The installation and servicing of offshore wind farms

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16th September 2010
A2SEA

• Started 1st July 2000
• 100% dedicated offshore wind
• 4 (5) vessels, 230 employees, 85 mio Euro turnover
• Owned 100% by Dong Energy
• Siemens Windpower 49% owner in 2011
• Installed 700 turbines, 300 foundations
Presentation Structure

• 2002 – 2012 Market
  • Foundations
  • Foundation installation
• Turbines
  • Turbine installation
• Cables
  • Cable Laying
• Other offshore activities
• The challenge
• Round Up
## Installed Capacity / MW per Country

### Installed MW per country by the end of 2010

<table>
<thead>
<tr>
<th>Year</th>
<th>Installed Cap. MW acc.</th>
<th>No. of Turbines</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>222</td>
<td>112</td>
</tr>
<tr>
<td>2004</td>
<td>476</td>
<td>263</td>
</tr>
<tr>
<td>2006</td>
<td>849</td>
<td>359</td>
</tr>
<tr>
<td>2008</td>
<td>1404</td>
<td>554</td>
</tr>
<tr>
<td>2010</td>
<td>3500</td>
<td>1235</td>
</tr>
<tr>
<td>2012</td>
<td>7500</td>
<td>2330</td>
</tr>
</tbody>
</table>
### Typical Offshore Installation

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Percentage</th>
<th>Software</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundations</td>
<td>15%</td>
<td>Installation Foundations</td>
<td>5%</td>
</tr>
<tr>
<td>Turbines</td>
<td>45%</td>
<td>Installation Turbines</td>
<td>5%</td>
</tr>
<tr>
<td>Cables</td>
<td>15%</td>
<td>Installation Cables</td>
<td>4%</td>
</tr>
<tr>
<td>Transformer Station</td>
<td>2%</td>
<td>Traffic Control/HSE/Project Management</td>
<td>4%</td>
</tr>
<tr>
<td>Scour protection etc.</td>
<td>5%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.5-3.0 Mil. Euro/MW

*Powered by knowhow*
Presentation Structure

- 2002 – 2012 Market
- Foundations
  - Foundation installation
- Turbines
  - Turbine installation
- Cables
  - Cable Laying
- Other offshore activities
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Offshore Foundations
Installation of Gravity Foundations

Nysted
Lillgrund
Thornton Bank
Rødsand II
Sprogø

Approx. 225 installed end of 2010

Photo: www.JanWinther.com
Installation of Monopile Foundations

Horns Rev I &II
Kentish Flats
Scroby Sands
Princes Amalia (Q7)
Egmond an Zee

Burbo Bank
Barrow
Robin Rigg
Lynn Inner Dowsing
Rhyl Flats
Gunfleet Sands
Thanet
Arklow
North Hoyle
Greater Gabbard
Blight Bank
Baltic 1
Walney 1

Total approx. 1000 installed end of 2010
Jackets, Tripod, Tripile
Presentation Structure

- 2002 – 2012 Market
- Foundations
- Foundation installation
- Turbines
- Turbine installation
- Cables
- Cable Laying
- Other offshore activities
- The challenge
- Round Up
Installation and equipment
Installation and equipment

HLV Svanen
Installation and equipment
Installation and equipment
Presentation Structure

- 2002 – 2012 Market
- Foundations
- Foundation installation

- Turbines
- Turbine installation
- Cables
- Cable Laying
- Other offshore activities
- The challenge
- Round Up
## Turbines

