WIND POWER OPPORTUNITIES IN DENMARK

80% Power from Wind in Denmark by 2030

pedsor@um.dk www.investindk.com
AGENDA

- OFFSHORE WIND POWER TRENDS
- DENMARK – A GLOBAL HUB FOR WINDPOWER
- NEW ENERGY AGREEMENT
- BUSINESS OPPORTUNITIES IN DENMARK
TRENDS

- GROWING GLOBAL MARKET
- RECORD LOW SUBSIDIES
- LARGER TURBINES
- CONSOLIDATION IN THE VALUE CHAIN
- NEW PLAYERS
MARKET TRENDS IN EUROPE

18.5 GW CAPACITY END OF 2018

- **EUROPE:**
  - Wind Europe Scenario 2016 = 70 to 100 GW Capacity in 2030
NORTH SEA POTENTIAL – 70 TO 150 GW CAPACITY BY 2040

Power Hub Island

Very Large potential in Danish Part

Source: Energinet and Northseawindpowerhub.eu
**BALTIC SEA POTENTIAL – 9.5 GW CAPACITY BY 2030 AND 35GW BY 2050**

<table>
<thead>
<tr>
<th>Country</th>
<th>BIG 2030 Upside</th>
<th>Additional 2030 2045</th>
<th>Further before 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>1,696</td>
<td>648</td>
<td>2,000</td>
</tr>
<tr>
<td>Germany</td>
<td>3,305</td>
<td>204</td>
<td>1,000</td>
</tr>
<tr>
<td>Sweden</td>
<td>472</td>
<td>6,048</td>
<td>4,500</td>
</tr>
<tr>
<td>Finland</td>
<td>616</td>
<td>0</td>
<td>1,500</td>
</tr>
<tr>
<td>Poland</td>
<td>2,232</td>
<td>3,076</td>
<td>2,000</td>
</tr>
<tr>
<td>Estonia</td>
<td>900</td>
<td>0</td>
<td>1,000</td>
</tr>
<tr>
<td>Lithuania</td>
<td>300</td>
<td>1,548</td>
<td>500</td>
</tr>
<tr>
<td>Latvia</td>
<td>0</td>
<td>0</td>
<td>1,500</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>9,521</strong></td>
<td><strong>11,524</strong></td>
<td><strong>14,000</strong></td>
</tr>
</tbody>
</table>

*Source: Baltic InteGrid, BVG*
WHY DENMARK

- Denmark is the global centre for wind turbine business and technology development – onshore and offshore
- Favorable framework conditions with supportive and stable political climate
- Growing market with many business opportunities
- Access to the entire wind energy supply chain
- Excellent facilities for R&D and testing
- Large talent base due to 40 years of experience
NEW ENERGY AGREEMENT

- Energy Agreement reached in June 2018 by all parties in the Parliament
- Commitment to net zero emissions in society by 2050 at the latest
- The effect will be 100% RE in electricity by 2030 equal to 80% wind power
- The agreement includes initiatives on RE deployment, system integration, R&D, EVs etc.
7 OUT OF TOP 10 TURBINE OEM’S HAVE PRESENCE IN DENMARK
TOP GLOBAL OFFSHORE DEVELOPERS PRESENT

