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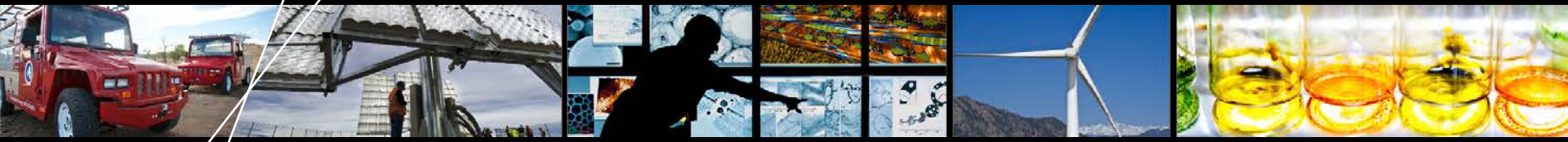
Proposed Methodology for New Jersey Offshore Leasing Zone Delineation



BOEM New Jersey Task Force Meeting
Trenton, New Jersey

Walt Musial
NREL Manger Offshore Wind, Principal Engineer

Dennis Elliott
NREL Principal Scientist

December 18, 2012

NREL Presentation Contents

- NREL offshore wind technical background
- Proposed project description
- Proposed technical approach
- Question and answers

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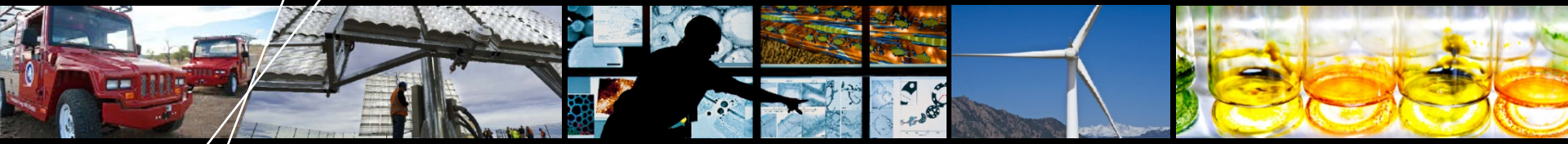
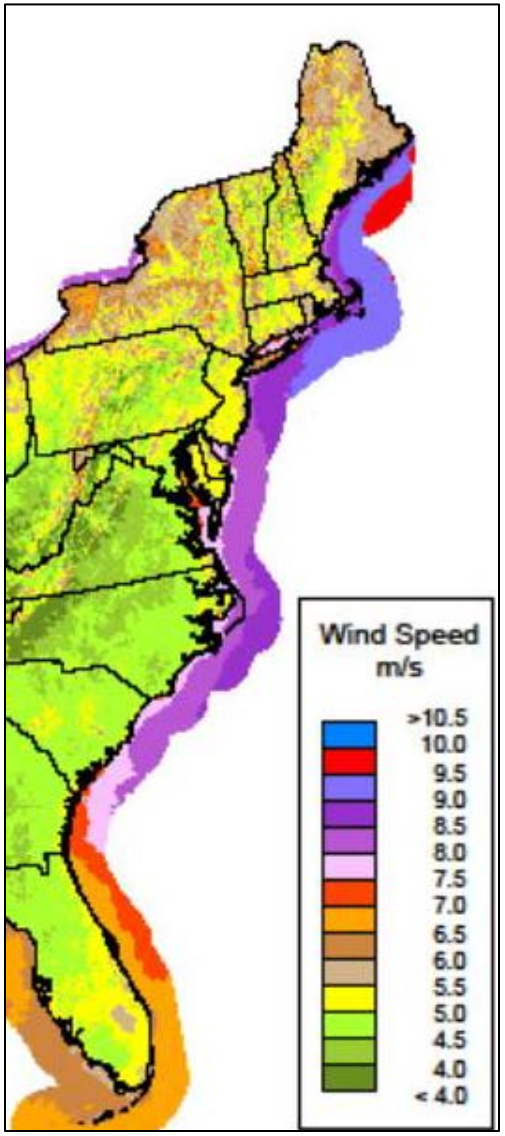
Background



