Case Study 2
Thilo Krupp, Stiftung OFFSHORE–WINDENERGIE
Warsaw, 7 June 2018
Outline

- Scenario Description
  - High and Low Offshore Wind Development
  - Integration Levels
- Scenario Design & Roadmap
- Scenario comparison
Scenarios

Integration level

- Zero Integration
- Partial Integration
- Max. Integration

OWP level

- High OWP
- Low OWP

Scenario

- Scenario 1a
- Scenario 1b
- Scenario 2a
- Scenario 2b
- Scenario 3a
- Scenario 3b

Focus on HIGH offshore wind for this presentation.
High OWP Vision: 2025 - 2040

OWP capacity: 3.7 GW

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A Side Note to Germany ...

Case Study Area
2025-2040

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Scenario Concept – Integration Level

Level of Integration

Scenario 1
Zero Integration

Scenario 3
Max. Integration
Scenarios

Integration level

- Zero Integration
- Partial Integration
- Max. Integration

OWP level

- High OWP
- Low OWP

Scenario

- Scenario 1a
- Scenario 1b
- Scenario 2a
- Scenario 2b
- Scenario 3a
- Scenario 3b

Focus on HIGH offshore wind for this presentation.

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Zero Integration

OWP capacity: 3,7 GW, 14 TWh/y

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## Scenarios

<table>
<thead>
<tr>
<th>Integration level</th>
<th>OWP level</th>
<th>Scenario</th>
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<tbody>
<tr>
<td>Zero Integration</td>
<td>High OWP</td>
<td>Scenario 1a</td>
</tr>
<tr>
<td></td>
<td>Low OWP</td>
<td>Scenario 1b</td>
</tr>
<tr>
<td>Partial Integration</td>
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<td>Scenario 2a</td>
</tr>
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OWP capacity: 3.7 GW, 14 TWh/y

Max. Integration

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Scenarios

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Partial Integration

OWP capacity: 3.7 GW, 14 TWh/y

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Scenario Comparison

Total length of cables passing through other uses of the sea
High Wind

Source: provided by FNEZ
## Zero vs Partial vs Max grid integration

<table>
<thead>
<tr>
<th>Component</th>
<th>Zero (1a)</th>
<th>Partial (2a)</th>
<th>Max (3a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC Converter substations</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>DC Cable length (km)</td>
<td>450</td>
<td>485</td>
<td>485</td>
</tr>
<tr>
<td>Total DC conductor weight</td>
<td>1 217 t Al (or 3 041 t Cu)</td>
<td>3 927 t Al (or 9 817 t Cu)</td>
<td>3 927 t Al (or 9 817 t Cu)</td>
</tr>
<tr>
<td>OWP on DC system (GW)</td>
<td>0,0</td>
<td>1,30</td>
<td>3,7</td>
</tr>
<tr>
<td>Onshore AC Transformers</td>
<td>10</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>AC export cable length (km)</td>
<td>832</td>
<td>733</td>
<td>0</td>
</tr>
<tr>
<td>Total AC export conductor weight</td>
<td>2 654 t Al (or 6 634 t Cu)</td>
<td>2 329 t Al (or 5 823 t Cu)</td>
<td>0 t Al (or 0 Cu)</td>
</tr>
</tbody>
</table>

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Thank you for your attention!

For further information:

Mail: info@baltic-integrid.eu
Web: www.baltic-integrid.eu

Baltic InteGrid represented by the Lead Partner:

Institute for Climate Protection, Energy and Mobility (IKEM)

Magazinstraße 15-16, 10179 Berlin, Germany
Phone: +49 (0) 30 408187015
Mail: info@ikem.de
Web: www.ikem-online.de

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Low OWP vision (2025–2040)

High OWP Vision: 2025-2040

OWP capacity: 1.9 GW

948 MW

928 MW

Commissioning year

- 2025
- 2030
- 2035
- 2040

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Technology Assumptions

Wind turbines
- Pre-2030: 8 MW
- Post-2030: 12 MW

Inter-array voltage
- Pre and post 2030: 66 kV AC

AC transformer substations
- Pre and post 2030: 600 MW

AC export cables
- Pre and post 2030: 300 kV AC

Converter technology
- VSC: Modular Multi level
- System: Symmetrical Monopole or Bipole

HVDC cable voltage (available)
- Pre-2030: ± 525 kV → 2500 MW
- Post-2030: ± 640 kV → 3000 MW

AC onshore grid
- Pre and post 2030: 300-400 kV AC
Power Densities

- Swedish waters: 5.2 MW/km²
- Danish waters: 5.7 MW/km²
- German waters: 12.7 MW/km²

Commissioning year:
- 2025
- 2030
- 2035
- 2041