Hywind Scotland – status and plans

EERA DeepWind’ 2016, Trondheim
Knut Erik Steen, Statoil
Offshore wind

Playing at our strengths

• Financial control and project management excellence

• Multi contracting interfaces
  • Marine operations

• Managing technology and subsurface
  • Operations excellence

• Managing technology risks and use
  • Safety culture and community engagement
Statoil positioning in offshore wind

**Current Portfolio**

<table>
<thead>
<tr>
<th>Project</th>
<th>Capacity</th>
<th>Energy (Twh/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hywind Demo</td>
<td>2.3MW</td>
<td>1.11</td>
</tr>
<tr>
<td>Sheringham Shoal</td>
<td>317MW</td>
<td>1.7</td>
</tr>
<tr>
<td>Dudgeon</td>
<td>402MW</td>
<td>1.7</td>
</tr>
<tr>
<td>Hywind Commercial Park</td>
<td>30MW</td>
<td>0.14</td>
</tr>
</tbody>
</table>

**Increase Portfolio & Acreage**

- **North West Europe**
- **Japan**
- **US**

- **Dogger Bank**
- **Hywind Commercial Park**

- In operation
- FID
- Construction and installation phase

**Timeline**

- 2009-2012
- 2017
- 2017-
- 2020-
Floating wind - *Potential markets*

- North sea – Norway and UK
- US, Atlantic and Pacific coast – and Great Lakes
- Japan and Korea
- Iberian Peninsula and Mediterranean Sea
What is Hywind?

- Floating wind turbine (FWT)
- A standard offshore wind turbine placed on a ballasted vertical steel cylinder, anchored to the seabed
- Active motion controller
- Statoil-owned technology

**Timeline**

- **Concept** 2001
- **Model test** 2005
- **Full-scale prototype** 2009
- **Pilot Park, 3-6 turbines** <5 years
- **Large Parks, 500-1000MW** <10 years
HYWIND DEMO
Hywind Demo – the World’s first full scale prototype

Conventional technology used in a new way

- slender floating cylinder (simple sub-structure)
- conventional 3-line mooring system
- use of standard offshore wind turbine

In operation from September 2009

- produced ~40 GWh since start-up
- capacity factor 50% in 2011 (overall 40%)
- experienced wind speed of 40 m/s and maximum wave height of 19 m

Blade pitch control to dampen out motions

Floater motions have no negative impact on turbine performance

Concept verified
Hywind Demo - assembly and installation - 2009

• Simple and safe assembly and installation
### Commercialisation of Hywind

<table>
<thead>
<tr>
<th>Status:</th>
<th>Next step:</th>
<th>End goal:</th>
</tr>
</thead>
</table>
| • The technical concept is considered proven | • Pilot park to demonstrate improvements and cost reductions | • Commercial scale parks of 500-1000 MW  
• Cost competitive with bottom fixed |

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**Concept** 2001  
**Model test** 2005  
**Full-scale prototype** 2009  
**Pilot Park, 3-6 turbines** <5 years
Hywind Scotland - project objectives

Demonstrate cost-efficient and low risk solutions for commercial scale parks

- Test multiple units in park-configuration
- Verify up-scaled design
- Verify reliability and availability of optimized multi-turbine concept
- Mobilize supply chain
Hywind Scotland Pilot Park

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hywind Scotland</strong></td>
<td></td>
</tr>
<tr>
<td>Area (sea level)</td>
<td>~4 km²</td>
</tr>
<tr>
<td>Water depth</td>
<td>95-120 m</td>
</tr>
<tr>
<td>Average wind speed (@100 m)</td>
<td>10.1 m/s</td>
</tr>
<tr>
<td>Mean waves, Hs</td>
<td>1.8 m</td>
</tr>
<tr>
<td>Installed capacity (5 WTGs)</td>
<td>30 MW</td>
</tr>
<tr>
<td>Offshore export cable length</td>
<td>30 km</td>
</tr>
<tr>
<td>Onshore cable length</td>
<td>2-3 km</td>
</tr>
<tr>
<td>Transmission voltage</td>
<td>33 kV</td>
</tr>
<tr>
<td>Tentative milestones:</td>
<td></td>
</tr>
<tr>
<td>• Final Investment Decision</td>
<td>Q3 2015</td>
</tr>
<tr>
<td>• Offshore installation &amp; commissioning</td>
<td>2017</td>
</tr>
</tbody>
</table>
Hywind Scotland test park at a glance