National Renewable Energy Laboratory and Offshore Wind Technology

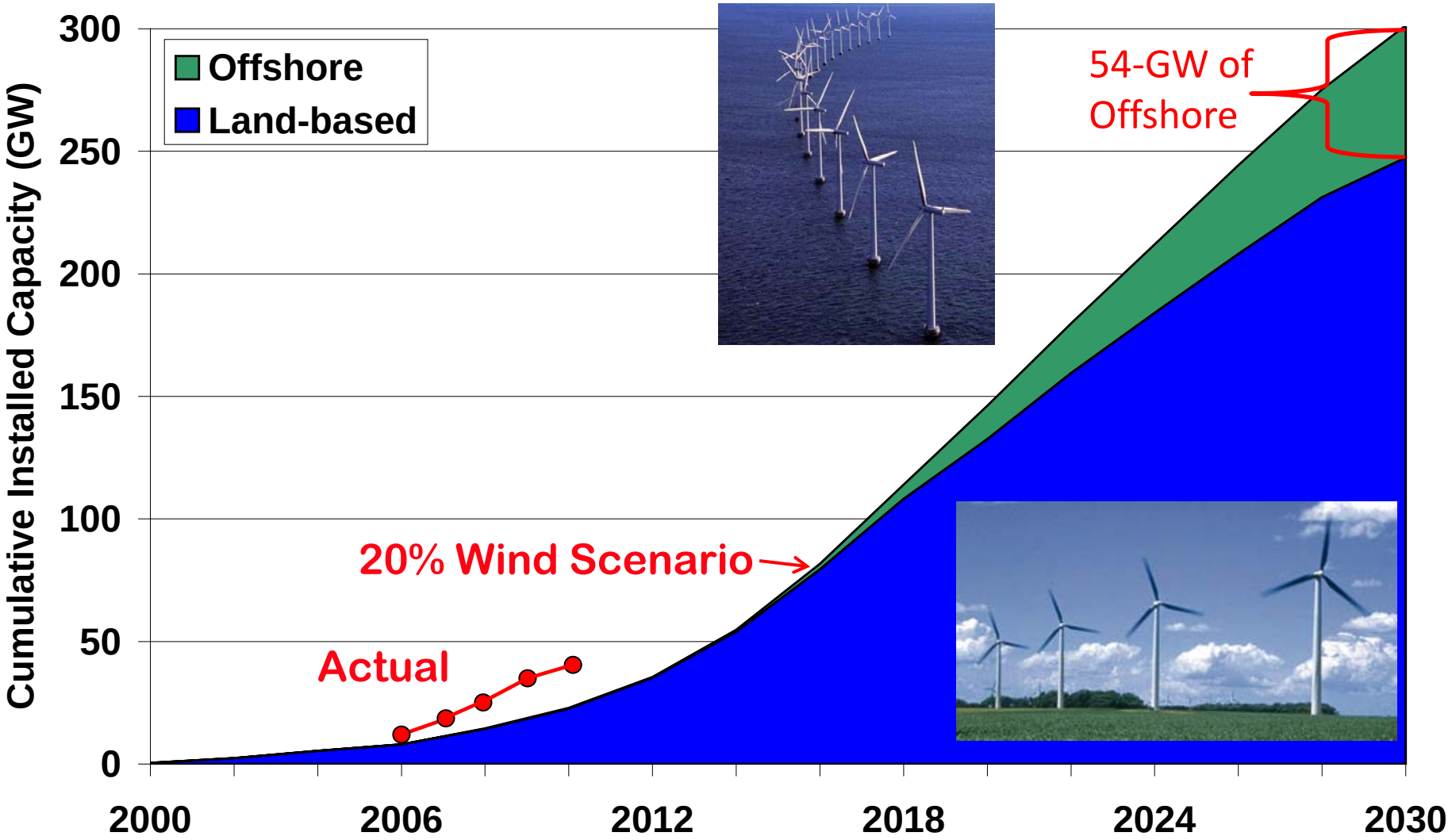
Project Background

- **Bureau of Ocean Energy Management (BOEM) requested assistance from the Department of Energy's National Renewable Energy Laboratory (NREL)**
- **NREL will provide objective technical input to help delineate leasing zones within the Wind Energy Areas for decision makers**
- **New Jersey delineation methods are flagship for other US states**
- **Focus is on balancing wind resource, assessing buffer zones and maximizing energy potential**



Atlantic Wind Energy Resources

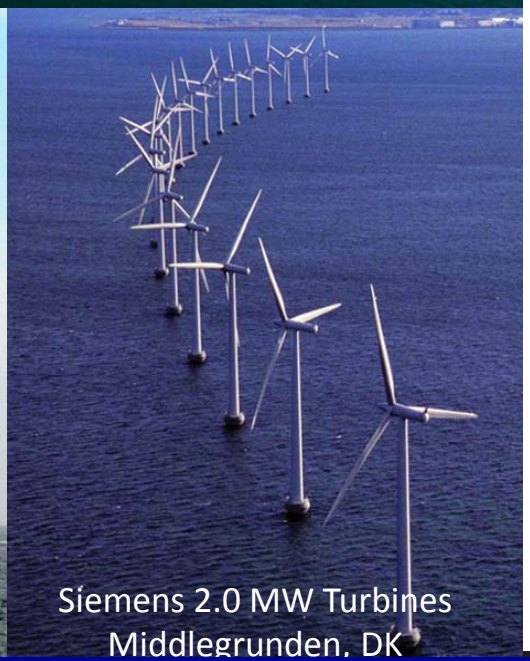
20% Wind Electricity Scenario: 54-GW from Offshore



Offshore Wind Technology Status

Horns Rev Wind farm - 160-MW


Alpha Ventus – RePower 5-MW Turbine


Siemens 2.0 MW Turbines Middlegrunden, DK

- 51 projects, 3,620 MW installed (end of 2011)
- 49 in shallow water <30meters depth
- 2-5 MW upwind turbines (3.8 MW average power)
- 80+ meter towers on monopoles, gravity bases, or truss (jackets)
- Modular geared drivetrains – trending toward direct drive
- Marine technologies
  - Submarine cable technology
  - Oil and gas experience essential
  - Marine operations/ vessels
- Capacity Factors 40% or more
- Higher Cost and O&M have contributed to project risk.

