WIND AND WATER POWER PROGRAM

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Offshore Wind Technology Overview

BOEMRE North Carolina Task Force Meeting

May 11, 2011

Jesse Johnson

SRA International / U.S. Department of Energy

Jesse.johnson@ee.doe.gov

- **The Opportunity**
- Technology Overview
- Cost of Energy
- National Strategy

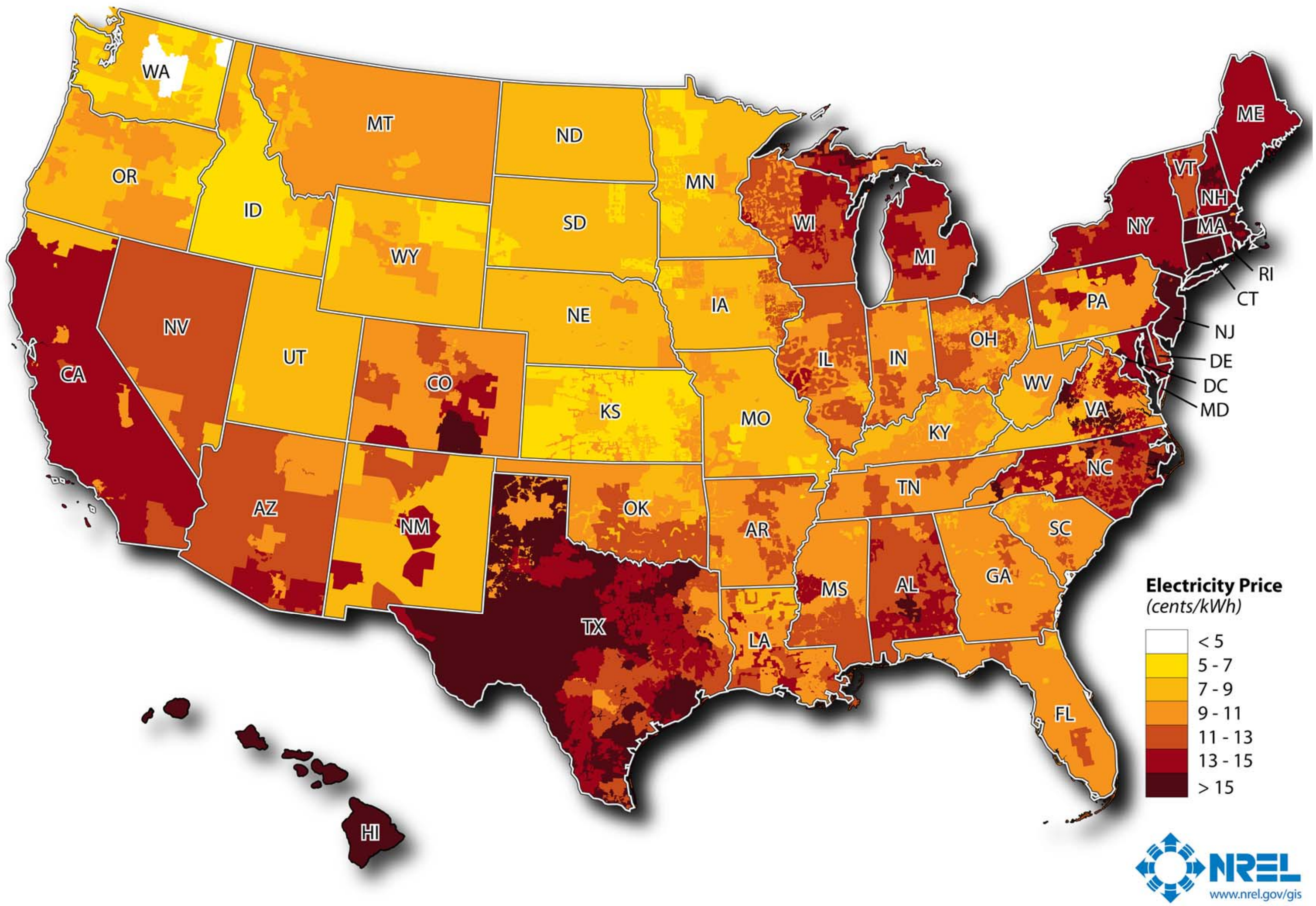
Benefits

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Energy	Environment	Economy
Large renewable resource close to demand centers	Reduced emissions of GHG and air pollutants	Jobs manufacturing, installing, operating, and maintaining systems
Availability matches peak load	Reduced water consumption	Economic recovery and industrial development
Energy diversity & security	Reduced need for new land-based transmission	Potential for cost-competitive electricity in high-price markets

Price of Electricity

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

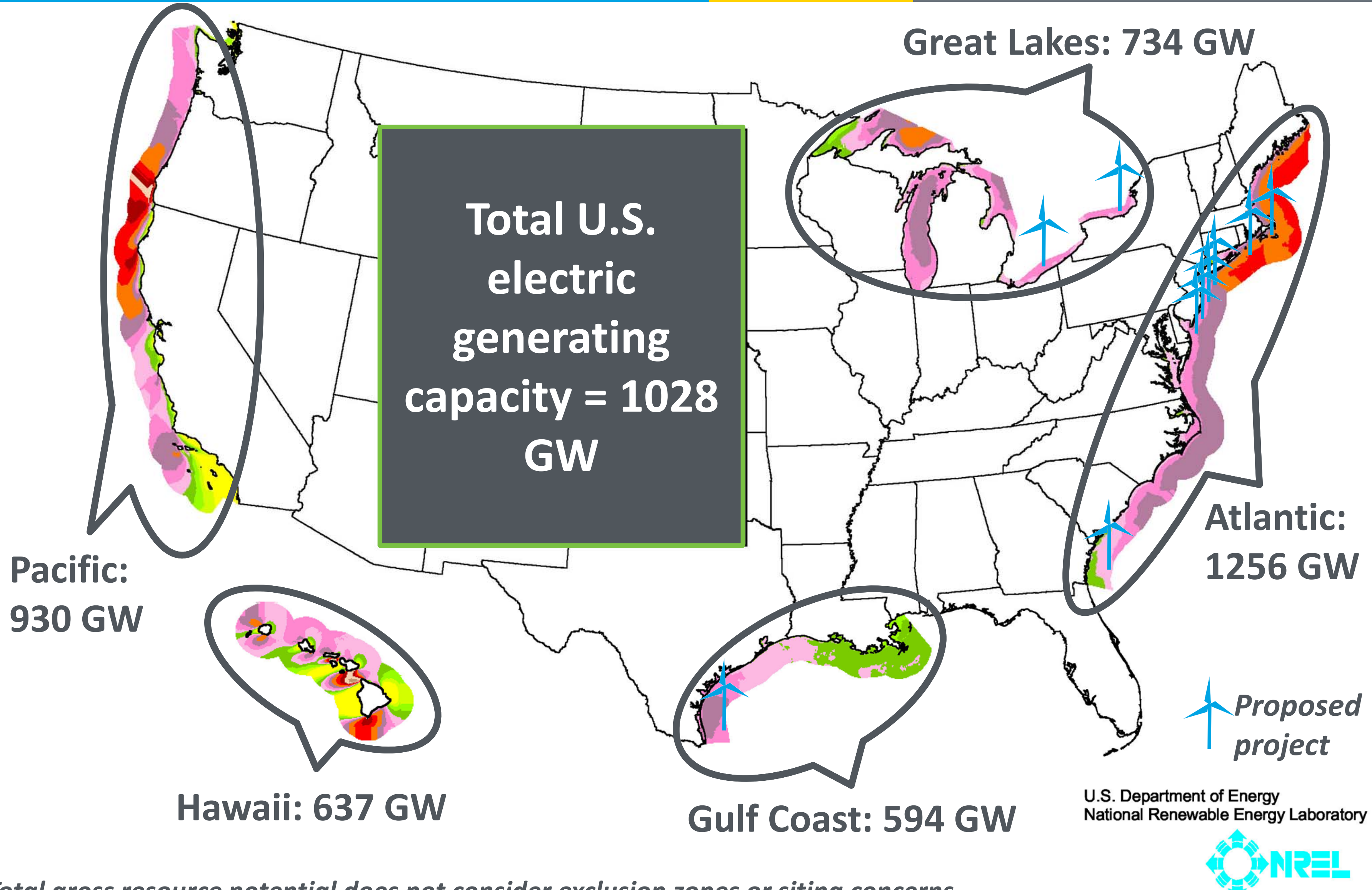


Author : Billy Roberts - March 30, 2010

This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy.

