Offshore Wind Energy Technology

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Offshore Wind Benefits

- Better wind resources
  - Reduced turbulence – steadier wind
  - Higher wind speed/ energy production
- Aesthetics – Greater distances minimize visual impacts.
- Shorter transmission distances
  - Proximity to high cost load centers
  - Access to less heavily loaded lines
- Avoid onshore size constraints
  - **Shipping** – onshore roadway limits
  - **Erection** – crane limits
  - Larger machines are more economical.

Wind Energy Cost Trends

1981: 40 cents/kWh

- **Increased Turbine Size**
- **R&D Advances**
- **Manufacturing Improvements**

2006: 9.5 cents/kWh

- **Multi-megawatt Turbines**
- **High reliability systems**
- **Infrastructure Improvements**

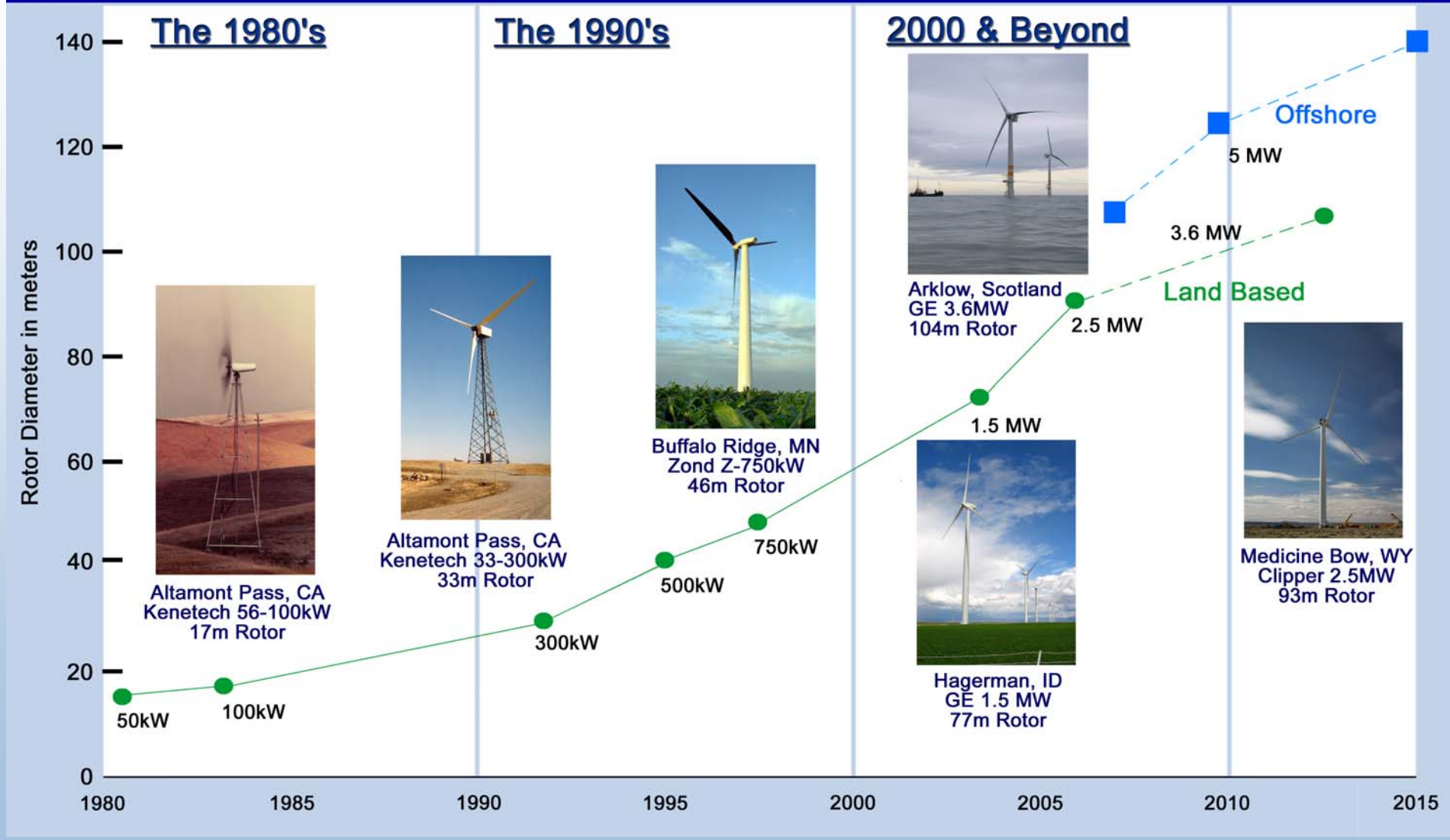
Land-based

Offshore

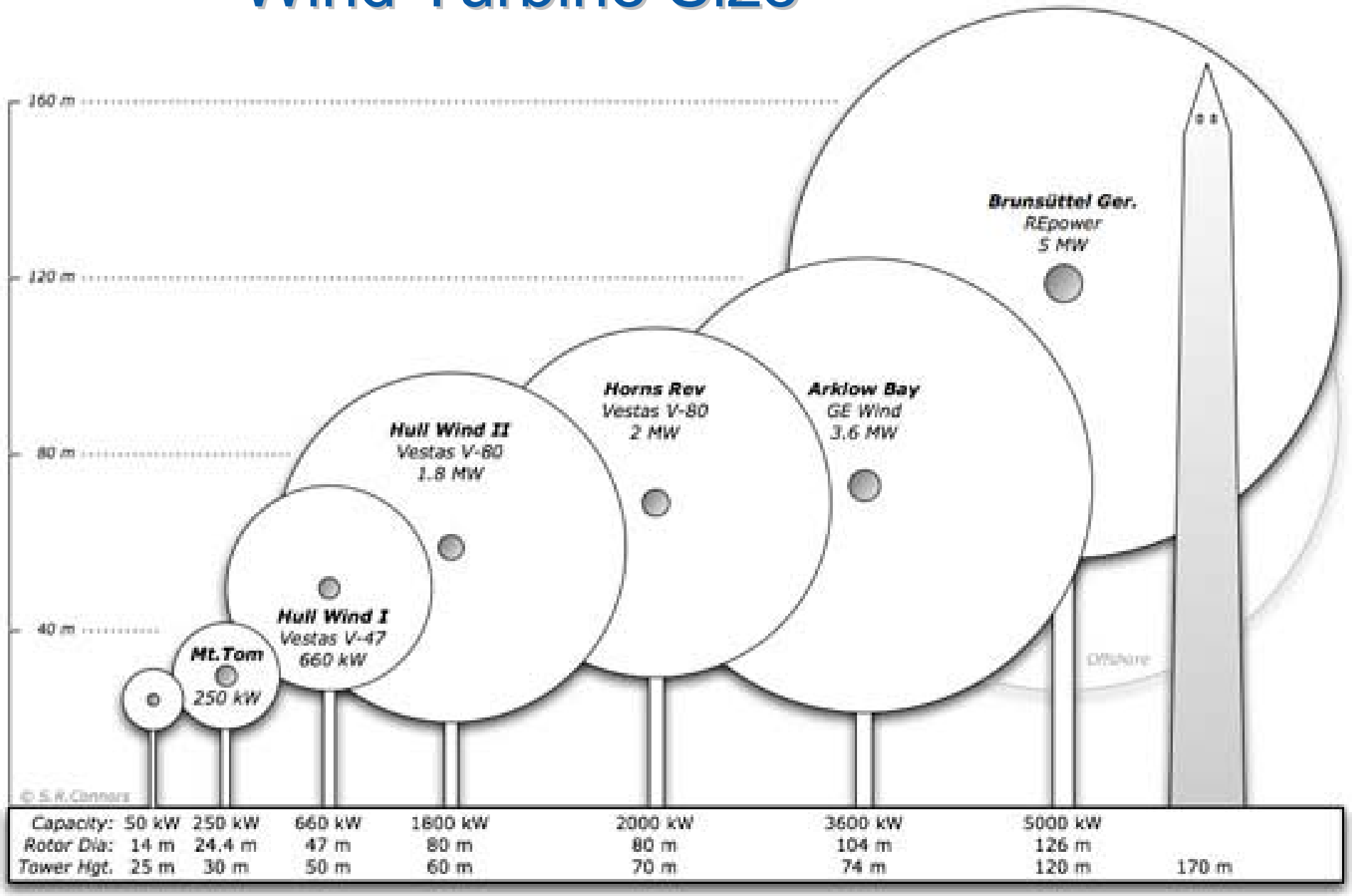
2006: 4 - 6 cents/kWh
2012: 3.6 cents/kWh