NREL is a Research Leader for DOE Offshore Wind Program

FFRDC (Federally Funded Research and Development Center)

- **Leading edge economic modeling & analyses** to inform policies, technology roadmapping, portfolio balancing, annual and multi-year plans, and market adoption strategies
- **World leading R&D focused on wind technology development** ranging from next generation to the improvement of existing technologies needed to achieve performance, reliability, cost, and scale-up targets
- **World leading grid integration and resource characterization & forecasting** to enable high wind penetration and inform the intelligent deployment of systems across the nation
- **Support DOE-funded partners** to enhance and accelerate their RDD&D, resulting in maximum benefit to the DOE Wind Program
- **Support DOE's accelerated deployment of wind technologies** with innovative market adoption approaches and activities
- **Maintain world class facilities for wind research**, helping the U.S. be a world leader in wind technology

NREL Wind Research and Test Facilities

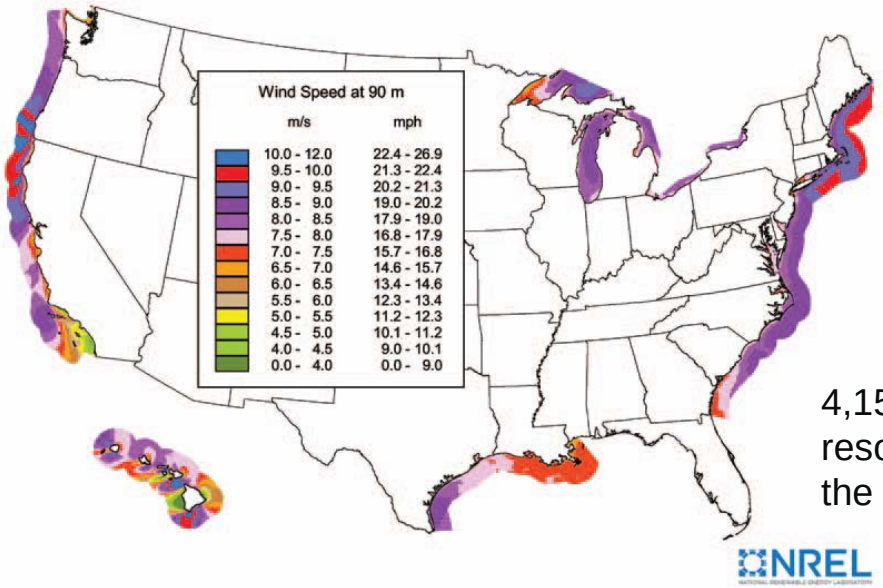
- ~150 professional staff at NREL's National Wind Technology Center (NWTC) near Boulder CO
- Dedicated dynamometer drivetrain testing facilities
- Proving ground for next generation utility scale wind turbines (GE 1.5 MW SLE (DOE), Siemens 2.3 MW-101, Alstom 3 MW-100, Gamesa 2.0 MW G97)
- Atmospheric research facilities
  - Tall Meteorological Towers – 135m
  - State of the art remote sensing (LIDAR, SODAR)
  - Chesapeake Light Tower manager
- 90-m blade testing facilities in Boston MA

