



# US Offshore Technology Overview

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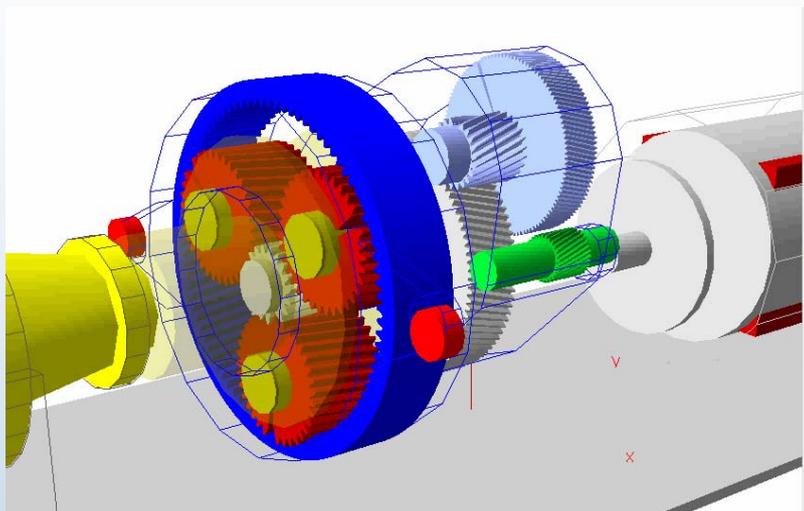
# Offshore Technology Summary

- European deployment continues to focus on offshore (currently ~ 1000MW)
- Companies are focusing more on reliability and less on larger turbines
- Monopiles continue to be the support structure of choice in shallow water (accept Beatrice project).
- US structural safety requirements yet to be defined
- US offshore will require deeper water technology for wide spread deployment

