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Offshore Wind O&M Challenges

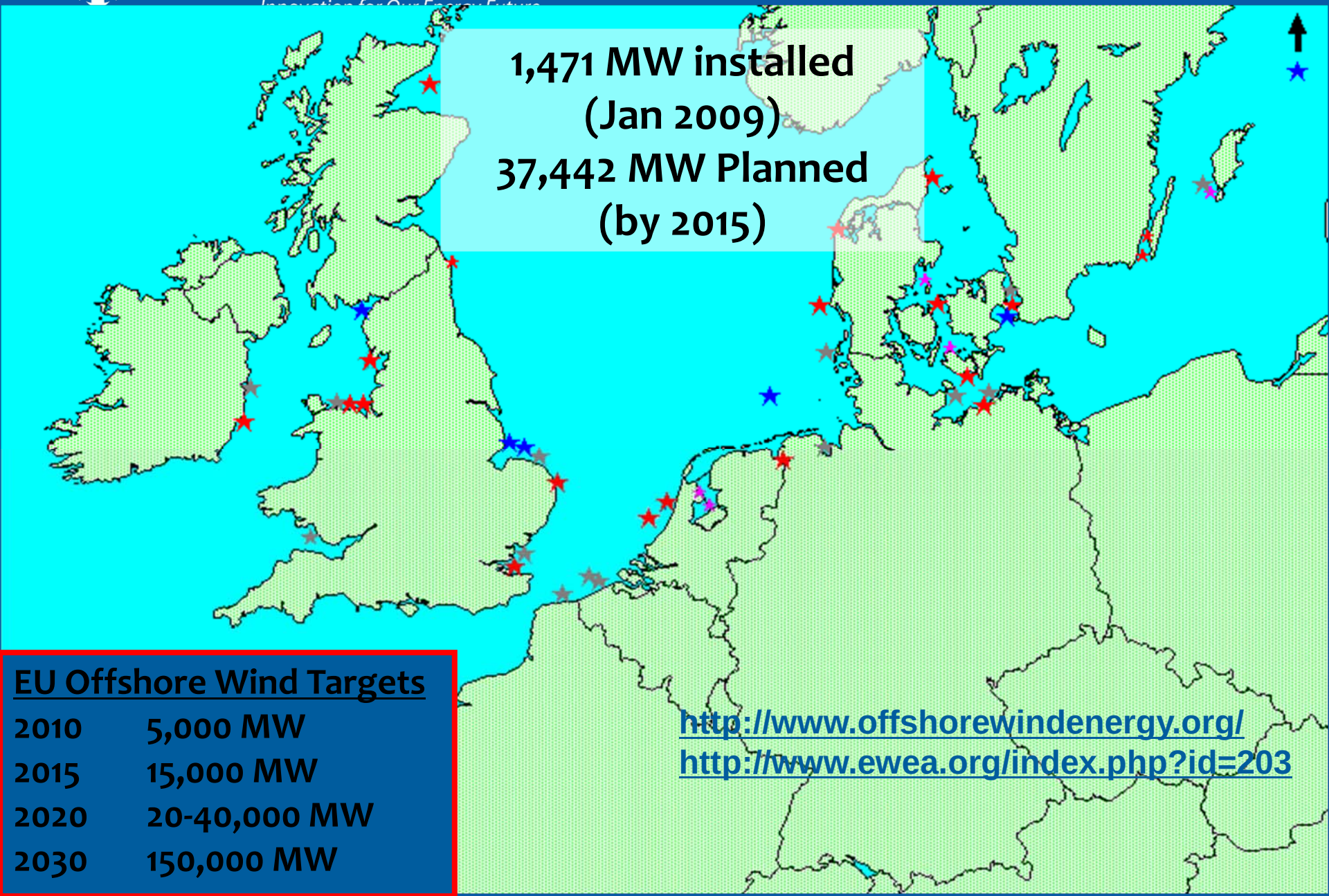
Credit: Siemens

NREL Condition Monitoring Workshop

Walt Musial
Principal Engineer
National Renewable Energy Laboratory

October 8, 2009
Omni Hotel
Broomfield, CO USA

European Offshore Wind



