From Hywind Scotland to our next project - Hywind Tampen

Vegard Nedrevåg
Principle Engineer Marine Operations – Offshore Wind
New Energy Solutions – Strategic Objectives
15-20 % of investments in 2030

Build a profitable renewable business

Develop new lower-carbon business opportunities for Equinor’s core products
Our renewable portfolio
Electricity to more than 1 million households

- Sheringham Shoal (UK): 316MW
- Dudgeon (UK): 402MW
- Arkona (Germany)*: 385MW

- Hywind Demo (Norway): 23MW
- Hywind Scotland: 30MW
- Hywind Tampen (Norway)*: 88MW

- Apodi (Brazil): 162MW
- Guanizul (Argentina)*: 117MW
- 10% ownership in Scatec solar

* Under development
Flytende vind - Et hav av muligheter

**Hywind Demo**
- Teknologiutvikling siden 2001
- I demo-drift siden 2009
- Produsert mer enn 40GWh siden oppstart

**Hywind Scotland**
- Verdens første flytende vindpark
- I drift siden 2017
- Leverer strøm til 22 000 skotske husstander

**Hywind Tampen**
- Potensielt første havvindprosjekt på norsk sokkel
- Vil redusere CO2-utsipp tilsvarende 100 000 biler

**Globale muligheter**
- Interessante marked i bl.a. Japan, UK, Frankrike, USA og Norge
- Potensielt 12GW innen 2030
- Forventet LCOE på 40-60 €/MWh innen 2030
What is Hywind?

A standard offshore wind turbine placed on a ballasted substructure and anchored to the seabed

- Conventional technology used in a new way
- Simple substructure construction that enables mass production
- Inshore assembly reduces time and risk of offshore operations
- Equinor’s floating motion controller uses blade pitch control to dampen out motions

<table>
<thead>
<tr>
<th>Year</th>
<th>Turbine Type</th>
<th>Capacity (MW)</th>
<th>Rotor Diameter (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>The idea</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>Hywind demo, Karmøy, Norway</td>
<td>1 turbine@2.3</td>
<td>85 m rotor</td>
</tr>
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<td>Hywind demo, Karmøy, Norway</td>
<td>1 turbine@2.3</td>
<td>85 m rotor</td>
</tr>
<tr>
<td>2017</td>
<td>Hywind Scotland: The world’s first floating wind park</td>
<td>5 turbines@6</td>
<td>154 m rotor</td>
</tr>
<tr>
<td>2022</td>
<td>Hywind Tampen: Wind powered offshore electrification</td>
<td>11 turbines@8</td>
<td>167 m rotor</td>
</tr>
</tbody>
</table>
Hywind Scotland – Main Objectives

- Demonstrate cost-efficient and low risk solutions for commercial scale floating wind
- Test, verify and further develop the Hywind motion controller (EMC) for a larger turbine
- Verify up-scaled design
- Verify reliability and availability of optimized multi-turbine concept
- Develop, test and verify a developed motion controller using individual pitch to control yaw motions
Operation of Hywind Scotland

- Hywind concept allows operation and maintenance as per bottom fixed industry
- O&M base in Peterhead
- Remote control room services integrated in the Equinor Wind Control Room in Great Yarmouth
- Back-office engineering and support functions from wider Equinor Wind Operational Organization
- Main difference is subsea inspection scope and potential main component replacement

Hywind Scotland is operated as a satellite field, using synergies across Equinor assets
Operational Experience – First Year of Operation

- Project delivered on time and without serious incidents
- Successful commissioning and start-up
- Opening in Scotland 18.10
- Initial teething issues
- Challenging weather conditions
- Handover to operations 15.11
- End of initial teething issues just before Christmas
- Production and performance significantly exceeding expectations

- **56% capacity factor** during first year of production 01.11.2017 – 01.11.2018
Production Numbers – Very Encouraging Results Above Budget

<table>
<thead>
<tr>
<th>Month</th>
<th>Production-Based Availability</th>
<th>Wind Speed vs. Budget</th>
<th>Generation vs Budget</th>
<th>Wind Turbine Capacity Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>November</td>
<td>81.6%</td>
<td>118%</td>
<td>108%</td>
<td>66%</td>
</tr>
<tr>
<td>December</td>
<td>87.8%</td>
<td>103%</td>
<td>102%</td>
<td>62%</td>
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<tr>
<td>January</td>
<td>98.2%</td>
<td>98%</td>
<td>102%</td>
<td>68%</td>
</tr>
<tr>
<td>February</td>
<td>98.0%</td>
<td>105%</td>
<td>106%</td>
<td>68%</td>
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<tr>
<td>Mars</td>
<td>89.2%</td>
<td>103%</td>
<td>99%</td>
<td>61%</td>
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<tr>
<td>April</td>
<td>98.5%</td>
<td>92%</td>
<td>95%</td>
<td>50%</td>
</tr>
<tr>
<td>May</td>
<td>99.0%</td>
<td>97%</td>
<td>103%</td>
<td>48%</td>
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<tr>
<td>June</td>
<td>99.5%</td>
<td>70%</td>
<td>74%</td>
<td>34%</td>
</tr>
<tr>
<td>July</td>
<td>97.1%</td>
<td>81%</td>
<td>80%</td>
<td>34%</td>
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<tr>
<td>August</td>
<td>96.6%</td>
<td>91%</td>
<td>92%</td>
<td>42%</td>
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<tr>
<td>September</td>
<td>97.4%</td>
<td>129%</td>
<td>132%</td>
<td>74%</td>
</tr>
<tr>
<td>October</td>
<td>93.5%</td>
<td>112%</td>
<td>107%</td>
<td>70%</td>
</tr>
</tbody>
</table>
Shutdown due to high wind above cut-out wind speed for some of the turbines
Hurricane Ophelia – Structure Pitch Motion Confirms Design

Turbines in idling after shutdown due to high wind above cut-out wind speed

~1 degree
High Stability in Heavy Waves

-2 degree at max variation
Summary – Hywind Scotland

- Performance above expectations and in accordance with design
- O&M as per bottom fixed, using synergies with other Equinor operations
- Challenging weather conditions, but with obvious upsides
- Continuous improvement ➔ future projects
Hywind Tampen
- An industrial part of the solution

Opens for Norwegian industry contribution in floating offshore wind developments

Contribute to NCS and Konkraft climate ambitions with a cost effective CO₂ abatement option

Demonstrate a fully integrated gas and renewable power generation system with large global deployment potential
Hywind Tampen – offshore wind farm in the North Sea

- 11 wind turbines between Snorre and Gullfaks
- Combined capacity of 88MW
- Considerable CO2 emission reductions
Technology development to reduce costs and for the benefit of future projects

- Larger turbines
- Installation method
- Simplified mooring
- Concrete substructure
- Gas and wind power generation system integration
Offshore wind in Norway beyond Tampen – what would it take?

- Close collaboration between authorities, developers, suppliers and R&D
- Cost reductions through scale
- Competitive supplier industry
- Appropriate framework conditions
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