Alstom 3-MW 100 – at NREL

Chesapeake Light Tower - VA

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

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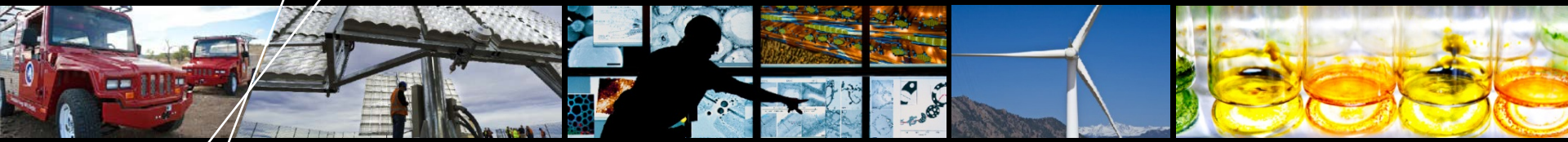
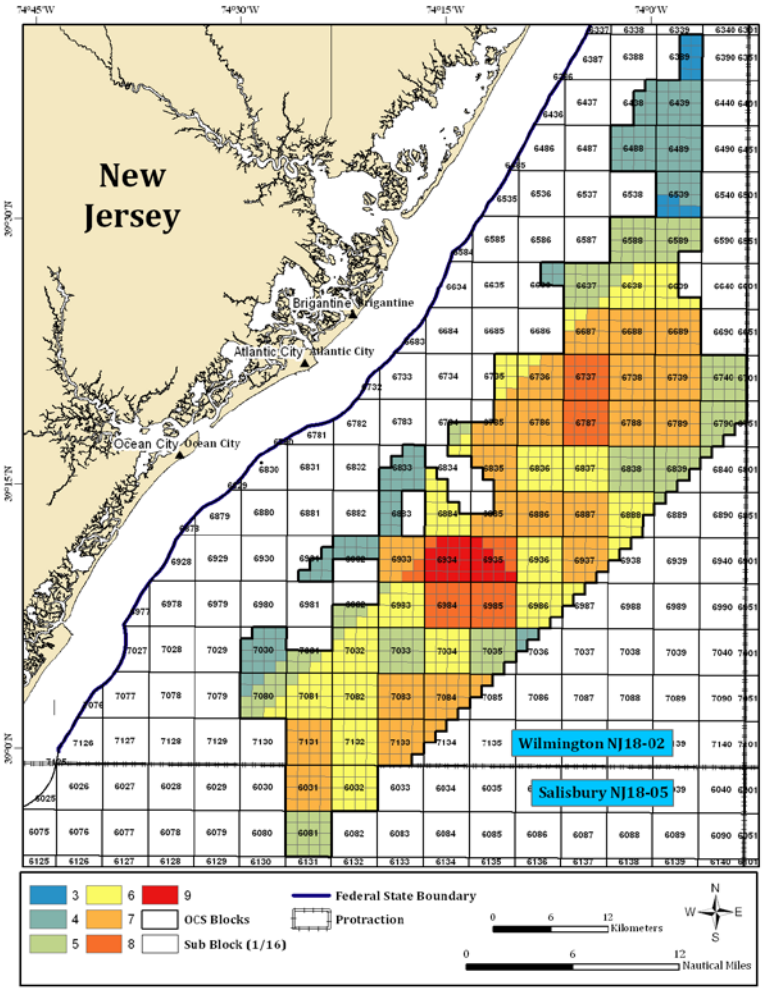
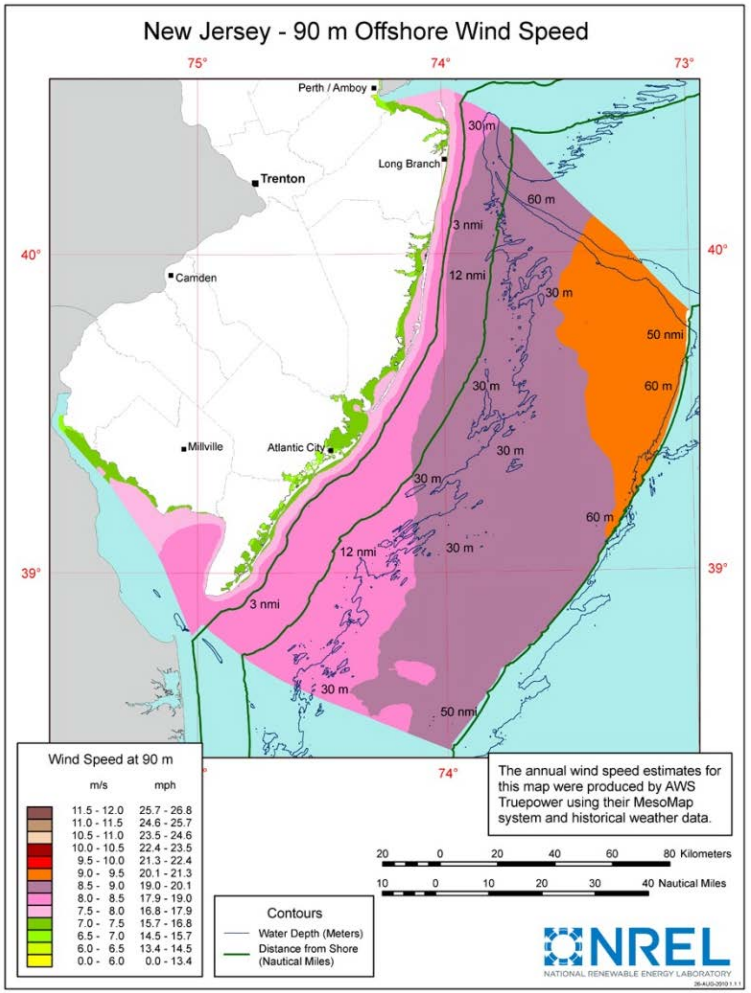


Proposed Project Description

Proposed Project Description

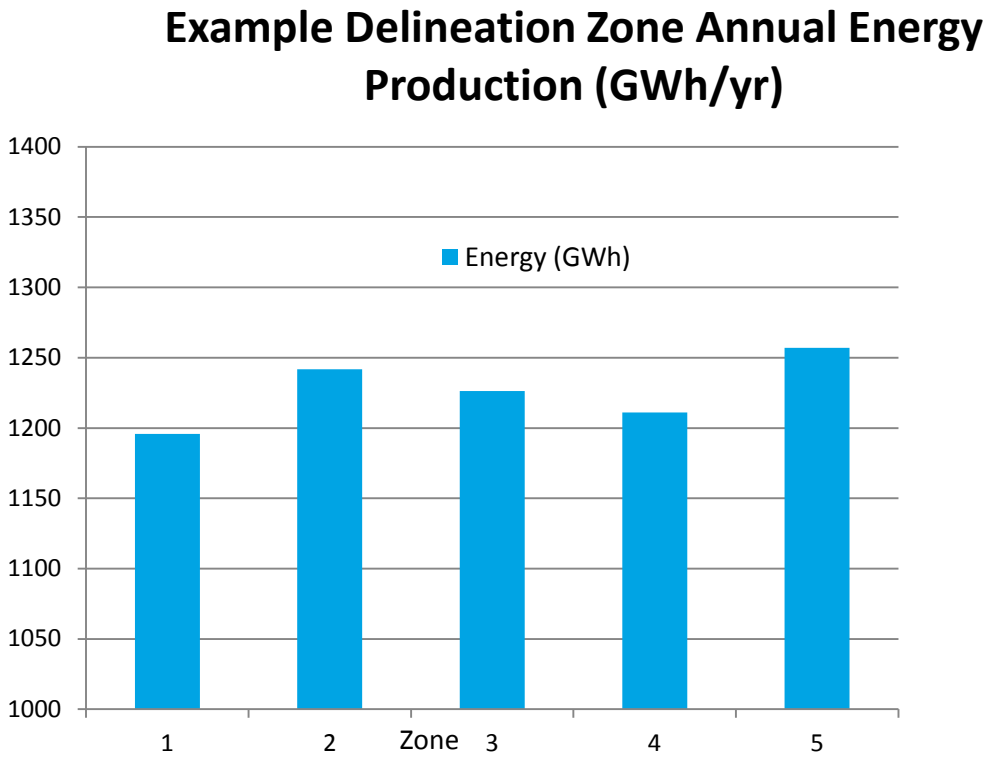
Objective: Create 3-5 development zones within the BOEM specified New Jersey Wind Energy Area (WEA)