<table>
<thead>
<tr>
<th>Siemens 2.3M</th>
<th>Units</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Hub</td>
<td>32.3</td>
</tr>
<tr>
<td>1b</td>
<td>Blades</td>
<td>9.2</td>
</tr>
<tr>
<td>1a + 1b</td>
<td>Hub + Blades</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>Nacelle</td>
<td>82</td>
</tr>
<tr>
<td>3</td>
<td>Tower (approx.)</td>
<td>130</td>
</tr>
<tr>
<td>(1+2+3)</td>
<td>Total Assembly</td>
<td>246</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Siemens 3.6M</th>
<th>Units</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Hub</td>
<td>42.4</td>
</tr>
<tr>
<td>1b</td>
<td>Blades</td>
<td>17.2</td>
</tr>
<tr>
<td>1a + 1b</td>
<td>Hub + Blades</td>
<td>95</td>
</tr>
<tr>
<td>2</td>
<td>Nacelle</td>
<td>125</td>
</tr>
<tr>
<td>3</td>
<td>Tower (approx.)</td>
<td>180</td>
</tr>
<tr>
<td>(1+2+3)</td>
<td>Total Assembly</td>
<td>400</td>
</tr>
</tbody>
</table>
# Turbines

## Vestas V90, 3MW

<table>
<thead>
<tr>
<th>Units</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a Hub</td>
<td>40</td>
</tr>
<tr>
<td>1b Blades</td>
<td>9+</td>
</tr>
<tr>
<td>1a + 1b Hub + Blades</td>
<td>67+</td>
</tr>
<tr>
<td>2 Nacelle</td>
<td>70</td>
</tr>
<tr>
<td>3 Tower (approx.)</td>
<td>110</td>
</tr>
<tr>
<td>(1+2+3) Total Assembly</td>
<td>247+</td>
</tr>
</tbody>
</table>

## Vestas V112, 3MW

<table>
<thead>
<tr>
<th>Units</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a Hub</td>
<td>45</td>
</tr>
<tr>
<td>1b Blades</td>
<td>11</td>
</tr>
<tr>
<td>1a + 1b Hub + Blades</td>
<td>78</td>
</tr>
<tr>
<td>2 Nacelle</td>
<td>80+</td>
</tr>
<tr>
<td>3 Tower (approx.)</td>
<td>130</td>
</tr>
<tr>
<td>(1+2+3) Total Assembly</td>
<td>288+</td>
</tr>
</tbody>
</table>
## Turbines

### Multibrid 5M

<table>
<thead>
<tr>
<th>Units</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a Hub</td>
<td>62</td>
</tr>
<tr>
<td>1b Blades</td>
<td>49.5</td>
</tr>
<tr>
<td>1a + 1b Hub + Blades</td>
<td>111.5</td>
</tr>
<tr>
<td>2 Nacelle</td>
<td>233</td>
</tr>
<tr>
<td>3 Tower (approx.)</td>
<td>200</td>
</tr>
<tr>
<td>(1+2+3) Total Assembly</td>
<td>544</td>
</tr>
</tbody>
</table>

### Repower 6M

<table>
<thead>
<tr>
<th>Units</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a Hub</td>
<td>84</td>
</tr>
<tr>
<td>1b Blades</td>
<td>72</td>
</tr>
<tr>
<td>1a + 1b Hub + Blades</td>
<td>156</td>
</tr>
<tr>
<td>2 Nacelle</td>
<td>316</td>
</tr>
<tr>
<td>3 Tower</td>
<td>285</td>
</tr>
<tr>
<td>(1+2+3) Total Assembly</td>
<td>757</td>
</tr>
</tbody>
</table>
Presentation Structure

- 2002 – 2012 Market
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- Turbine installation
- Cables
- Cable Laying
- Other offshore activities
- The challenge
- Round Up
Turbine Installations
Turbine Installation

Vestas
2.0MW/3.0MW

Siemens
2.3MW
Turbine Installation

Siemens 3.6 MW Single Blade Installation

Photo: Project Burbo
2006

Repower 5.0 MW Full Rotor Installation

Photo: With courtesy by Jan Oelker
Feeding Offshore
Presentation Structure

- 2002 – 2012 Market
- Foundations
- Foundation installation
- Turbines
- Turbine installation
- Cables
  - Cable Laying
  - Other offshore activities
- The challenge
- Round Up
Presentation Structure