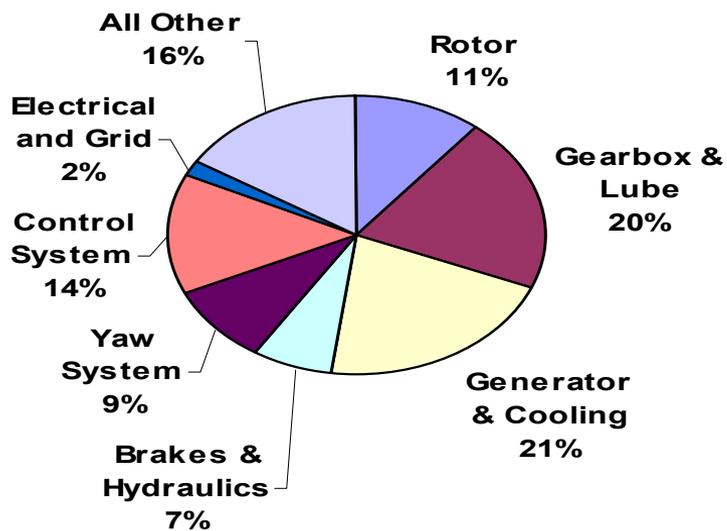
# O&M / Reliability / Drivetrain R&D

Today: Reliability R&D

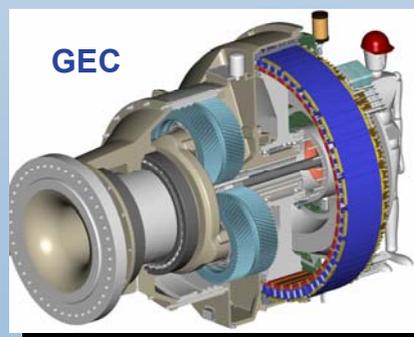
Tomorrow: Advanced Technology



## O&M Costs



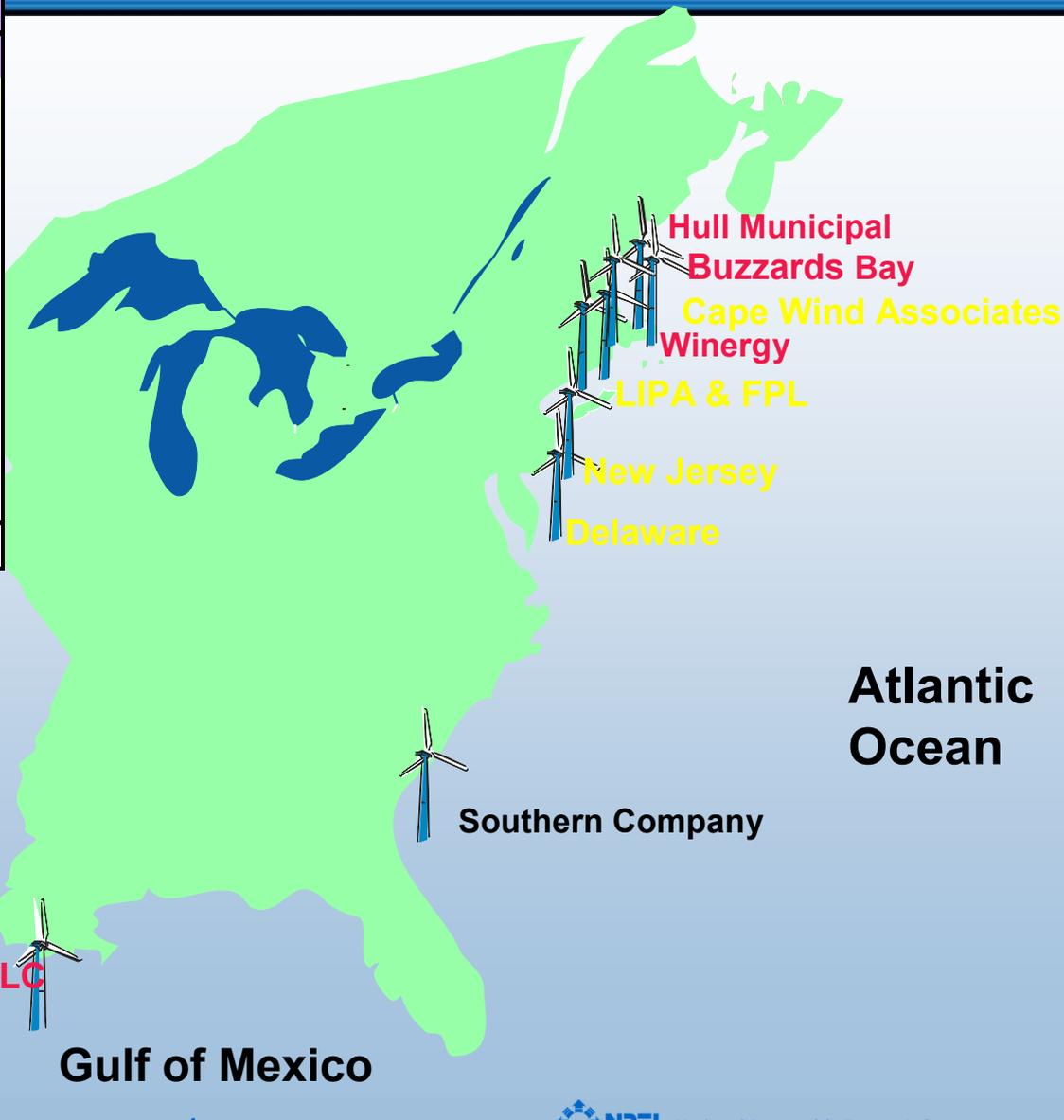
Clipper 2.5MW



# US Projects Proposed

## US Offshore Projects

Project	State	MW
Capewind	MA	420
LIPA	NY	150
Winergy (plum Island)	NY	10
Southern Company	GA	10
W.E.S.T.	TX	150
Superior Renewable	TX	500
Buzzards Bay	MA	300
New Jersey	NJ	300
Hull Municipal	MA	15
Delaware	DE	600
<b>Total</b>		<b>2455</b>