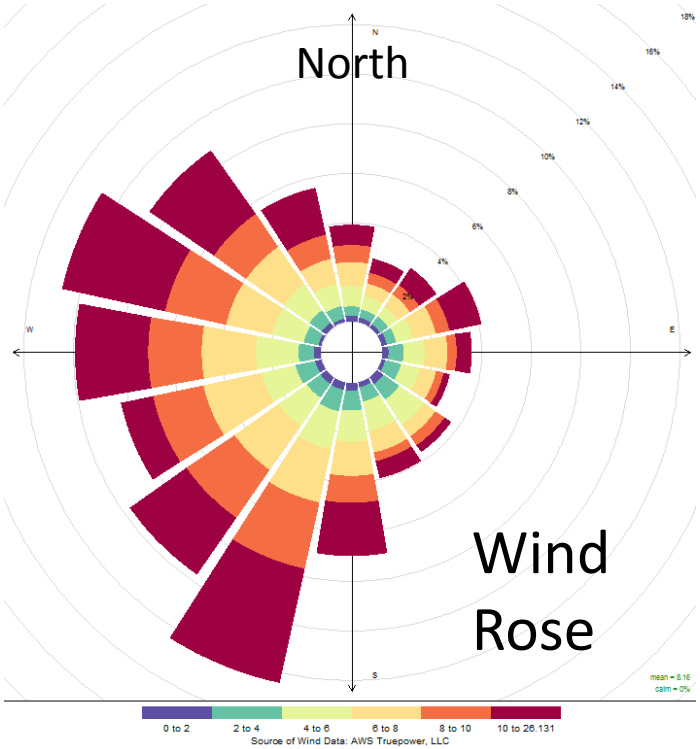
Proposed Major Zone Delineation Criteria

- Approximate energy production balance among each area
- Minimize wake losses for all zones when developed
- Maximize developable area in each zone considering buffers



Proposed Assumptions for Zone Delineation

- Investigate options for 3,4, and 5 development zones
- Minimum project size – 350 MW
- Baseline turbine size – 5-MW (126-m rotor NREL Reference)
- Total maximum capacity – ~1450 turbines (7250 MW)
- Baseline array spacing 8D x 8D as used for resource assessment at NREL (5 MW/km^2)
- All zones are commercially developed
- Developers will be responsible for deploying buffers within their own zones



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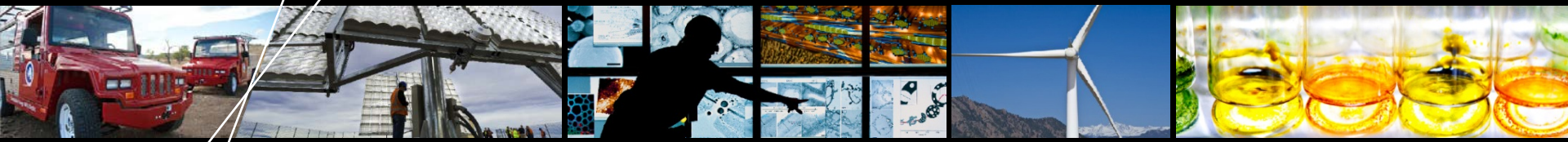
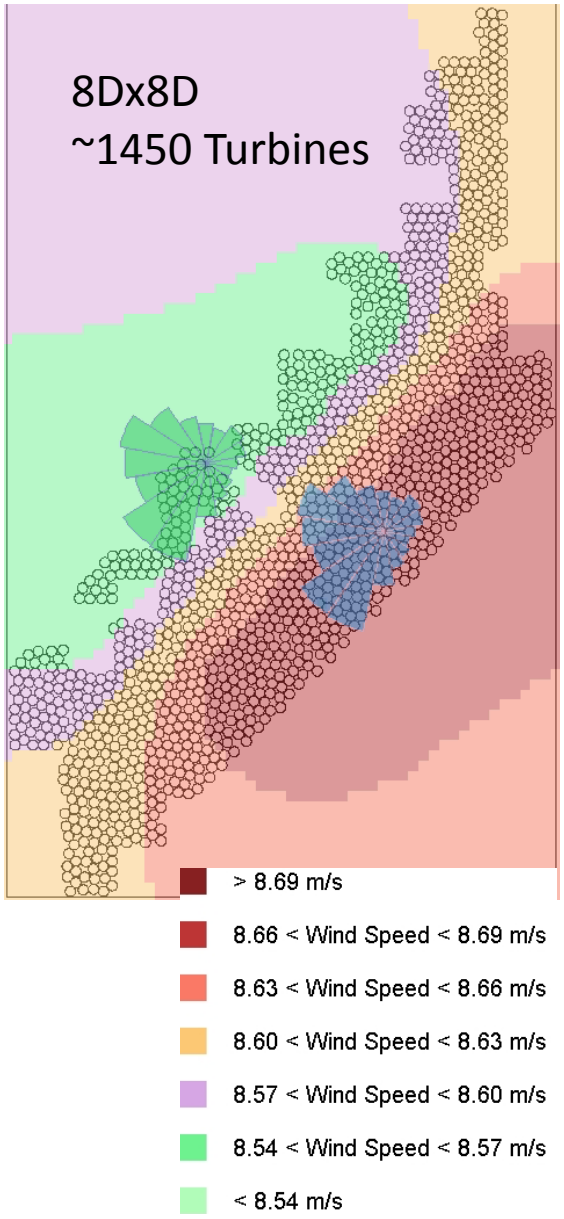


