Offshore Wind Energy Update
State Summit 2006

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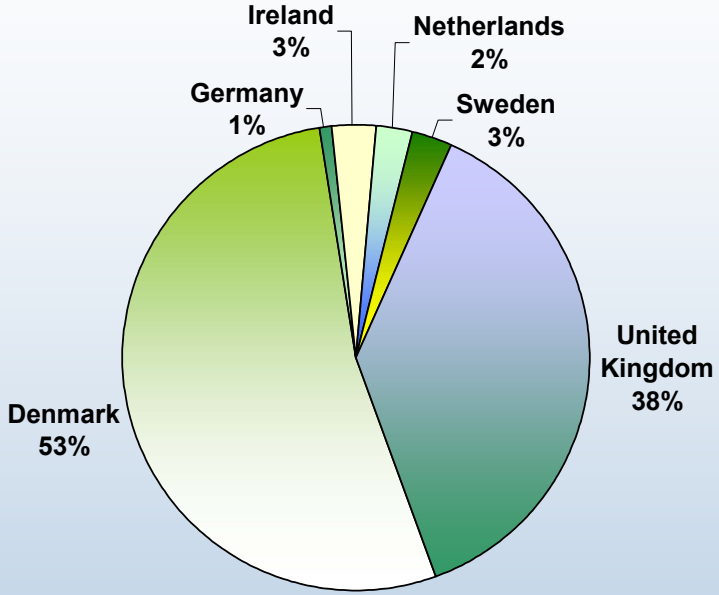
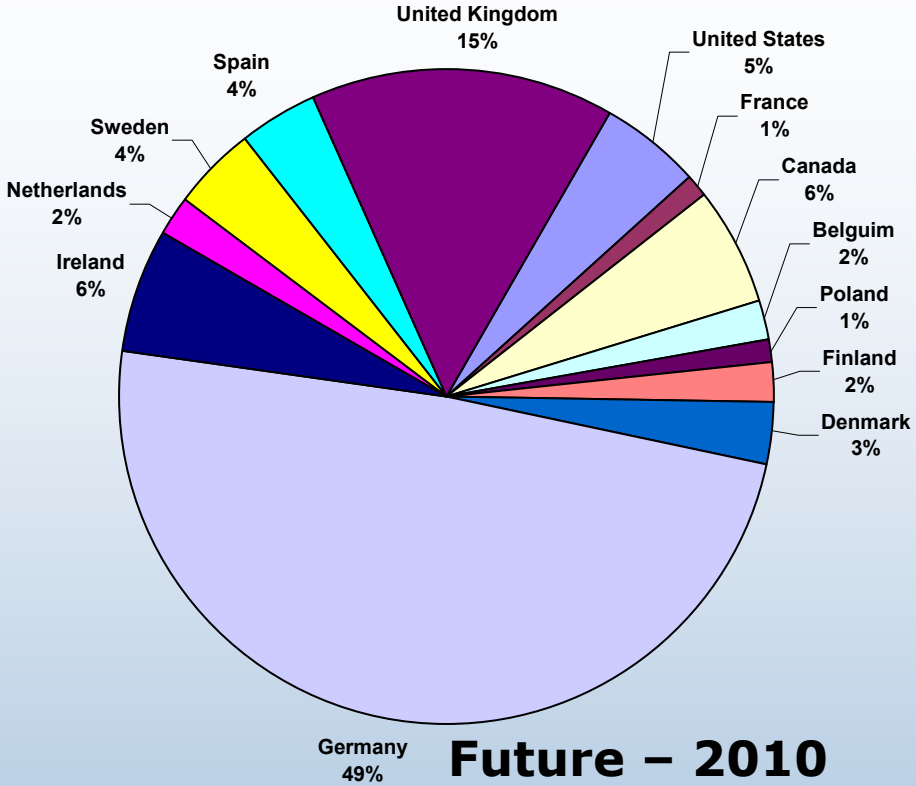
Offshore Wind Benefits

- Better wind resources
  - Reduced turbulence – steadier wind
  - Higher mean wind speed
- Aesthetics Visual concerns can be less objectionable at greater distances.
- Shorter transmission
  - Proximity to high value load centers
  - Access to less heavily loaded lines
- Avoid constraints on turbine size
  - Larger machines may be more economical.
  - **Shipping** – onshore roadway limits
  - **Erection** – onshore crane limits

Status of Offshore Wind



Current -804-MW

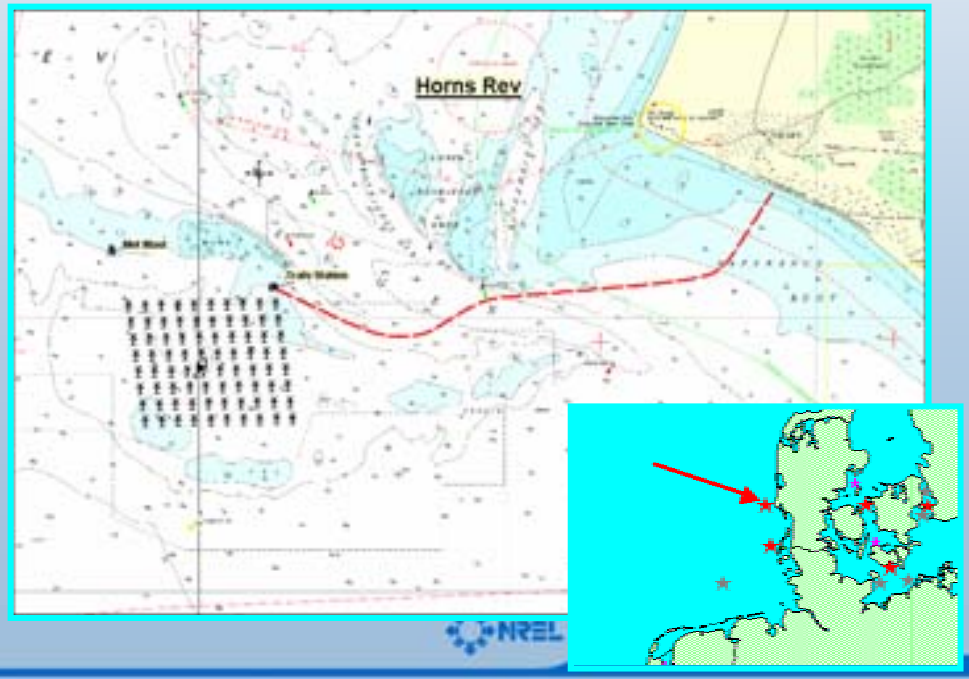


Future – 2010

- 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.

