Offshore Micrositing & Certification: From the North Sea to the Baltic – Lessons Learned

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UL Renewables

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AGENDA

Introduction: UL Renewables

Moving to the Baltic Sea

Offshore Micrositing

- Technological Development
- Wake Modelling
- Lessons Learned

Offshore Certification

- Scope & Experience
- „Lessons Learned“

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UL Renewables

HISTORY

DEWI

DEWI OCC

AWS Truepower®

2012

2016

UL

UL Renewables

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TESTING
CERTIFICATION
ADVISORY SERVICES
for
Clean Energy Technologies

FORECAST PROVIDER for
60+ GW
of installed renewable energy projects

450+ Projects
Investor/Lender's engineer on over 400 wind & solar projects since 2012

ADVISED
90%
of the industry's top
Project Developers & Owners

UL
RENEWABLES

500+ Renewable Energy Experts

140+
Countries where UL customers are located

200,000+ MW
Total capacity of renewable energy projects assessed

- Wind
- Solar
- Energy Storage
- E-Mobility

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Offshore & onshore
Onshore only

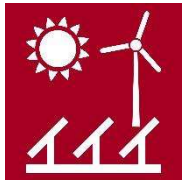
SERVICES

Certification
- Projects
- Wind Turbines
- Components
- Design Basis
- Grid Code Compliance

Testing
- Power Perf. Tests
- Site Calibration
- Mechanical Loads
- Power Quality & LVRT
- Acoustic Noise

Operation
- Performance
- Reporting
- Blades degradation
- O&M Costs

Inspections
- Manufacturing
- Root Cause Analysis

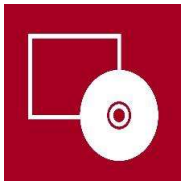


Project Development
- Screening
- Pre-feasibility
- Measurements
- Energy Resource Assessments
- Site Suitability
- Environmental Studies

Due Diligence
- Contractual Revision
- Technology Revision
- Financial Model
- CAPEX / OPEX
- Portfolio Effect
- M & A

Maps and Data
- Wind Atlas
- High Resolution Maps (200m)
- Virtual Data Series
- Wind Resource Grid (WRG)
- Site Reports

Policy and Planning
- Market analysis
- Grid Studies
- Economic Analysis
- Development Studies
- Seminars & Workshops



Software and Tools
- Windographer®
- OpenWind®
- WindNavigator®
- Wind Developer Suite
- Wind Data Management

Structural Integrity
- Exploratory (M&A)
- Remaining Useful Life Analysis
- LTE Solutions