**No offshore wind projects installed in the US yet.**

**Atlantic Ocean**

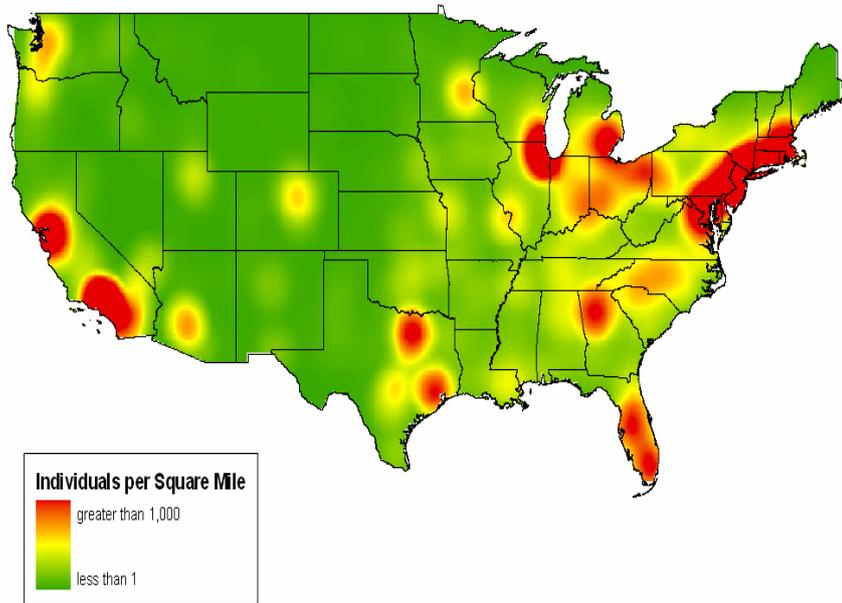
**Gulf of Mexico**

# Why Offshore Wind ?

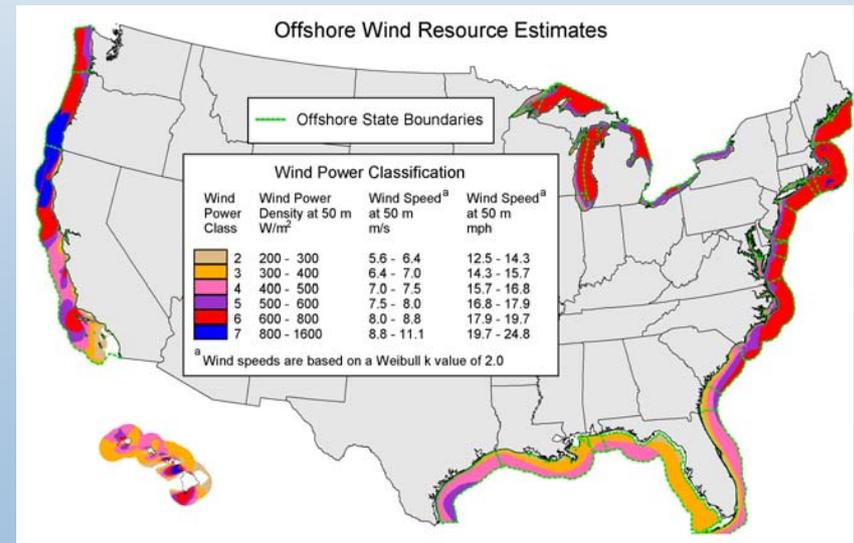
## ■ Proximity

- Land-based sites are not close to coastal load centers
- Load centers are close to offshore wind sites
- 28 coastal states use 78% of electricity in the US