Offshore Wind Resource Potential

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

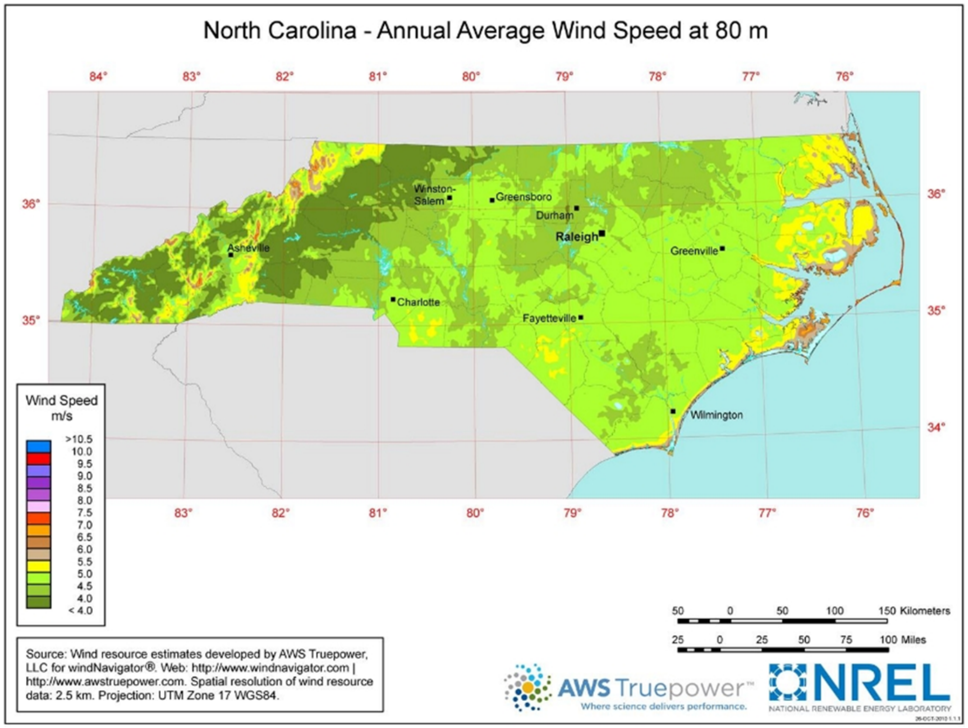


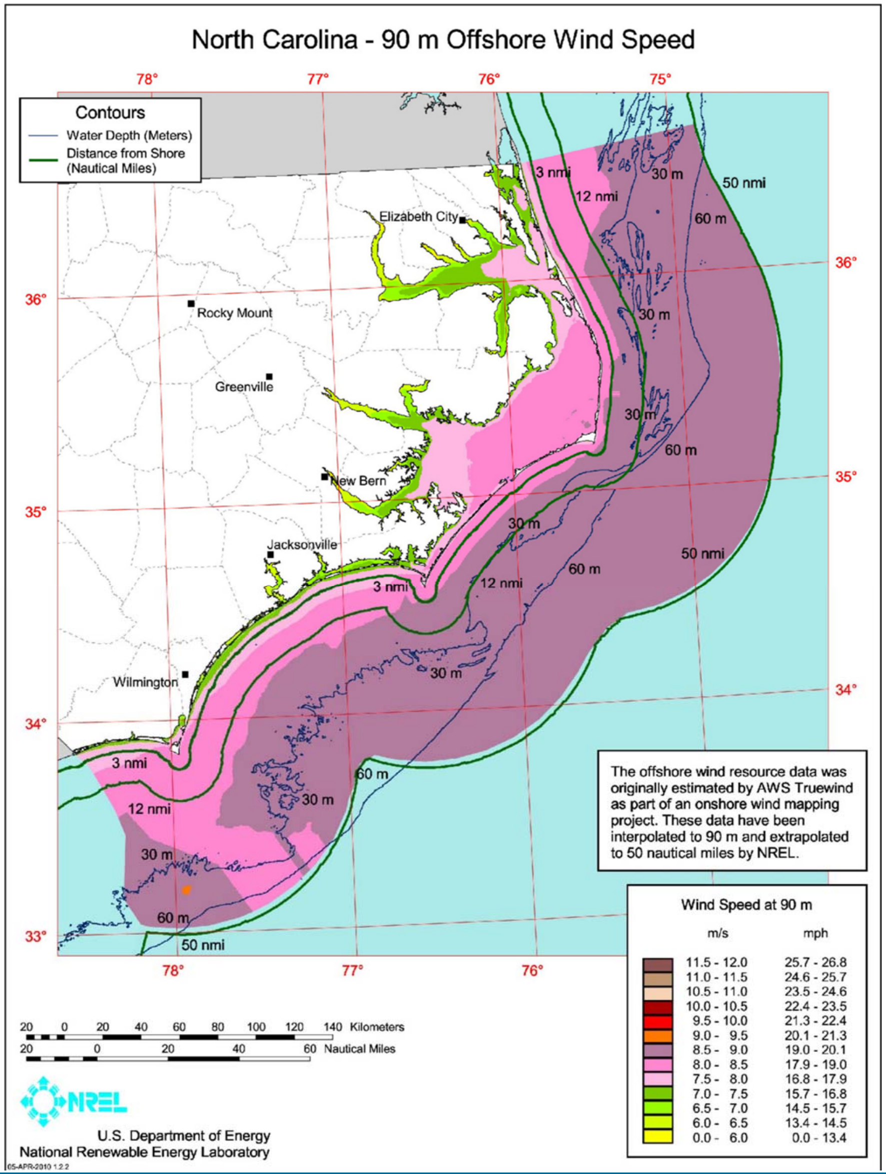
Total gross resource potential does not consider exclusion zones or siting concerns

NC Wind Resource Potential

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

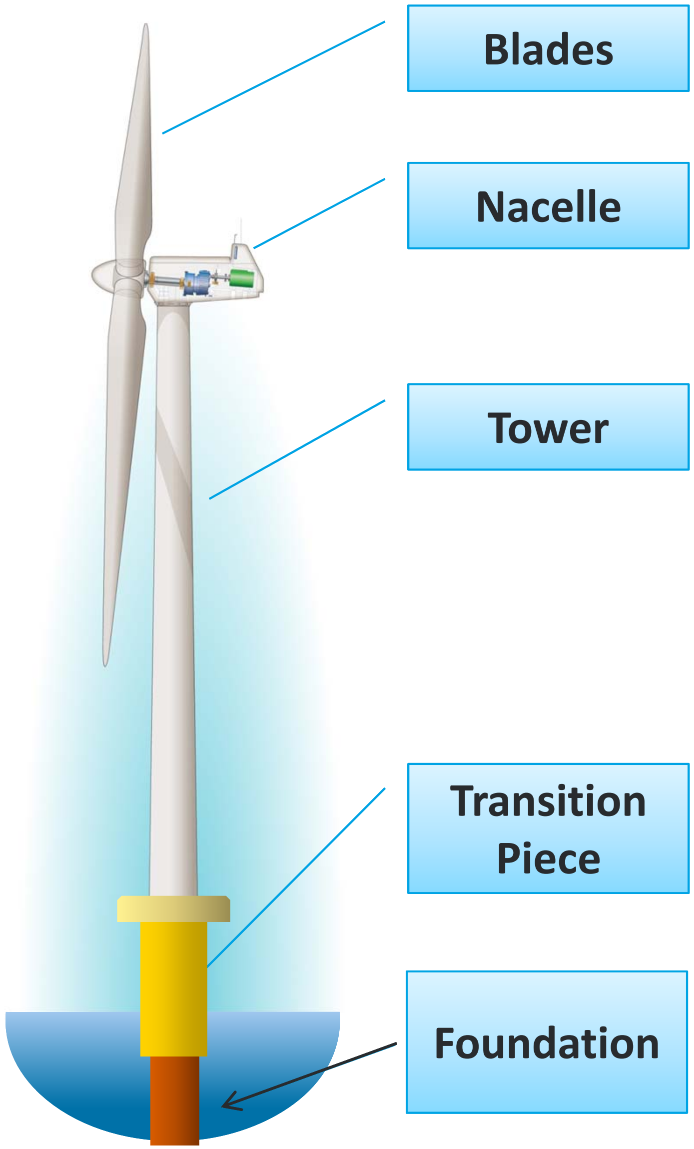
Land-based	Shallow (0-30 m)	Transition (30-60 m)	Deep (60+ m)
1,156 km^2	28,006 km^2	15,544 km^2	15,942 km^2
0.8 GW	**140 GW**	78 GW	80 GW

