GLOBAL WIND ENERGY SHIPPING AND LOGISTICS

CHANGING BUSINESS MODELS FOR SHIPPING AND LOGISTICS IN OFFSHORE WIND

MARCH 17, 2015, GÅ-HJEM MEETING, PER AARSLEFF, HVIDOVRE

March 17, 2015
### Top 10 global onshore markets

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Country</th>
<th>Cumulative</th>
<th>2013 new</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>China</td>
<td>91460</td>
<td>16052</td>
</tr>
<tr>
<td>2</td>
<td>USA</td>
<td>61292</td>
<td>1084</td>
</tr>
<tr>
<td>3</td>
<td>Germany</td>
<td>34468</td>
<td>2729</td>
</tr>
<tr>
<td>4</td>
<td>Spain</td>
<td>22637</td>
<td>175</td>
</tr>
<tr>
<td>5</td>
<td>India</td>
<td>20589</td>
<td>1987</td>
</tr>
<tr>
<td>6</td>
<td>UK</td>
<td>10946</td>
<td>1028</td>
</tr>
<tr>
<td>7</td>
<td>Italy</td>
<td>8448</td>
<td>450</td>
</tr>
<tr>
<td>8</td>
<td>France</td>
<td>8128</td>
<td>535</td>
</tr>
<tr>
<td>9</td>
<td>Canada</td>
<td>7813</td>
<td>1599</td>
</tr>
<tr>
<td>10</td>
<td>Portugal</td>
<td>4557</td>
<td>196</td>
</tr>
</tbody>
</table>

**Rest-of-the-world** 51221 10299

**Grand total** 321559 36134

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**Cumulative percentage distribution**

- China: 28.4%
- USA: 19.1%
- Germany: 15.9%
- Spain: 10.7%
- India: 9.0%
- Australia: 7.0%
- France: 6.4%
- Italy: 5.3%
- UK: 4.5%
- Canada: 3.4%

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Source: BTM Consult part of Navigant (2013) and own construction
Number of offshore annual MW and wind farms installed up to and including 2013

<table>
<thead>
<tr>
<th>Year</th>
<th>MW installed</th>
<th>Number of wind farms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>1992</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>1993</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>1994</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>1995</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>1996</td>
<td>17</td>
<td>1</td>
</tr>
<tr>
<td>1997</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>1998</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>1999</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>2000</td>
<td>55</td>
<td>3</td>
</tr>
<tr>
<td>2001</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>2002</td>
<td>183</td>
<td>2</td>
</tr>
<tr>
<td>2003</td>
<td>251</td>
<td>3</td>
</tr>
<tr>
<td>2004</td>
<td>60</td>
<td>1</td>
</tr>
<tr>
<td>2005</td>
<td>90</td>
<td>1</td>
</tr>
<tr>
<td>2006</td>
<td>198</td>
<td>2</td>
</tr>
<tr>
<td>2007</td>
<td>200</td>
<td>2</td>
</tr>
<tr>
<td>2008</td>
<td>344</td>
<td>4</td>
</tr>
<tr>
<td>2009</td>
<td>666</td>
<td>8</td>
</tr>
<tr>
<td>2010</td>
<td>1,428</td>
<td>9</td>
</tr>
<tr>
<td>2011</td>
<td>470</td>
<td>10</td>
</tr>
<tr>
<td>2012</td>
<td>1,131</td>
<td>9</td>
</tr>
<tr>
<td>2013</td>
<td>1,720</td>
<td>13</td>
</tr>
</tbody>
</table>

Source: BTM Consult a part of Navigant (2014a) and own construction
Onshore and offshore distribution

Cumulative distribution ultimo 2013 (MW)

- Onshore: 321.559
- Offshore: 6.832

Installed distribution in 2013 (MW)

- Onshore: 36.134
- Offshore: 1.721

Source: BTM Consult a part of Navigant (2014a) and own construction
End-to-end life-cycle focus

Two different flows: Onshore and Offshore

Shipping & logistics

Development and consent phase
Installation & commissioning phase
Operations & maintenance phase
Decommissioning phase