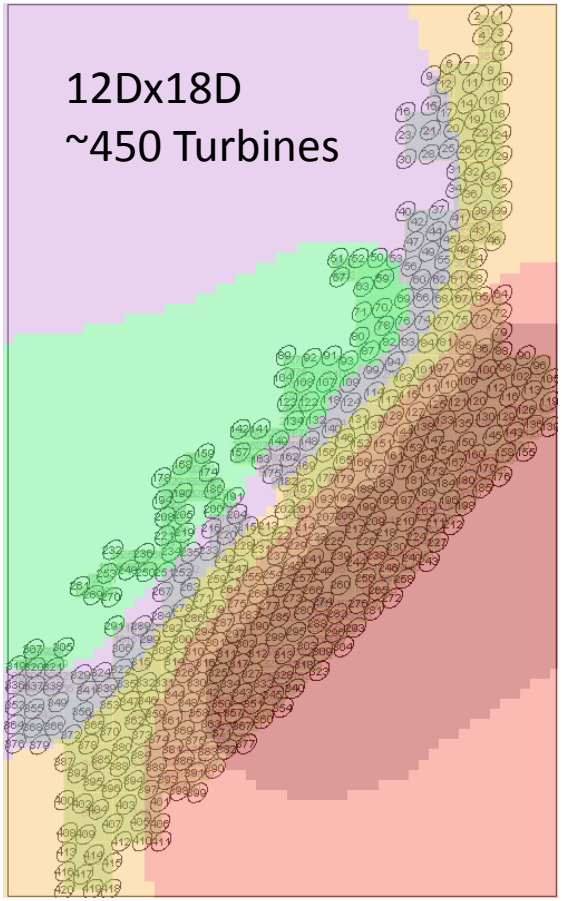
Proposed Technical Approach

Proposed Technical Approach

- Develop summary matrix from NJ nominations of interest and other stakeholder input
- Utilize AWS Truepower openWind® Enterprise program to delineate offshore Leasing Zones
- Perform sensitivity analysis on key variables:
  - Wind Resource Variability
  - Turbine Type/Size
  - Wake Model Fidelity
  - Array Spacing