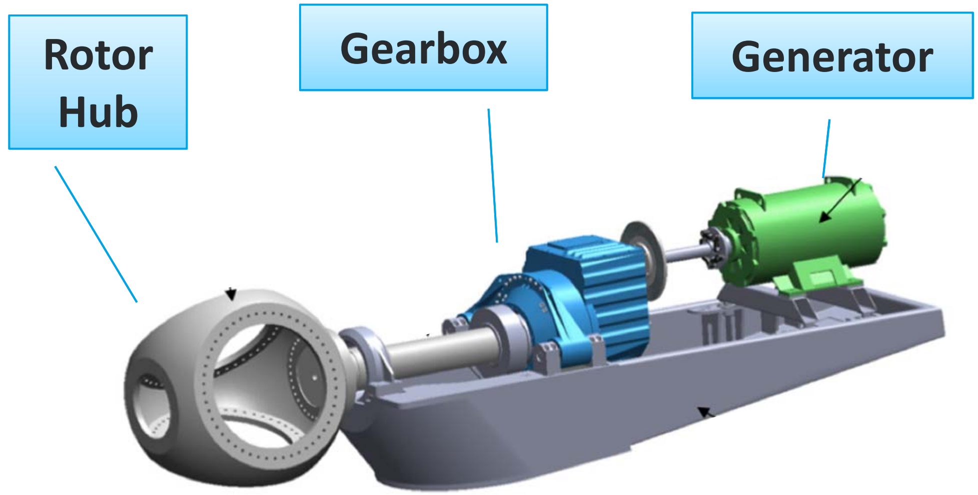


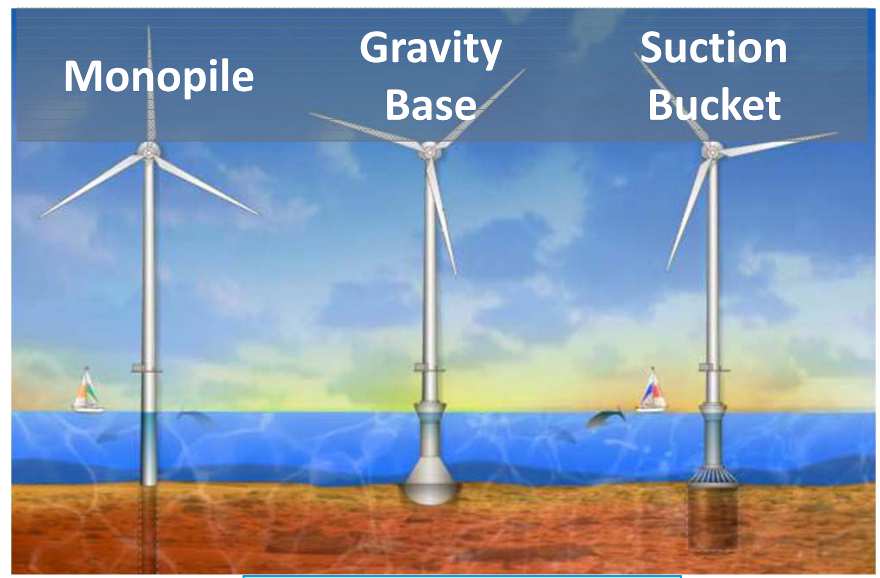


- The Opportunity
- **Technology Overview**
- Cost of Energy
- National Strategy

Turbine Components



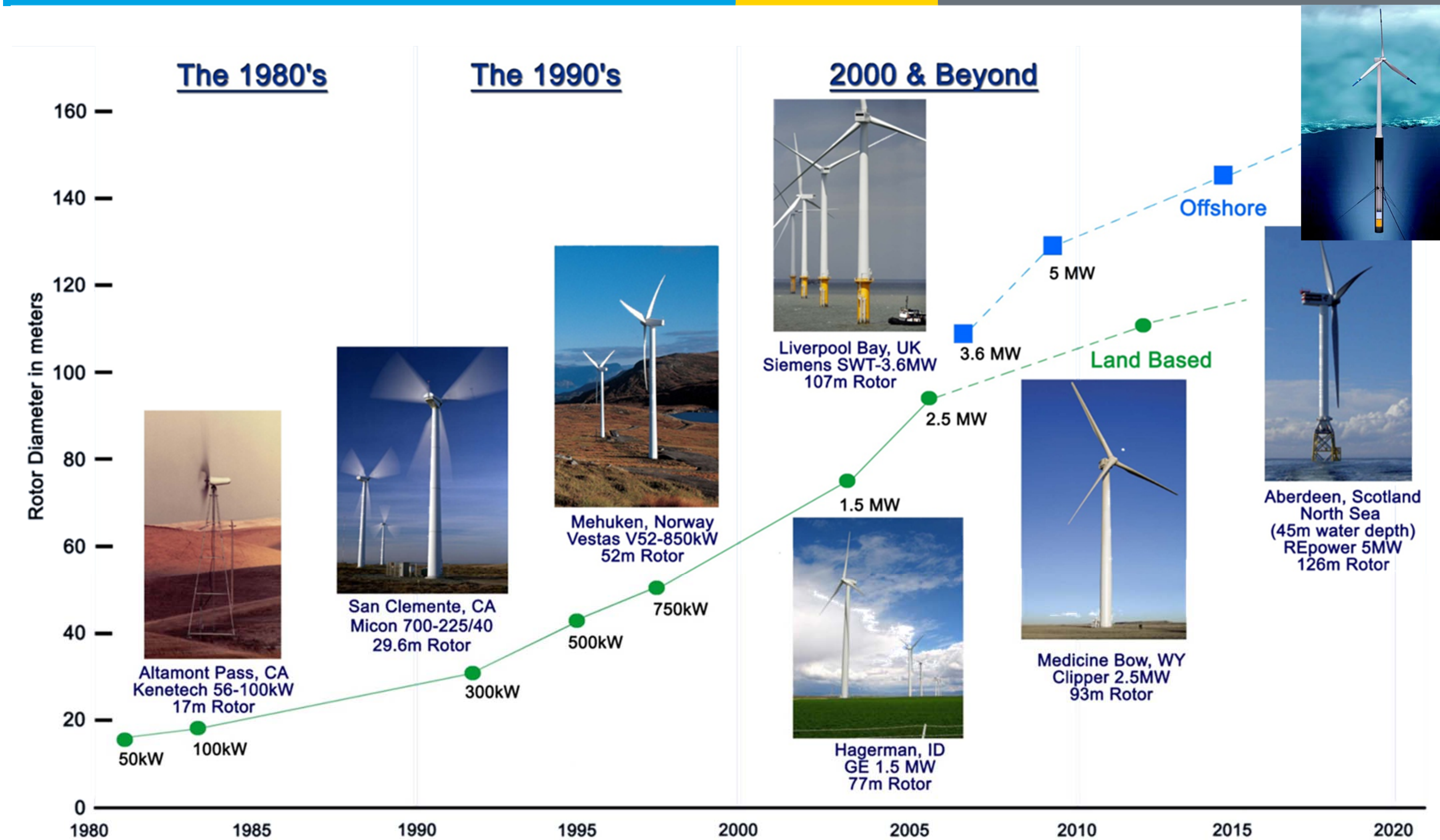




Foundation Designs

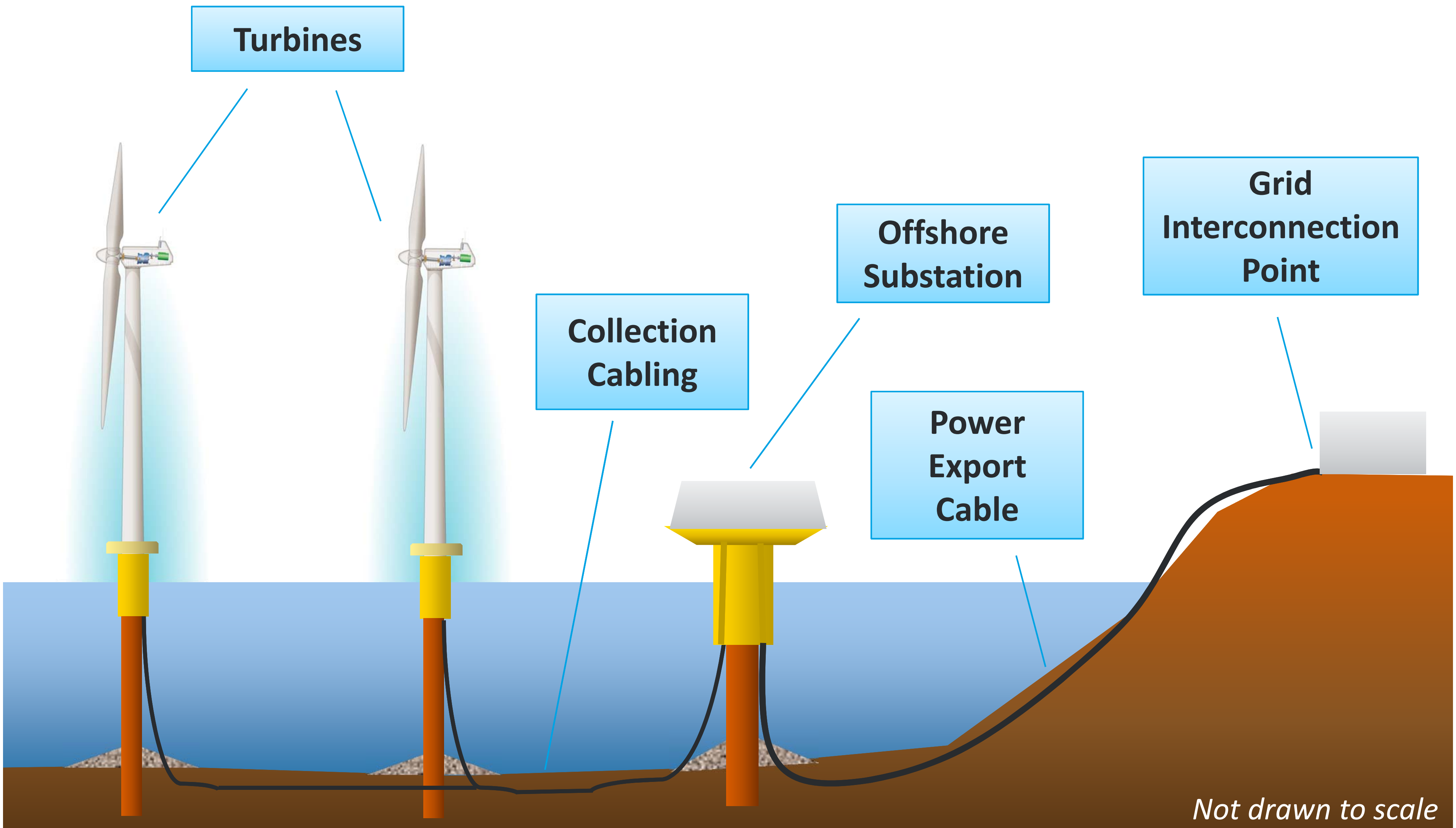
Evolution of Wind Power Technology

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



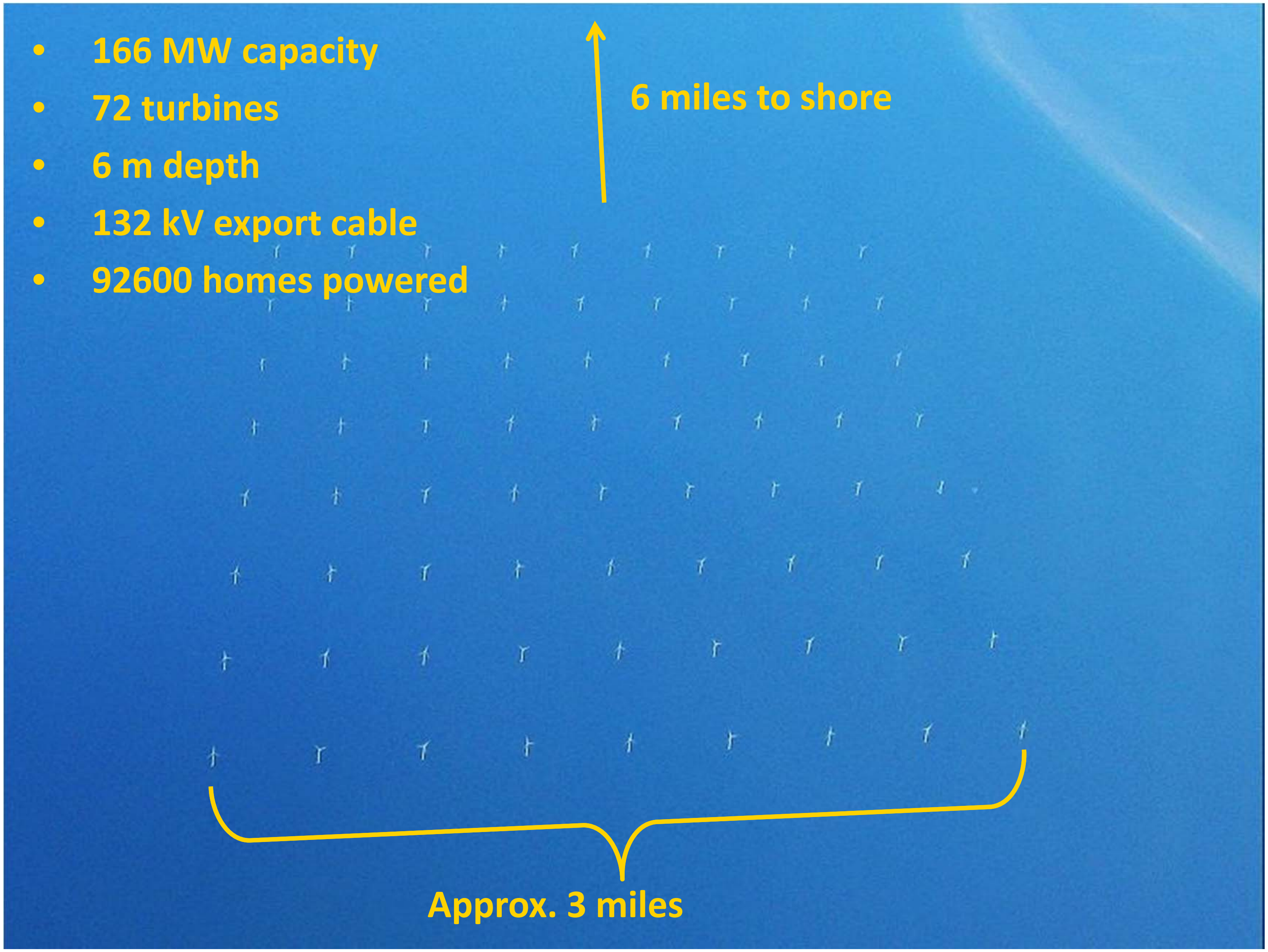
Facility Layout

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



Example: Nysted Windpark

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



Offshore Wind Industry

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- 3,000 MW installed in European waters, ~135 MW in China
- 2 – 5 MW capacity turbines
- Turbine technology largely adapted from land-based turbines
- 70+ meter tower height on monopiles and gravity bases
- Mostly fixed-bottom foundations in shallow water (0-30m)
- Mature submarine power cable technology
- Leverage existing oil and gas experience
- Early growing pains: reliability shortfalls and turbine shortages
- European industry:
  - 1,000 to 1,500 MW of new offshore wind in 2011
  - 19,000 MW currently fully consented
  - $3.75B in investments in 2010
  - 6370 jobs in 2007

Development, Construction, and Operations

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Development

- Wind resource measurement
- Geotechnical & environmental data collection
- Permitting
- Power sale agreement
- Financing