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AALBORG UNIVERSITY

Source: LogMS conference paper, 2013, Singapore 2013, Poulsen et.al.
Onshore and offshore - logistics
Key differences offshore/onshore

- Bigger WTG output
- Bigger size
- Heavier weight
- Quality (corrosion, wind, water)
- Balance of plant modules (foundation, cables, substation, etc.)
Case study efforts

**Number of companies**

**Time spent**

**Extent of case study scope**

**Depth**

**Width**

Europe

- Offshore, simple and easy cases

Asia

- Offshore, one case

Americas

- Onshore, rail focus
Case study – OW base case
Anholt Offshore wind farm

Fact box

- Operator: DONG Energy
- Ownership: DONG Energy, PKA, and PensionDanmark in JV
- Construction cost: DKK 11.5B
- Number of positions: 111 WTG’s
- WTG type: 3.6 MW geared Siemens Wind Power
- Foundation type: MP/TP
- Total windfarm output: 400 MW
- Area covered: 88 km²
- Distance from installation / service port (Grenå): 15 km
- Water depth 15.5 – 18 meters

Source: DONG Energy, MTH, AAU research (meetings and site visits), EAWE conference paper, 2013 (Poulsen et.al.)
## Main supply chain constituencies

<table>
<thead>
<tr>
<th>Phase</th>
<th>Contract party</th>
<th>Product/service</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development &amp; consent</td>
<td>Geo</td>
<td>Geotechnical and geophysical investigations</td>
<td>Denmark</td>
</tr>
<tr>
<td>Installation &amp; commissioning</td>
<td>Siemens Wind Power</td>
<td>Nacelles/hubs</td>
<td>Denmark</td>
</tr>
<tr>
<td>Installation &amp; commissioning</td>
<td>Siemens Wind Power</td>
<td>Towers</td>
<td>Denmark</td>
</tr>
<tr>
<td>Installation &amp; commissioning</td>
<td>Siemens Wind Power</td>
<td>Blades</td>
<td>Denmark</td>
</tr>
<tr>
<td>Installation &amp; commissioning</td>
<td>Siemens</td>
<td>Substation control systems</td>
<td>Denmark</td>
</tr>
<tr>
<td>Installation &amp; commissioning</td>
<td>Siemens</td>
<td>Offshore substation electrical equipment</td>
<td>Denmark</td>
</tr>
<tr>
<td>Installation &amp; commissioning</td>
<td>Nexus</td>
<td>Array cables</td>
<td>Germany</td>
</tr>
<tr>
<td>Installation &amp; commissioning</td>
<td>MTH/Bladt Industries</td>
<td>MP and TP</td>
<td>Denmark</td>
</tr>
<tr>
<td>Installation &amp; commissioning</td>
<td>MTH/Ballast Nedam</td>
<td>MP installation - HLV &quot;Svanen&quot;</td>
<td>Holland</td>
</tr>
<tr>
<td>Installation &amp; commissioning</td>
<td>MTH/Jumbo Shipping</td>
<td>TP installation - HLV &quot;Jumbo Javelin&quot;</td>
<td>Holland</td>
</tr>
<tr>
<td>Installation &amp; commissioning</td>
<td>Visser &amp; Smit Marine</td>
<td>Array cable installation</td>
<td>Holland</td>
</tr>
<tr>
<td>Installation &amp; commissioning</td>
<td>A2SEA</td>
<td>Wind turbine installation</td>
<td>Denmark</td>
</tr>
<tr>
<td>Operations &amp; maintenance</td>
<td>Hvide Sande Skibs- &amp; Baadebyggeri</td>
<td>Service vessels</td>
<td>Denmark</td>
</tr>
<tr>
<td>Operations &amp; maintenance</td>
<td>Port of Grenaa and misc. companies</td>
<td>35-50 jobs over coming 25 years</td>
<td>Denmark</td>
</tr>
</tbody>
</table>

Source: DONG Energy, MTH, AAU research (meetings and site visits), EAWE conference paper, 2013 (Poulsen et.al.)
Anholt offshore wind farm timeline

Source: DONG Energy, MTH, AAU research (meetings and site visits), EAWE conference paper, 2013 (Poulsen et.al.)
Initial phases - A closer look...