2014: 5 cents/kWh

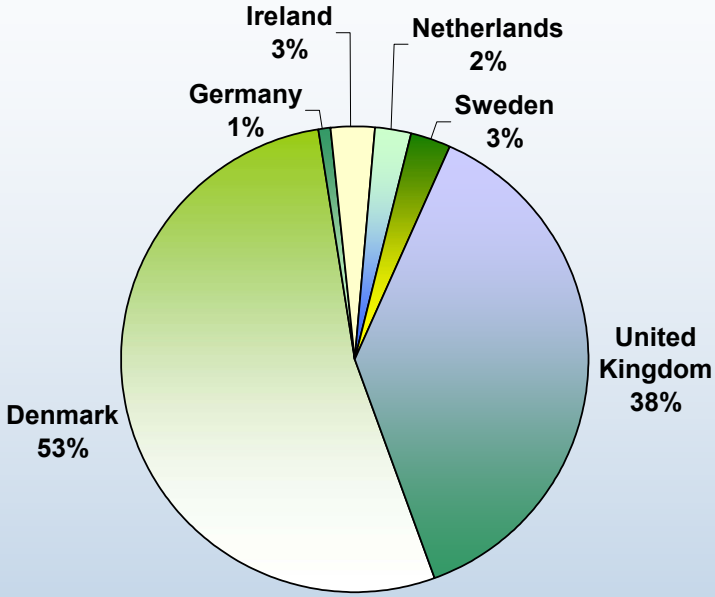
Evolution of U.S. Commercial Wind Technology



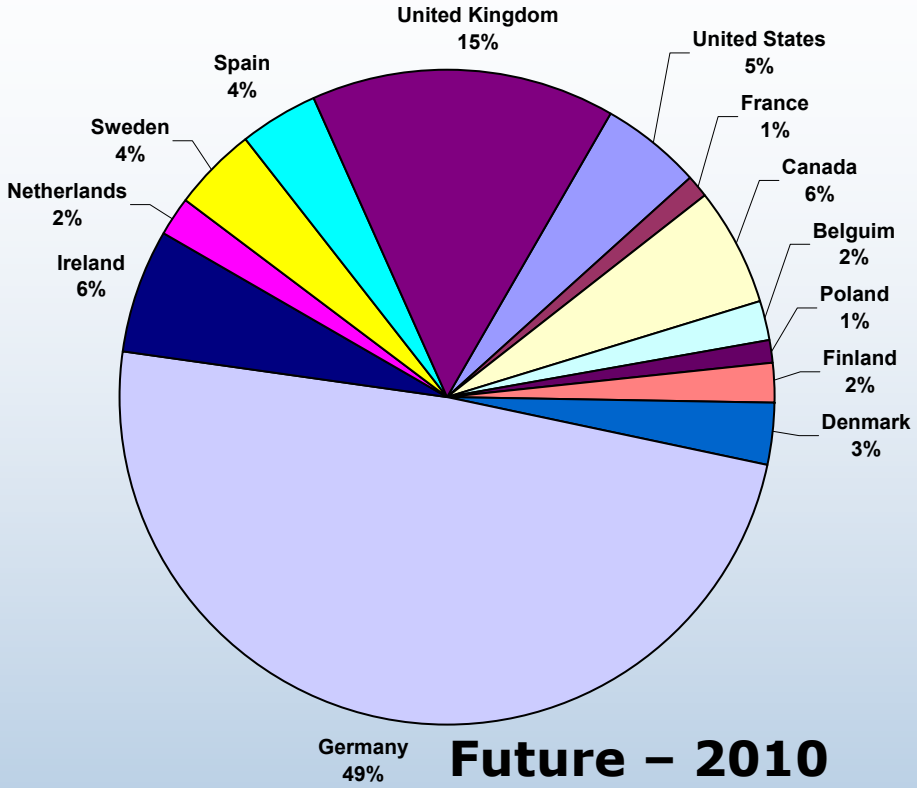
Wind Turbine Size



Status of Offshore Wind



Current -804-MW



Future – 2010

- Offshore 804-MW of 60,000 MW+ world-wide – less than 2%
- 11-GW+ offshore is projected for 2010
- Offshore has affected current onshore systems
- Offshore will continue to influence European markets.