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Moving to the Baltic Sea

FROM THE NORTH SEA…

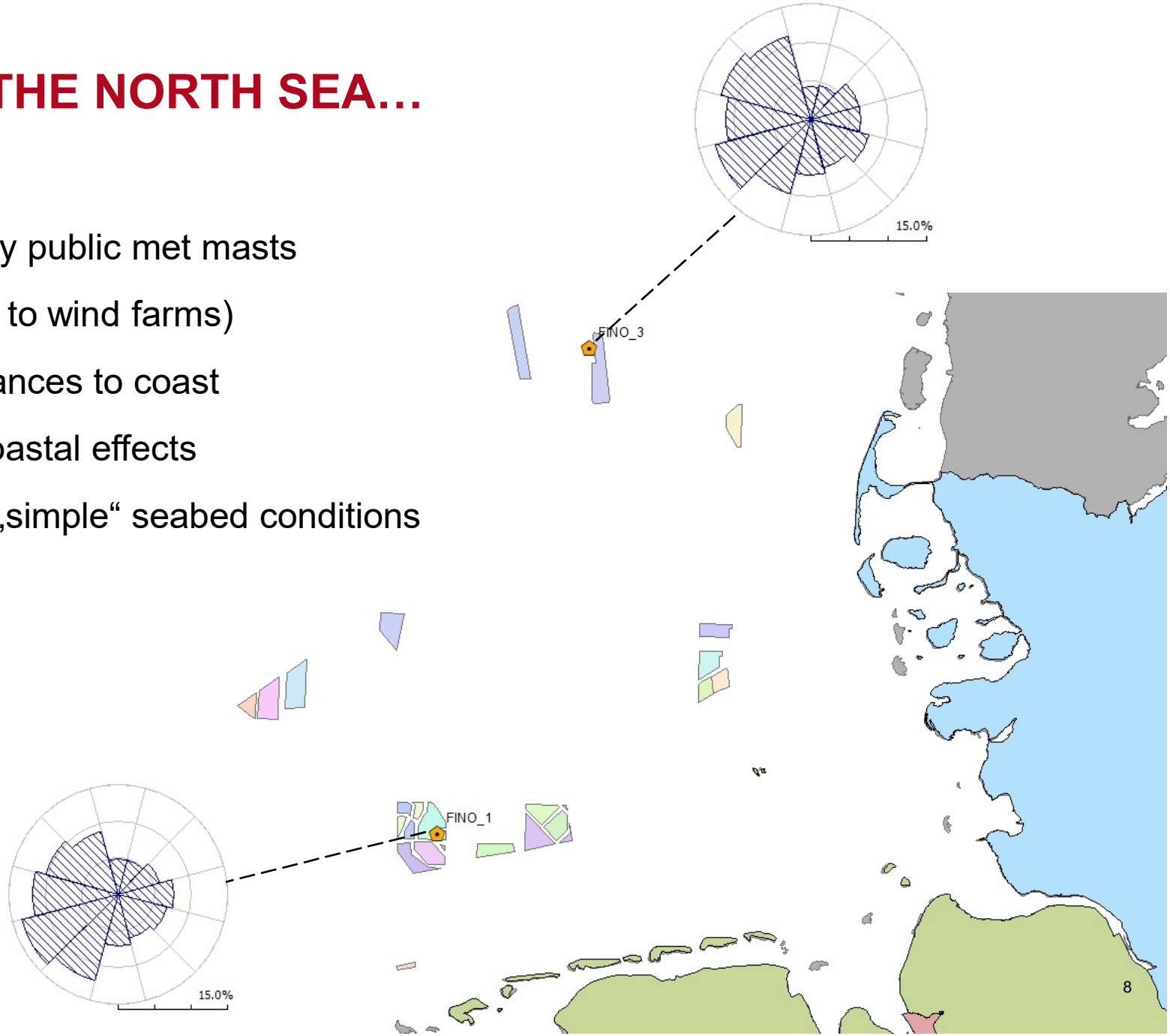
High quality public met masts

(close to wind farms)

Large distances to coast

few coastal effects

Generally „simple“ seabed conditions



… TO THE BALTIC SEA

High quality data less abundant

(proprietary or far away)