**Tender phase:**
- April 2009: Release of tender specifications
- April 2010: Tender submission
- July 2, 2010: DONG Energy concession confirmed

**Development & consent phase:**
- July 2010: Geological surveys commenced

**Installation & commissioning phase:**
- Autumn 2011: Shore landing cables (export cables) commenced
- January 2012: Offshore construction commenced

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Source: DONG Energy, MTH, AAU research (meetings and site visits), EAWE conference paper, 2013 (Poulsen et.al.)
Outbound I&C offshore double-port supply chain set-up

Flow of finished wind turbine modules

Start → Transition Pieces → Trucking → Port area storage → Vessel loading, shipping, unloading, or trans-shipment → Vessel barge loading, shipping → End

Start → Towers → Port area storage → Barge storage → W.I.Vessel loading, shipping → Wind Turbine Components → Erection at sea site → End

Start → Nacelles → Port area storage → Wind Turbine Components → Erection at sea site → End

Start → Hubs → Trucking → Port area storage → Wind Turbine Components → End

Start → Blades → End

Legend:
- Start/end
- Process flow
- Optional
- SC navigation

Source: Own construction using Chambers et al (2010) framework
“Build it and they may come?!”

Port of Esbjerg is a lone example of an industry player that has been ahead of the industry and is now harvesting the benefits from this strategy.

Source: Port of Esbjerg
Race for larger WTG output - and importance of shipping/logistics/SCM

Source: Upwind Project (design limits and solutions for very large wind turbines) and Aalborg University Copenhagen photos
Research and development (R+D)

Transport industry always caught back-footed – need to get in front of industry R+D trends…

First WTG serial production 1979
## Wind R+D

### Implications on:
- Transport equipment
- Assets
- HSSEQ

### Transport Equipment
Trucks, trains, roads, bridges, storage facilities, lifting equipment, ports, vessels…

### Makers of wind turbines (OEMs):

#### The pioneers
- NEG Micon
- Vestas
- Siemens
- GE

#### The “other” Europeans
- Enercon
- AREVA
- Nordex
- Alstom

#### Examples of the Asian “newcomers”
- Sinovel
- Goldwind
- United Power
- Hyundai
- Samsung
- Unison
- Suzlon

Source: AAU research, DHL Global Forwarding, Renewable Energy Solutions
Dimensions – Logistics challenges

Source: Danish Shipowners’ Association, courtesy Siemens Wind Power
5 critical offshore wind factors

1. Distance to shore
2. Water depth
3. Number of wind farm turbine positions
4. Weight and dimensions of WTG and foundation
5. Seabed conditions

- Near shore
- Offshore
- Far offshore
Different ways to estimate LCoE

Over view of assets included in cost of energy

<table>
<thead>
<tr>
<th>Transmission grid</th>
<th>Onshore substation</th>
<th>Export Cable</th>
<th>Offshore Substation</th>
<th>Array Cables</th>
<th>Turbines</th>
</tr>
</thead>
<tbody>
<tr>
<td>National grid owner scope</td>
<td>DONG Energy scope in The United Kingdom</td>
<td></td>
<td>DONG Energy Scope in Germany</td>
<td></td>
<td>DONG Energy scope in Denmark</td>
</tr>
</tbody>
</table>

Target considered for country scope

- 100 €/MWh for DONG Energy scope in The United Kingdom

Source: DONG Energy
GLOBAL WIND ENERGY SHIPPING AND LOGISTICS

Source: BVG Associates for the UK Crown Estate, 2014
Involved parties...

**Freight forwarders:**
- Global
- Regional
- Local

**Ocean transportation and related:**
- RO/RO (“Roll-on/Roll-off”)
- LoLo (“Lift-on/Lift-off”)
- Short-sea/regional operators
  - Tug/barges and landing crafts (“LCTs”)
- Multi-purpose vessels (“MPV”)/Floating cranes
- Container vessel operators
- Safety vessels, work boats, and crew/hotel vessels
- Special vessels like offshore wind turbine installation and cable laying vessels

