Welcome

WIND. ASSURING CONFIDENCE
THROUGH COMPETENCE

Assessment of effects of adverse weather conditions on offshore projects

Gerrit Wolken-Möhlmann
Dr. Marcel Wiggert
Agenda & Goals

- Introduction to weather risks
- COAST concept
- Case study
- Summary and outlook

Goals:
- Introduction to a holistic approach to analyze Transport and Installation (T&I) strategies using long weather time series
- Case study for different locations and a downtime map
- Where to apply the analysis method and principles how to reduce your weather risks

Figure: Florian Meier
Weather Risks
Offshore Wind Projects

Example: Project Delays
- 2001 Middelgrunden
- 2004 Scroby Sands
- 2009 Horns Rev 2
- 2009 Alpha Ventus “Weather conditions delay construction work at sea”
- 2010 Robin Rigg
- 2011 Bard Offshore 1
- 2012 “London Array delay costs Dong millions”
- 2012 Greater Gabbard “where weather problems contributed to a $400m loss”
- 2012 “Bad weather causes delay to Sheringham Shore windfarm project”
- 2012 “DONG Fights Weather Condition During Anhold Wind Turbine Installation”
- 2013 Meerwind Ost
- 2014 Amrumbank West

Example: Positive Effects
- 2010 Thanet
- 2012 Alpha Ventus (energy yield)

Risk Optimization = Cost Reduction
Wind Energy Update’s - Market Survey 2015
Offshore Wind Construction and Installation

General comment of a participant:
“Purely financially speaking: weather risk management solutions to make budgets workable and stable”

(300+ participants)
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Figure: Florian Meier
Offshore Wind Farm
Setting the Scene

ENVIRONMENTAL AND BOUNDARY CONDITIONS

VESSEL RESTRICTIONS

ENVIRONMENTAL CONDITIONS

RISKS

MARINE OPERATION

Project Area

OWF – Components

Wind Turbine
Substructure
Converter
Inner array cable

Harbor A

Harbor B

13.10.2015
Wind Farms and Local Weather Conditions

- Location:
  - E.g. Fraunhofer Virtual Reference Wind Farm

- Local weather conditions:
  - Waves (e.g.: significant waves height, peak period, …)
  - Wind (e.g.: speed, gusts, …)
  - Currents, Temperature, Visibility, Clouds, Daylight, …

- Weather Data: (Example)
  - HZG CoastDat v1
    (Helmholz Zentrum Geesthacht)
Individual Vessel Strategy and Project Schedule

### Installation Strategy

#### Vessel concept

- \( H_S = 2.5 \text{m}; \ U = 15 \text{m/s} \)
- Costs: 250.000 €/d
- Expensiv, lower weather risk

#### Project Schedule

- **Project 12 WTs**
  - Anfang: Do 06.06.13
- Installation of pin pil:
  - port activities: Do 06.06.13
  - outbound trip: Do 06.06.13
- Drive 48 piles:
  - Fr 07.06.13
  - drive 4 piles: Fr 07.06.13
- Drive 4 piles:
  - Sa 08.06.13
  - drive 4 piles: Mo 10.06.13
  - drive 4 piles: Mi 12.06.13
  - drive 4 piles: Do 13.06.13
  - drive 4 piles: Fr 15.06.13
  - drive 4 piles: Sa 15.06.13
  - drive 4 piles: Mo 17.06.13
  - drive 4 piles: Di 18.06.13
  - drive 4 piles: Mi 20.06.13
  - drive 4 piles: Do 22.06.13
- Inbound trip:
  - Mi 26.06.13
- Installation of jacket:
  - Mi 26.06.13
- Port activities:
  - Mi 26.06.13
- Outbound trip:
  - Do 27.06.13
- Installation of 3 lkr Do 27.06.13
Information Profile

- Local weather conditions, e.g.
  - Significant wave heights
  - Wind speeds
  - Currents
  - Temperature
  - Visibility

- Required T&I processes and sequences
- Project overall project time schedule

- Design of the structure
- Location wind farm/ports
- Vessel and equipment concept
- Guideline requirements
- Contractual agreements
Information Profile

- Local weather conditions, e.g.
  - Significant wave heights
  - Wind speeds
  - Currents
  - Temperature
  - Visibility

- Required T&I processes and sequences
- Project overall project time schedule

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**WEATHER PARAMETERS**

**LOCAL WEATHER CONDITIONS**

**MEASURED**

**HINDCAST**

**WEATHER TIME SERIES**

**T&I CONCEPT**

**PROJECT SCHEDULES**

**INSTALLATION STRATEGY**

**BOUNDARY CONDITIONS**

**MEASUREMENT**
Information Profile

WEATHER PARAMETERS
- Local weather conditions, e.g.
  - Significant wave heights
  - Wind speeds
  - Currents
  - Temperature
  - Visibility

WEATHER TIME SERIES
MEASURED
HINDCAST

PROJECT SCHEDULES
- Required T&I processes and sequences
- Project overall project time schedule