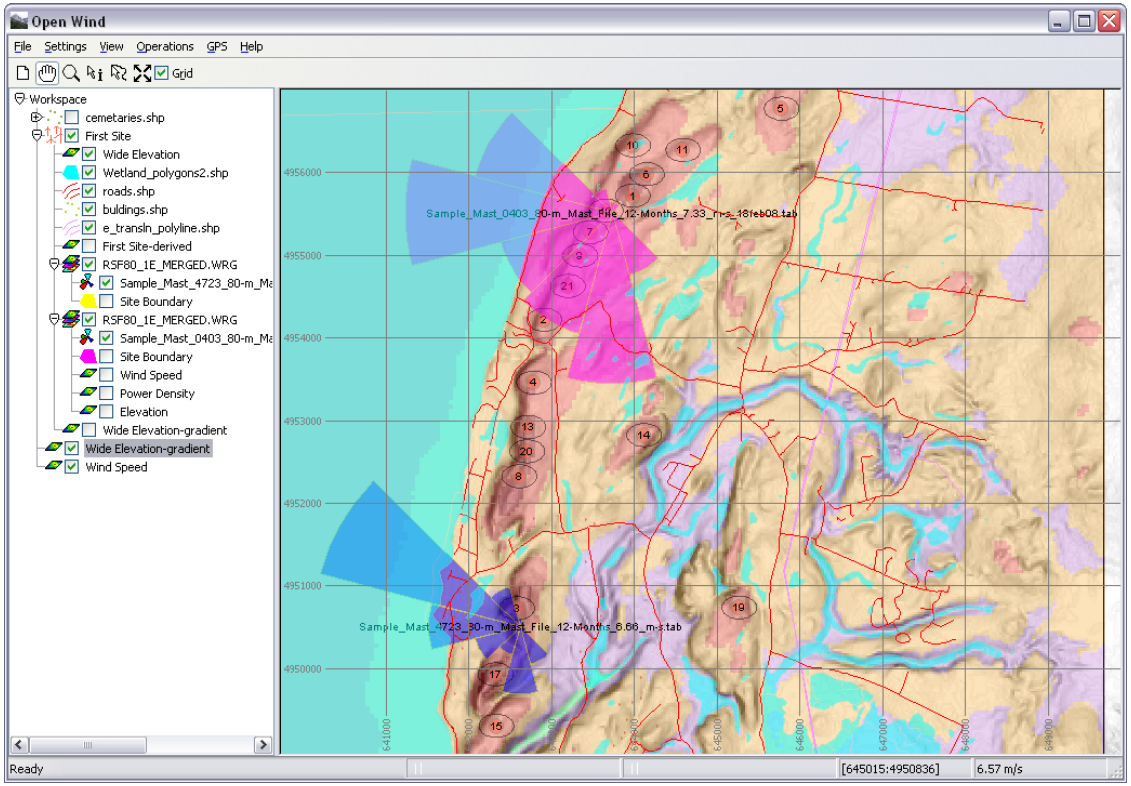


New Jersey Wind Energy Area – Comparison of Two Different Array Spacing Criteria



Description of openWind® Enterprise Program

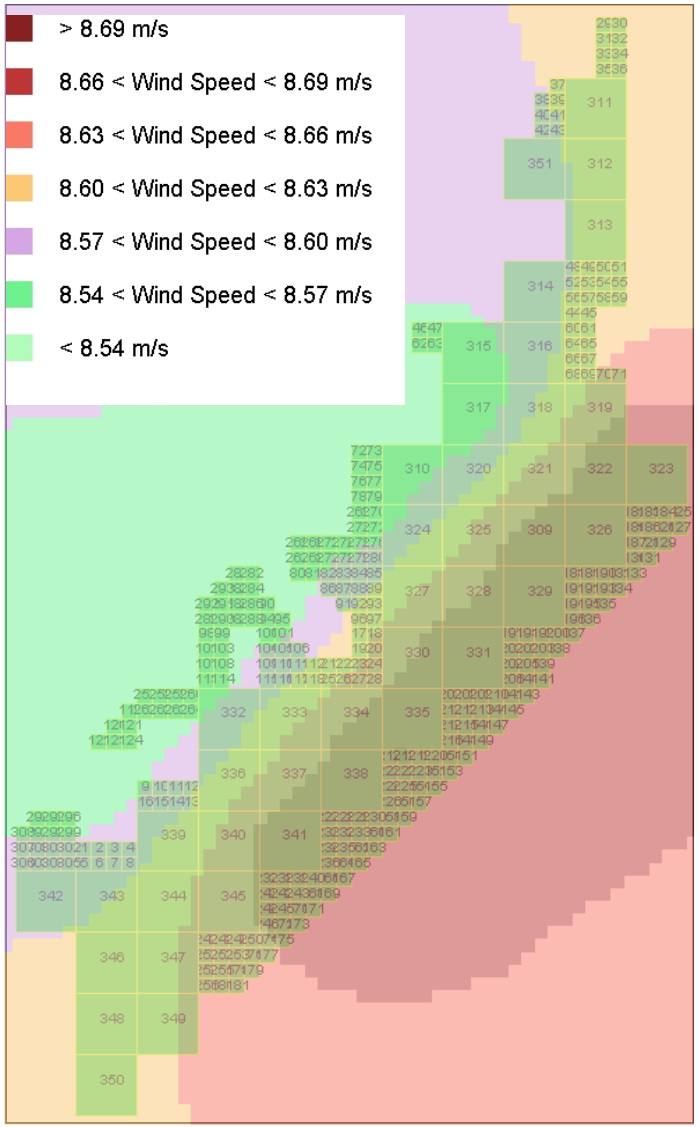
- Wind power facility design software program
- Open source software with NREL licensed options for deep array wake losses and other features
- Energy computations using standard wind farm design practices
- GIS based architecture
  - GIS file compatibility
  - Spatial logic with hierarchical structure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



Example of Map Taken from openWind ® Enterprise Tool Showing GIS Layers of Key Parameters

Proposed Technical Approach (1) - Step by Step

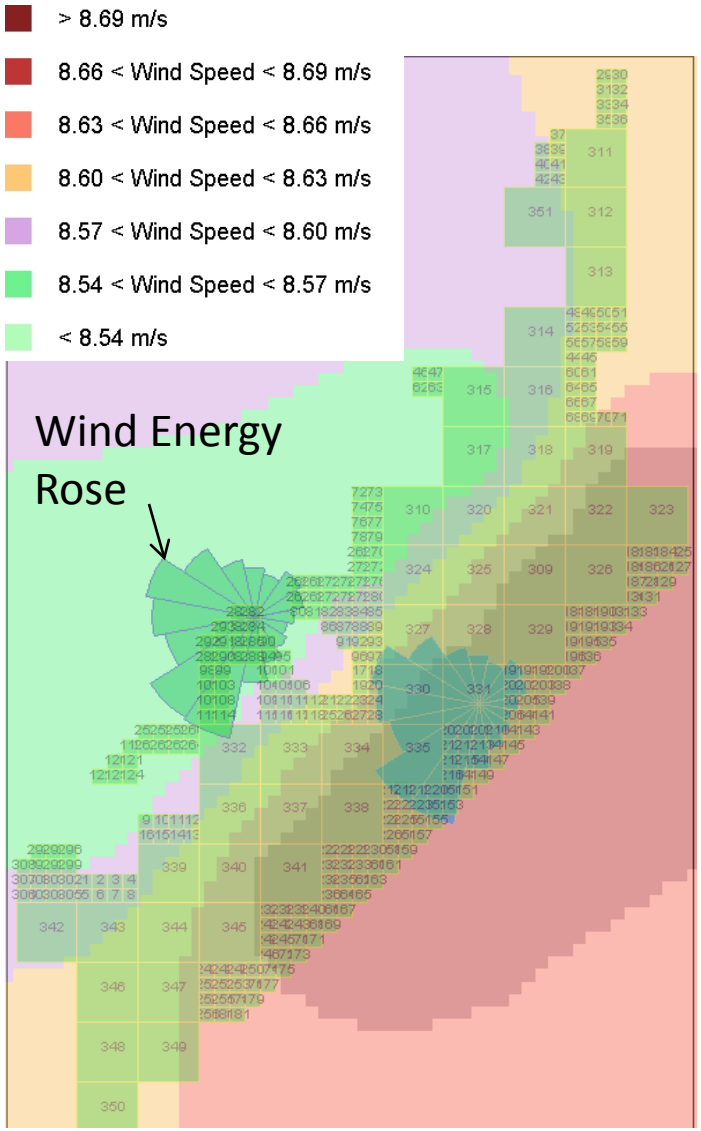
1. Identify and analyze available wind resource data sets and determine best option
2. Establish spatial and temporal distribution of wind characteristics across NJ-WEA
   A. Mean wind speeds
   B. Wind directions
   C. Turbulence intensities