Vestas

Siemens Gamesa

Goldwind

Orsted

Vattenfall

GE Renewable Energy

MV

Envision

CIP

e.on

Suzlon

Nordex

MINYANG WIND POWER

Shanghai Electric
## Offshore Wind Parks in Denmark

<table>
<thead>
<tr>
<th>Danish Offshore Windparks</th>
<th>Year in operation</th>
<th>MW</th>
<th>Number of turbines</th>
<th>Turbines</th>
<th>Owner (present)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vindeby</td>
<td>1991</td>
<td>5</td>
<td>11</td>
<td>Bonus 0.45</td>
<td>Decommissioned by Ørsted in 2017</td>
</tr>
<tr>
<td>Tune Knob</td>
<td>1995</td>
<td>5</td>
<td>10</td>
<td>Vestas V39 0.5</td>
<td>Ørsted</td>
</tr>
<tr>
<td>Middelgrunden</td>
<td>2000</td>
<td>40</td>
<td>20</td>
<td>Bonus 2</td>
<td>Middelgrunden &amp; HOFOR (in 2018)</td>
</tr>
<tr>
<td>Horns Rev I</td>
<td>2002</td>
<td>160</td>
<td>80</td>
<td>Vestas V80 2</td>
<td>Vattenfall (60%) &amp; Ørsted (40%)</td>
</tr>
<tr>
<td>Rønland I</td>
<td>2003</td>
<td>17</td>
<td>8</td>
<td>Vestas V80 2 &amp; Bonus 2.3</td>
<td>Local Owners</td>
</tr>
<tr>
<td>Hystad</td>
<td>2003</td>
<td>165</td>
<td>72</td>
<td>Bonus 2.3</td>
<td>Pension DK (50%) Ørsted (42.75%) Stadtwerke Lübeck 7.25%</td>
</tr>
<tr>
<td>Samsø</td>
<td>2003</td>
<td>23</td>
<td>10</td>
<td>Bonus 2.3</td>
<td>Samsø Havvind acquired by Wind Estate in 2018</td>
</tr>
<tr>
<td>Frederikshavn</td>
<td>2003</td>
<td>7</td>
<td>3</td>
<td>Vestas V90 3 Bonus 2.3 Nordex 2.3</td>
<td>Ørsted</td>
</tr>
<tr>
<td>Horns Rev II</td>
<td>2009</td>
<td>209</td>
<td>91</td>
<td>Siemens 2.3</td>
<td>Ørsted</td>
</tr>
<tr>
<td>Avedøre Holme</td>
<td>2009/2010</td>
<td>11</td>
<td>3</td>
<td>Siemens 3.6</td>
<td>Ørsted</td>
</tr>
<tr>
<td>Sprogø</td>
<td>2009</td>
<td>21</td>
<td>7</td>
<td>Vestas V90 3</td>
<td>Acquired by European Energy in 2017</td>
</tr>
<tr>
<td>Rødsand II</td>
<td>2010</td>
<td>207</td>
<td>90</td>
<td>Siemens 2.3</td>
<td>EON (20%) SEAS NVE (80%)</td>
</tr>
<tr>
<td>Anholt</td>
<td>2013</td>
<td>400</td>
<td>111</td>
<td>Siemens 3.6</td>
<td>Ørsted (50%) PKA (20%) PensionDK (30%)</td>
</tr>
<tr>
<td>Nissum Bredning</td>
<td>2018</td>
<td>28</td>
<td>4</td>
<td>Siemens 7.0 154 DD</td>
<td>Nissum Bredning Vindmøllelaug (55%) and Jysk Energi (45%)</td>
</tr>
<tr>
<td>Horns Rev 3</td>
<td>2019</td>
<td>406</td>
<td>49</td>
<td>MHI/Vestas V164 8.3</td>
<td>Vattenfall</td>
</tr>
</tbody>
</table>

- Long history and experience
- First OWP is decommissioned
- Total Offshore Wind Capacity is 1,699 MW
- Major Owners are Ørsted and Vattenfall
### Offshore Wind Projects

<table>
<thead>
<tr>
<th>Offshore Wind Projects</th>
<th>Installation Year</th>
<th>MW</th>
<th>Number of turbines</th>
<th>Turbines</th>
<th>Developer</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kriegers Flak</td>
<td>2020 - 2021</td>
<td>604.8</td>
<td>-</td>
<td>SWT 8.4 167</td>
<td>Vattenfall</td>
<td>tender won in 2016</td>
</tr>
<tr>
<td>Oma Syd</td>
<td>-</td>
<td>200-320</td>
<td>&lt; 80</td>
<td>-</td>
<td>European Energy</td>
<td>open door</td>
</tr>
<tr>
<td>Jammerland Bugt</td>
<td>2024</td>
<td>240</td>
<td>34 - 60</td>
<td>3-7 MW</td>
<td>European Energy</td>
<td>open door</td>
</tr>
<tr>
<td>Frederikshavn</td>
<td>-</td>
<td>&lt; 50</td>
<td>5</td>
<td>-</td>
<td>European Energy</td>
<td>pre- open door</td>
</tr>
<tr>
<td>Mejl Flak</td>
<td>-</td>
<td>60 - 120</td>
<td>20</td>
<td>-</td>
<td>European Energy</td>
<td>open door</td>
</tr>
<tr>
<td>Lillebælt</td>
<td>-</td>
<td>100 - 160</td>
<td>20 - 44</td>
<td>-</td>
<td>Sønderborg Forsyning</td>
<td>open door</td>
</tr>
</tbody>
</table>