## US Population Concentration



## US Wind Resource



# Wind Energy Technology Challenges & Future

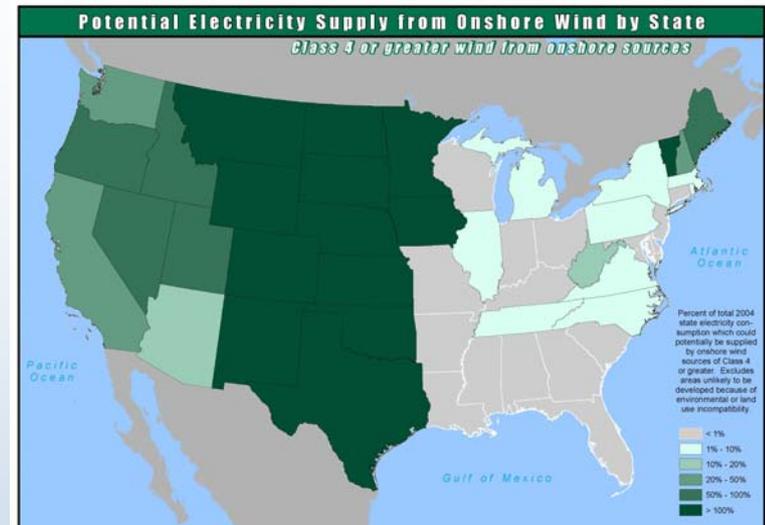
## Land-Based Energy Potential

### Land Based

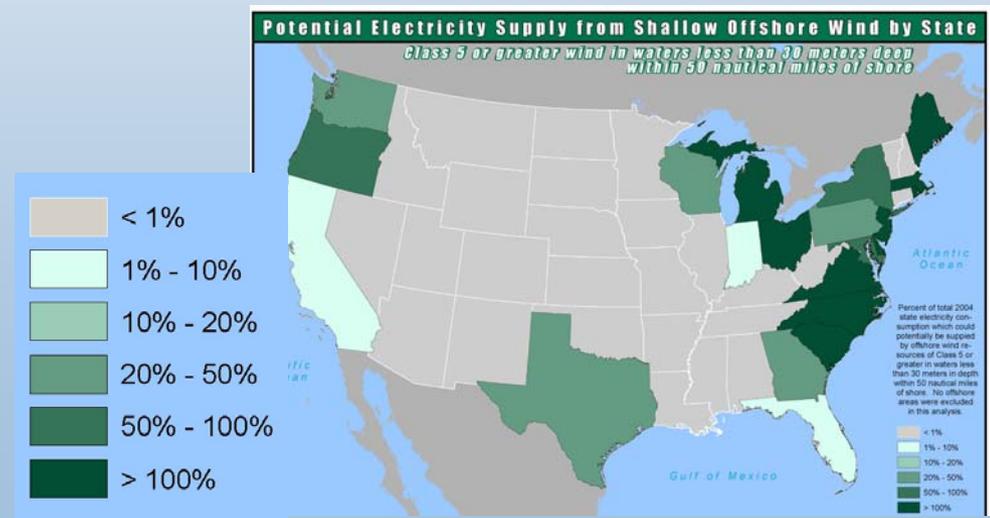
- Reliability improvement
  - Drive trains, blades, electronics,
- Low wind speed turbine technology
  - Higher capacity factors (larger rotors, tall towers)
  - Lower initial capital cost
  - Advanced Rotor Development