Offshore Technology Status

Vestas 2.0 MW Turbine
Horns Rev, DK

Talisman Energy:
Repower 5-MW
Beatrice Fields,
Scotland

GE 3.6 MW Turbine
Arklow Banks

Seimens 2.3 MW Turbines
Middlegrunden, DK

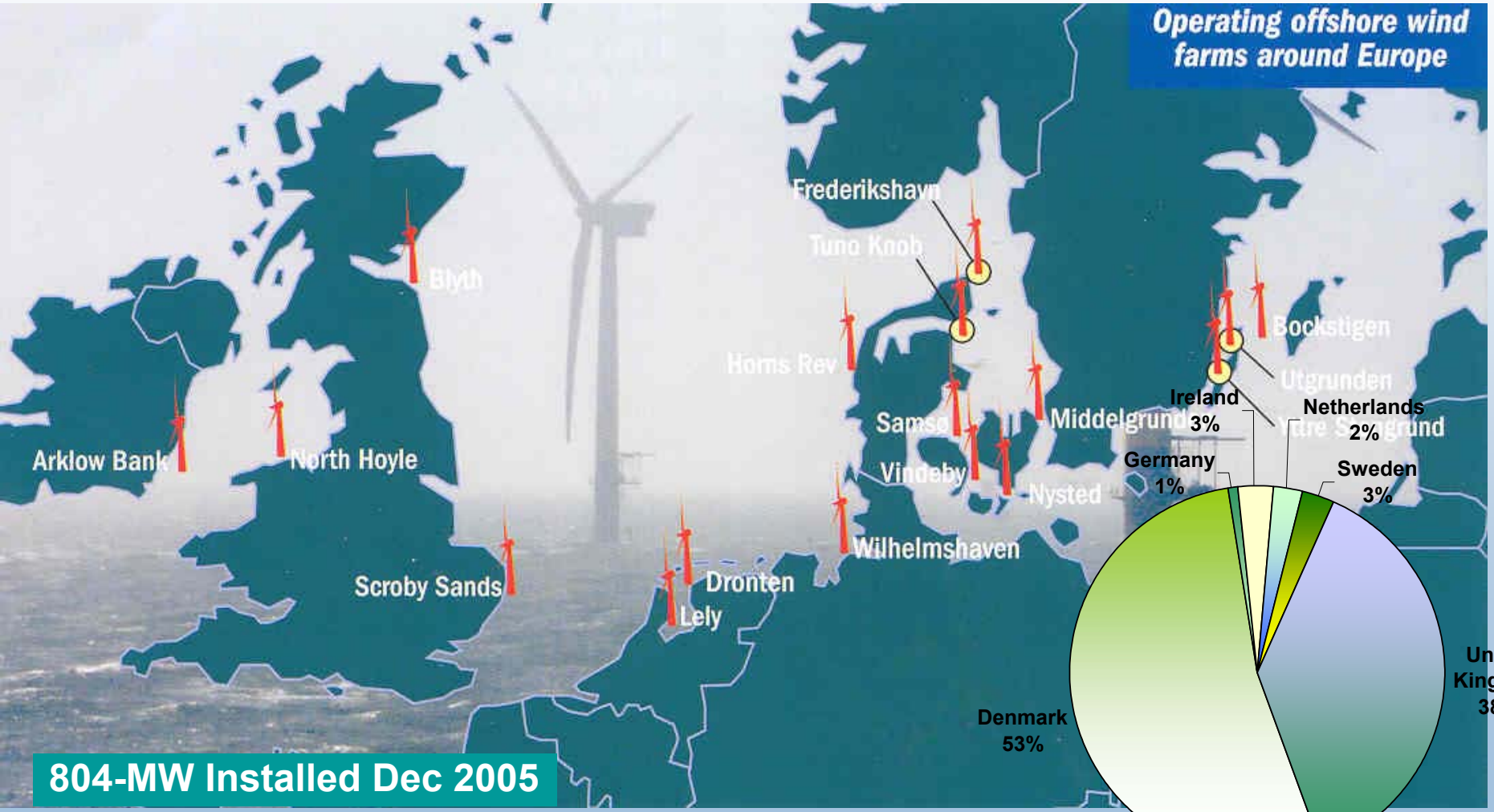
Offshore Technology

- 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

Location of Existing Offshore Installations Worldwide

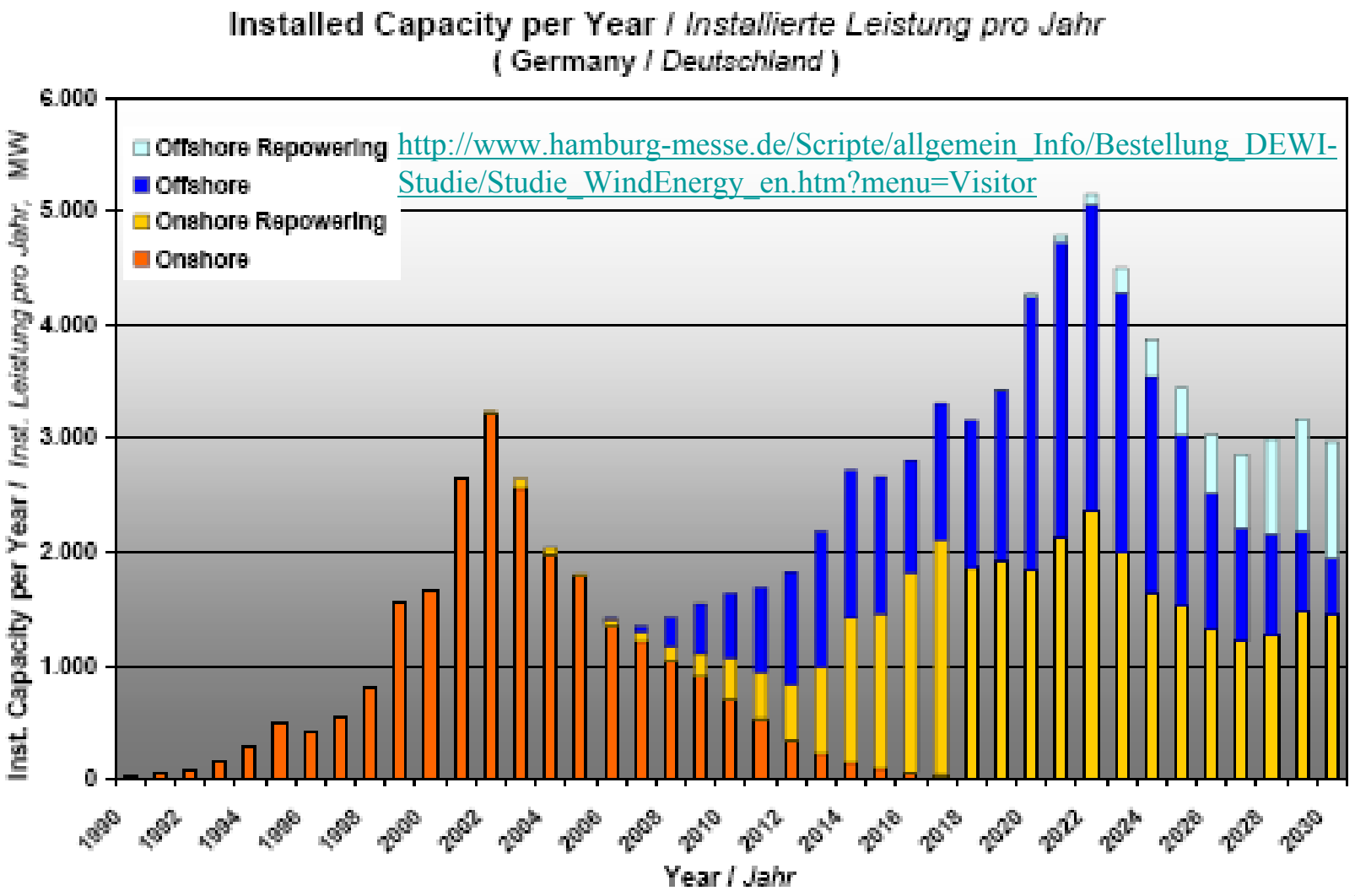


Source: Wind Directions, September 2004

Predicted Growth of German Wind Energy Markets

WindEnergy

WindEnergy-Study 2008 - Assessment of the Wind Energy Market until 2014
WindEnergy-Studie 2008 - Marktabschätzung der Windindustrie bis zum Jahr 2014



http://www.hamburg-messe.de/Scripte/allgemein_Info/Bestellung_DEWI-Studie/Studie_WindEnergy_en.htm?menu=Visitor