**Ports**
- Storage:
  - Warehouses
  - Yards
  - Storage areas

**Operators**
- Rail
- Specialty trucks
- Land based cranes

**Utilities**
- EPC companies

**Extent of services**

**DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING - SHIPPING & LOGISTICS**
M&A is picking up

<table>
<thead>
<tr>
<th>Company</th>
<th>Acquisitions and Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DSV</strong></td>
<td>Acquired Baltship / Seatainers:</td>
</tr>
<tr>
<td><strong>Mammoet</strong></td>
<td>Acquired KR Wind (cranes) and subsequently Brande Maskintransport (trucking):</td>
</tr>
<tr>
<td><strong>Marubeni</strong></td>
<td>Acquired Sea Jacks:</td>
</tr>
<tr>
<td><strong>Beluga</strong></td>
<td>Company was restructured by private equity Oak Tree (US) into Hansa Heavy Lift, many Beluga vessels taken over by banks and given to Döhle and Oldendorff to manage on behalf of the banks</td>
</tr>
<tr>
<td><strong>Mitsubishi</strong></td>
<td>Joint venture with Vestas</td>
</tr>
</tbody>
</table>

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**- SHIPPING & LOGISTICS**

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M&A changes the landscape

<table>
<thead>
<tr>
<th>Company</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hochtief</strong></td>
<td>Beluga joint venture with Hochtief dismantled and Belgian firm GeoSea took over Beluga’s shares and formed new company with Hochtief called HGO IntraSea Solutions:</td>
</tr>
<tr>
<td><strong>A2SEA</strong></td>
<td>Acquired by DONG Energy who subsequently sold 49% to Siemens Wind Power</td>
</tr>
<tr>
<td><strong>Swire</strong></td>
<td>Acquired Danish Blue Ocean and formed Swire Blue Ocean</td>
</tr>
<tr>
<td><strong>Aarsleff</strong></td>
<td>Joint venture with German shipping company Bilfinger Berger called AB-JV:</td>
</tr>
<tr>
<td>PORTS</td>
<td>SHIPPING</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>LORC</td>
<td>A2 SEA powered by knowhow</td>
</tr>
<tr>
<td>Essbjerg Havn</td>
<td>NT Offshore Marine &amp; Offshore services</td>
</tr>
<tr>
<td>Aalborg Havn</td>
<td>ESVAGT</td>
</tr>
<tr>
<td>Grenaa Havn A/S</td>
<td>MAERSK Line</td>
</tr>
<tr>
<td>AARHUS HAVN</td>
<td>THORCO</td>
</tr>
</tbody>
</table>

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- SHIPPING & LOGISTICS

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DENMARK
Acquired Danish companies

Mergers & Acquisitions
- DANBORG
- BLUE OCEAN
- KR Wind
- BRANDE
- MAMMOET
- NorSeaGroup
- Wilh. Wilhelmsen
- SWIRE

Joint Ventures
- A2 SEA
- SIEMENS
- COMBI LIFT
- BILFINGER BERGE
- J. Poulsen Shipping A/S
- Aarsleff
- abjv
- abjv.com

(49%)
(50%)
(50%)
Foreign operators in Denmark
Shipping/logistics order flow 2015

Hypothesis: Europe

EPC

Shipping & Logistics

Developers & Utilities

OEM:
- WTG
- BOP
Shipping/logistics assets 2020

Hypothesis: Europe

EPC

Shipping & Logistics

Developers & Utilities

OEM:
- WTG
- BOP
Continued divestment 2030

Hypothesis: Europe

EPC

Developers & Utilities

Shipping & Logistics

OEM:
- WTG
- BOP
China offshore wind – the need is adamant
Offshore wind - official 12th 5 year plan targets

Cumulative MW in 2012: 320 MW
Cumulative target for 2015: 2 GW
Cumulative target for 2020: 10 GW

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Wind resource map of China

- 18,000 km long coastline
- From shoreline to water depth of 20m = 157,000 km²
- Assuming only 10%-20% is suitable for offshore wind and the use of an average 5 MW WTG’s

→ **100-200 GW offshore capacity**

Offshore resources in China are spread across:
- Jiangsu
- Zhejiang
- Fujian
- Shandong
- Guangdong
- Shanghai