- 955 MW is under preparation
- 2,400 MW is part of the 2018 Energy Agreement
- Approximately 450 MW is open door projects in investigation phase

Projects on-going
- Open door projects under investigation
- 2018 Energy Agreement coming tenders
FUTURE OFFSHORE WIND POSSIBILITIES IN DENMARK
WORLD CLASS R&D INSTITUTIONS SUPPORT AND DRIVE TECHNOLOGY DEVELOPMENT
R&D – TECHNOLOGY DEVELOPMENT
EXAMPLES OF PROJECTS FUNDED BY THE DANISH ADVANCED TECHNOLOGY FOUNDATION, NOW PART OF THE INNOVATION FUND DENMARK

Off-shore turbines at deeper water
Vestas, LORC, MTH, DNV, Bladt Risø, Aalborg University
Total budget: Over Euro 10m

Blade King
LM, Comfill, Risø, Aalborg University
Total Budget: Over Euro 8m

Multi-functional surfaces
Vestas, Strecon, Image meterology DTU Mekanik
Total budget: Approx. Euro 2m

Built-in laser-based wind scanners
LM, NKT Photonics, Risø
Total Budget: Over Euro 3m

New yaw systems
Svendborg Brakes, DTU Mekanik, Kirkholm Mekanik
Total budget: Approx. Euro 8m

Blades with active flaps
Vestas, Risø, DTU Mekanik
Total budget: Euro 4m

Storage, control and power output
Vestas, Aalborg University, Skovgaard Invest
Total budget: Approx. Euro 8m
STRONG TALENT BASE

- Around 30,000 people work in the wind industry in Denmark.
- A large number of experienced engineers, due to more than 40 years of experience in wind power and more than 20 years in offshore wind.
- Specialized curriculums at schools and universities in Denmark secures a stable flow of new talents.
  - DTU Wind DTU offers a complete two-year MSc programme in Wind Energy
    [http://www.dtu.dk/english/Education/msc/Programmes/wind_energy](http://www.dtu.dk/english/Education/msc/Programmes/wind_energy)
  - Aalborg University has a MSc specialisation in Wind Power System (WPS) focuses on the electrical aspects of wind power systems
    [www.en.aau.dk/education/master/energy-engineering/specialisations/wind-power-systems](http://www.en.aau.dk/education/master/energy-engineering/specialisations/wind-power-systems)
  - Aarhus University School of Engineering conducts a summer school in Wind Power
Østerild - National Testcenter for large wind turbines
Denmark's National prototype test sites for offshore turbines up to 250 metres height. 7 test stands. Siemens, Vestas, Envision Energy, EDF/GE.

Expansion of test centre with 3 test stand put forward by government in January 2017. Height up to 330 metres at centre test stands. EIA in 2017. In operation in 2019

Høvsøre – Teststation for large wind turbines
National Test site for turbines up to 165 metres tip height. 5 test stands. Vestas, Siemens, Nordex/Acciona.

OTHER TEST FACILITY INVESTMENTS

**DTU Wind Tunnel**


**LORC**

LORC tests and demonstrates technology for harvesting renewable energy offshore. The Lindoe Nacelle Testing offers Functional tests and Highly Accelerated Lifetime Testing (HALT). The HALT tester will be finalised in mid 2017.
COMPANIES TESTING IN FULL SCALE
BUSINESS OPPORTUNITIES IN THE DANISH WIND INDUSTRY

• Using Denmark as a **platform for market entrance** to Northern Europe
• Using Denmark as a **hub for technology development** by tapping into the expertise
• **Leveraging existing expertise** by working closely together with Danish companies
• Gaining supremacy in the development of automation within **component manufacturing and smart grid solutions**
The Danish Wind Power Value Chain Represents an Attractive Cluster for Entry to the Northern European Offshore Market

- Central Location for European Market
- Experienced Value Chain with Co-operative Approach
- Experienced People with Wind Power Knowledge
- Excellent R&D Centers
- Support Mechanisms
- Market Position
- Policy Support
- Competative Drivers
- Offshore Wind Market
- R&D Centers and test facilities
- Grid Integration Expertise
- Specialized Education in Wind Power
- Human Resources
- Know How & Technology
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OF DENMARK
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