EU Offshore Wind Targets

2010	5,000 MW
2015	15,000 MW
2020	20-40,000 MW
2030	150,000 MW

http://www.offshorewindenergy.org/
http://www.ewea.org/index.php?id=203

European Project Status

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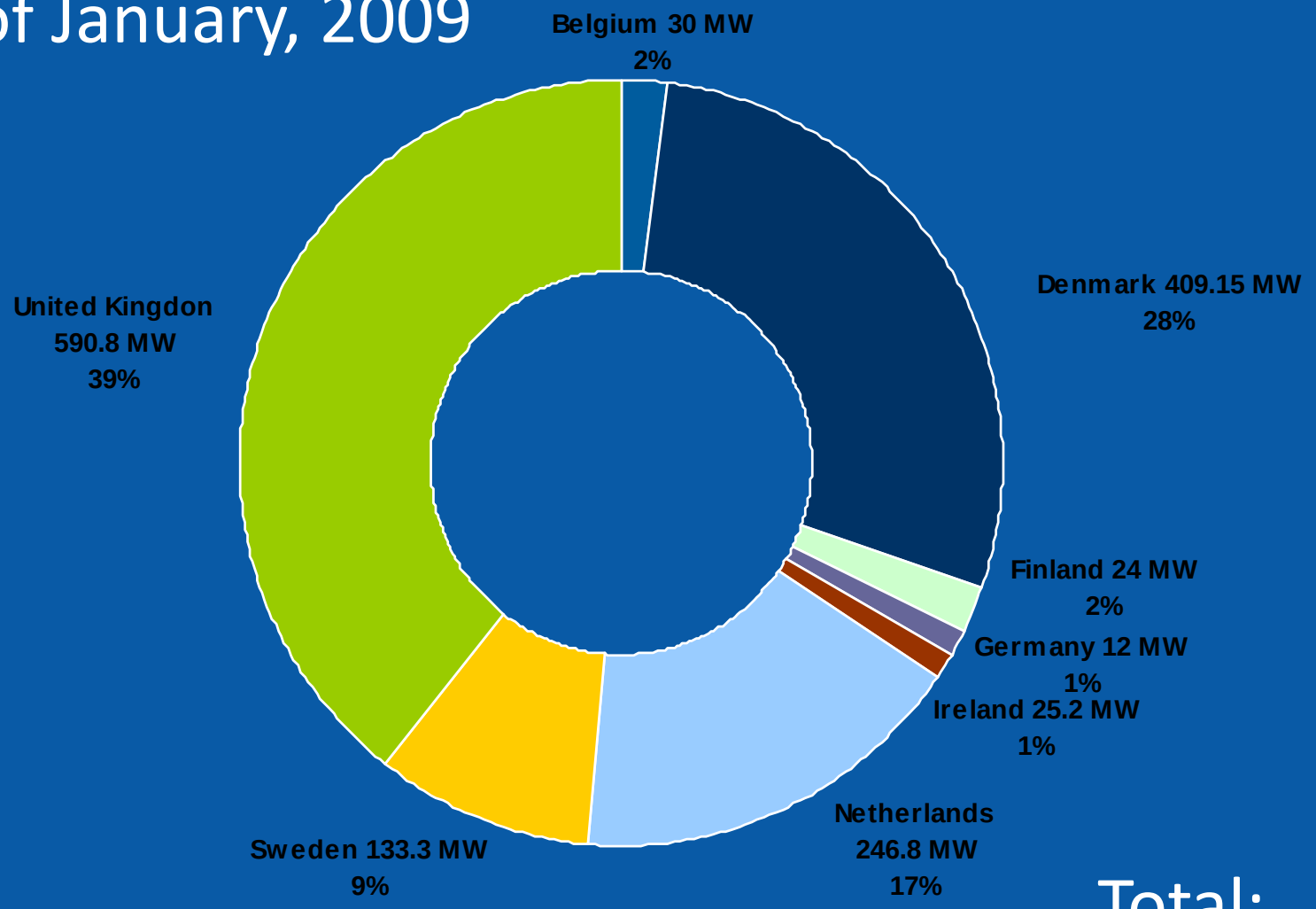
...as of January, 2009



