OFFSHORE WIND ENGINEERING

Jan Rønberg  Sr Market Director OWF
Arne Ivar Hansen  Chief Project Manager
ABOUT US

COWI IN NUMBERS
- 709 MILLION EUR IN TURNOVER
- MORE THAN 80 YEARS OF HISTORY
- WORKING IN 124 COUNTRIES
- OVER 6,100 EMPLOYEES
- 17,000 ONGOING PROJECTS

Consultancy Offshore Wind
VT3

Waiting for number of staff per division

Vaida Totilaite, 2014/09/08
Marine market segments

- Marine Terminals
- Ports and Harbours
- Coastal Engineering and Waterfront Development
- Offshore Wind Farms
- Cooling Water Systems
- Locks and Dams
COWI's key marine and coastal engineering offices
Main offshore wind offices

- London
- Hamburg
- Aalborg
- Aarhus Lyngby
- Oslo

Around 100 staff working with offshore wind foundation design

Including US (Connecticut/Boston)
Our OWF services
Different services

- Hydrodynamic Studies
- Geotechnical Design & Investigations
- Feasibility Studies
- Design (Feed, Prelim, Basic Detailed)
- Preparation of Tender Documents
- Construction Supervision
- Construction Management (PMc)
Our Foundation Design Experience in OWF

The European experience

Understanding the complete design process

- Statutory requirements
- Employers-, owners requirements
- WTG manufacturers requirements
- Fabrication-, installation contractors requirements
- Geotechnical-, met-ocean-, structural contraints
General offshore wind foundation
General offshore wind foundation
London Array 630 MW offshore wind farm, UK
With 175 monopiles, designed to carry the Siemens 3.6 MW turbines, London Array will be the largest offshore wind farm in the world when completed in 2012. Monopiles of 4.7 m and 5.7 m in diameter will be installed in water depths between 0 m and 25 m. With a total length of up to 85 m, these foundations will range among the largest ever built.

A consortium of DONG, E.ON and Masdar has commissioned Aarsleff Bilfinger Berger Joint Venture (ABJV) as contractor to undertake fabrication and installation of the steel foundations. To carry out the detailed design of the steel foundations, ABJV has engaged COWI as lead in a joint venture with IMS GmbH. COWI services comprised detailed structural design of 175 monopiles and appurtenances, detailed geotechnical design for 175 locations and detailed hydraulic design. COWI DKK 30 mio, total costs DKK 3 bill.

Susanne Johnna Johansen, 2014/11/08
<table>
<thead>
<tr>
<th>Offshore Wind Farm</th>
<th>Country</th>
<th>Capacity</th>
<th>SWP</th>
</tr>
</thead>
<tbody>
<tr>
<td>London Array offshore wind farm</td>
<td>UK</td>
<td>630 MW</td>
<td>3.6 MW</td>
</tr>
<tr>
<td>Rentel offshore wind farm</td>
<td>Belgium</td>
<td>300 MW</td>
<td>6 MW</td>
</tr>
<tr>
<td>Merkur offshore wind farm</td>
<td>Germany</td>
<td>400 MW</td>
<td>6 MW</td>
</tr>
<tr>
<td>Hohe See offshore wind farm</td>
<td>Germany</td>
<td>500 MW</td>
<td>7 MW</td>
</tr>
<tr>
<td>German OWF</td>
<td>Germany</td>
<td>110 MW</td>
<td>7 MW</td>
</tr>
<tr>
<td>DanTysk offshore wind farm</td>
<td>Germany</td>
<td>290 MW</td>
<td>6 MW</td>
</tr>
<tr>
<td>Formosa 1 offshore wind farm</td>
<td>Taiwan</td>
<td>150 MW</td>
<td>6 MW</td>
</tr>
</tbody>
</table>
Iberdrola Renovables intends to build an off-shore wind farm at Wikinger in the Baltic See NE of the island of Rügen. COWI in joint venture with IMS will assist in defining, specifying, monitoring and interpreting the surveys to be done during the construction permit update process which will extend until the end of 2011. The work will be developed according to the regulations of the Bundesamt fur Seeschifffahrt und Hydrographie. Within the scope of the technical assistance, the following work will be carried out:

- Technical specification for the bathymetric and geophysical survey
- Assistance during the tender
- Evaluation of technical offers for the survey
- Monitoring of the geophysical campaign
- Analysis of results and proposal of geotechnical campaign
- Support to Iberdrola Renovables in the relationship with BSH, as an independent geotechnical advisor
- Technical specification for the geotechnical campaign
- Assistance during the tender
- Evaluation of technical offers for geotechnical survey
- Monitoring of the geotechnical survey
- Evaluation of results and conclusions on the structural design and installation of foundations and cable laying
- Coordination with certification body. 2010-2014. EUR 125,000

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OFFSHORE WIND FARMS
Jacket foundations – Detailed Design

- Wikinger offshore wind farm DD, Germany 350 MW Areva 6 MW
- Thornton Bank Phase 2+3 DD, Belgium 240 MW RePower 5 MW
- Ormonde Offshore Wind farm DD, UK 150 MW RePower 5 MW
- Alpha Ventus offshore wind farm DD, Germany 30 MW RePower 5 MW
- Le Carnet DD, France 5 MW Alstom 5 MW
Thornton Bank 30 MW offshore wind farm, Belgium
Phase II of 24 wind turbines project off the North Sea coast of Belgium. Gravity based foundations set in 21 to 27 m of water depth some 30 km from the coast. COWI services comprised structural, geotechnical and hydrodynamic design as well as installation analysis. Services also include programming and analysis of mathematical and physical modelling of shear leg movements and sling forces during transport and installation. 2008-2011. COWI DKK 10 mio

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OFFSHORE WIND FARMS
Gravity Base foundations – Detailed Design

› Thornton Bank offshore wind farm – phase 1 DD, Belgium RePower 5 MW
› Kaarehamn offshore wind farm DD, Sweden Vestas 3 MW
› Nysted offshore wind farms DD, DK SWP 2.3 MW
› Rødsand 2 offshore wind farms DD, DK SWP 2.3 MW
Horns Rev C, Kriegers Flak A and B, Transformer Platforms, Denmark
Offshore Wind Farm located 15 km east of the Danish coast in the southern part of the Baltic Sea is planned with a total capacity of 600 MW. Depending on the turbine type, the number of turbines will between 60 and 200 (+2 additional turbines). The site area of 250 km² encircles the bathymetric high called "Kriegers Flak" with water depth generally between 16 and 20 m and up to 30 m along the edges of the site area. The foundations for the wind turbines will comprise driven monopiles, gravity base structures, jackets or suction buckets. 2014 COWI services comprised preliminary review and assessment of available geotechnical factual data to determine suitability of ground conditions for gravity base foundations based on previous foundation conceptual designs. 2014 COWI EUR 5,000

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Design Process
COWI BTM Marine & Foundation Engineering

Floating wind

COWI offer an unique setup for floating wind through:

› Experience to perform design of all major floating concepts (semi, TLP, spar)
› Extensive track-record for bottom-fixed foundations for OWF
› Established interface with all major WTG suppliers
› Hands-on experience with secondary steel design to accommodate WTG equipment in the substructure
› Concept independent with no patent strategy on substructure designs
Floating wind - methodology

Our approach:
› Fully coupled analysis using state of the art analytical tools
› Coupled NREL FAST + ANSYS AQWA
› Structural Design in ANSYS Workbench
› Sequenced and iterative design:
  › Hydrodynamic model
  › Load Integrated Analysis
  › Structural model
  › Plus scripting for software interface, pre and post-processing
Key Project Drivers

The Market is still politically driven
Transition to commercial expected around 2020 - 2023

Key Market Drivers: LCOE - RISK

For a designer, this means

- Technical Excellence and experience
- Flexibility (execution, staff, planning, dialog)
- Capacity (execution, expedience)
- Size of organisation (insurance, redundancy etc.)
What characterizes our projects are:

› High degree of complexity
› Multiple stakeholders
› State-of-the-art technology - Innovation
› Compressed time frame
› Requirements for redundancy
› Cost for initial activities
WHAT IS COWI?

Experience, Reliability, Innovation
Thank You for your time