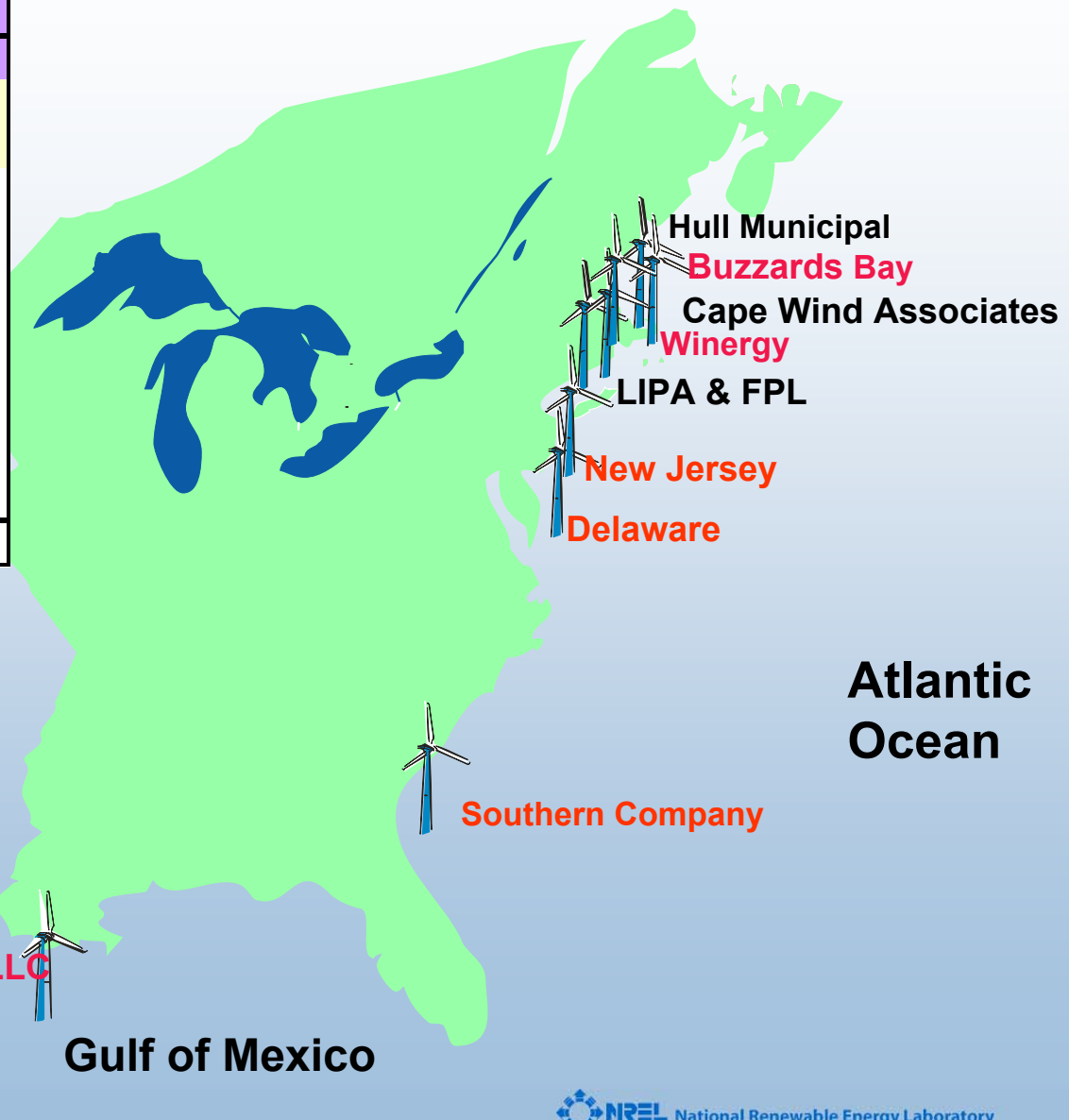
Fig. 3
Abb. 3

Source: WindEnergy-Study 2008

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
Total		2455

No offshore wind projects installed in the US yet.



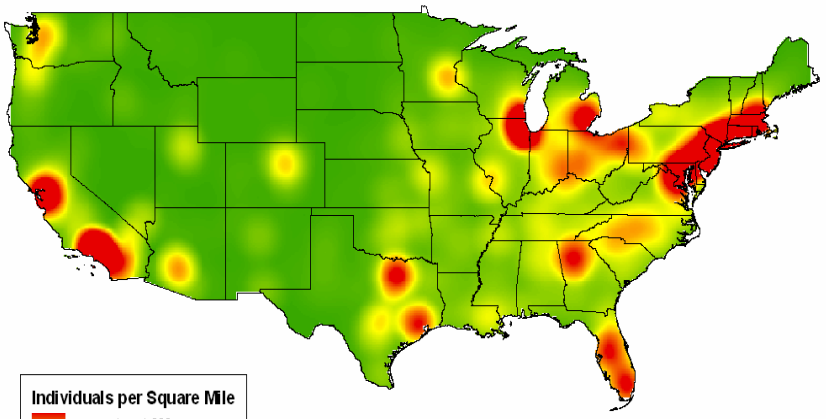
Why Offshore Wind ?

Land-based sites are not close to coastal load centers

Load centers are close to offshore wind sites

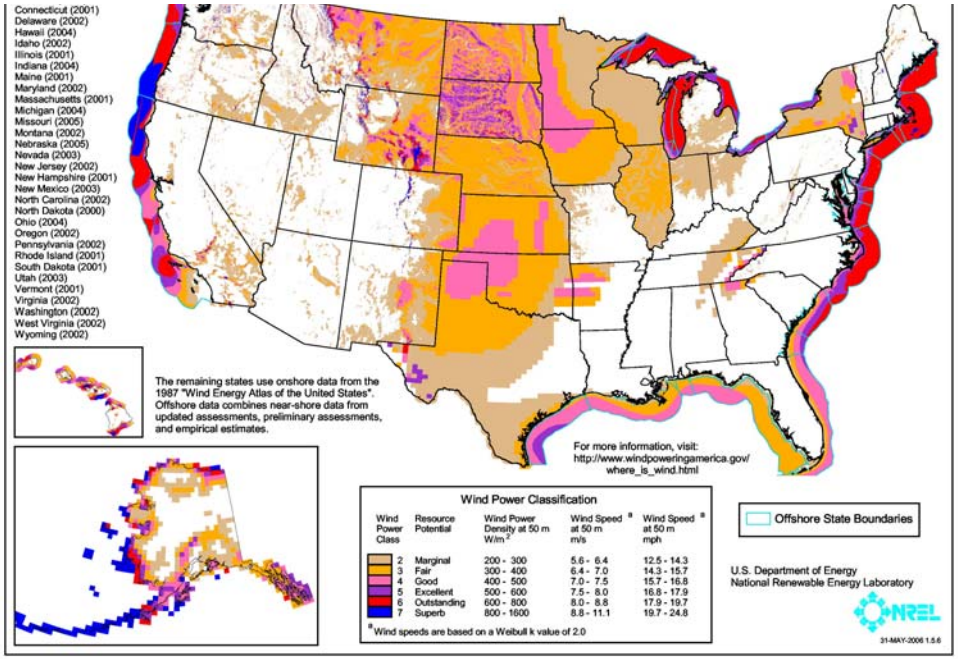
28 coastal states use 78% of the electricity in US