Source: EWEA, 2009

Total:
1,471 MW

20% Wind by 2030

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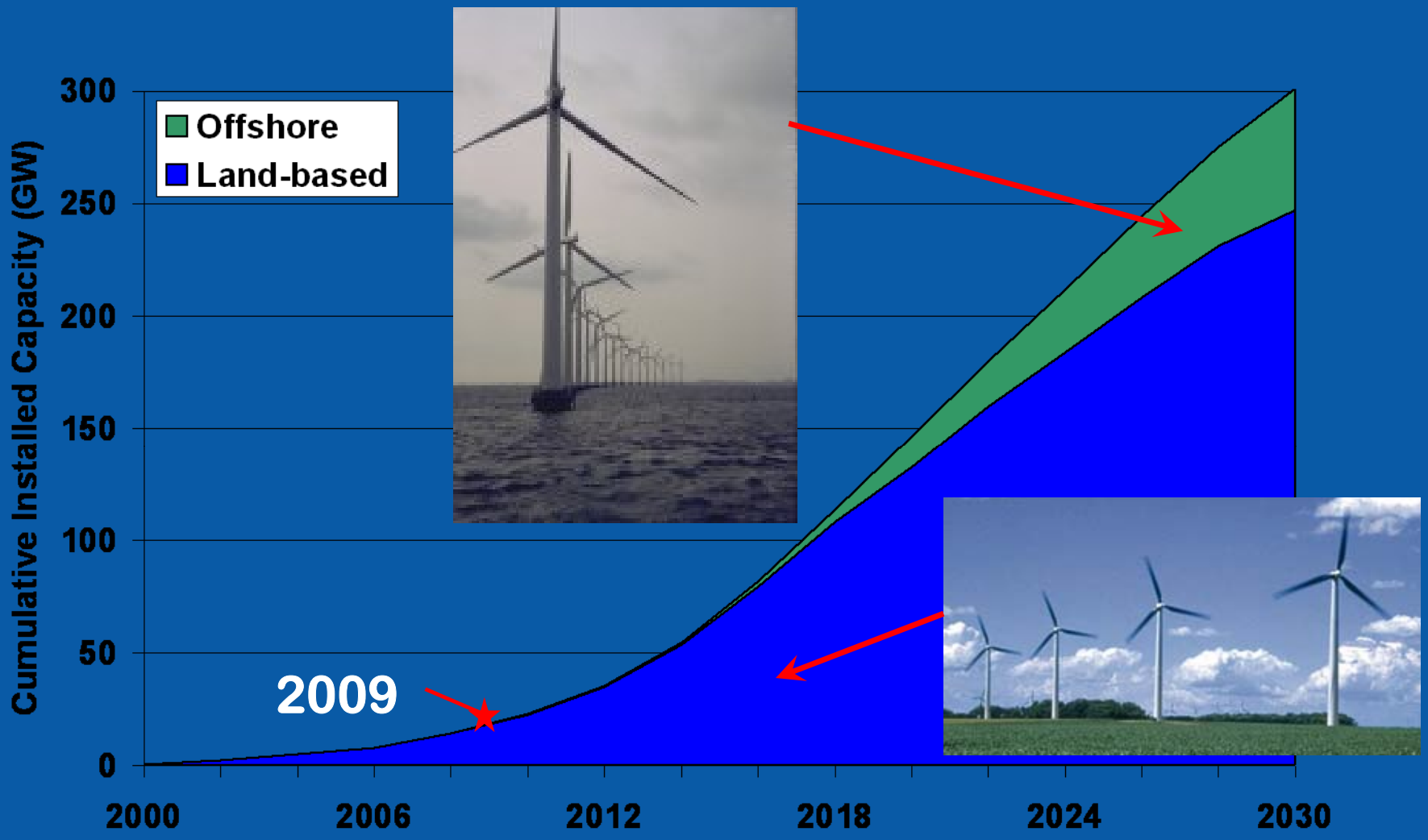
(54,000 MW from Offshore)