INSTALLATION STRATEGY
- Design of the structure
- Location wind farm/ports
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- Guideline requirements
- Contractual agreements

WEATHER CONDITIONS
RESTRICTIONS
GUIDELINES

PROJECT DURATION
Sensitivity and Scenario Analysis
ROBUST PROJECT SCHEDULES

COST AND RISK OPTIMIZATION

13.10.2015
COAST – Research Project
Comprehensive Offshore Analysis and Simulation Tool

Munich RE
HOCHTIEF SOLUTIONS AG
Fraunhofer IWES
Deutscher Wetterdienst
Wetter und Klima aus einer Hand
BUGSIER
WindMW

Supported by:
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
based on a decision of the Parliament of the Federal Republic of Germany

Source: shutterstock
WaTTS – Method
Weather Time Series Scheduling

- Consideration of:
  - Task sequence
  - Contingencies in guidelines
  - Different weather restrictions
  - Weather forecast error

- Calculation of project durations and their probabilities
- Calculation of installation cycles
Principle of Yearly Simulation

TIME SCALE

DURATION VS. START DATE

START DATE: E.G. 01.01.
COAST - Software
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Fraunhofer IWES
Virtual Reference Wind Farms

Location:
- FINO1 (54.0°N 6.6°E)
- FINO3 (55.2°N 7.2°E)
- NSBIII (54.7°N 6.8°E)

Weather Data:
- Approx. Alpha Ventus
- HZG CoastDat v1
(Helmholz Zentrum Geesthacht)

Weather Parameters (used)
- Significant Wave Height (h_S)
- Wind speed (U)
Case Study: Installation Sequence

**Repetitive Operational Sequence**

<table>
<thead>
<tr>
<th>Vorgangsnr.</th>
<th>Vorgangsnr.</th>
<th>Anfang</th>
<th>Fertigstellung</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Installation of 20 Foundations, cable works and WIG</td>
<td>Mi 01.07.15</td>
<td>Mo 03.07.17</td>
</tr>
<tr>
<td>2</td>
<td>Start of Project</td>
<td>Mi 01.07.15</td>
<td>Mi 01.07.15</td>
</tr>
<tr>
<td>3</td>
<td>Installation of Foundations</td>
<td>Mi 01.07.15</td>
<td>Mi 24.06.17</td>
</tr>
<tr>
<td>4</td>
<td>Loop 1: Foundation 01-10</td>
<td>Mi 01.07.15</td>
<td>Di 02.07.15</td>
</tr>
<tr>
<td>5</td>
<td>1. Load of at Baseport</td>
<td>Mi 01.07.15</td>
<td>Do 02.07.15</td>
</tr>
<tr>
<td>6</td>
<td>LoadOut of 3 sets at Port</td>
<td>Mi 01.07.15</td>
<td>Mi 01.07.15</td>
</tr>
<tr>
<td>7</td>
<td>Loading Foundation 01</td>
<td>Mi 01.07.15</td>
<td>Mi 01.07.15</td>
</tr>
<tr>
<td>8</td>
<td>Loading Foundation 02</td>
<td>Mi 01.07.15</td>
<td>Mi 01.07.15</td>
</tr>
<tr>
<td>9</td>
<td>Loading Foundation 03</td>
<td>Mi 01.07.15</td>
<td>Mi 01.07.15</td>
</tr>
<tr>
<td>10</td>
<td>Loading 9 piles</td>
<td>Mi 01.07.15</td>
<td>Mi 01.07.15</td>
</tr>
<tr>
<td>11</td>
<td>Loading Grout Materials</td>
<td>Mi 01.07.15</td>
<td>Mi 01.07.15</td>
</tr>
<tr>
<td>12</td>
<td>Seafastening</td>
<td>Mi 01.07.15</td>
<td>Mi 01.07.15</td>
</tr>
<tr>
<td>13</td>
<td>Jack DOWN</td>
<td>Mi 01.07.15</td>
<td>Mi 01.07.15</td>
</tr>
<tr>
<td>14</td>
<td>Port Departure Procedures</td>
<td>Mi 01.07.15</td>
<td>Mi 01.07.15</td>
</tr>
<tr>
<td>15</td>
<td>Travel to Offshore Site [100NM@10km±1h]</td>
<td>Mi 01.07.15</td>
<td>Do 02.07.15</td>
</tr>
<tr>
<td>16</td>
<td>Installation of Hot Tapping WIG on 1</td>
<td>Do 02.07.15</td>
<td>Di 01.04.17</td>
</tr>
<tr>
<td>17</td>
<td>Jack UP</td>
<td>Do 02.07.15</td>
<td>Do 02.07.15</td>
</tr>
<tr>
<td>18</td>
<td>Preloading</td>
<td>Do 02.07.15</td>
<td>Do 02.07.15</td>
</tr>
<tr>
<td>19</td>
<td>Preparation works</td>
<td>Do 02.07.15</td>
<td>Do 02.07.15</td>
</tr>
<tr>
<td>20</td>
<td>Foundation Installation to Seabed</td>
<td>Do 02.07.15</td>
<td>Mo 10.04.17</td>
</tr>
<tr>
<td>21</td>
<td>Lift Foundation onto seabed</td>
<td>Do 02.07.15</td>
<td>Mo 10.04.17</td>
</tr>
</tbody>
</table>