Example NJ-WEA Map of Mean Wind Speeds

Proposed Technical Approach (2) - Step by step

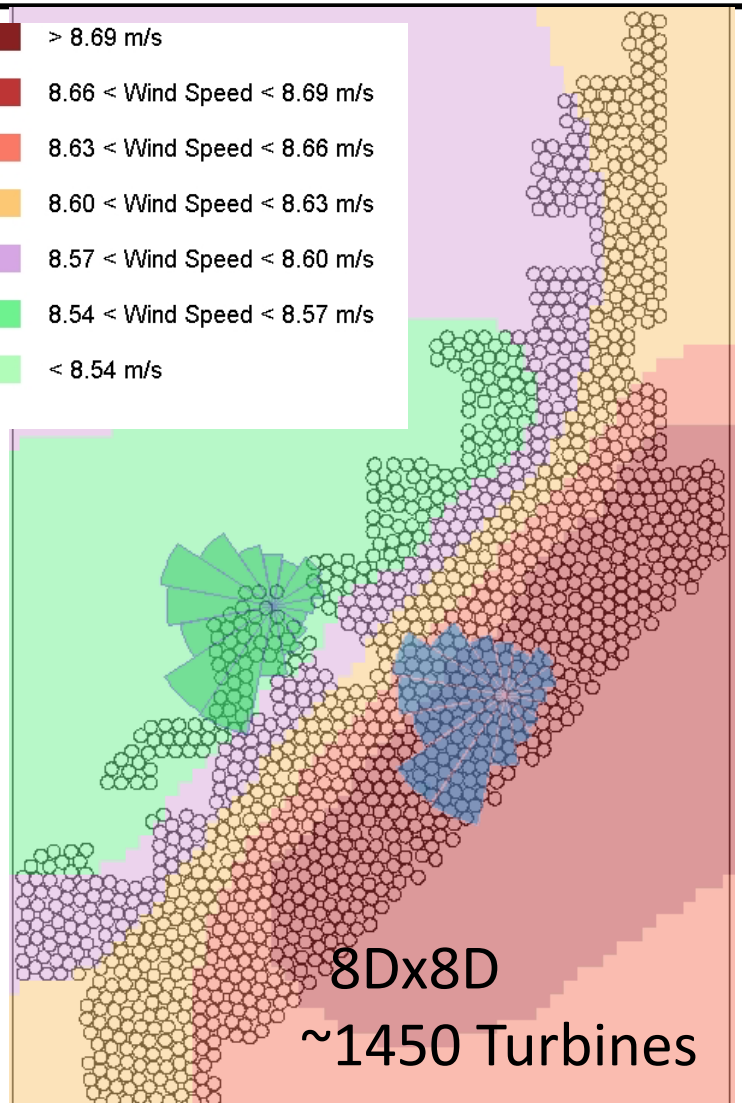
3. Perform detailed analysis of joint wind speed/direction frequency distributions (wind rose) across NJWEA
4. Model the atmospheric turbulence and stability parameters for wake loss calculations



Example NJ-WEA Map of Mean Wind Speeds

Proposed Technical Approach - Step by step

5. Establish various turbine placement options for sensitivity analysis
6. Identify pre-existing buffers due to WEA boundaries
7. Perform analysis to minimize wake losses
8. Identify options to delineate zones and boundaries
9. Vary delineation to generate equitable buffers
10. Finalize layout for best energy production scenarios



NJ-WEA Map Showing Maximum Turbine Development – Upper Bound

Proposed Output to BOEM

- Presentations explaining the methods and process evolution
- Proposed offshore wind zones from a technical resource perspective
- Report detailing:
  - Wind resource data and computational models used
  - Assumptions
    - Turbine type survey
    - Array spacing options
    - Energy loss parameters
  - Results and Conclusions
  - Recommendations and next steps

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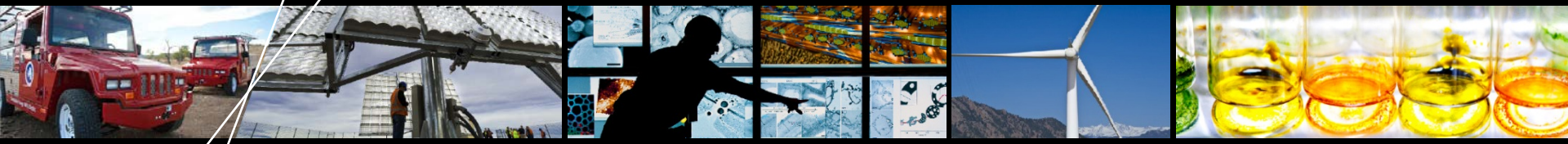

Questions?