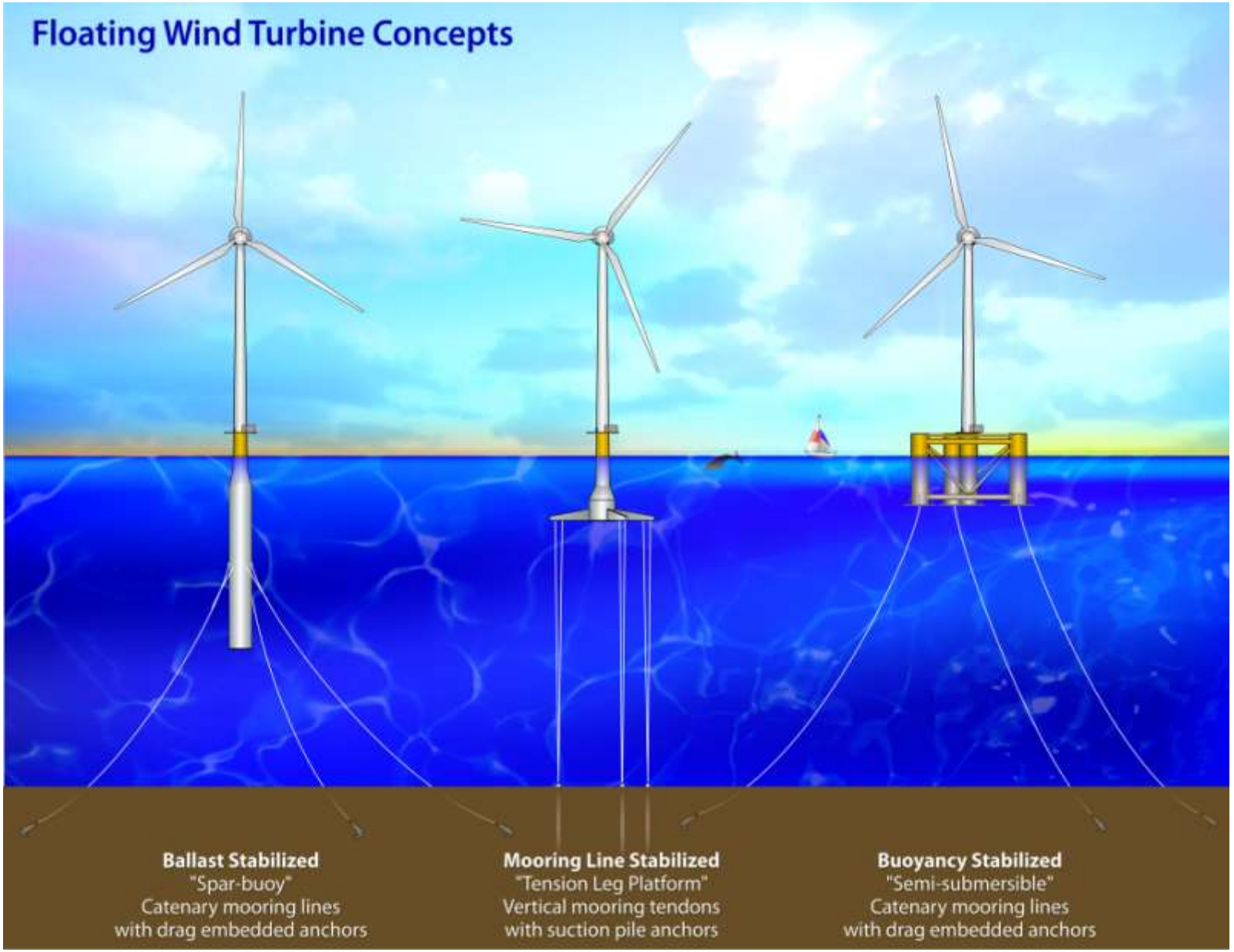


Tripod Type



Jacket or Truss Type

Possible Floating Options Include Semi-submersible Type Support Structures



Preliminary Observations

- Massachusetts Wind Energy Area is the largest of the BOEM areas so far.
- Deep water will dominate development concerns
- Nominations were submitted with shallow water options
- Wind resource is excellent across MA WEA
- Timelines for development from proposals were between 4 and 16 years with average near 8 years

Process deliverables to BOEM

- Presentation to MA Task Force May 15, 2013
- Draft report on MA Delineation June 13, 2013
- Final report on MA Delineation July 20, 2013
- Final presentation to MA Task Force TBD