### TenneT offshore by 2023

#### Germany
- Fifteen grid connections for offshore wind farms
- Twelve DC connections, three AC connections
- 4,300 MW at present
- 9,832 MW by 2023 (7,132 MW by 2019)
- NordLink: 1,400 MW (2020)

#### Netherlands
- Five grid connections for offshore wind farms
- Only AC connections
- 3,500 MW by 2023
- NorNed (2008): 700 MW
- BritNed (2010): 1,000 MW
- COBRA cable (2019): 700 MW

By 2023 TenneT will have realized 17.1 GW of offshore connection capacity (13.3 GW for offshore wind energy, 3.8 GW for interconnection): 13,000 km cable.
# Offshore Wind Lessons Learned

**June 14, 2017**

## Project Capacity (MW) Commissioning

### Operational

<table>
<thead>
<tr>
<th>Project</th>
<th>Capacity (MW)</th>
<th>Commissioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha Ventus</td>
<td>62</td>
<td>2009</td>
</tr>
<tr>
<td>BorWin1</td>
<td>400</td>
<td>2010</td>
</tr>
<tr>
<td>BorWin2</td>
<td>800</td>
<td>2015</td>
</tr>
<tr>
<td>DolWin1</td>
<td>800</td>
<td>2015</td>
</tr>
<tr>
<td>DolWin2</td>
<td>916</td>
<td>2016</td>
</tr>
<tr>
<td>HelWin1</td>
<td>576</td>
<td>2015</td>
</tr>
<tr>
<td>HelWin2</td>
<td>690</td>
<td>2015</td>
</tr>
<tr>
<td>Riffgat</td>
<td>113</td>
<td>2014</td>
</tr>
<tr>
<td>SylWin1</td>
<td>864</td>
<td>2015</td>
</tr>
</tbody>
</table>

### Under construction

<table>
<thead>
<tr>
<th>Project</th>
<th>Capacity (MW)</th>
<th>Commissioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>BorWin3</td>
<td>900</td>
<td>2019</td>
</tr>
<tr>
<td>DolWin3</td>
<td>900</td>
<td>2018</td>
</tr>
<tr>
<td>Nordergründe</td>
<td>111</td>
<td>2017</td>
</tr>
</tbody>
</table>

| Σ              | 7,132         |

To be built by 2025

DolWin6, DolWin5, BorWin5 and SylWin2

3,236

**Investments so far: over EUR 7 billion**
Experiences in Germany

- 6.5 GW by 2020
- Realistic planning
- Masterplan
- Coordination with onshore
- Standardisation
- Synergies in O&M
- Clarity liabilities and risks
- Bundling infrastructure
Offshore grid connections Netherlands

- TenneT: offshore grid operator
- 3,500 MW to 2023
- 5x700 MW in standardized concept

<table>
<thead>
<tr>
<th>Project</th>
<th>Operational</th>
<th>3.500 MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borssele Alpha</td>
<td>2019</td>
<td>700</td>
</tr>
<tr>
<td>Borssele Beta</td>
<td>2020</td>
<td>700</td>
</tr>
<tr>
<td>Hollandse Kust (zuid) Alpha</td>
<td>2021</td>
<td>700</td>
</tr>
<tr>
<td>Hollandse Kust (zuid) Beta</td>
<td>2022</td>
<td>700</td>
</tr>
<tr>
<td>Hollandse Kust (noord)</td>
<td>2023</td>
<td>700</td>
</tr>
</tbody>
</table>

Investments: EUR 2 billion

5 million households supplied with green electricity
TenneT’s NL roll-out strategy

- Five platforms, capacity 700 MW
- Export cable system: 220 kV, AC
- Increased availability
- Standardisation
- Structured approach: no stranded assets
- Lean and mean (bundling)
- Development with market parties
- Minimal habitat disturbance
- Future proof design
- Lifetime extension possibilities
Schematic comparison DE - NL

Offshore converter station (e.g. 900 MW)

TenneT offshore cable connection

TenneT existing onshore grid

High voltage grid

Offshore wind farm

Inter-array cables

65 kV inter-array cables

220 kV cables

TenneT existing onshore grid

Offshore 700 MW AC substation

Dunes

Extention

Substation

TenneT offshore grid

TenneT existing onshore grid

AC (three-phase alternating current)

DC (direct current)
Consultation process

- Optimised grid configuration
- Monthly expert meetings with offshore wind farm developers
- Online consultation input for expert meeting by all stakeholders
- All information online
  www.tennet.eu/consultation
Exampletory outcome: 66 kV

Impact of using 66kV instead of 33kV:

• Reduction of cable length: 25%
• Less cable crossings: 40%
• Stimulating innovation in large capacity turbines
• Future proof
• Cost reduction
Outcome: AC Platform NL

- Lean philosophy → Grid connection design
- Input from consultation process

Need to have

Nice to have
AC & DC grid connections

Germany (mostly DC converters)

Netherlands (all AC transformers)
Conclusion

- **Cables**
  - World first 66 kV inter-array cables
  - Bundled export cables 220 kV

- **Platforms**
  - Standardization
  - Lean & mean
  - Maximizing wind output
  - Future proof

- **Structured approach**
  - No stranded assets
  - Lowest cost of capital
  - Shorter lead times
  - Support by consultation
  - Economies of scale