Horns Rev Wind Farm Installation

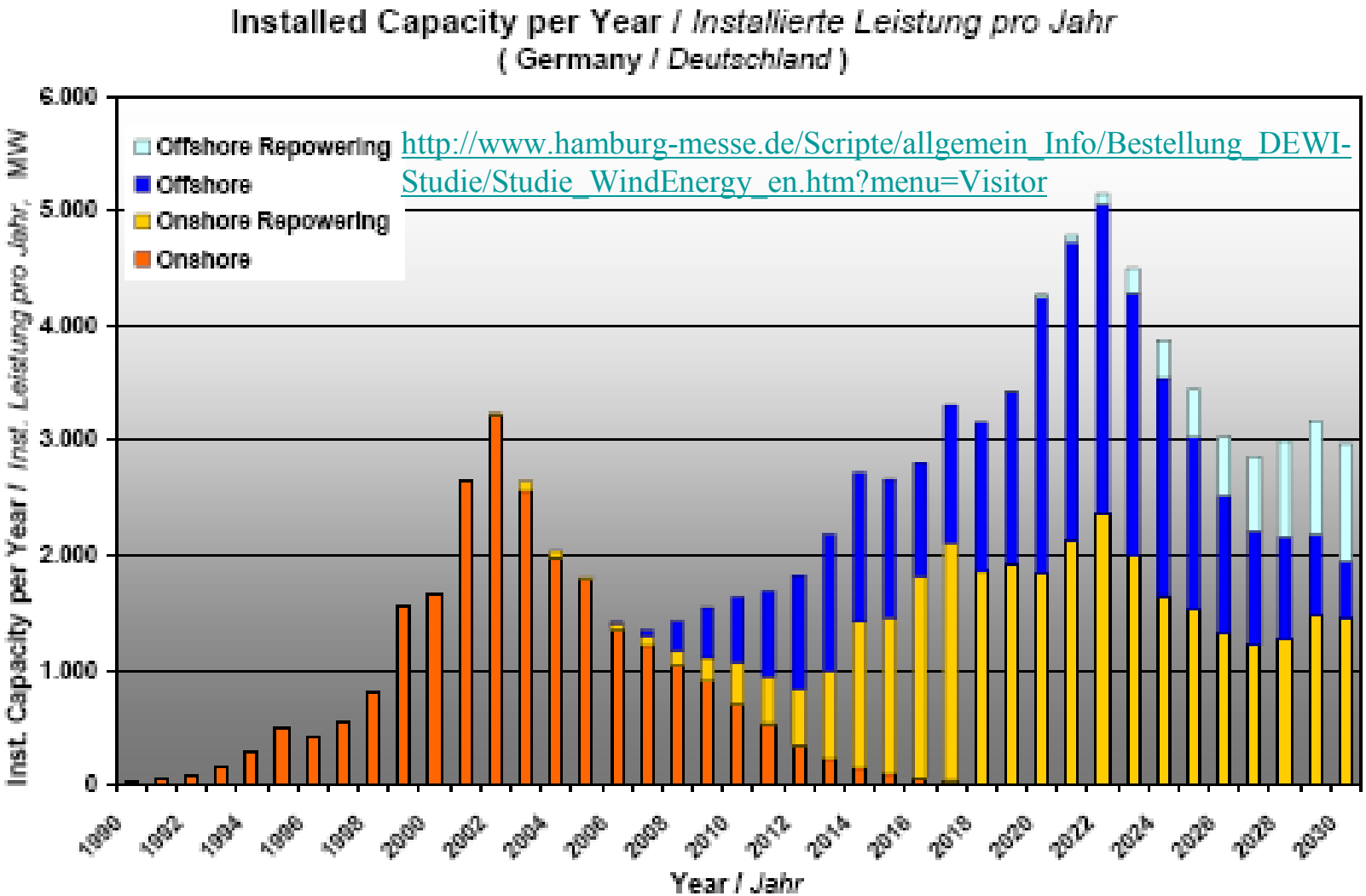
Country: Denmark
Location: West Coast
Total Capacity: 160 MW
Number of Turbines: 80
Distance to Shore: 14-20 km
Depth: 6-12 m
Capital Costs: 270 million Euro
Manufacturer: Vestas
Total Capacity: 2 MW
Turbine-type: V80 - 80m diameter
Hub-height: 70-m
Mean Windspeed: 9.7 m/s
Annual Energy output: 600 GWh



Predicted Growth of German Wind Energy Markets

WindEnergy

WindEnergy-Study 2006 - Assessment of the Wind Energy Market until 2014
WindEnergy-Studie 2006 - 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

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Source: WindEnergy-Study 2006

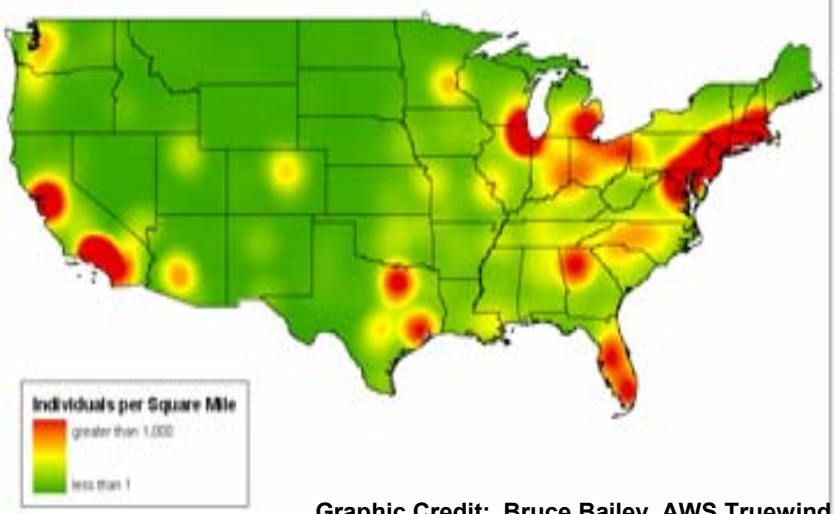
Why Offshore Wind ?

Land-based sites are not close to coastal load centers

Load centers are close to offshore wind sites

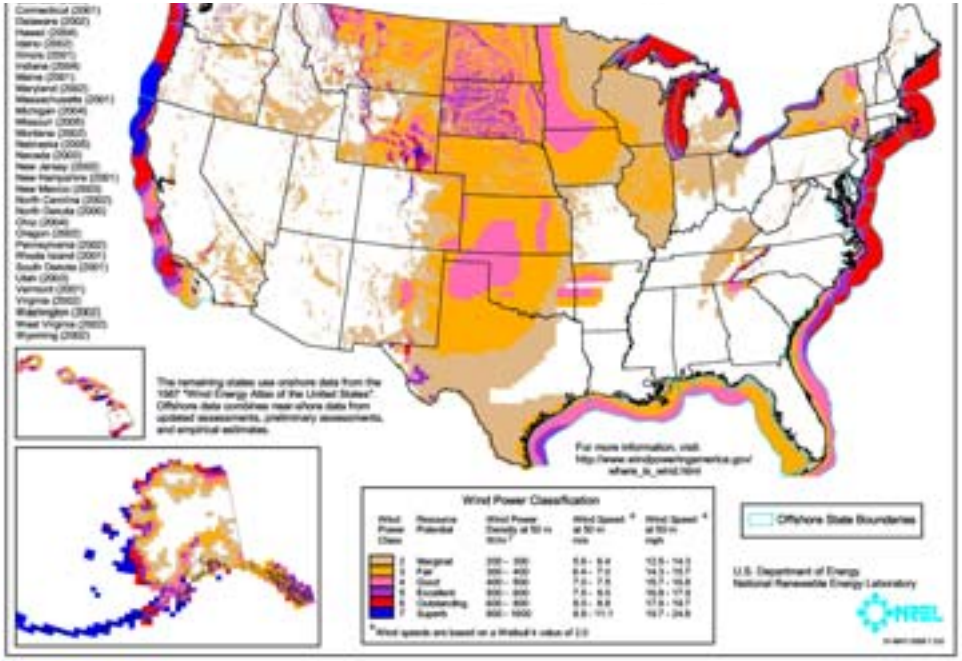
28 coastal states use 78% of the electricity in US