http://www1.eere.energy.gov/windandhydro/pdfs/41869.pdf

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US Offshore Wind Projects

US Offshore Wind Initiatives		
Project	**State**	**MW**
Capewind	MA	468
Hull Municipal	MA	15
Buzzards Bay	MA	300
Rhode Island (OER)	RI	400
Winergy	NY	12
New Jersey (BPU)	NJ	350
Delmarva	DE	350
Southern Company	GA	10
W.E.S.T.	TX	150
Cuyahoga County	OH	20
Total MW		2075

No Offshore Wind Projects Installed In North America Yet

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Offshore Wind Technology Issues

Photo Credit: Vestas Wind Turbines

- Corrosion Protection
- Nacelle pressurization
- Personnel Access, shelter, and safety
- Wind/Wave Structural Design
- Hurricanes
- Grids and submarine electrical infrastructure
- Condition monitoring and predictive maintenance
- Inspection
- Decommissioning
- Environmental impacts

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Current Technology

Photo Credit: GE Energy

- Fixed bottom shallow water 0-30m depth
- 2 – 5 MW upwind rotor configurations
- 70+ meter tower height on monopoles and gravity bases
- Mature submarine power cable
- Existing oil and gas experience is essential
- Reliability problems and turbine supply shortages have discouraged early boom in development.
- Costs are 2X land-based due to higher than expected cost and uncertainty with O&M, logistics, and installation.

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Offshore Maintenance Issues

Credit: ABB

Credit: GE Energy

- Vessel deployment cost and logistics
- Accessibility and Availability
- Weather Windows
- Status and Health Monitoring
- Reliability

Offshore Wind farm Maintenance Egmond aan Zee

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Offshore demonstration project supported by Dutch government

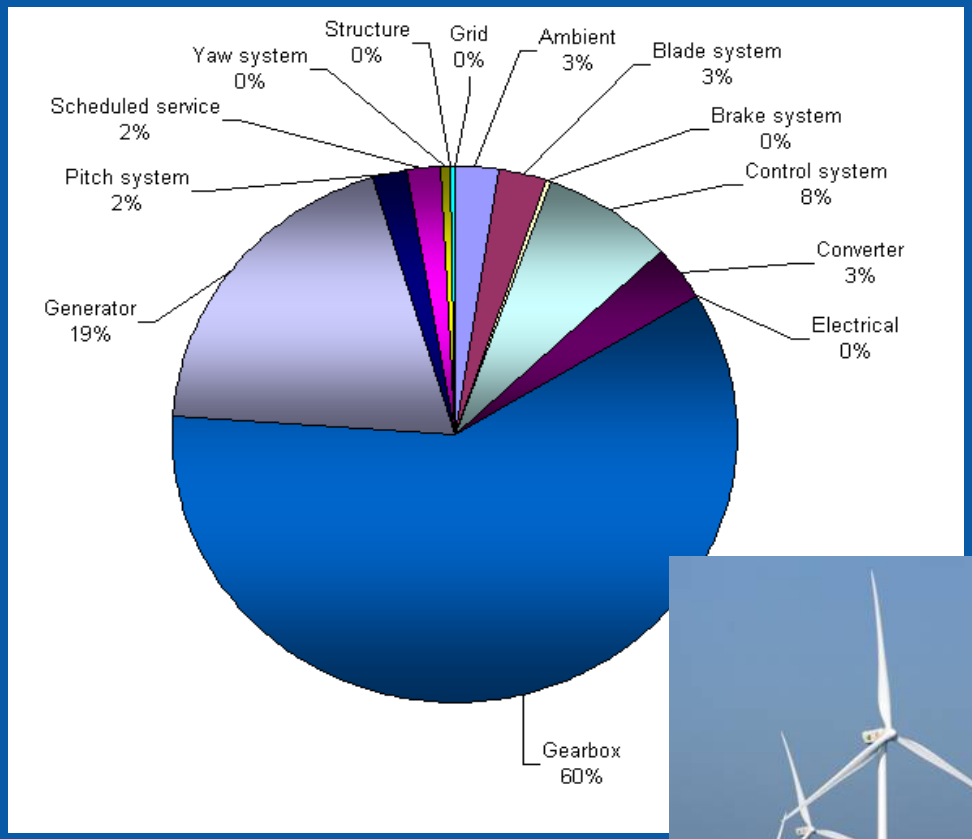
- Selection of site
- Issue of building permits
- Investment subsidy
- Production subsidy