- Electrical switchgear plant
- Export cable
- 5 x 6MW WTG units
  - Mooring system
## Upscaling from Demo 2009 to Hywind Scotland 2014

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Hywind Demo</th>
<th>Hywind Scotland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>5300 tons</td>
<td>~11500 tons</td>
</tr>
<tr>
<td>Hub height</td>
<td>~65 m</td>
<td>~100 m</td>
</tr>
<tr>
<td>Draught</td>
<td>100 m</td>
<td>~75 - 80 m</td>
</tr>
<tr>
<td>Diameter of sub-structure</td>
<td>8.3 m</td>
<td>~14 - 15 m</td>
</tr>
<tr>
<td>Water depth</td>
<td>220 m</td>
<td>~95 - 120 m</td>
</tr>
<tr>
<td>Rotor diameter</td>
<td>~85 m</td>
<td>154 m</td>
</tr>
<tr>
<td>Capacity</td>
<td>2.3 MW</td>
<td>6.0 MW</td>
</tr>
</tbody>
</table>
Substructure & Tower

Height: 91m
Diameter: 14.4m → 7.5m

Height: 83m
Diameter: 7.5m → 6.5m
Mooring System

- Normal safety class (confirmed by DNV GL)
- Suction anchor: 5m dia x 15.5m high

<table>
<thead>
<tr>
<th>Classification:</th>
<th>Open</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridle dimension</td>
<td>132 mm</td>
</tr>
<tr>
<td>Bridle length</td>
<td>50 m</td>
</tr>
<tr>
<td>Moring line dimension</td>
<td>147 mm</td>
</tr>
<tr>
<td>Pretension at triplate</td>
<td>900 kN</td>
</tr>
<tr>
<td>Mooring line length (in DeepLines model)</td>
<td>609.4 m</td>
</tr>
<tr>
<td>Anchor radius (in DeepLines model)</td>
<td>640 m</td>
</tr>
</tbody>
</table>

132mm dia NVR4S

147mm dia NVR4S

Seabed

Estimated point of chain embedment

Horizontal length of embedded chain approximately 50m

Shortest anchor radius in park 690 m
Mooring Details

Classification: Open

Fairlead chain stopper
Dynamic cable layout (Lazy-Wave)
SWT-6.0-154 turbine

Rotor Diameter: 154m
Rotor Area: 18,600m²
Upscaling effects

• Fabrication
  – Increased diameter of the substructure is an important challenge for the fabrication

• Marine operations, assembly site
  – Lifting height increased significantly
  – Available vessels to install under floating conditions very limited
  – The operation related to lifting from a floating installation to another floating installation is very challenging with regards to load transfer
Hywind – WTG and tower assembly on shore
Project execution strategy

Contract overview

- Multi-contracting strategy to minimise CAPEX and maximize market effects
- Building on Hywind Demo, Sheringham and Dudgeon experience
- Reuse existing supplier relations, where possible
- Ensure competition where possible
- Bundling explored
- Synergies with other Statoil projects for inshore heavy lift & marine operations
- Synergies with vessels on long-term hire for Statoil
- Enable Scottish content
- Interfaces
Hywind Scotland Pilot Park

- 3.5 ROC and grace period of 18 months
- Agreement for Lease signed Nov. 2013
- Grid offer signed December 2014
- WTG contract with Siemens signed December 2014
- FEED for substructure and mooring finished January 2015
- Detailed engineering of substructure, tower and mooring system started January 2015

- Concept selection (DG2) March 2015
- Consent Q4 2015
- FID (DG3) Q4 2015
- Final commissioning (DG4) Q3 2017
- Energy production approx. 0.13 TWh/yr
- Lifetime 20 years operation
THANK YOU FOR YOUR ATTENTION.

Knut Erik Steen
Statoil ASA
www.statoil.com