US Population Concentration

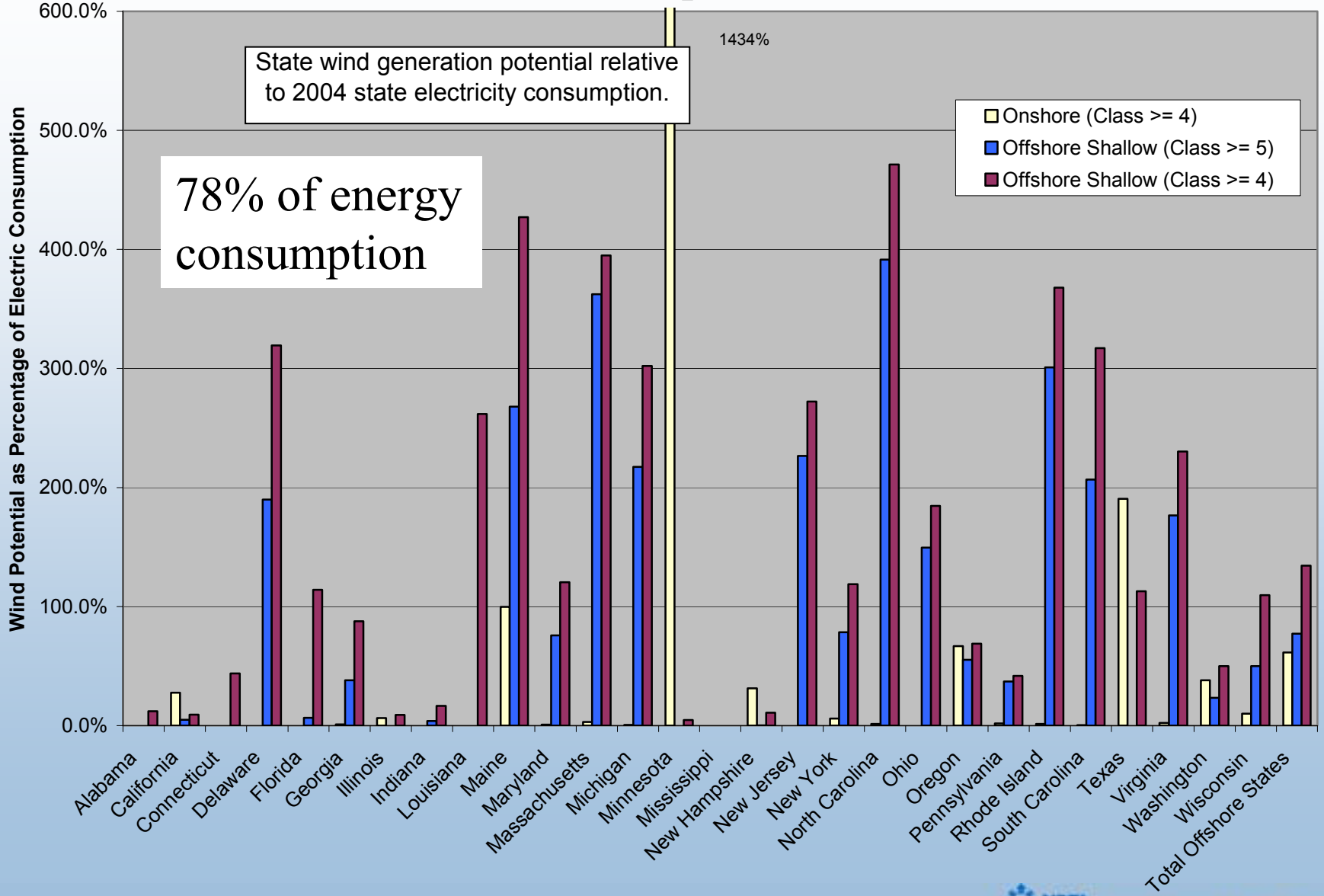


Graphic Credit: Bruce Bailey AWS Truewind

U.S. Wind Resource



28 Offshore States Wind Energy Potential Preliminary Estimates



Near-term Barriers

- MMS Regulatory Process
  - Forward progress frozen during rulemaking process
  - Structural certification standards
  - Hurricane worries
- Environmental Uncertainties
- NIMBY
- On-shore sellers market

Expected Trends

- MMS: 1-2 year+ PEIS development for OCS
- CapeWind and LIPA will be brought forward independent of new OCS rules.
- European market slow but steady.
- 2009-2010 industry arrival for offshore
- Offshore oil and gas diversification
- State demonstrations may lead.
  - Texas, Massachusetts, New Jersey
- Cost reductions and technology improvements