Built and operated by NoordzeeWind

- 36 Vestas 3 MW V90 wind turbines
- 1 met mast, 116 m high
- Hub height 70 m, rotor diameter 90 m
- Monopiles with scour protection
- Water depth 20 m
- 3 x 34 kV cables to the shore
- 34/150 kV substation on shore
- Renewable electricity for +/- 100.000 house holds (~ 330 GWh)
- Design life 20 years

Percent Lost MWh

Ref: Operations Report 2008, NoordzeeWind, Doc No. OWEZ_R_000_20090807 Operations 2008.pdf, websites: www.noordzeewind.nl



Slide Credits:

Jaap 't Hooft
SenterNovem

Henk Kouwenhoven
NoordzeeWind

EOW 2009 Stockholm

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Vessels Deployment Cost and Logistics

- Day rates for vessels are very expensive
- Vessels are scarce and may not be available when needed.
- To minimize costs maintenance actions should limit use
- Turbine designs should incorporate strategies to avoid large vessel dependence.

Accessibility

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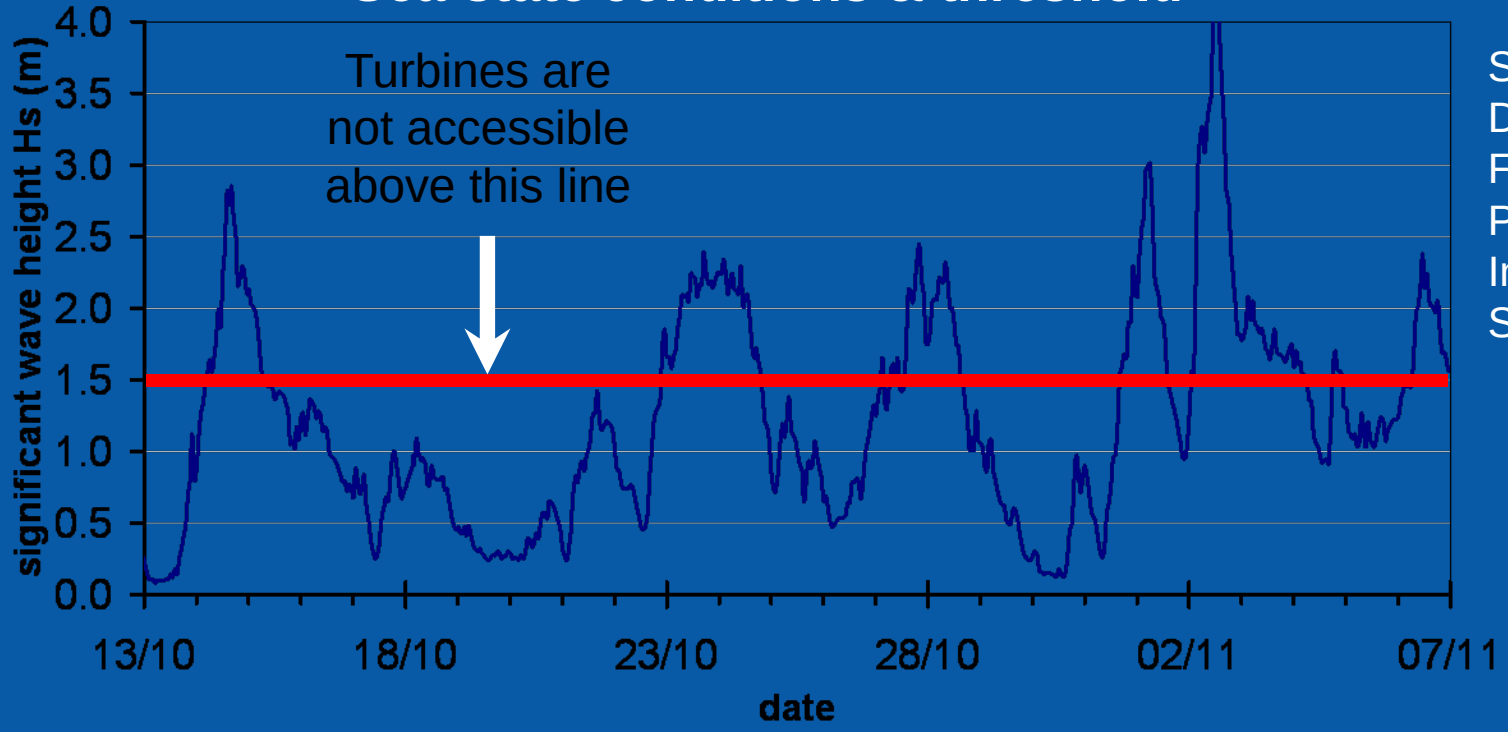
Credit: GE Energy

