The Wind & The Waves ... Renewable Energy
Developments Through Learnings From Oil & Gas

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HSE standards and culture in Offshore Wind should be and are at minimum the same level as in Offshore Oil & Gas.
Driven / motivated by:
* the need for an Energy Transition and the drive to contribute to that
* the Opportunities & Challenges in Offshore Wind
* the entrepreneurial spirit in Offshore Wind:
  - a market becoming mature rapidly,
  - hardly anyone was working in Offshore 10 years ago,
  - people, knowledge and assets coming from Oil & Gas and other markets
  - many young & promising people choose to work in renewables / Offshore Wind
2: VARIOUS ASPECTS OF RENEWABLES DEVELOPMENTS

- EPCI Foundations
- WTG T&I
- Substation T&I
- Land- fall and cable pull-in
- Inter array cables
- Export cables
- Scour protection
- UXO Removal
- Side and geotechnical survey
3: OPPORTUNITIES AND CHALLENGES FOR OFFSHORE WIND IN THE NEAR FUTURE
There is good wind potential around the globe, but also challenges, e.g. high water depths at the coastal line.
3: OFFSHORE WIND OPPORTUNITIES

There already are well-established, but also developing markets in different parts of the world.

Well-established markets:
- Germany
- France
- Belgium
- Netherlands
- Denmark
- UK

Developing markets:
- Turkey
- USA
- India
- Taiwan
- South Korea
- Japan
- China (well progressing)
- Poland
Now that offshore wind is ‘in the money’, capacity is growing significantly. Up to 2030 most installed capacity probably will be in Europe, but much can be expected from Asia-Pacific and the US.
3: OFFSHORE WIND CHALLENGES

- (IN EU) MOST FAVORABLE SITES USED:
  - Water depths increasing
  - More challenging Soil & Wave parameters
  - Distance to shore increasing

- INSTALLATION ON WINDY LOCATIONS

- WIND TURBINE SIZE & POWER INCREASING

- NEW MARKETS -> LOGISTICS
  - Taiwan / United States (Jones act) / Australia

- FLOATING FOUNDATIONS

- PRICES / SUBSIDY PER MW DECREASING

- MARKET CAPACITY
  - Shortage of Fabrication & Installation capacity foreseen after 2020
    (especially when oil price picks up as well)
4: VEJA MATE OFFSHORE WIND FARM (402 MW)
EPCI-contract for 67 XXL Monopile Foundations in the German Bight

VEJA MATE PROJECTMOVIE (4:30 minutes)
5: MONOPILE DESIGN (VEJA MATE PROJECT)

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<th>Length (m)</th>
<th>Weight (T)</th>
<th>Diameter (m)</th>
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<tr>
<td>Mono Piles</td>
<td>MAX 84.8</td>
<td>MAX 1304</td>
<td>MAX 7.8</td>
</tr>
<tr>
<td></td>
<td>MIN 76.2</td>
<td>MIN 1157</td>
<td>MIN 6.5</td>
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<tr>
<td>Pile Penetration</td>
<td>Max. 41m</td>
<td></td>
<td></td>
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<tr>
<td>Water Depth</td>
<td>-38.5 till -39.8m LAT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transition Pieces</td>
<td>Length 22.2 m, Weight 350 T, Diameter 6.81 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MP-TP Connection</td>
<td>Bolted with Grout Skirt Flange @ +4.5 LAT</td>
<td></td>
<td></td>
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<tr>
<td>Scour Protection</td>
<td>Double Layer (Rock) Pre-installed</td>
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Scope: EPCI 67 Wind Turbine Foundations (6MW Siemens SWT-6.0-154)
5: INSTALLATION – MONOPILES

MAIN INSTALLATION VESSEL
• SeaJacks Scylla (new build)

OUTFITTING
• 1540T crane
• Stacked MP storage line
• Upending line with bucket on SPMTs
• MP lifting tool (FMUT)
• Pile Gripper Frame (PGF)
• S-4000 Hydro-hammer spread
• Hydro Sound Damper Noise Mitigation

SUPPORT VESSEL
• Noise Mitigation vessel operating DBBC

PROGRESS
• Started in April 2016, last MP installed in August 2016
6: MP-INSTALLATION : NOISE MITIGATION

Requirement for underwater noise at 750 m in Germany (BSH):

- $L_{\text{Peak}} \leq 190 \text{ dB}$
- $SEL_{05} \leq 160 \text{ dB}$

1: HYDRO SOUND DAMPER (HSD)

2: DOUBLE BIG BUBBLE CURTAIN (DBBC)

3: ACTIVE HiLo PILING
Controlling piling energy based upon direct monitoring of $SEL_{05}$ development during piling
HiLo: High Frequency / Low Energy
7: INSTALLATION – TRANSITION PIECES

VESSEL:
• Sea Jacks JU Zaratan (subcontract)

OUTFITTING:
• TP Lifting Tool
• TP Access System
• Grout spread
• Bolting Tools
7: TP-INSTALLATION
7: BOLTING AND GROUTING IN PROCESS
BOLTING AND GROUTING IN PROCESS

BOLTING AND GROUTING CONSIDERATIONS

- Connection between jacket / TP or MP/TP is a weak link and has caused major challenges in the early days.
- Choice for bolted, grouted or hybrid is strongly depending on project specific circumstances
- Bolted connections:
  - require a flange (piling on the flange challenging w.r.t. very strict margins)
  - bolting protocol and pre-tensioning techniques challenging
  - relaxation possible
  - easy to retension, replace bolts and decommission
- Grouted connections:
  - create a fixed solution, no flange required
  - mix in place offshore: very strict quality and temperature requirements
- Hybrid connections:
  - best of both worlds, reducing MP and TP wall thickness
- Recent design solutions: MP or jacket without separate Transition Piece (requiring alternative piling methods for MP's)
8: JACKET INSTALLATION

DIFFERENT CONCEPT JACKETS COMPARED TO MONOPILES

• In deeper water jackets become more economic than monopiles
• Design of jackets is more challenging (more elements, fatigue on nodes)
• Fabrication complexity is different:
  - Monopiles require large can rolling equipment and welding robots
    (diameter up to 10 m, wall thickness up to 120 mm)
  - for jackets 3D construction within margins and corrosion protection is more challenging
• Fabrication time for a jacket is longer due to complexity and more elements
• Piling for jackets produces less underwater noise (Suction Buckets produce hardly any noise)
• More challenging lifting, transport and seafastening requirements for jackets
  (jackets mostly transported in vertical position, monopiles horizontally)
8: JACKET INSTALLATION
8: EXAMPLE: WIKINGER PROJECT
DRILLED PIN PILES

Transport

Pile Installation

In pile Dredging

Jacket Installation

Jacket-Pile Grouting

Motion compensated Drilling
8: EXAMPLE: ABERDEEN BAY SUCTION BUCKET FOUNDATIONS

Design and fabrication
Pre-layer scour protection
Transport of jackets
Installation of jackets

WTG installation
Export and array cable installation
Grouting and post scour protection
Secondary works and handover
9: DISCUSSION & QUESTIONS