    - Generator, Drivetrain, and Power Electronics

### Offshore

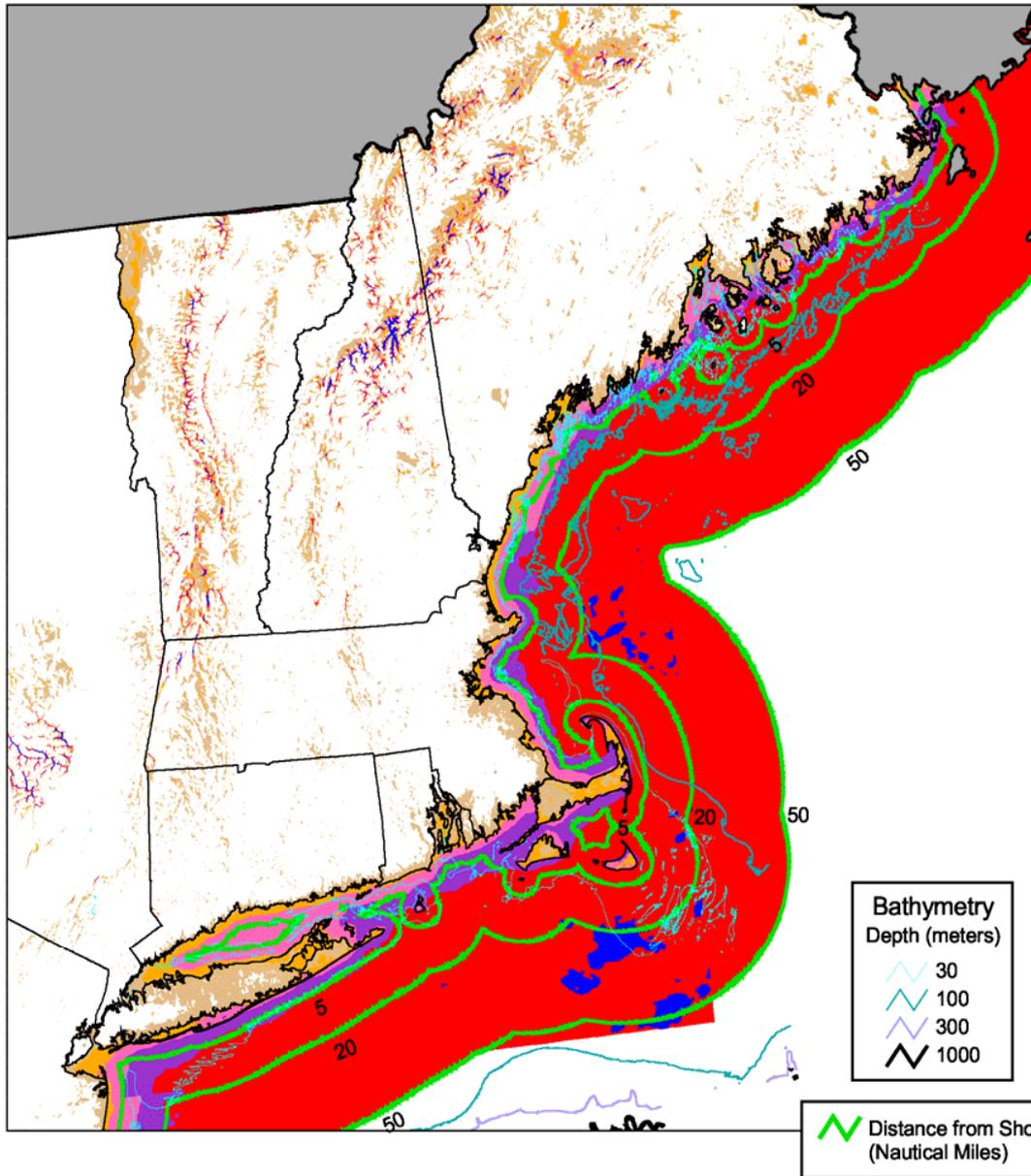
- Regulatory, community acceptance, supply
- Cost Reduction (25% - 35%: \$2400 \$1800/kw)
- Reliability
  - Light weight rotor/nacelle assemblies (high tip speed, down wind, flexible blades) →
  - Larger turbines (5 – 10 MW)
  - Innovative low cost support structures (shallow & medium depth first)
  - Long term: floating platforms (after extensive research and offshore experience)