Long-term 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**

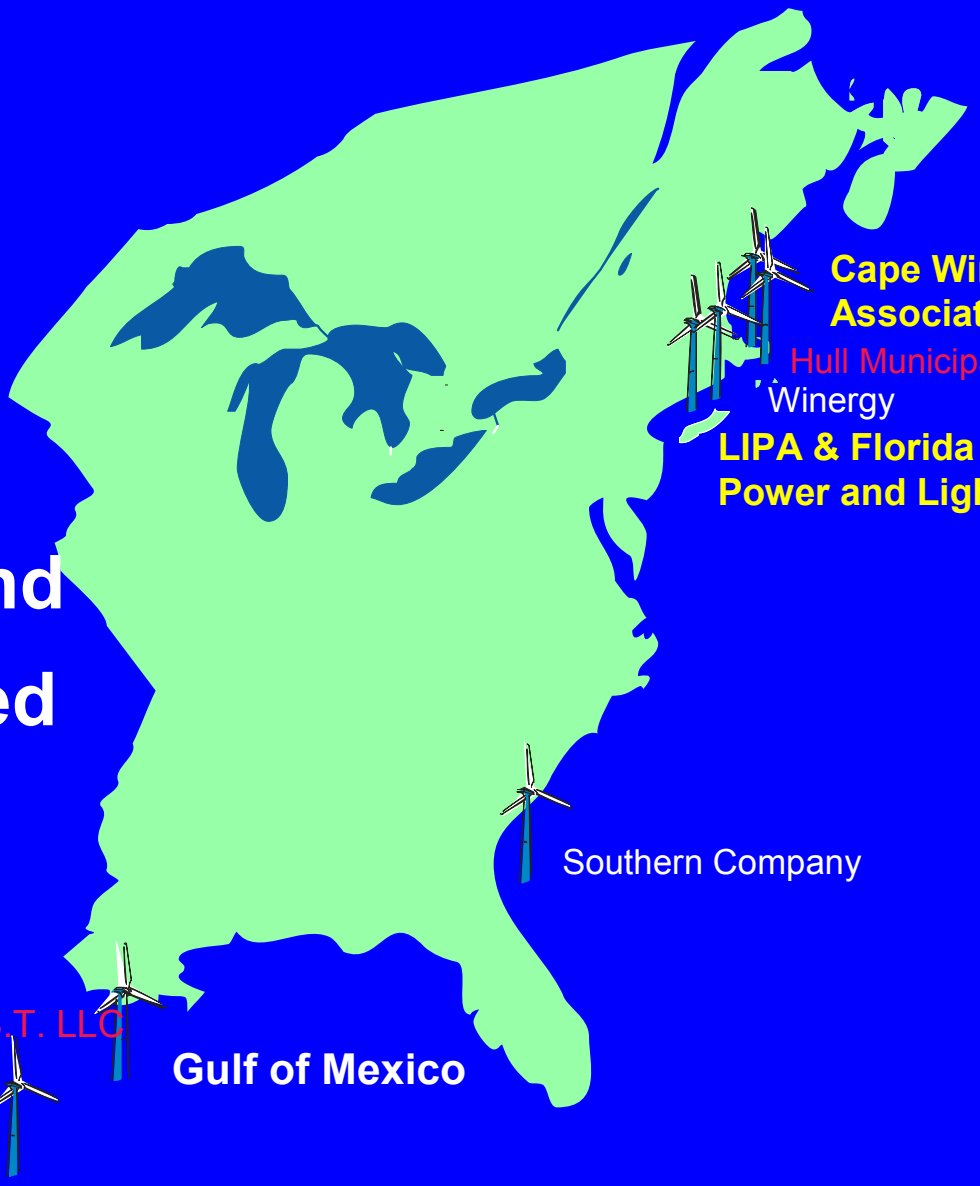
Land-based

Offshore

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

2014: 5 cents/kWh

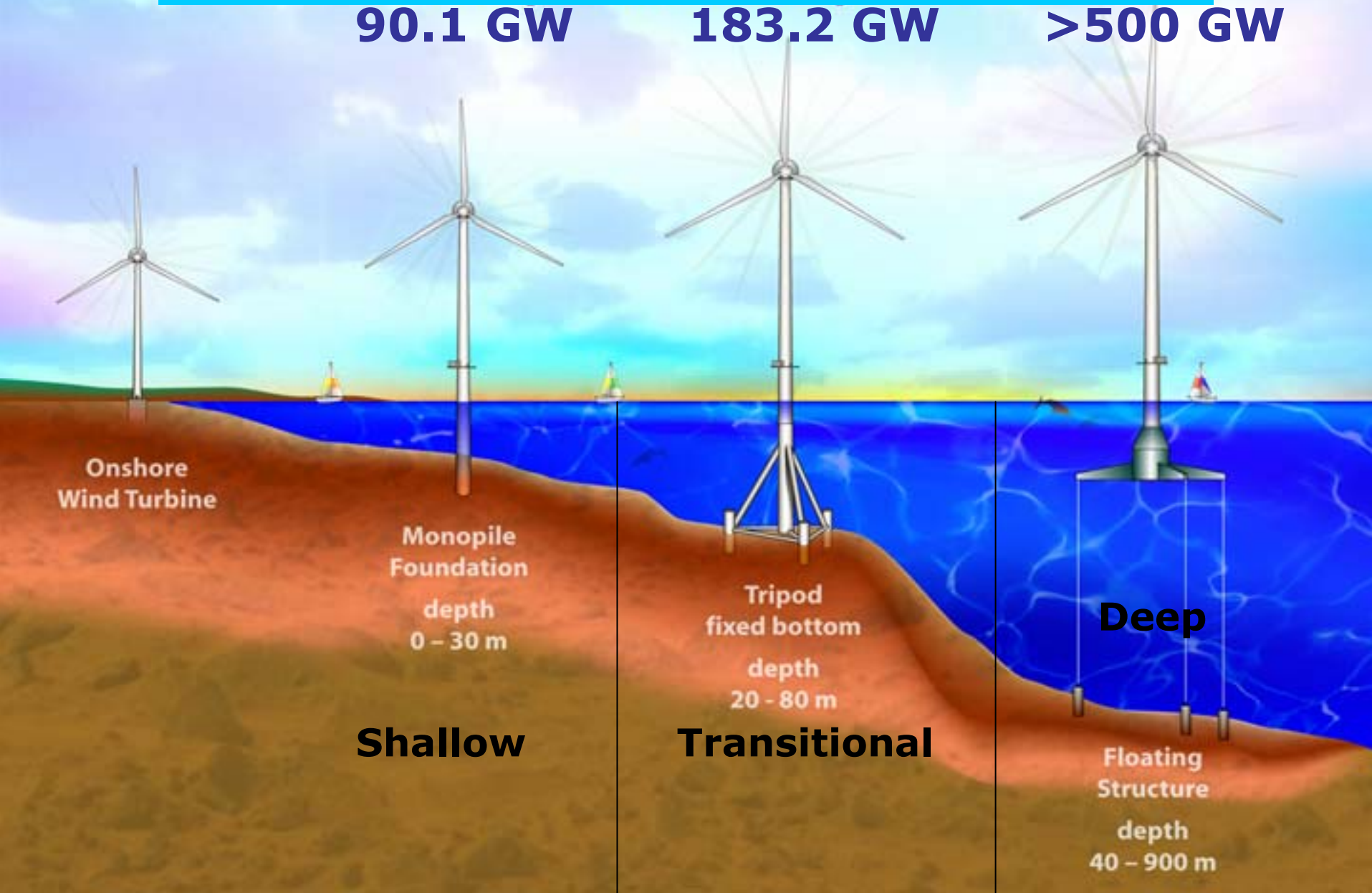
US Projects Proposed



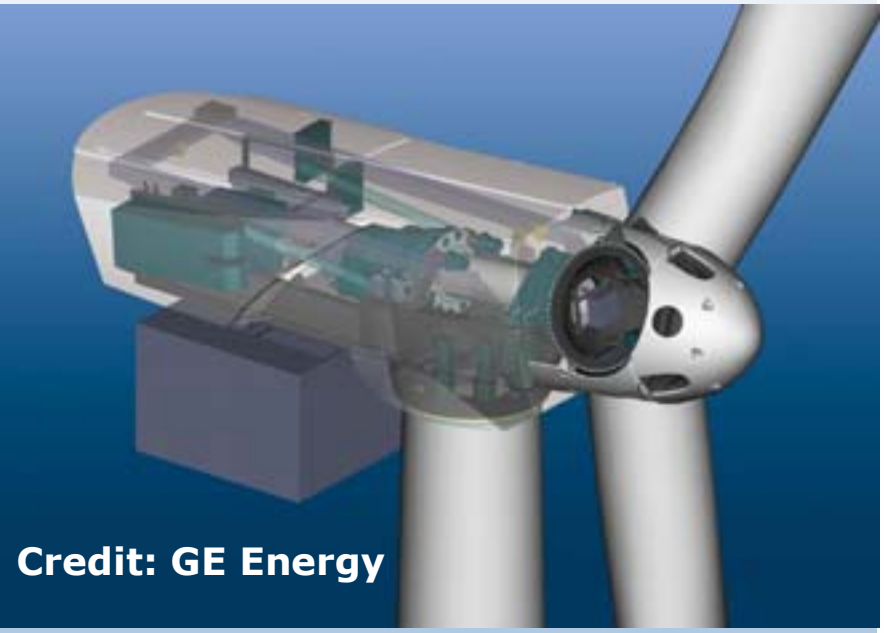
No Offshore wind projects Installed in U.S. yet