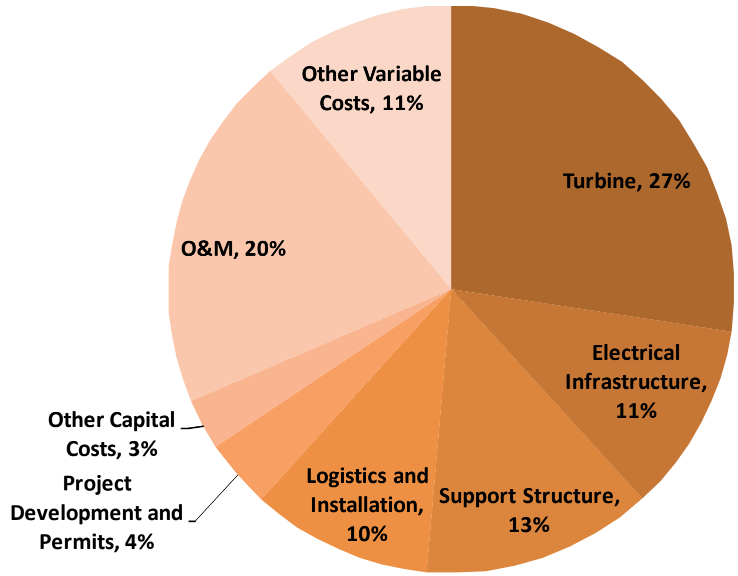
Construction

- Portside staging areas
- Turbine installation vessels
- Cabling vessels
- Narrow weather windows
- Interface issues between multiple contracts

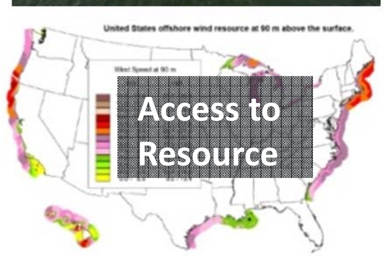
Operations

- Challenging maintenance environment
- Difficulties accessing turbines
- Boat access vs helicopter
- Remote sensing and preventative maintenance are critical

- The Opportunity
- Technology Overview
- **Cost of Energy**
- National Strategy

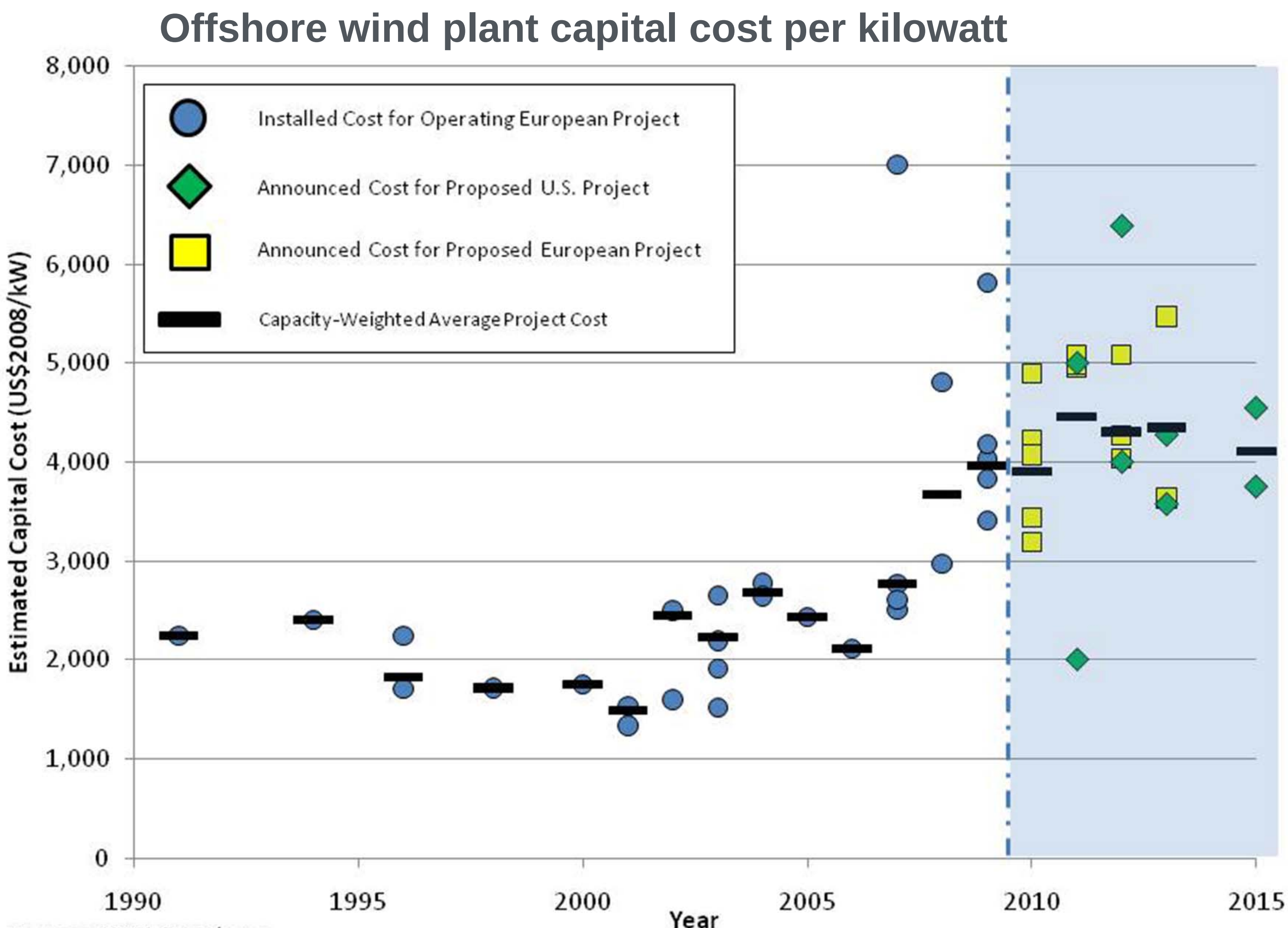


Cost of Energy = Lifetime cost ($) / Lifetime energy capture (kWh)



Capital Cost for Offshore Wind

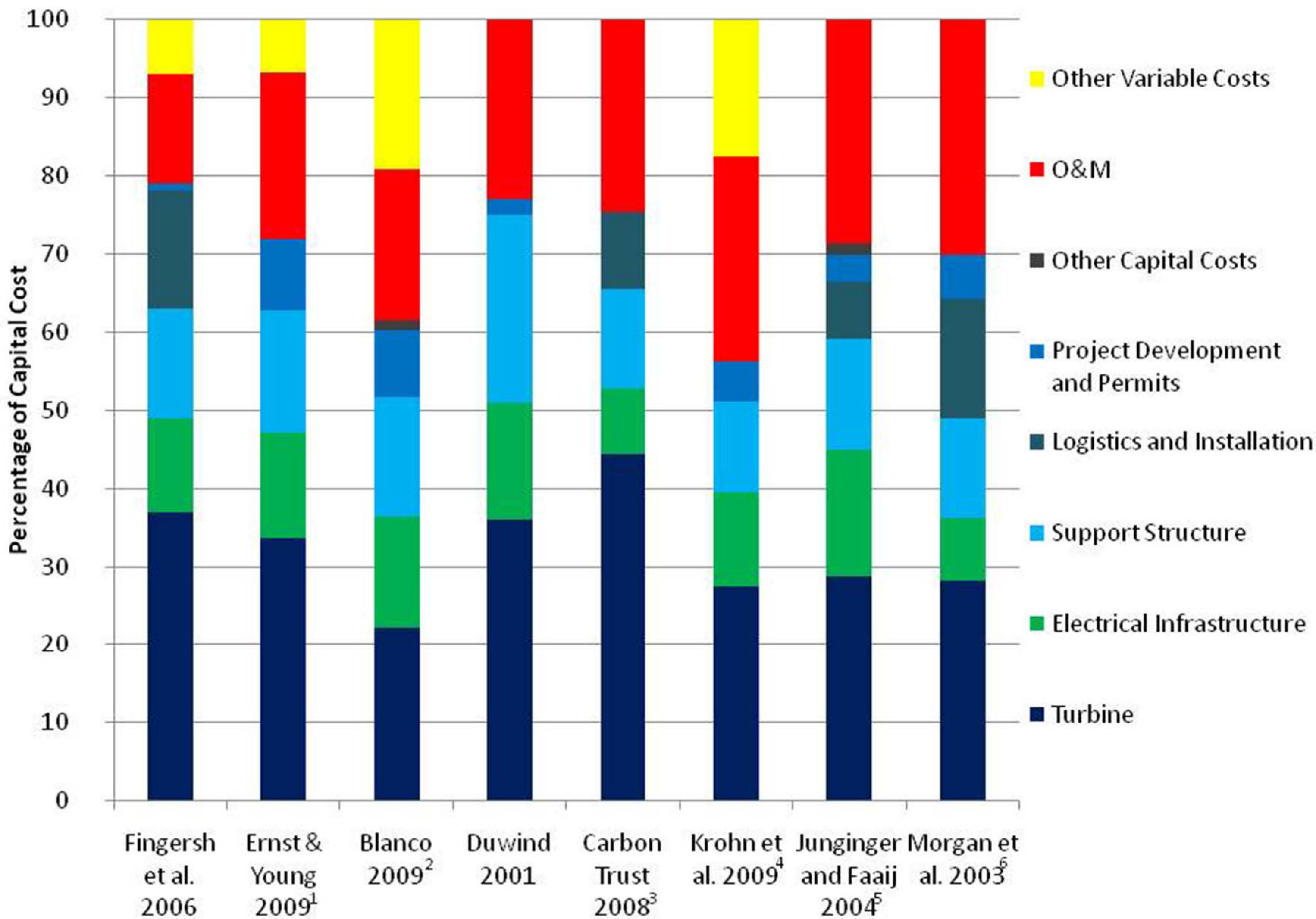
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