US Population Concentration

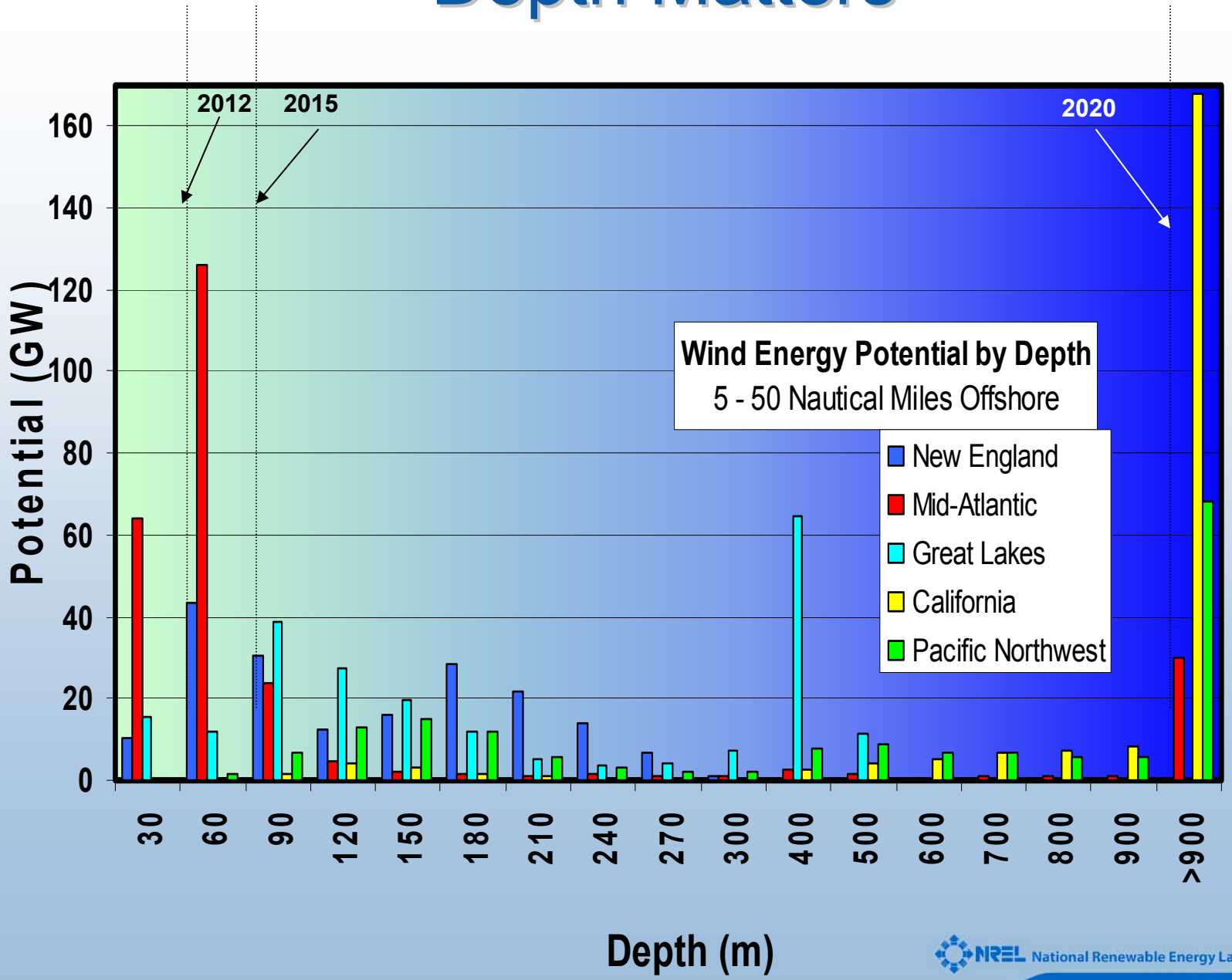


Graphic Credit: Bruce Bailey AWS Truewind

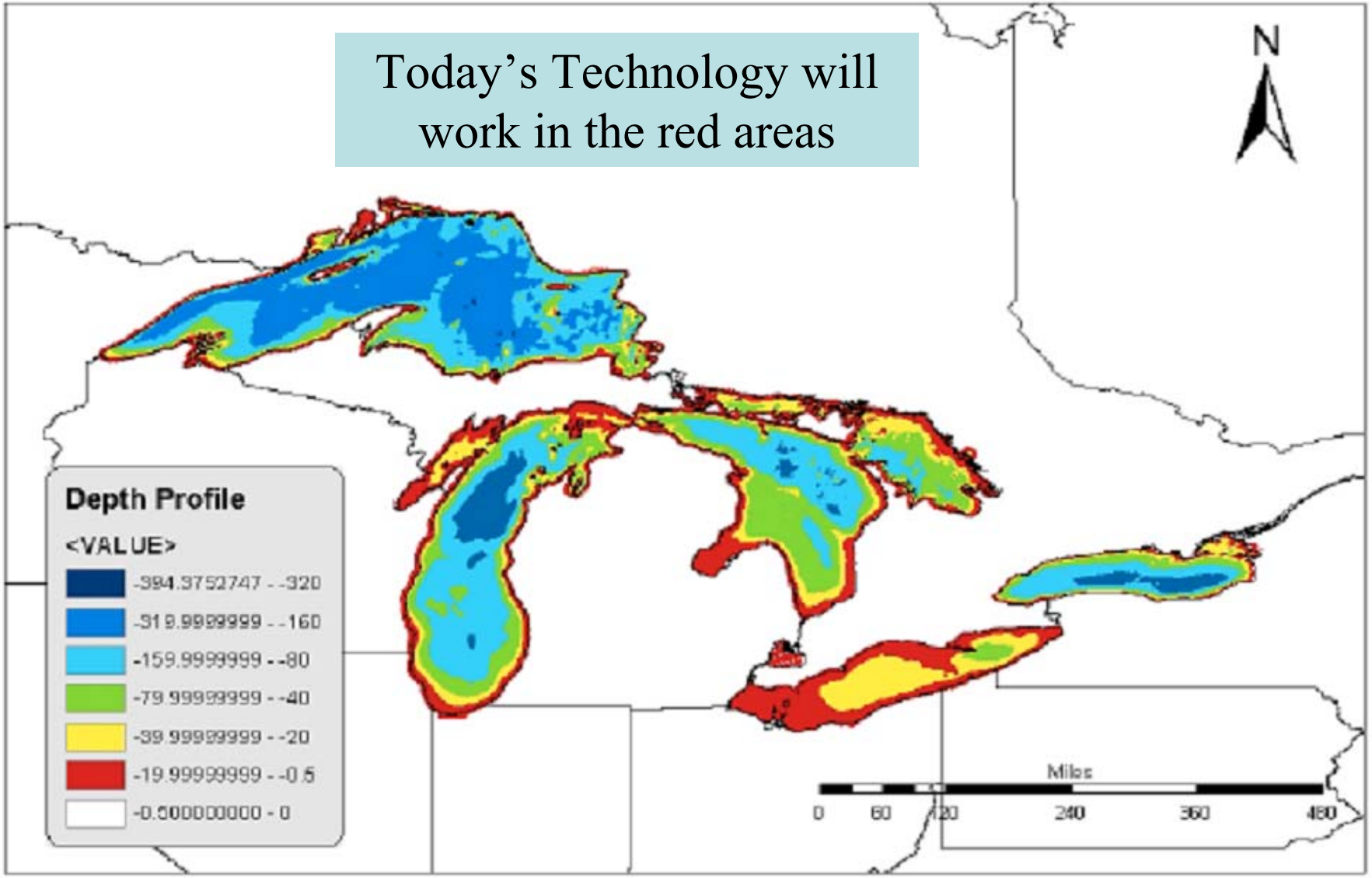
U.S. Wind Resource



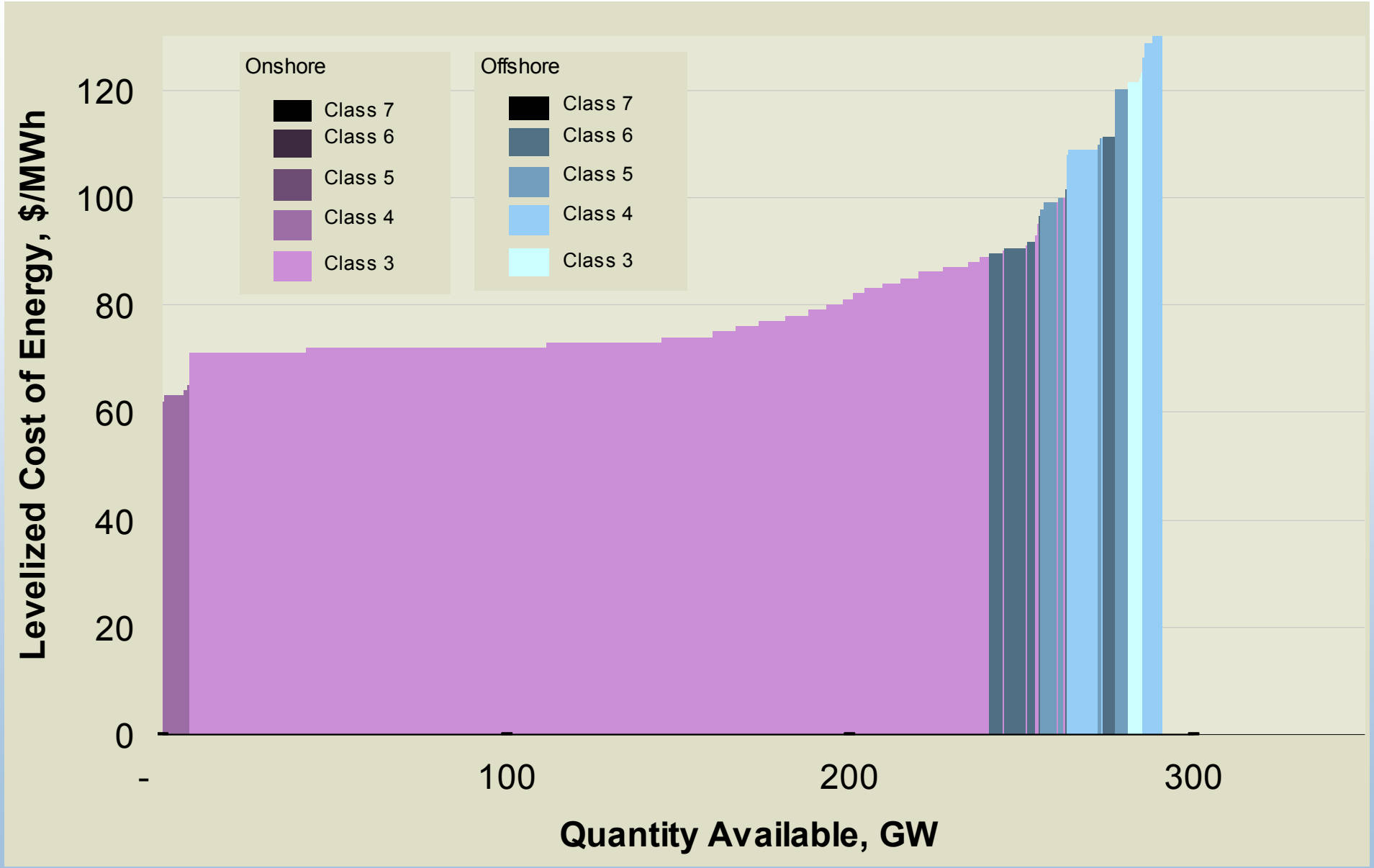
Depth Matters



Great Lakes Bathymetric Map

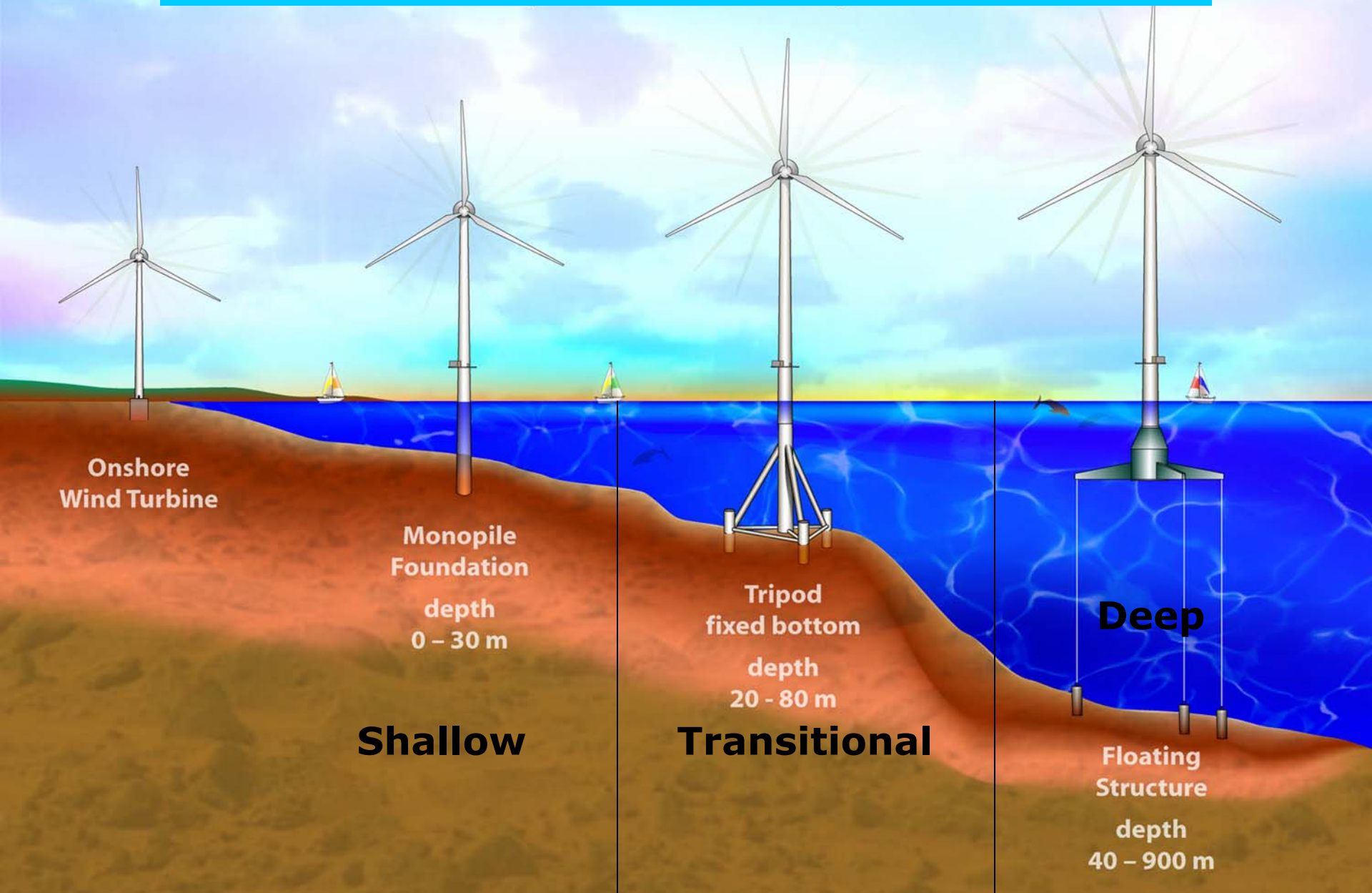


Great Lakes



2010 Costs w/ PTC, $1,600/MW-mile, w/o Integration costs

Offshore Wind Technology Development