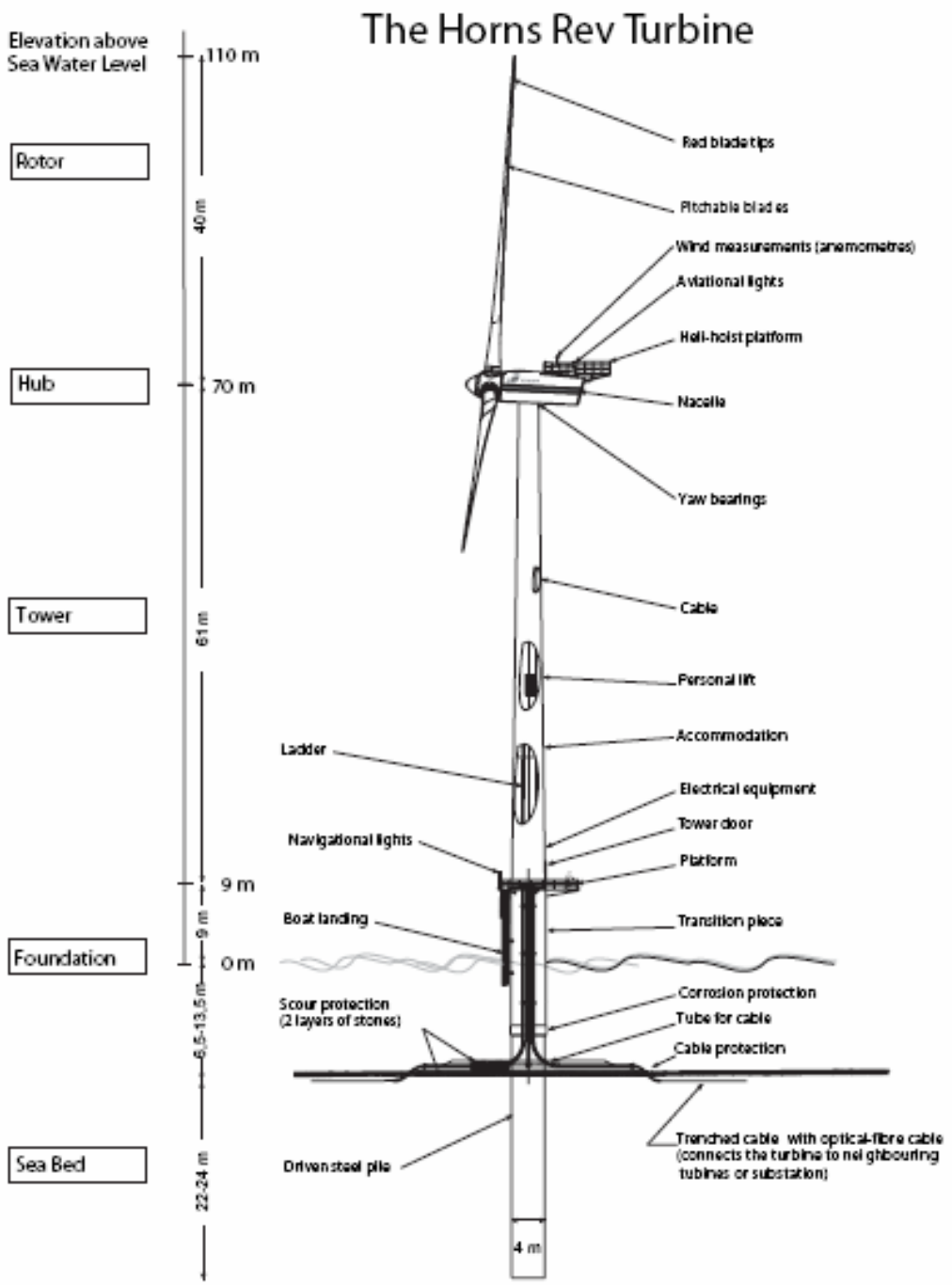
Atlantic Ocean

Offshore Wind Technology Development



Typical Offshore Wind Turbine



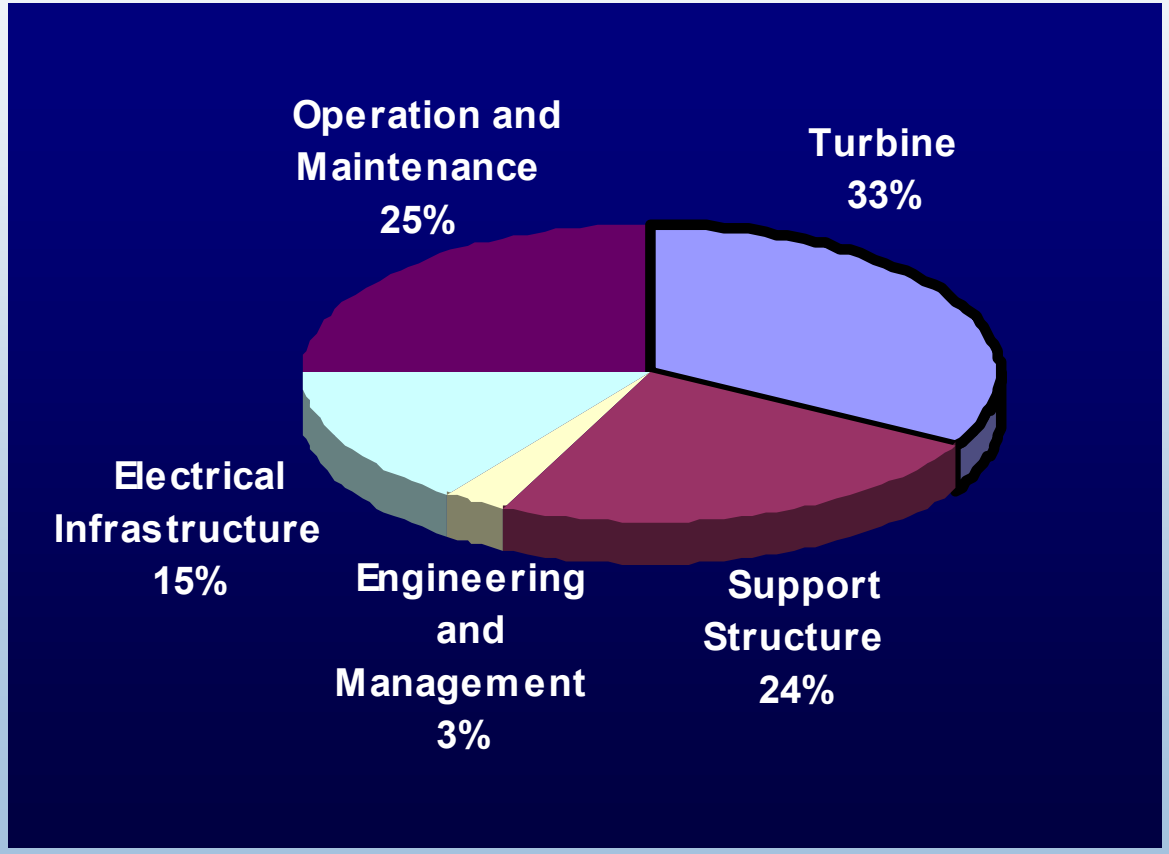


Principal Components and Dimensions of an Offshore Wind Turbine

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