Source: *NREL Database*

Offshore Wind Life-Cycle Costs

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

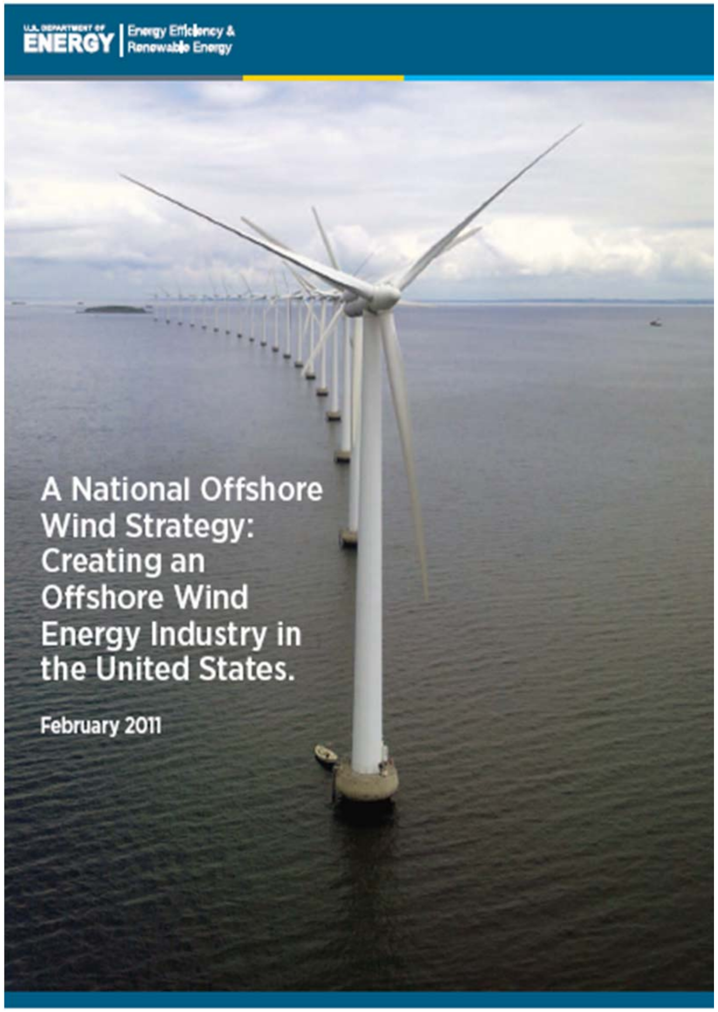


- The Opportunity
- Technology Overview
- Cost of Energy
- **National Strategy**

National Offshore Wind Strategy

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- Department of Energy & Department of the Interior
- Commitment by federal government to developing offshore wind energy resources in a responsible manner
- Supported by $50.5 M in funding for offshore wind research and development



www1.eere.energy.gov/windandhydro/pdfs/national_offshore_wind_strategy.pdf

Major Challenges & DOE Solutions

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

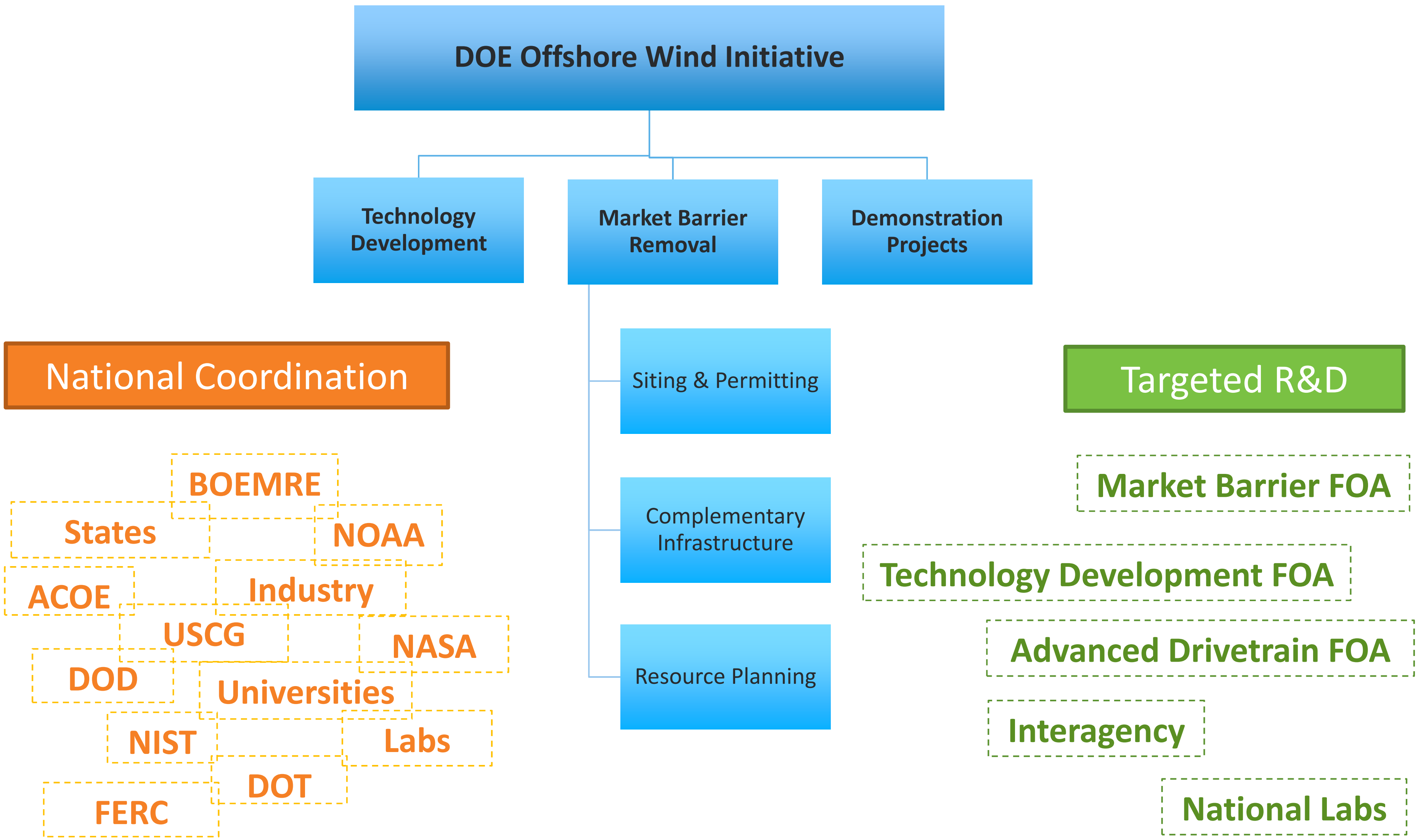
Cost of Energy

- **Reduce capital costs**
  - Larger-scale systems with greater capacities
  - Innovative foundations and platforms
- **Decrease IO&M costs**
  - Ruggedized designs to reduce maintenance
- **Decrease financing costs**
  - Design codes & standards to reduce deployment risks
  - Offshore wind characterization to improve output projections
- **Increase energy capture**
  - Larger rotors, longer blades, and taller towers