## Shallow Water (0 – 30m) Energy Potential



# New England Offshore Resource



Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m <sup>2</sup>	Wind Speed <sup>a</sup> at 50 m m/s	Wind Speed <sup>a</sup> at 50 m mph
2	Marginal	200 - 300	5.6 - 6.4	12.5 - 14.3
3	Fair	300 - 400	6.4 - 7.0	14.3 - 15.7
4	Good	400 - 500	7.0 - 7.5	15.7 - 16.8
5	Excellent	500 - 600	7.5 - 8.0	16.8 - 17.9
6	Outstanding	600 - 800	8.0 - 8.8	17.9 - 19.7
7	Superb	> 800	> 8.8	> 19.7

<sup>a</sup> Wind speeds are based on a Weibull k value of 2.0

U.S. Department of Energy  
National Renewable Energy Laboratory

# Offshore Technology Status



Vestas 2.0 MW Turbine  
Horns Rev, DK



GE 3.6 MW Turbine  
Arklow Banks  
ITI Energy CRADA Midterm



Talisman Energy:  
Repower 5-MW  
Beatrice Fields,  
Scotland



Seimens 2.3 MW Turbines  
Middlegrunden, DK

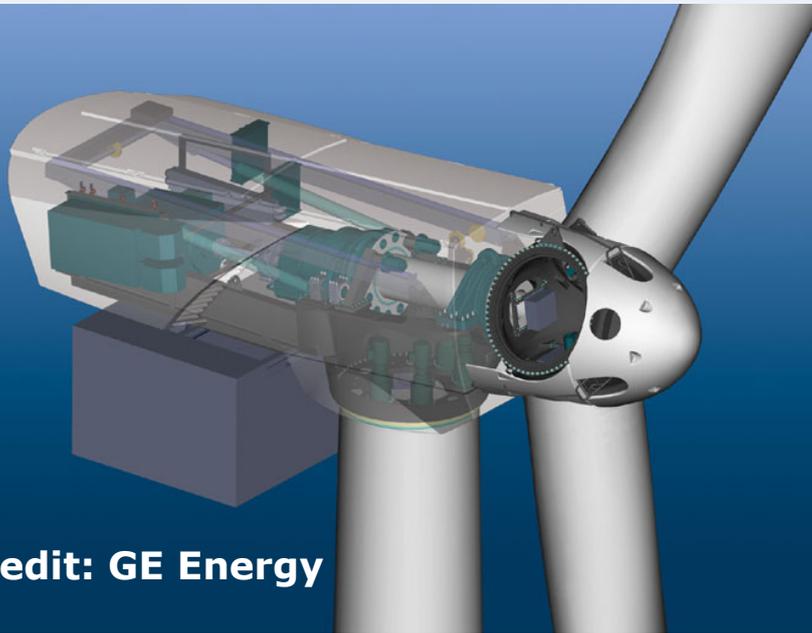
## Offshore Technology

- In the initial development and demonstration stage; 19 Projects, 900 MW Installed, shallow water
- 3 – 5 MW Upwind Configuration
- 80+ Meter Towers on Monopoles
- Three stage hybrid planetary-helical gearbox
- Full Span Pitch Control
- Advanced Controls for Load Dampening
- Full Power Conversion
- Steel Tapered & Lattice Towers

## Performance

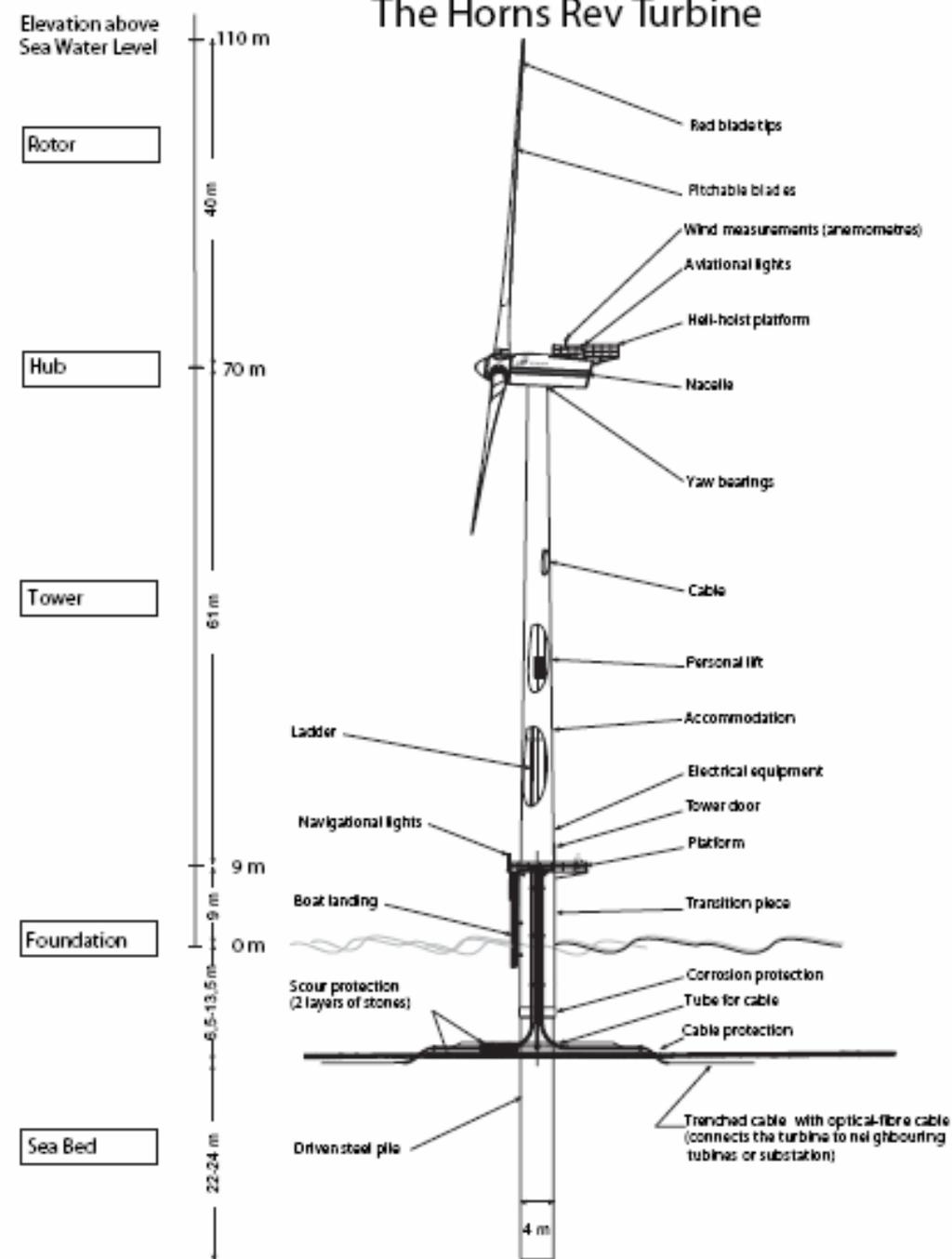
- Average 40% Capacity Factor
- Technology Development, Deployment & Demonstration Stage; Availability & Cost Are Not Well Established