Lower wind speeds

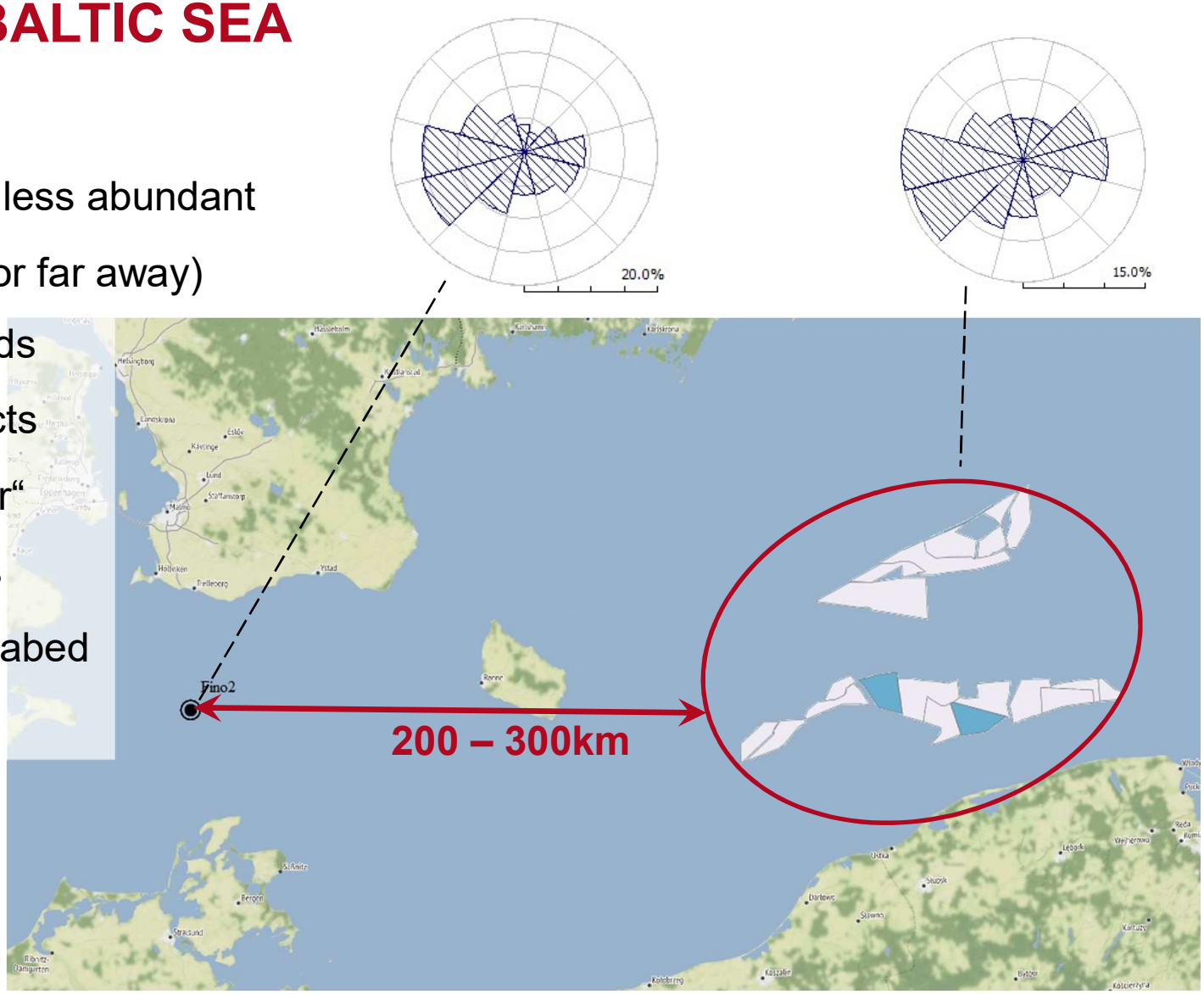
Coastal effects

„One large cluster“

Wake effects

More „difficult“ seabed

Avifauna



INDEPENDENT OFFSHORE EXPERTISE

Measurements

- FINO1 mast: responsible for metocean data since 2003

Micrositing („Site Assessment“)

- Wind Resource & Energy Yield Assessments
  - >80% GER North Sea farms, ~60% of (planned) GER Baltic Sea farms
  - 20 GW worldwide (GER, UK, NL, USA, KOR, TWN)

Technical Due Diligence (several GW of reviews)

Certification

- Project Certifications, Design Basis, Turbine Type Certifications, Integrated Load Analyses, Surveillance Services, Cable Design Evaluations, …

Research (publicly funded: Fino123, RAVE, OWEA, WIPAFF, …)

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Offshore Micrositing

OFFSHORE MICROSITING IN GENERAL…

Meteo data evaluation

- Short-term measurements
- Long-term wind potential

Energy yield assessments

- Wake model

Layout optimisation

Loss & uncertainty assessment

Parameters for Design Basis

- Extreme winds
- Ambient & farm turbulence
- Wind shear
- Temperature/Air density

Other services

- Electrical losses
- Third party review
- Individual requests

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… AND OVER TIME (1)

Measurements then	Now also
Meteorological Towers	LiDAR: • Vertical fixed • Vertical floating • Scanning