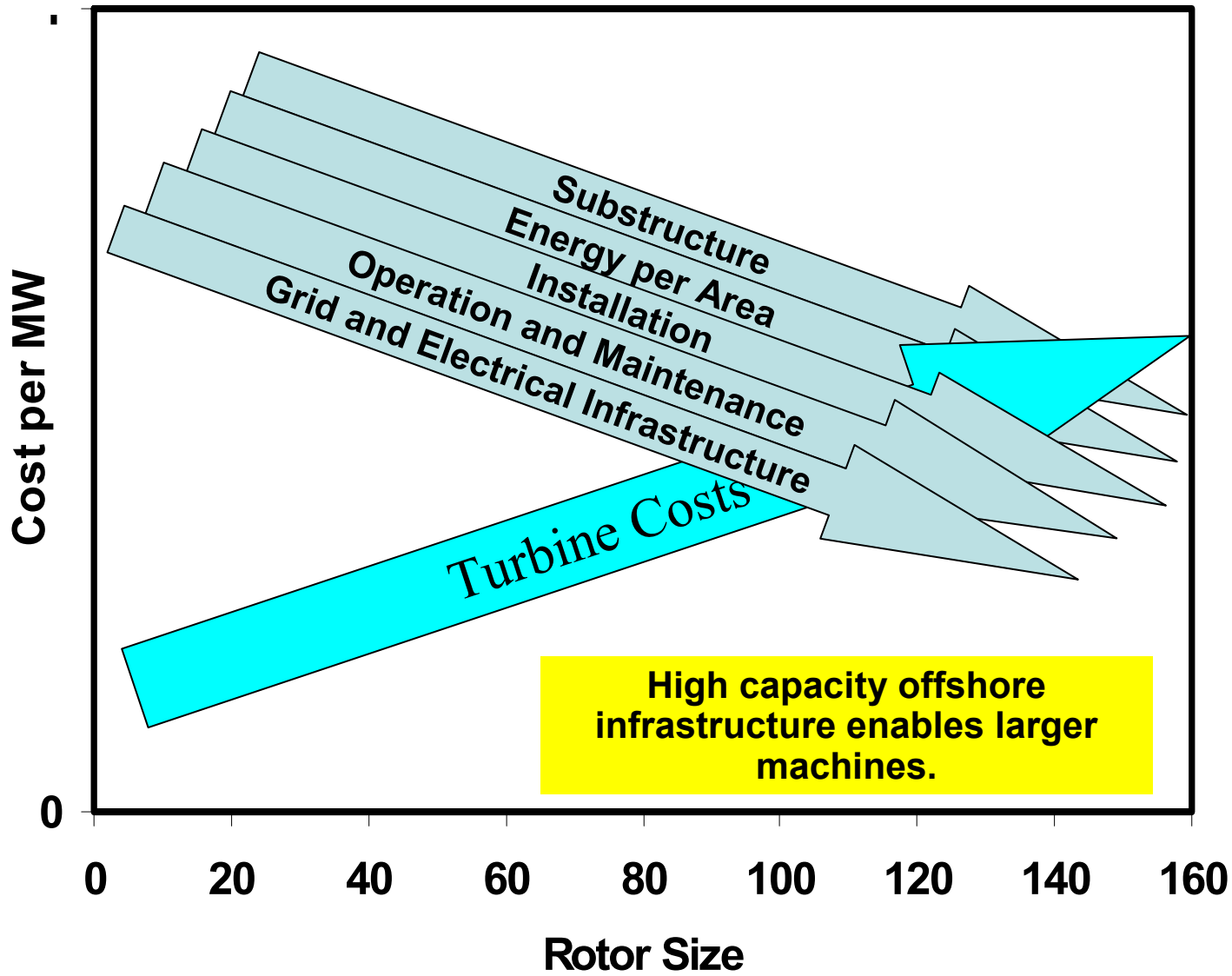
Offshore Wind Economics

- 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

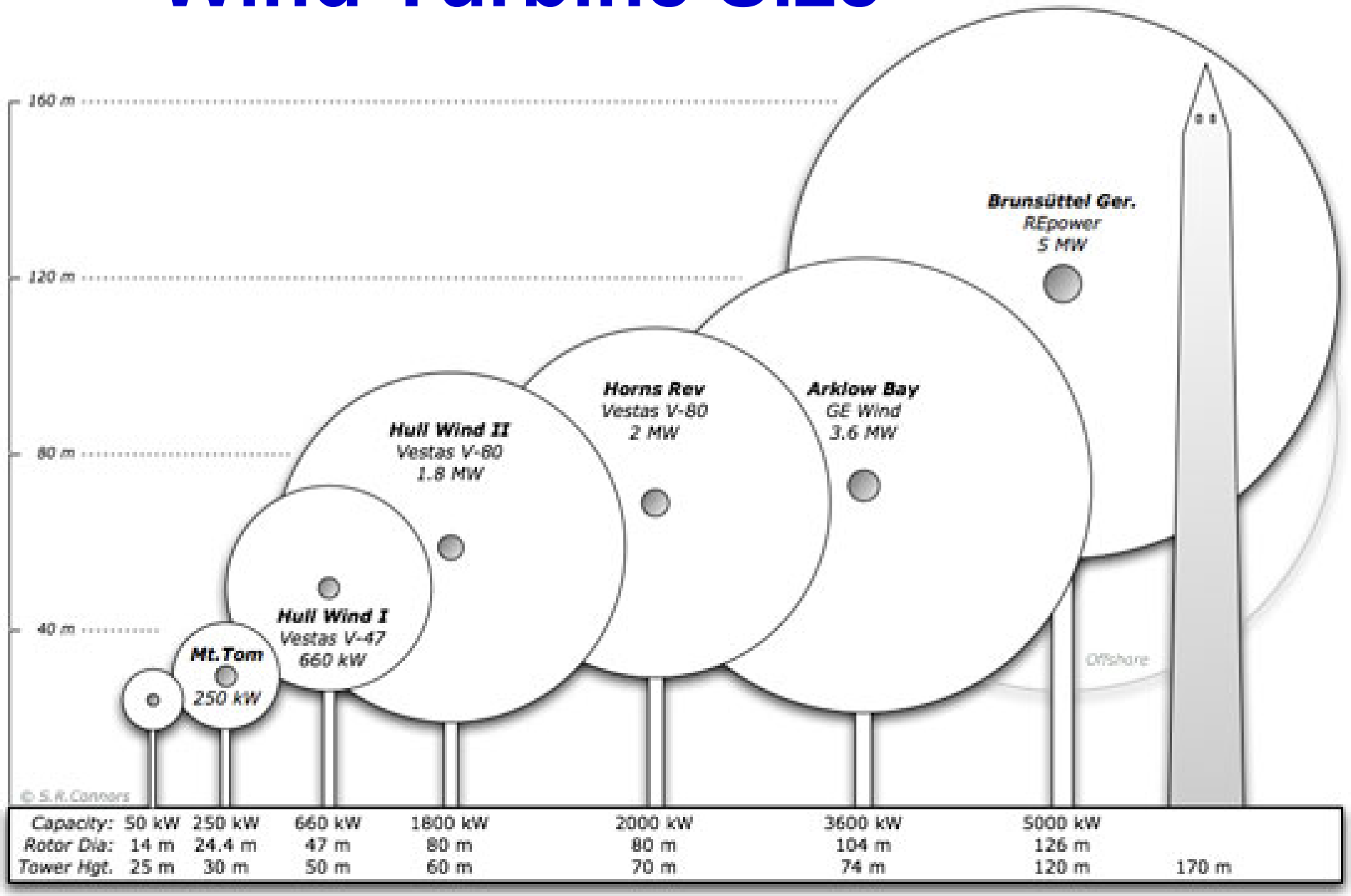


(Typical numbers derived from NREL cost model and ***CA-OWEE report 2001)***

Offshore Scaling and System Optimization – How Big Will Offshore Turbines Get?



