



Offshore Wind Energy Standards and Guidelines

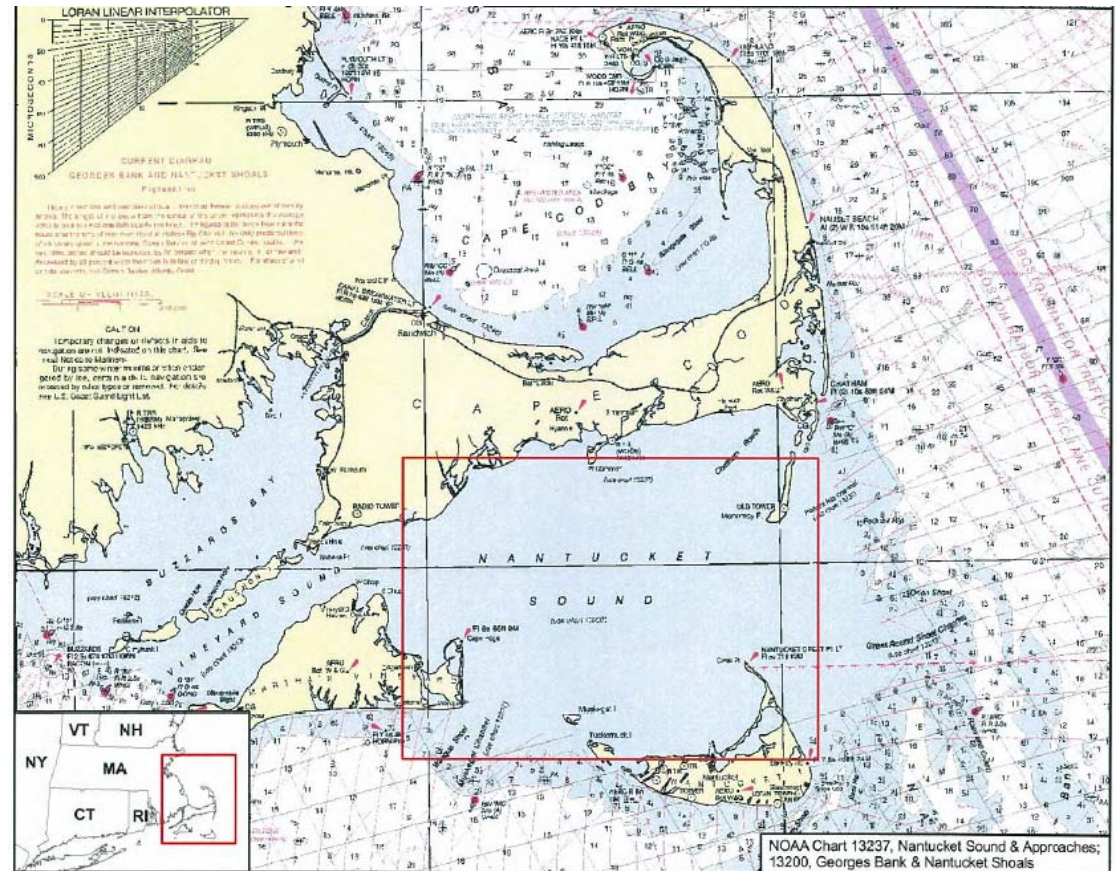
Lessons Learned from Cape Wind



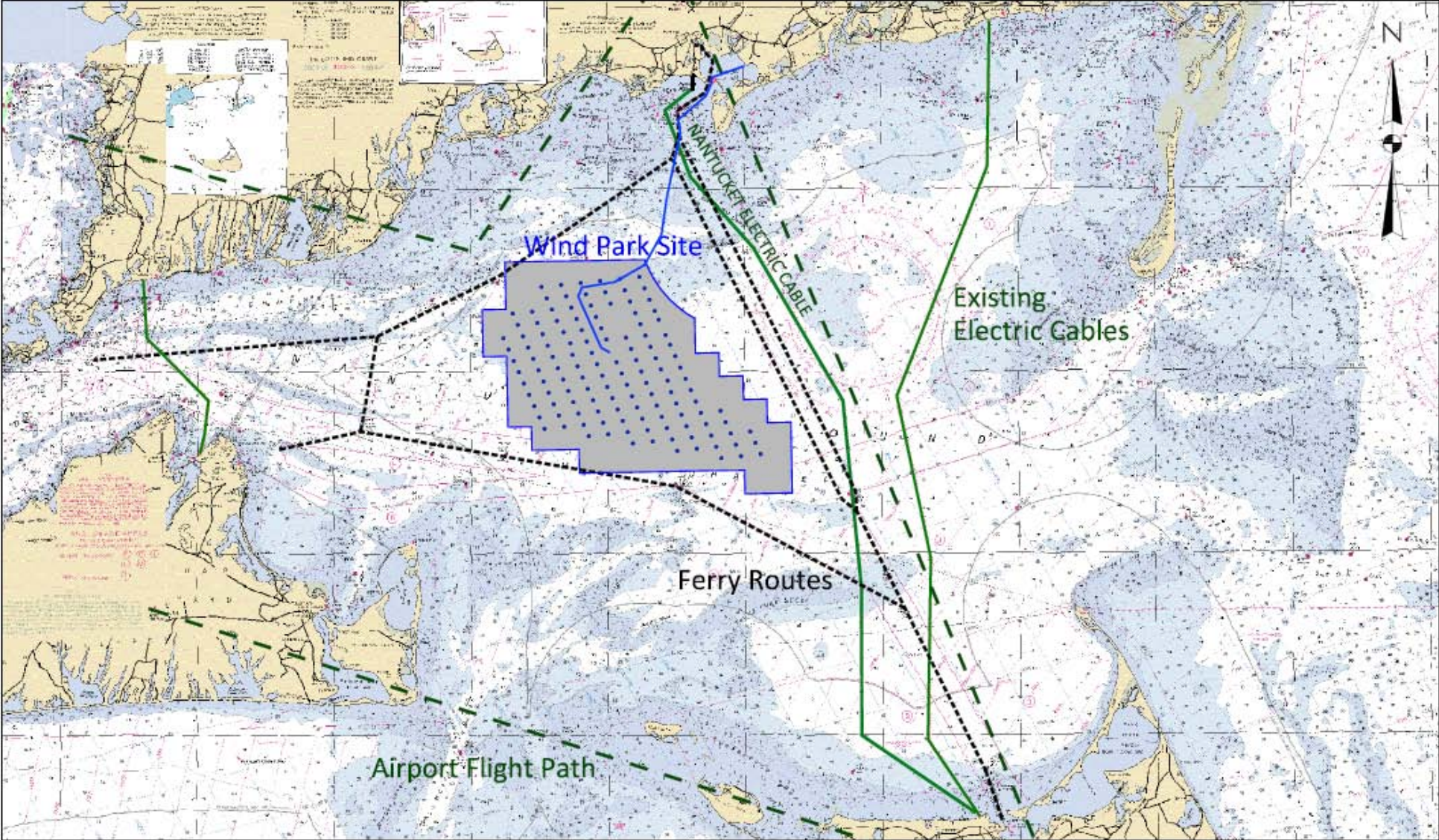
June 18, 2014

Cape Wind Project

- First offshore wind farm in US waters
- 130 Siemens 3.6MW turbines
- Fully approved with all Federal, State and Local permits
- Cape Wind granted nation's first commercial lease to operate an offshore wind farm
- Cape Wind Construction & Operations Plan Approved
- Site characteristics:
 - Shallow water
 - Protected location
 - Near load center



Project Siting



Design and Site Investigations Team



Certified Verification Agent (CVA)

- BOEM Regulations 30 CFR 585.705
- CVA must conduct an independent assessment of the design of the facilities
- CVA must make an independent assessment of the fabrication and installation activities
- CVA required to use “good engineering judgment and practices”
- DNV GL nominated and approved by BOEM as Cape Wind CVA