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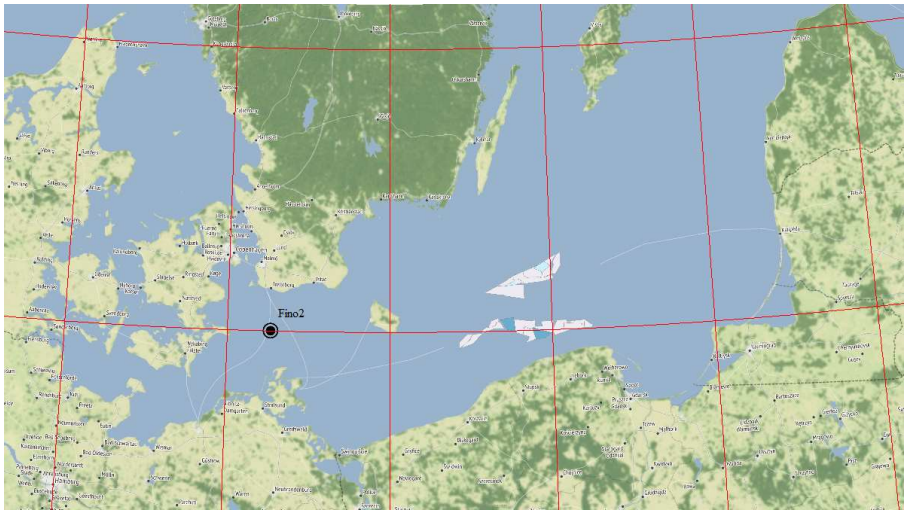
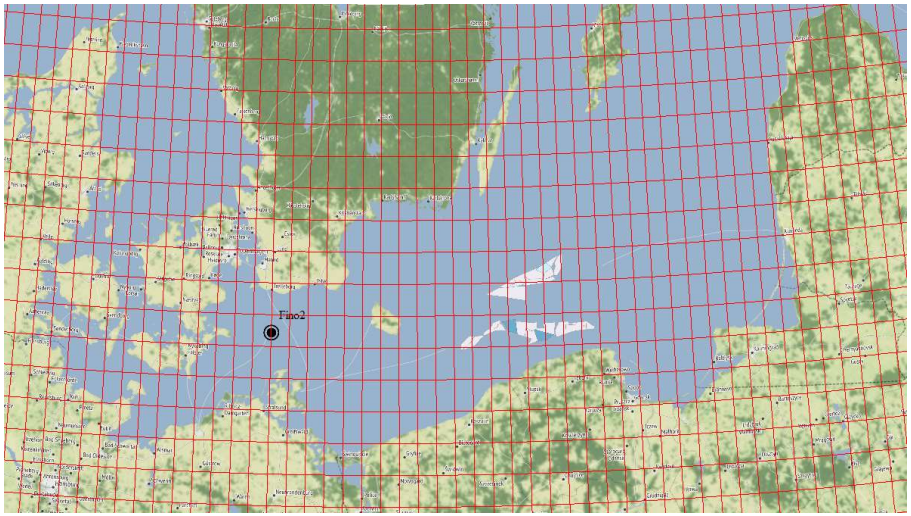
… AND OVER TIME (2)

Reference & Long-term Data Sets Then	Now also
Meteorological Stations	Third Generation Reanalysis Data (ERA5, 0.28°)
First Generation Reanalysis Data (NCEP, 2.5°)	Mesoscale Simulations (~0.03°)





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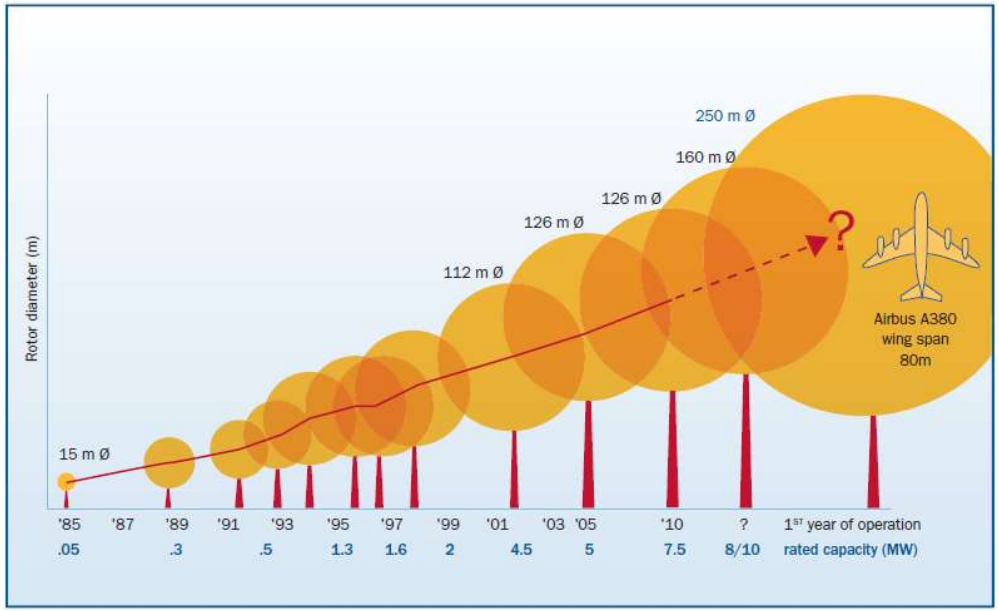
… AND OVER TIME (3)