Sea-state conditions & threshold



Slide Credit:
Dr. Julian Feuchtwang
Prof. David Infield
Strathclyde

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Weather Windows

- Maintenance can only be performed when turbines are accessible
- Accessibility is dependent on weather conditions
- Weather windows can be widened with better access and construction methods
- Improve forecasting integrated into maintenance strategy
- Improve remote sensing and turbine health monitoring to report accurate status

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Health Monitoring

- Offshore machines will have a higher value proposition for health monitoring technology.
- Sensor technology is fairly mature but still needs integration.
- Wind turbine-specific interpretive algorithms are needed for actionable responses
- Establish failure response criteria with high confidence.
- Database of HM data should identify long-term strategies for design and service.
- Optimization of repair actions to save on vessels, labor, and downtime.

Example of Alarm Severity Responses

Severity	Type	Planning of Inspection
6	Danger	Immediate Response
5	Alert	One week response
4	Alert	Inspect on next scheduled visit
3	Alert	scheduled visit
2	Good	No action
1	System	Check on next visit

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Research at Alpha Ventas (RAVE)

- Strain gauges
- acceleration
- acoustic sensors
- hydrographic sensors
- echo sounders
- water pressure sensors
- met data / USA, LIDAR
- SCADA
- corrosion
- Video Cam, Radar

RAVE metrology

RAVE metrology system

- ~ 1,200 sensors
- Available to accredited researchers

Other measurements

- Electrical data P,Q, f, … from offshore and offshore substations

Environm. observations

- Benthos
- Fishes
- Porpoise
- Bird migration
- Bird collisions
- …

Graphics © DOTI, www.alpha-ventus.de

Slide Credit: *Michael Durstewitz Fraunhofer Institute for Wind Energy and Energy System Technology – IWES*

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Reliability

- Reliability is central to offshore economic viability.
- Reliability must be improved at the design stage.
- How to improve reliability:
  - All systems and subsystems should be specified. Understand failure modes and risk of failure
  - Certification
  - Comprehensive testing at full systems level and subcomponent level
  - Redundancy only where appropriate
- What should the target be?

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Key Messages

- Offshore wind is expanding globally
- Offshore Operation and Maintenance is more difficult and more costly than land based.
- Integrated condition-based monitoring systems can improve the value proposition for offshore wind in many areas:
  - Failure rate estimation
  - Scheduling repair actions
  - Optimizing vessel usage
  - Minimizing logistics overhead
- Improving Offshore Turbine Reliability is essential. Offshore turbines should be designed for:
  - Low maintenance
  - In-situ replacement with minimal equipment support