WTG Codes and Standards

- IEC 61400-3 → ISO 19902 → DNV-OS-J101 – primary standard used for design in European projects
- Need to account for differences in environmental conditions between Cape Wind site and European waters
- Extreme wind conditions more severe (hurricanes)
- Other conditions:
 - Operational wind - comparable to European sites
 - Waves – very benign
 - Ice – benign compared to European sites
 - Soil Conditions – different, but generally within experience of European sites
- Added load cases to Load Case Table to assess extreme storm loads under API criteria for identified 100-year storm conditions

WTG Foundation Design Process



- Iterative process between foundation designer and WTG/tower designer
- Load exchange at the interface point
- Load data in time series – processing time intensive
- 3-step process, typically performed 2-3 times
- Minimum 2 locations (deepest and shallowest)
- Proprietary manufacturer data protected

Geotechnical

- Fugro performed site investigations for design from July to October 2012
- High Resolution Geophysical (HRG) survey
- Cone Penetrometer Test's (CPT's) (up to 18 m)
- Deck-push CPT's (up to 40 m and 67 m at ESP)
- Full penetration borings
- Choosing the right balance in up-front data gathering



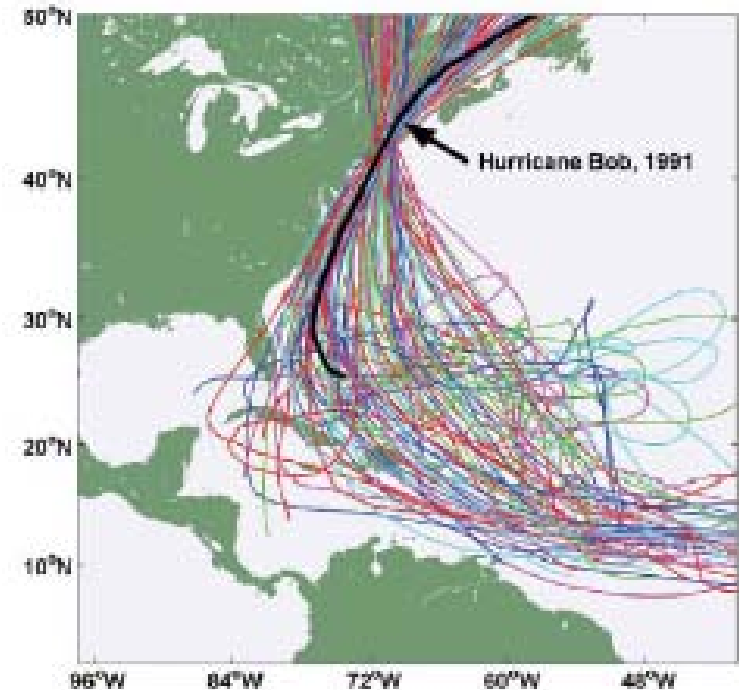
Metocean



- Metocean analysis performed by Ramboll
- Purchased 26 year data set from Ocean Weather
- Calibrated to site with met tower data
- Met tower includes 16 months of Acoustic Doppler Current Profiler (ADCP) data
 - Waves, currents, tide, and temperature
- Data entered into MIKE 21 software for modelling
 - Included nearby tidal measurement stations
- Results: metocean conditions very benign
- Wave action largely generated by wind, so wind/wave misalignment is very low (reducing loads on foundations)

Extreme Storm

- Extreme storm analysis developed by Sgurr Energy
- Inadequate number of storms available for accurate hindcasting
- Synthetic database of ~10k hurricanes used to provide data
- Data set interrogated for storms within 25km of the Cape Wind site – 2,000 results
- Results used to extract wind speeds for different return periods



Wind Resource

- AWS Truepower performed wind resource analysis
- Wind data collected and validated from April 2003 to December 2007
- Wind speed sensors at 3 levels, both cup anemometer and ultrasonic
- Long-term correlation done with 5 local towers – good correlation with Buzzards Bay
- Relevant design data passed to Siemens
- Data reviewed and verified by DNV GL



Lessons Learned



- CVA is critical to success
- Experienced design team
- The right amount of G&G data
- Interface between WTG manufacturer and foundation designer
- High level of scrutiny on wind resource assessment
- Over-communicate

Conclusion

Thank you!

Questions?