Wind Turbine Size



RePower 5-MW - Worlds Largest Turbine

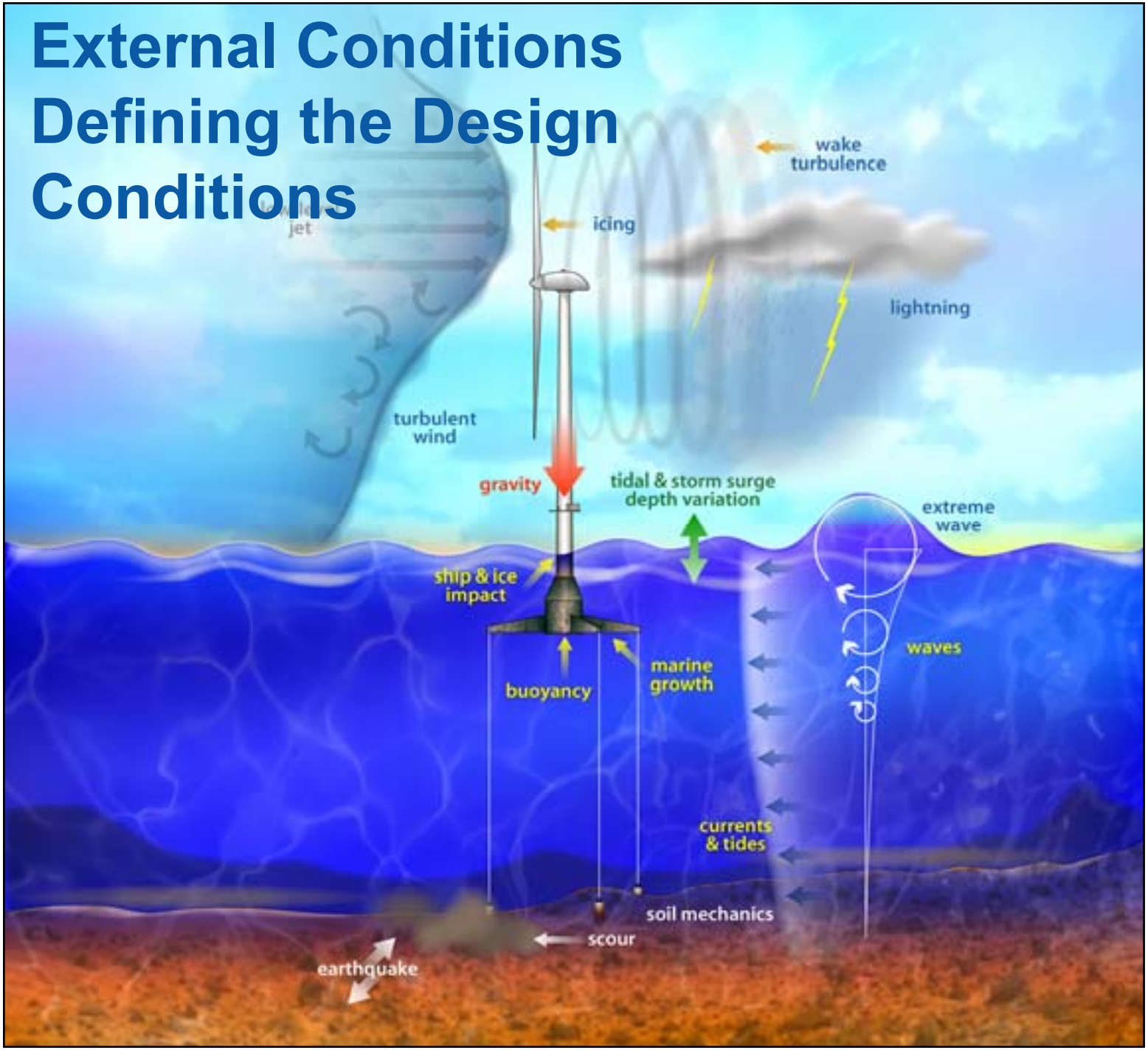
- 5-MW Rating
- 61.5-m blade length (LM Glasfibres)
- Offshore Demonstration project by Talisman Energy in Beatrice Fields
  - 45-m Water Depths
  - Two machines