Deployment & Infrastructure

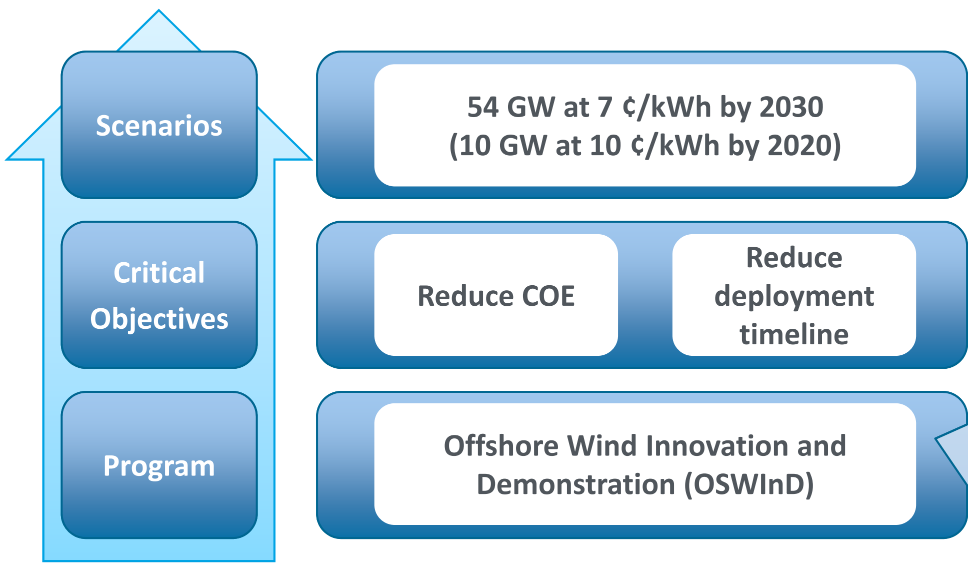
- **Support effective permitting**
  - Provide technical input & assistance to federal & state agencies
  - Applied research on key issues
  - Policy and economic analysis to inform decision-makers
- **Support resource planning**
  - Gather wind resource data for CMSP
  - Provide technical input and data
- **Promote infrastructure development**
  - Domestic supply chain development
  - Interconnect planning
  - Research on specialized vessels and IO&M technology.

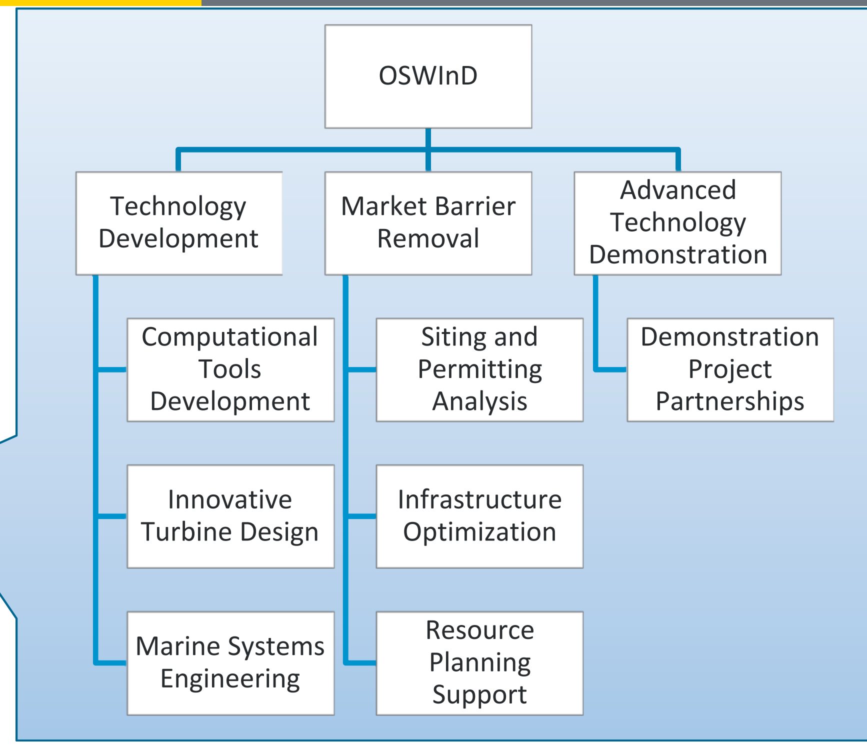
DOE Offshore Wind Initiative

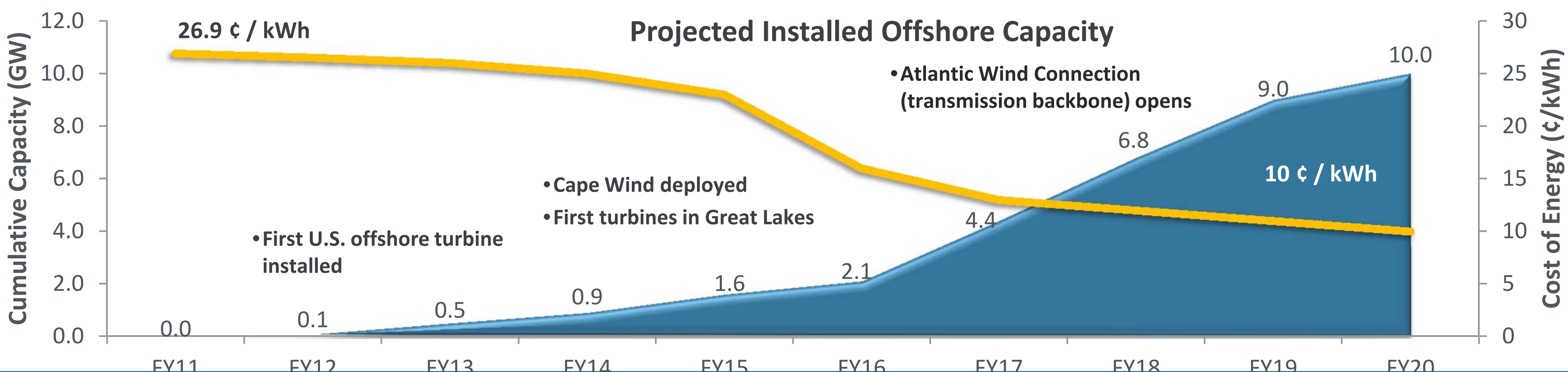


DOE Offshore Wind Strategy

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy








Thank You
Offshore Wind
A Part of our Clean Energy Future

Key Takeaways

1. **The environmental & economic benefits of offshore wind energy are significant.**

2. **The offshore wind resource is substantial.**

3. **The challenges facing offshore wind deployment are daunting:**
   - High capital & financing costs.
   - Lack of specialized infrastructure.
   - Lack of site data and experience with permitting processes.

4. **To realize these benefits in spite of the challenges, DOE will:**
   - Reduce the levelized cost of energy from 26.9 ¢/kWh to 7 ¢/kWh by 2030.
   - Help reduce project deployment timelines.
   - Partner in the installation of the first demonstration-scale projects.