2020 target: 30 GW offshore wind

Source: Own analysis, BTM Navigant and data from National Climate Center of the China Meteorological Administration, June 2010
Example of unique China offshore-inter-tidal wind farm outbound I&C challenges

Example Jiangsu Dafeng project (installation by Guodian/CCCC JV):
• 30 km from shore, Western part of farm will have riverbed exposed during low tide
• Eastern part of farm will need WTIV’s to be permanently jacked up out of the water
• Requires different kinds of vessels than in Europe

Source: NEA & World Bank (2010), BTM Consult part of Navigant & Poulsen (2012), and first author research
South Korea wind status
- as of February, 2013 (onshore and offshore)

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of projects</th>
<th>Total installed capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incheon City</td>
<td>1</td>
<td>~22MW</td>
</tr>
<tr>
<td>Gyeonggi-do</td>
<td>3</td>
<td>~8.3MW</td>
</tr>
<tr>
<td>Jeollabuk-do (Jeonbuk)</td>
<td>2</td>
<td>~9.9 MW</td>
</tr>
<tr>
<td>Jeollanam-do (Jeonnam)</td>
<td>4</td>
<td>~17MW</td>
</tr>
<tr>
<td>Jeju-do</td>
<td>12</td>
<td>~111MW</td>
</tr>
<tr>
<td>Gangwon-do</td>
<td>10</td>
<td>~195.9MW</td>
</tr>
<tr>
<td>Gyeongsangbuk-do (Gyeonbuk)</td>
<td>6</td>
<td>~122.2 MW</td>
</tr>
<tr>
<td>Ulsan City</td>
<td>1</td>
<td>~1.7 MW</td>
</tr>
<tr>
<td>Busan City</td>
<td>1</td>
<td>~0.8 MW</td>
</tr>
<tr>
<td>Gyeongsangnam-do (Gyeognam)</td>
<td>1</td>
<td>~3.0 MW</td>
</tr>
</tbody>
</table>

Total number of projects: 41
Total installed capacity: 491.65MW
Total number of units: 295

7.5 GW home market offshore wind target by 2030

Source: Korea Wind Energy Association (2013)
Business Model in Denmark

SIEMENS

SIEMENS Energy

SIEMENS Siemens Wind Power

DONG energy

Joint Venture

A2 SEA powered by knowhow
Vertically and horizontal integrated business model China

**GUODIAN:**
- One of the five largest national utilities and power generation companies in China
- Development, investment, construction, operation and management within coal, wind, power generation equipment, transportation, high tech environment protection, technological services and consultancy
- It was founded in 2002 and has a HQ in Beijing

**UNITED POWER**
- China’s second largest OEM

**LONGYUAN WIND POWER**
- Wind farm operator

- A total of 16 regional and provincial branch companies
- 13 extra large subsidiary companies (including Longyuan and United Power)
- Approximately 200 power enterprises
Horizontal and vertical integration

HYUNDAI

HYUNDAI HEAVY INDUSTRIES CO., LTD.

GROUP

HYUNDAI MIPO DOCKYARD
HYUNDAI SAMHO HEAVY INDUSTRIES
HYUNDAI CORPORATION
HYUNDAI VENTURE INVESTMENT
HYUNDAI FUTURES
HYUNDAI FINANCE
HYUNDAI OILBANK

SHIPBUILDING
ENGINE & MACHINERY
GREEN ENERGY
ELECTRO ELECTRIC SYSTEMS
CONSTRUCTION EQUIPMENT
INDUSTRIAL PLANT & ENGINEERING
OFFSHORE & ENGINEERING
Key points of today

- Shipping/logistics/SCM is an important support function for the wind market
- Especially offshore wind is driving the step-change in technology development
- Different strategies and business models are being applied – in Europe and globally
- The market is changing
- M&A is on the rise
Thank you – Thomas Poulsen

Aalborg University, Copenhagen Campus
Department of Mechanical and Manufacturing Engineering

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Research interest:
Global wind energy shipping and logistics

Background:
25 years of global shipping, logistics, and SCM experience having lived in 8 different countries working at practical, strategic, general management, and consulting level
Discussion

Does the Danish heritage matter?
Can Danish firms keep up?
Does country of origin matter?