Turbine Technology Then	Now
Modified onshore turbines • 2 – 3 MW power, 120m diameter	Dedicated offshore turbines • 8 – 10 MW, 160m diameter • Proven track records Soon: 12-15 MW, >200m diameter



Source: UpWind, 2011

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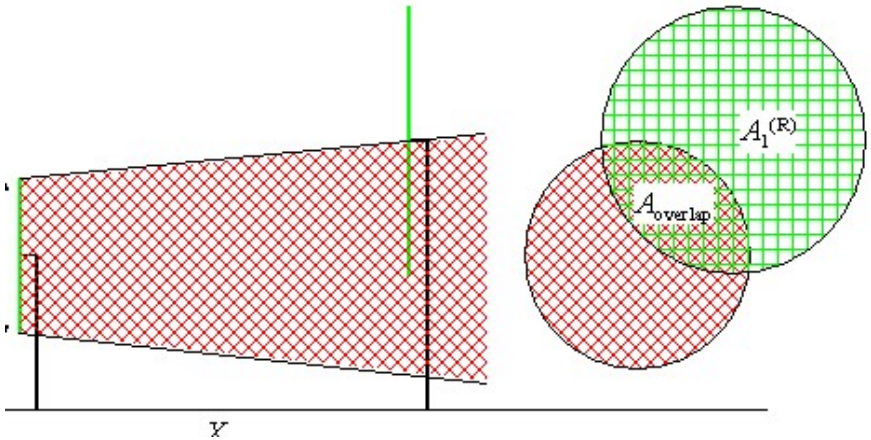
WAKE MODELLING



Direct Wake Models

- Jensen, Eddy-Viscosity, …
- Localized reduced wind speed/increased turbulence

Internal Boundary Layer Models ("Deep Array"/"Large Farm")

- (Large) wind farms add "roughness" to sea surface
- General wind speed reduction inside the farm

Combination of both currently state of the art

Source: C. Steiness/Vattenfall

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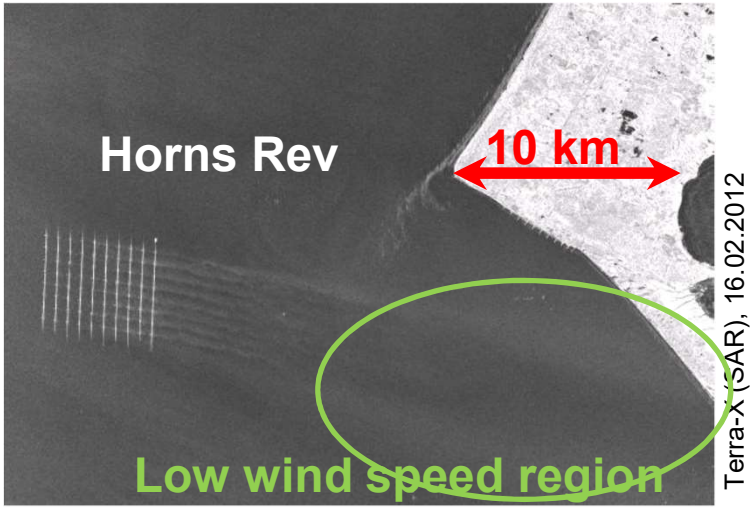
WAKE MODELLING: FUTURE ISSUES



"Far wakes"

- Wakes decay too fast in current models
  - stable stratification
- Relevant for distances >20km
- Research projects WIPAFF & XWakes

"Blockage effect"

- Wind farms as 'obstacles': wind has to move around
- Wind speed reduction already upstream/first row
- Already covered by wake model calibration?