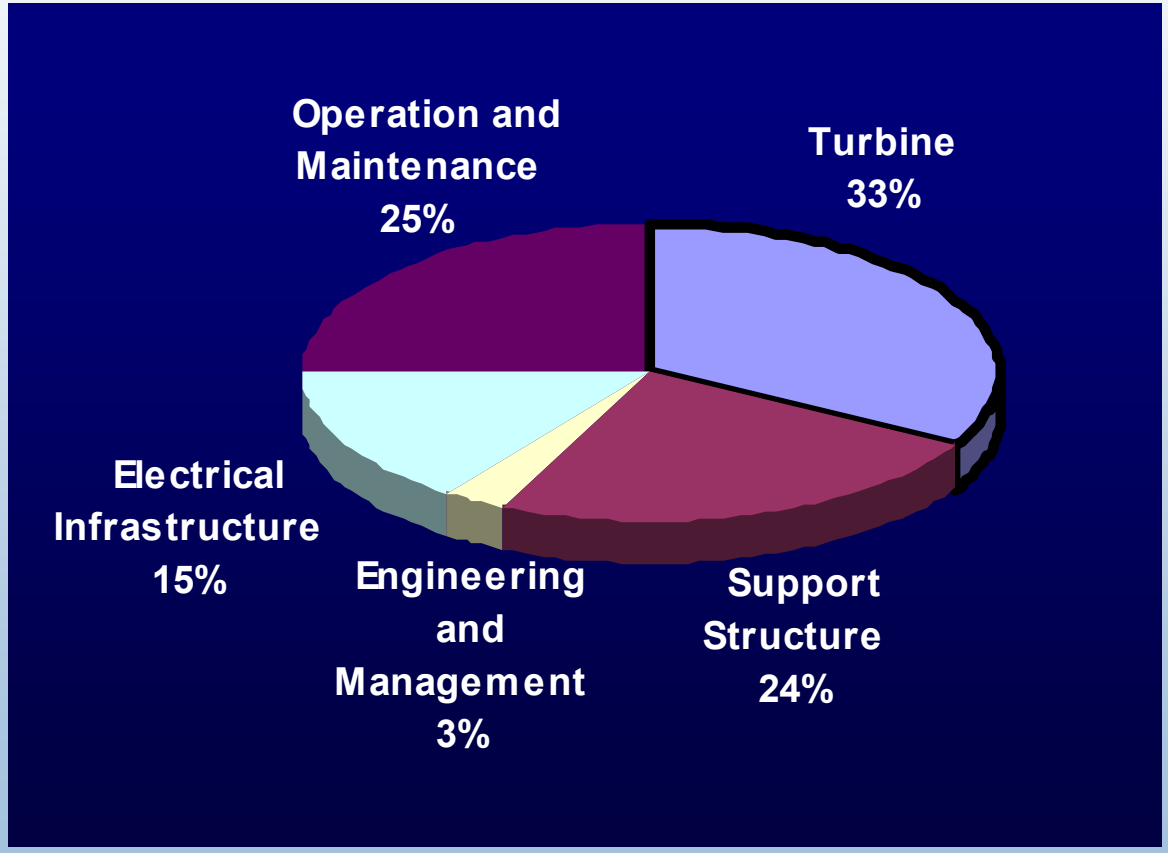


Monopiles at Arklow Banks Wind Farm

7 - 3.6 MW Turbines

Offshore Wind Economics

- Only about 1/3 of the cost is in the production of the turbine
- US projects may be feasible with incentives
- Costs need to decrease



(Typical numbers derived from NREL cost model and ***CA-OWEE report 2001)***

45-m Depth Offshore Demonstration Project Talisman Energy in Beatrice Fields

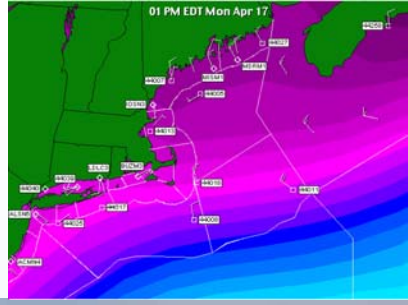
- 5-MW Rating
- 61.5-m blade length (LM Glasfibres)
- RePower 5-MW - Worlds Largest Turbine
- Two machines 45-m Water Depths

Offshore Turbine Reliability

Credit: GE Energy

- Design turbines that need less maintenance.
- Design for in-situ repair
- Develop condition monitoring and advanced self-diagnostic systems to minimize collateral damage and down-time.