# Typical Offshore Wind Turbine



Credit: GE Energy

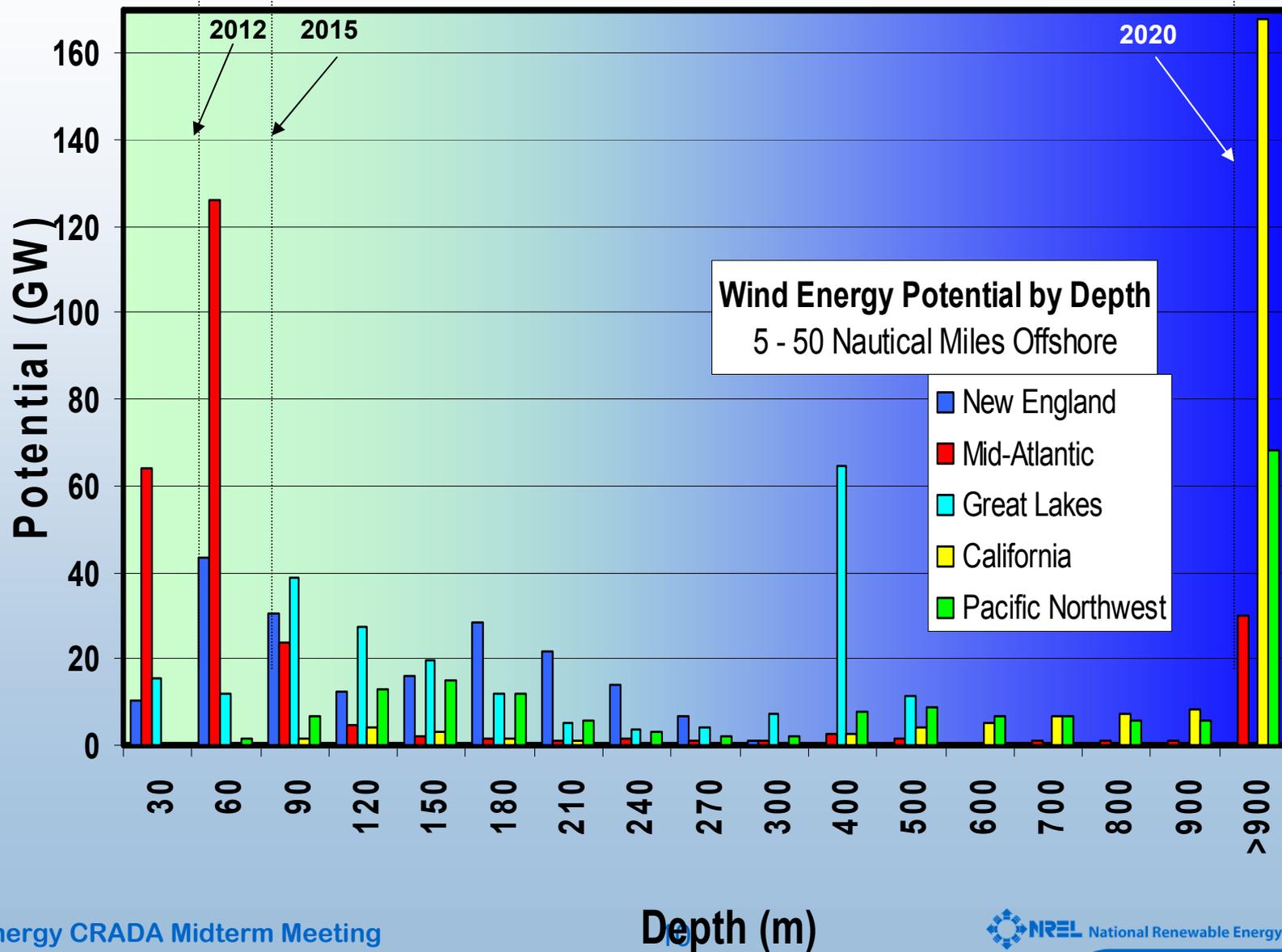
## The Horns Rev Turbine



Principal Components and Dimensions of an Offshore Wind Turbine

Graphic courtesy of Horns Rev wind project, Denmark (<http://www.hornsrev.dk>). Copyright Elsam A/S.