**Input Data:**
- 20 Jacket
- > 1.400 Activities
- No Guidelines considered
- Sign. Wave Height
- Wind Speed
- Start Date: Continues Simulation

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Case Study:
Result FINO1 – Duration vs. Start Day
Case Study: Result FINO1 – Duration vs. Start Day
Case Study:
Result FINO1 – Distribution Comparison

- Primary weather risk
- Secondary weather risk
Case Study: Result FINO1 – Task vs. Duration
Location:
- FINO1 (54.0°N 6.6°E)
- FINO3 (55.2°N 7.2°E)
- NSBIII (54.7°N 6.8°E)

Weather Data:
- Approx. Alpha Ventus
- HZG CoastDat v1 (Helmholz Zentrum Geesthacht)

Weather Parameters (used):
- Significant Wave Height ($h_S$)
- Wind speed (U)
Case Study: Comparison of Different Locations

![Graph showing project duration vs. start date for different locations. The graph compares WaTSS results with P50, P05, and P95 confidence levels. The x-axis represents the start date ranging from January to January, and the y-axis represents project duration in days ranging from 80 to 240. The graph highlights the variability and distribution of project durations across different locations.]
Case Study:
Comparison of Different Locations

![Duration comparison graph]

- P50: FINO1
- P50: FINO3
- P50: NSBIII

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Case Study:
Comparison of Different Locations
Maps of Parameters

Mean wind speed

Capacity factor

Extreme sea states
Maps of Project Downtimes
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Figure: Florian Meier
Further Fields of Application
Comparison of Installation Strategies

**SZENARIO I**
Classical Approach

- \( H_S = 1,5 \text{m}; \ U = 10 \text{m/s} \)
- Costs: 150.000 €/d
- Cost efficient, high weather risk

**SZENARIO II**
Specified Installation Vessel

- \( H_S = 2,5 \text{m}; \ U = 15 \text{m/s} \)
- Costs: 250.000 €/d
- Expensive, lower weather risk

**SZENARIO III**
Floating Structure (Feeder Strategy)

- \( H_S = 1,0 \text{m}, \ U = 10 \text{m/s} \)
- Costs: 100.000 €/d
- Cost efficient, high weather risk

www.scaldis.com
www.hochtief.de
www.wordpress.com
Fields of Application

Transport and Installation
- Analysis and optimization of project schedules, costs and risks; overall project plan
- Analysis and optimization of vessel and installation concepts; vessel designs
- Analysis and optimization of contractual payments, penalties and weather risk distribution
- Determination of remaining weather risks during installation
- Proof of project progress, delays or working times, claim management
- Support to determine insurance cover

Operation and Maintenance
- Analysis and optimization of planned and simple condition based maintenance
- Analysis and optimization of large component replacements
- Prediction of accessibility
- Analysis, comparison and optimization of (seasonal) accessibility strategies
- Analysis and optimization of weather risk distribution for vessel clubs

Civil Engineering
- All fields of application adapted for Civil Engineering topics

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Summary

- COAST Approach:
  - Assess the weather risk
  - Combating the weather risk by scenario investigations
  - Case studies for different locations
Acknowledgements

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Our employees are all

innovation accelerators  efficiency boosters  competence linkers

class expander  knowledge intensifiers  planing secure
THANK YOU FOR YOUR ATTENTION

Any questions?
marcel.wiggert@iwes.fraunhofer.de
Background

**DETAILED INFORMATION**
Methods to Forecast Weather Dependent Activity Durations

1 WaTTS - Weather Time Series Scheduling
Methods to Forecast Weather Dependent Activity Durations

1 WaTTS - Weather Time Series Scheduling
COAST – Results

All results can be exported as .csv for further MS Excel use.
Schedule Risk Analysis

Example

- Project plan: including weather influence and project risks
Cost Pyramid
Significance of Early Decisions

Cost Pyramid by Lechner (for Civil Engineering Projects)

- PPH 1: Project preparation
- PPH 2: Planning
- PPH 3: Execution planning
- PPH 4: Execution
- PPH 5: End of project

Cost accuracy – cost pyramid – tolerance area:
- ± 20% ± 40%
- ± 15% ± 30%
- ± 5% ± 20%
- ± 3% ± 10%
- ± 0% ± 0%

Traditional prediction
Professional approaches

IDEA → PROJECT DEVELOPMENT → PLANNING & DESIGN → TRANSPORT & INSTALLATION → OPERATION & MAINTENANCE → DECOMMISSIONING/REPOWERING → END

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