• 2002 – 2012 Market
• Foundations
• Foundation installation
• Turbines
• Turbine installation
• Cables
• **Cable laying**
• Other offshore activities
• The challenge
• Round Up
KABEL-SKIØB / CABLE SHIP

1. Cleaning trench with air lift, diver supervision

2. Cable pulled by wire through tube in foundation

Kabelskib trækkes med ankerspil & wire
Cables are pulled by anchor winch

Ankerwire
Anchor wire

Afslutning
Final step

Spil Winch
Spill Winch

Anker/anchor
Anchor

Lysleder / Fiber cable for data transmission
Coaxial cable for data transmission

med 3 kobberledere / cobber cores
with 3 copper cores
Cable laying
Presentation Structure

• 2002 – 2012 Market
• Foundations
  • Foundation installation
• Turbines
  • Turbine installation
• Cables
  • Cable laying
• Other offshore activities
• The challenge
• Round Up
Service - Lifetime
Service
Crew vessels

Service vessels
Other vessels will be required as well...

- Cable laying vessels
- Personnel transfer vessels
- Tugs
- Hotel ships

Totally 52 different vessels involved in Horns Rev II.

Totally up to 30 different vessels on the site at a time.
Presentation Structure

• 2002 – 2012 Market
• Foundations
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• Cable laying
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• The challenge
• Round Up
Future Selection of Harbour

- Decide the logistic flow for:
  - Foundation installation
  - Turbine installation
  - Cable Installation

- Cost / Time
- Contingency
- Storage
- Risk (delivery / handling / damage)
- Safety
Port Logistics
**Turbines**

**6,0 MW Turbine (Siemens/Vestas)**
- Rotor diameter: 126 m;
- Hub Height: 90 m;
- Total Weight at hub height (nacelle + blades): 250-350 tons;
- Weight of tower: 500 tons;

**8,5 MW Turbine**
- Rotor diameter: 160 m;
- Hub Height: 110 m;
- Total Weight at hub height (nacelle + blades): 800 tons;
- Weight of tower: 1000 tons;

**10 MW turbine (Clipper)**
- Rotor diameter: 150 meter
- Hub height: 100 meter
Turbines

• 3 – 5 – 6 MW
• Vestas
• Siemens
• RePower
• Multibrid
• Gamesa
• BARD
• Alstrom
• Nordex
• 2-4 Chinese exporters
And foundations even larger and different …
Floating Vessel Types

- DP vessels from O&G sector for piling operations
- Floating heavy lift cranes & shear leg cranes
New Vessels
(from Oil & Gas)

Master Marine

SeaJacks
Typical design of new vessels

Logistikkonzept Installationsphase
From design to installation

- Conceptual design → 1 year
- Basic design → ½ year
- Detailed Design
- Class Approval etc. → 2-2½ year
- Construction

- Test → ?

1st vessel ready in 3-4 years.

- Start 2011-2012 → Usage 2015-2016
By 2015-2016?

- Deeper waters in Germany
- Round 2½ in UK
- Start Round 3 in UK

New Markets need the same
- US market
- Canada
- China
- South Europe
Presentation Structure

• 2002 – 2012 Market
• Foundations
• Foundation installation
• Turbines
• Turbine installation
• Cables
• Cable laying
• Other offshore activities
• The challenge
• Round Up
Offshore wind - hardware

• Grid / Cables / Transformers
  • Distribution of 50 GW offshore wind in 2030
  • Cable production
  • Technology

• Foundations
  • Steel
  • Production facilities
  • New designs
  • Materials

• Turbines
  • Production
  • Development
  • Onshore - offshore
Offshore wind - software

• Harbours
  • Germany
  • UK
  • Others

• Vessels
  • Installation
  • Service
  • Other vessels

• Manpower / Know-how
  • NAREC, Newcastle UK
  • Bremen / Oldenburg, Germany
  • Esbjerg, Denmark
  • The Netherlands
  • From oil and gas
  • From shipping
  • Technical / engineering
  • Managers
Thank you for listening - Any questions?