# Depth Matters



# Offshore Wind Turbine Development for Deep Water

Europe today:  
1000 MW

500 GW



Onshore  
Wind Turbine



Monopile  
Foundation  
depth  
0 - 30 m



Tripod  
fixed bottom  
depth  
20 - 80 m



Floating  
Structure  
depth  
40 - 900 m

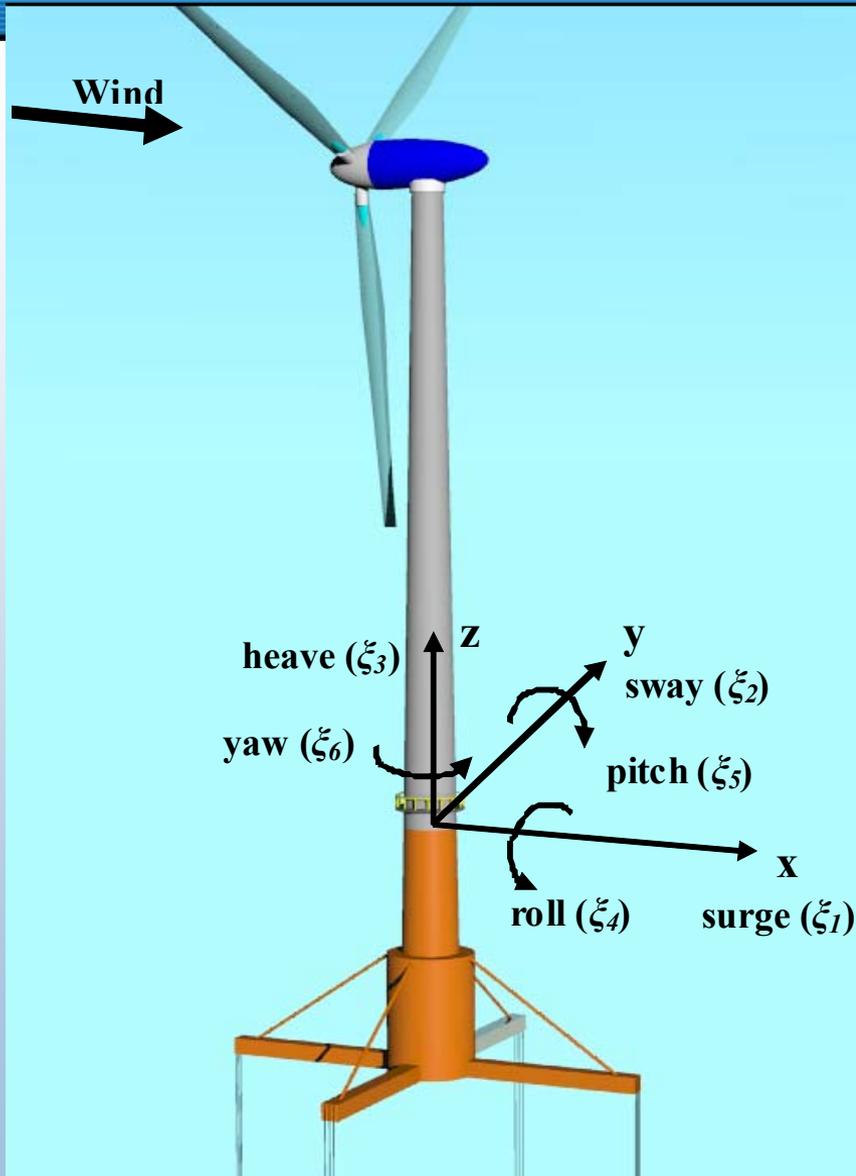
US Potential 90 GW

Current Technology

180 GW



# Key Offshore Research



- Reliable analytical design techniques
- Design basis
  - External conditions
  - Installation
  - Access
  - Stability
- Low cost deepwater support structures
- Offshore turbine designs

# Deeper Water Technology

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