Enercon Offshore Prototype

Enercon 4.5MW 112 meter rotor

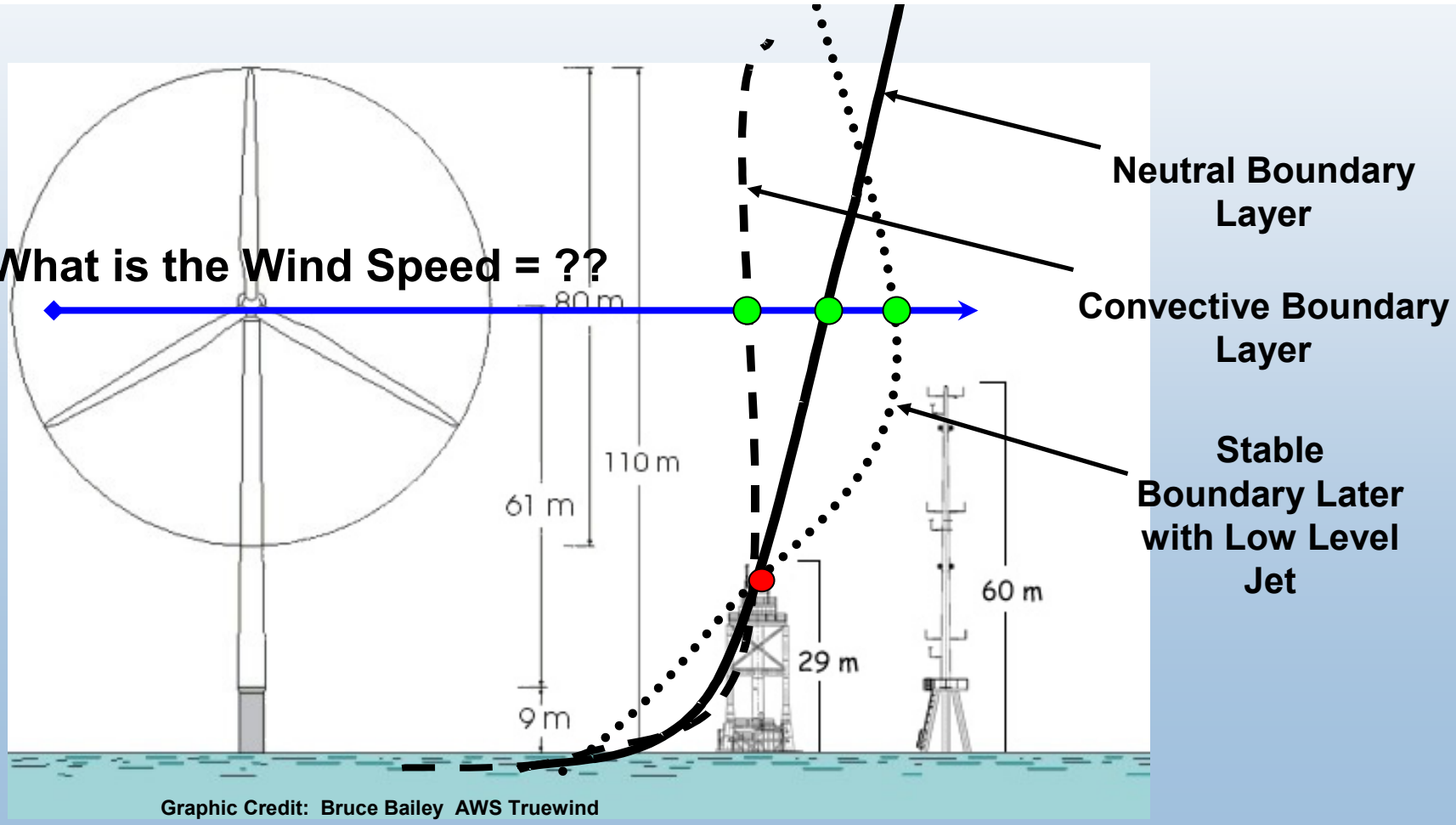
440 metric tonnes

External Conditions Defining the Design Conditions



Understanding Offshore Wind

- Methodology for wind measurements without MET towers!
- Methodology for hybrid wind data from multiple sources.
- Validate wind speed/energy potential – from meso-scale to micro-scale.
- Understand boundary layer – stable vs. unstable, wind shear variations



Graphic Credit: Bruce Bailey AWS Truewind

Reliability and Testing

Photo: GE Energy

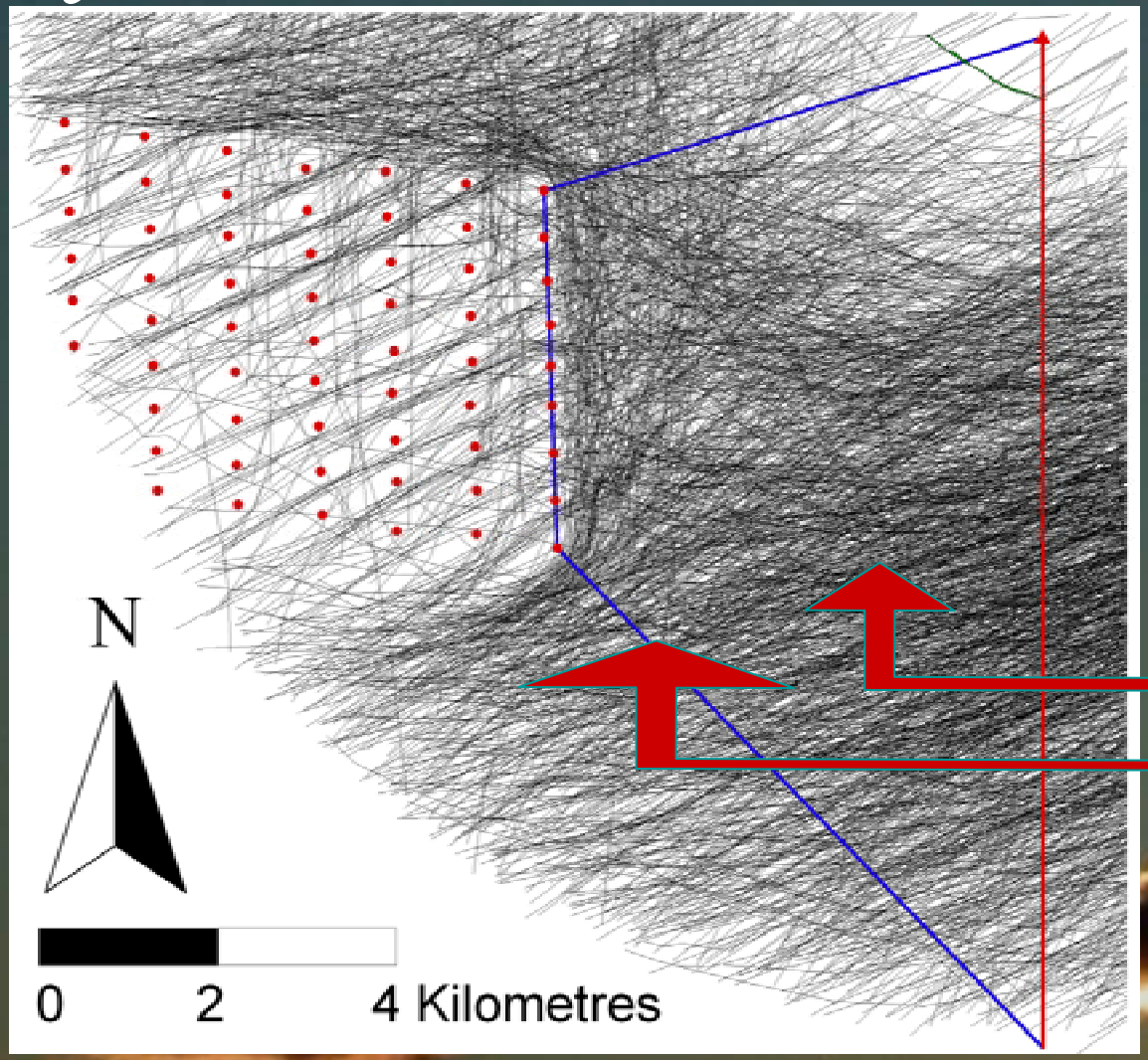
- Increased reliability requires more extensive testing
- Full-scale Component Testing
  - Field deployment foolish without component verification – coupon to full-scale
  - CRADA announcement for Large Blade Test Facility
- Field testing – System verification land and sea
  - Deployment stages – How to prove a system seaworthy?
  - Baseline measurements for condition monitoring
  - Failure rates – parameter tuning

Photo: LM Glasfibres

Environmental Analyses
Lessons Learned from Europe

- 5 years of BACI (Before After Control Impact) studies in Denmark – mostly government funded
- 280+ studies in Europe
- Preliminary conclusions indicate no “showstoppers”
- Further research & cost-effective methodologies needed for post-construction monitoring
- Need to apply innovative mitigation strategies e.g., temporal construction impacts
- Siting policies consider level of scientific uncertainties, multiples uses of the sea, & ecological risks

Radar Images of Migrating Birds at Nysted Wind Power Plant - Denmark



Operation (2003):

Bird perceive the presence of wind turbines even in bad visibility

Response distance:

day = c. 3000m

night = c. 1000m

Offshore Wind
European Environmental References

- European Union, COD, Principal Findings 2003-2005, prepared by SenterNovem, Netherlands,

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- Offshore Wind: Implementing a New Powerhouse for Europe, Greenpeace International, March 2005

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- Danish (Horns Rev and Nysted) Ecological Studies

  http://www.hornsrev.dk/Engelk/default_ie.htm and

  http://uk.nystedhavmoellepark.dk/frames.asp?Page_ID=44&Page_Ref=44&Templates_ID=1
- U.K.'s Strategic Environmental Assessment

  http://www.og.dti.gov.uk/offshore-wind-sea/process/envreport.htm

Kentish Flats

V-90