Activities to Date

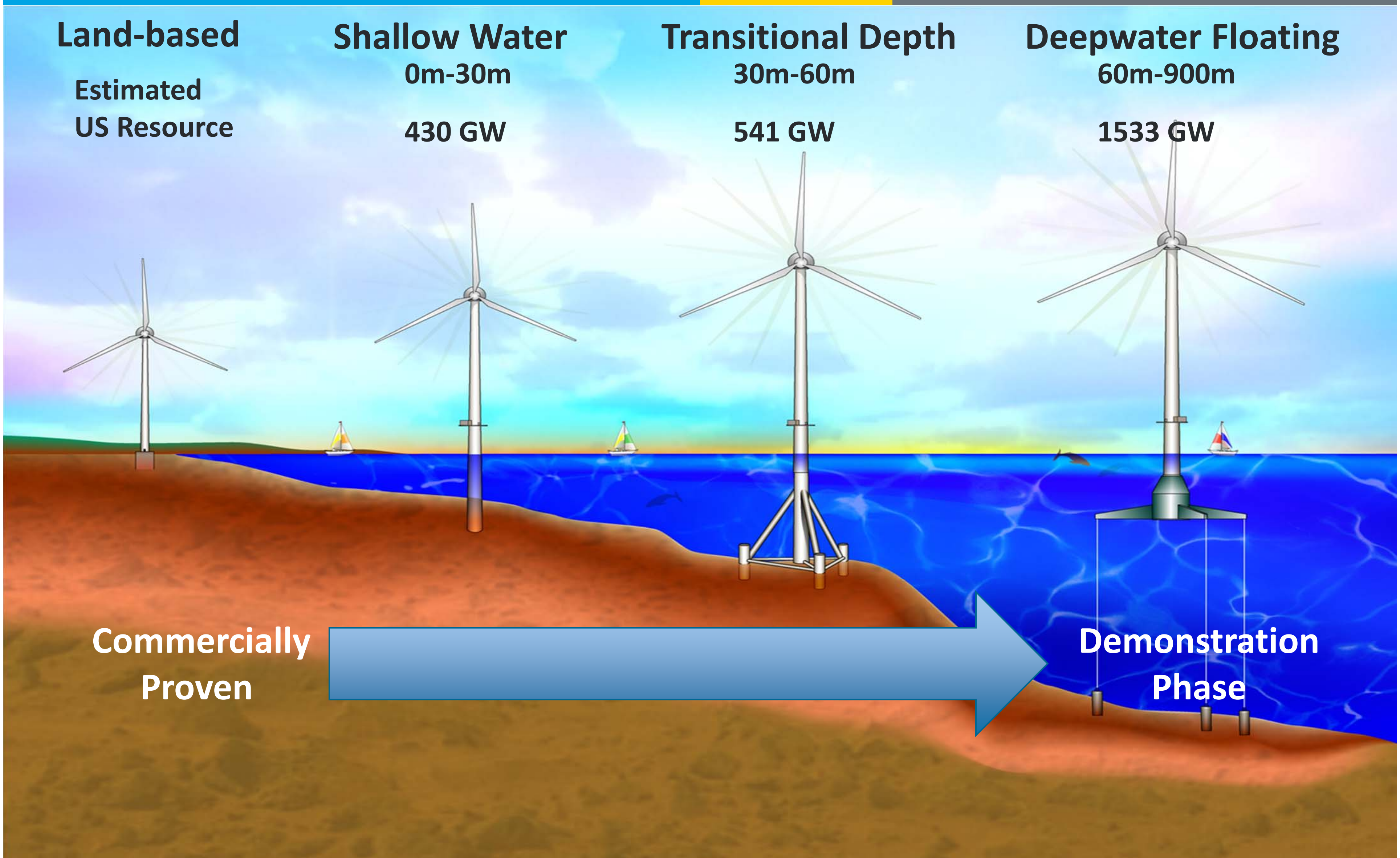
- **FY09 ($1.6 M)**
  - Lab support on environmental impacts and technology assessments.
  - Broad solicitations including offshore awards.
- **Recovery Act ($77.0 M)**
  - Large Blade Test Facility, $25M: facility will test up to 90-m blades for offshore wind turbines to ensure reliability and performance
  - Large Drivetrain Test Facility, $45M: facility will test up to 15 MW drivetrains for large offshore turbines to validate designs
  - U-Maine Floating Turbine Development, $7M: developing innovative floating turbine platforms for deepwater deployment (2450 GW resource)
- **FY10 ($8.8 M)**
  - Signed MOU with DOI-BOEMRE to facilitate offshore wind deployment.
  - NREL published *Large-Scale Offshore Wind Power in the United States*.
  - Awarded $ 500k for research to fill critical data gaps in the permitting process.
- **FY11 ($49.1 M requested)**
  - Published *National Offshore Wind Strategy* in conjunction with DOI.
  - Issued $50.5 M in solicitations for offshore wind R&D.

Offshore Wind Technology Tomorrow

Offshore Technology is Dynamic: 7+ MW Power, Vertical Axis Turbines, Tripod, Floating, and Jacket Foundations are already in prototype stage.

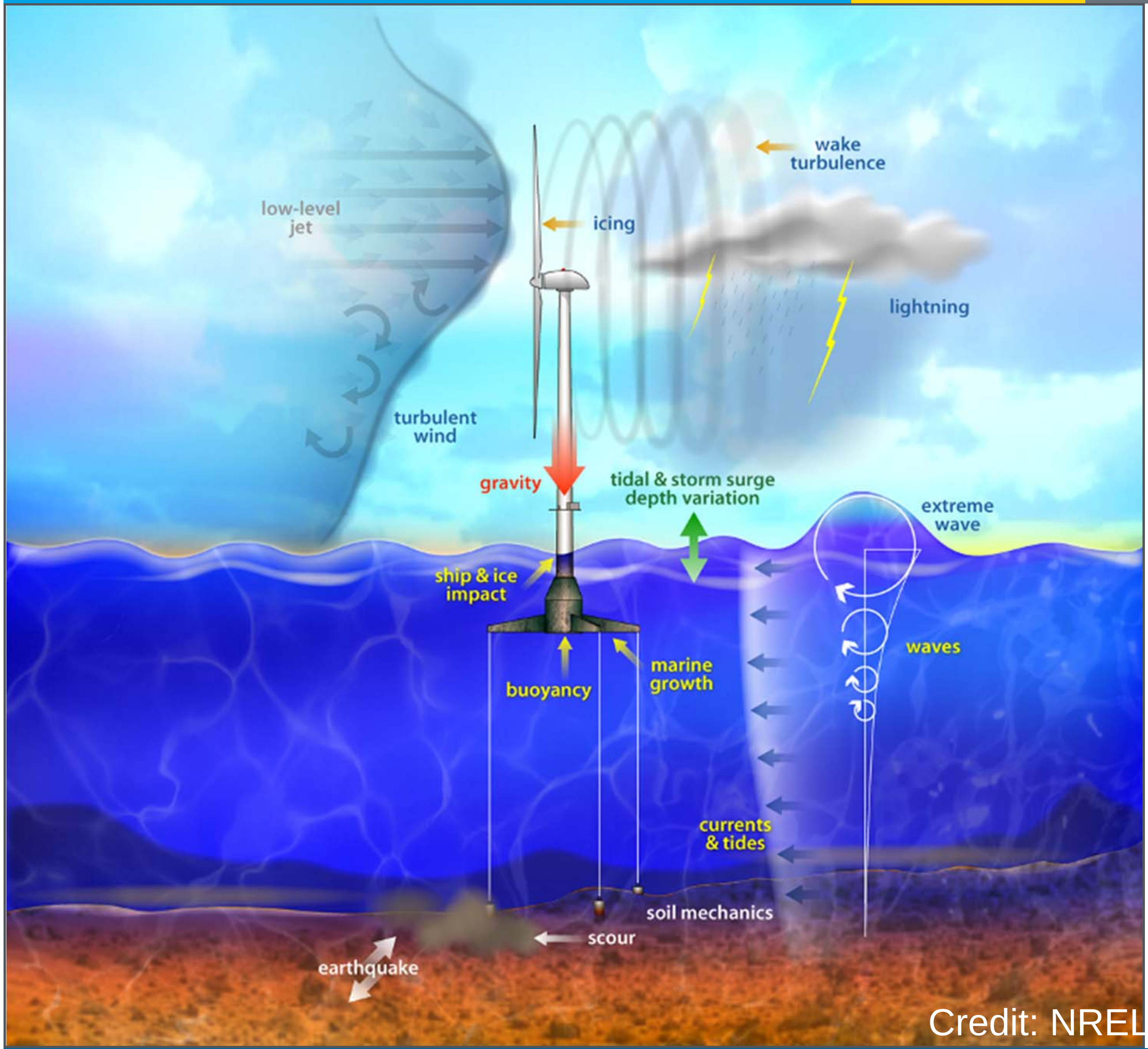
Offshore Wind Platform Development

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



Environment Drives the Design

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



Land-Based Turbine

Offshore Turbine