Both issues currently under investigation

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MICROSITING: LESSONS LEARNED

± : pros and cons
😐 : uncertainty enhanced
☹ : uncertainty strongly enhanced
💣: uncert. too high, not bankable

Topic	Best Practice	Alternative
Meteo data	• On-site mast (±) • On-site (floating) LiDAR (±)	• Distant offshore mast/LiDAR 😐 • Onshore mast/LiDAR ☹ • Standalone mesoscale model 💣 • Buoys, oil rigs,… 💣
Vertical Extrapolation to Hub Height	Not needed (Measurement at hub height)	Measured wind profile
Horizontal Extrapolation…		
…to Wind Farm Area	Not needed (on-site measurement)	Mesoscale modelling
…inside Wind Farm	Wind flow modelling	Wind flow modelling
Long-term Correction	Various methods of comparable quality: Time series correlation (MCP), Monthly/Daily Means Correlation, …	
Annual Energy Yield	Wind Statistics (histogram)	Time Series
Wake Losses	Validated model; usually combined direct wakes + IBL	
Systematical Losses	Project specific details	Standard assumptions 😐

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Offshore Certification

CERTIFICATION

Ensures compliance of a project with international Schemes, Standards & Guidelines

- Define State-of-the-Art (knowledge, technology, methods)
- Safety, Security, Reliability

Examples:

IEC 61400-22 Ed.1 (2010-05)
IEC 61400-1 Ed.4 (2018-08)
IEC 61400-3-1 Ed.1 (2019-04)

OD 502
IEC 61400-3
IEC 61400 series

UL 6141
UL 6142
UL 6171

37-GC-P0850
37-GC-P0851
37-GC-P0852

DNVGL-SE-0073:2014
DNVGL-SE-0190:2015

Check whole project or individual steps

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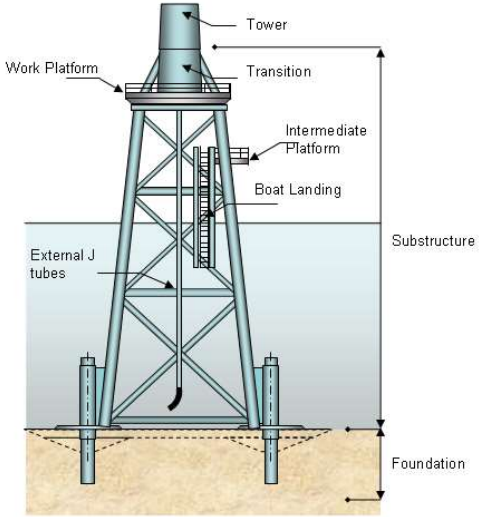
PROJECT CERTIFICATION SCOPE

Covers the full development and installation chain

- Site Conditions Evaluation
- Design Basis Evaluation
- Integrated Load Analysis/ Integrated Load Model
- Site Specific Turbine/RNA Design Evaluation
- Site Specific Support Structure Evaluation
- Other Installations Design Evaluation (OSS, Cables)
- Surveillance
  - Manufacturing (Turbine, Support, Other Components)
  - Transport & Installation
  - Commissioning
- Final Evaluation



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PROJECT CERTIFICATION EXPERIENCE

Scope	Volume	Location
Project Certification	5 WFs	BEL, GER
Site Conditions/ Design Basis	15 WFs	FRA, GER, USA
Load Analysis/ Design Evaluation	7 WFs	UK, NL, BEL, GER, KOR
Surveillance Services	5 WFs	GER, BEL
Other Components	2 WFs	GER, BEL
WTG Type Certification	6 WTG	GER, KOR

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CERTIFICATION: *"LESSONS LEARNED"*

Topic	Trends and Challenges	Examples
Wind Turbine Size	• **Trend** to bigger and taller WTG • **Challenge**: Structure design (WTG/Support) Transport and Installation	• WTG: 3MW -> 10MW (-> 12MW+) • Monopiles: 6.5m -> 8 m (-> 12m+)
Site Conditions Measurement	• **Trend** from met mast data to other data sources (e.g. LiDAR) • **Challenge**: Codes and standards often lag behind state of the art methods	English Channel and Atlantic coast: No offshore met masts available
Water depth	• **Trend** to greater water depths • **Challenge**: Longer/larger support structures Greater probing depths	Foundation depth increased during project development beyond soil investigation depth → Extrapolation, additional investigations
Soil conditions and investigation	• New locations tend to have more diverse soil conditions • **Challenge**: Adapt foundation design and investigation methods	Atlantic coast: Bedrock → Seismic investigation difficult Baltic Sea, English Channel: Chalk and Flint Layers → Problematic for pile driving

Experience

Know-How

Thank you!

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