Minimize Work at Sea

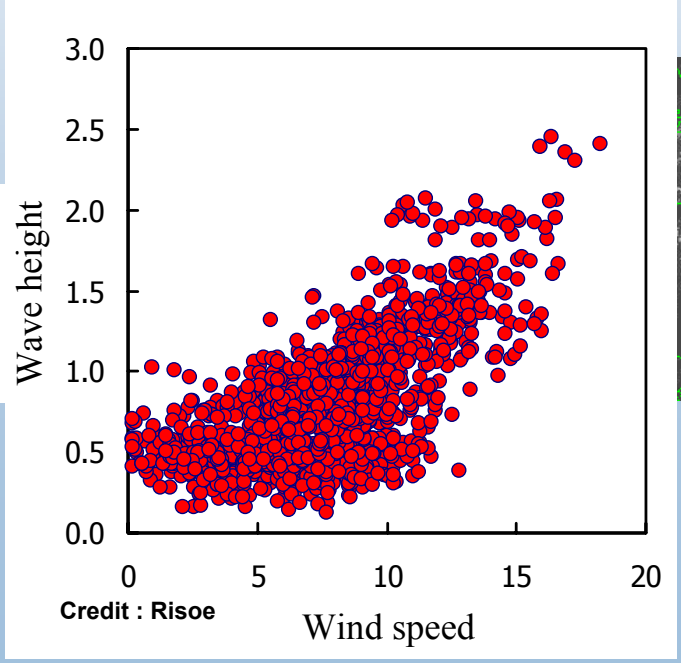


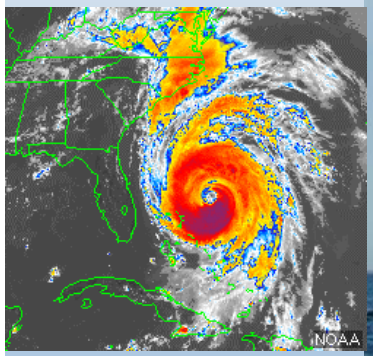
- Lower Installation costs

  (up to 20% of total project) Garrad-Hassan
- Widen weather windows
- Reduce large vessel dependency
- Improve forecasting

Wind/Wave Performance and Design Requirements

- Meteorological Tower
- Wind Resources
- Physical Ocean
- Site Monitoring Begins Early





Offshore Project Development Depends on Accurate Long Term Knowledge of the Wind Speed

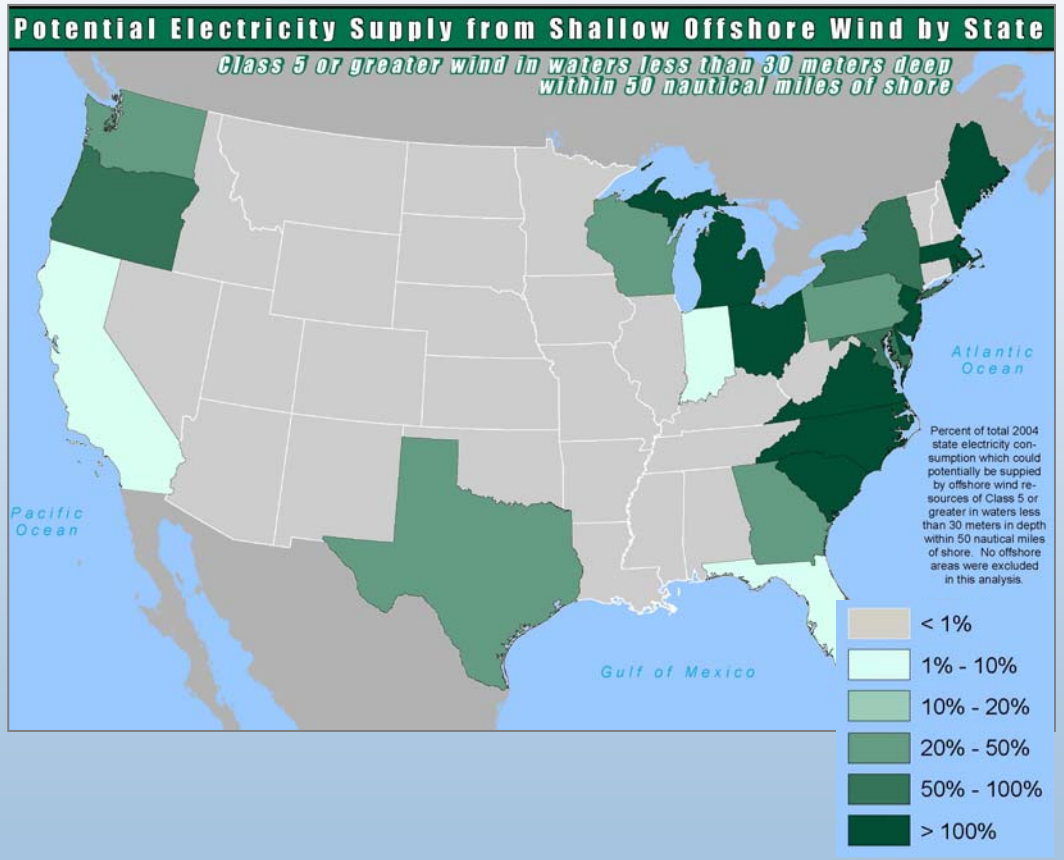
Ice Floes Can Introduce Significant Design Challenges

Credit: Wind Power Monthly Cover Photo Feb 2003

Offshore Wind Energy Technology Challenges & Future

- 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



Environmental & Siting Challenges

- Reasonable siting requirements
- Public perception & involvement
- Scientific research & peer review
- Risk analysis
- Interagency leadership on energy policy
- Lessons learned

Overview of the Danish Monitoring Program

- Sea mammals – harbor porpoises and seals
- Fish
- Birds
- Hydrography
- Coastal effects
- Artificial reef
- Socioeconomics
- Community acceptance
- Noise emissions
- Temperature gradients around the cables
- Electromagnetic fields
- Benthic fauna
- Viewshed

The Elements of a Viable Permitting Process

- Solve the leadership void
  - States, local, regional
- Define the need and the utility interest
- Develop a siting process
  - Streamline permitting needs
  - Well-sited demonstrations lead to big payoffs
  - Avoid sensitive habitats
  - Focus on industrialized locations
- Process evolves with experience
  - Just do it – expedite pilots

Source: B. Ram, Energetics

Recommendations

- Identify the lead agencies and the roles they will play
- Gather baseline information
  - Wind resources/Ecology
  - Research partnerships
- Establish a knowledge base for comparative risks and benefits of energy options
- Devise state siting strategies & sustained public involvement
- Move forward applying lessons learned from Europe and the U.S.

Source: B. Ram, Energetics

Carpe Ventem










www.windpoweringamerica.gov