Inter Array Cable Technology Development

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2016 NSRI/ORE Subsea Technological Challenges in Offshore Wind
Aberdeen
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AGENDA

- Offshore Wind Introduction
- JDR Diversification from Oil & Gas into Offshore Wind
- Similarities & Differences
- Technological Challenges
- Summary
RenewableUK website:

UK Onshore Wind: 5483 turbines, 8997MW
UK Offshore Wind: 1465 turbines, 5097MW
Total Current UK Capacity: 14095MW

• First offshore wind farm in the UK started operating in 2000.
• Series of licensing ‘Rounds’ co-ordinated by The Crown Estate (landlord and owner of the seabed)
• 2001 - Round 1 was launched involving 18 sites in England and Wales, with a potential capacity of 1.5GW.
• 2003 - Round 2 issued - further offshore and in deeper waters, formed of the 3 strategic areas; Greater Wash, Greater Thames and Irish Sea - added another 7GW of capacity.
• 2010 - Round 3 - the biggest so far with 9 zones across the UK. (circa 25 GW)
• In addition to these Rounds, there is a further development programme in Scottish Territorial Waters overseen by the Scottish government.

Offshore Wind now meets 5% annual demand, moving to 10% by 2020
OFFSHORE WIND

UK Electricity National Grid Demand and Output per Production Type

last update 2016-09-27 14:30:00 GMT

GridWatch.co.uk

Home  co2 emissions  Frequency  Widgets  FAQ  About

PROVIDING THE VITAL CONNECTION
• Further growth in UK build out
• Further growth in non UK build out
• Growth in Offshore Maintenance work – especially as turbines coming out of supplier maintenance agreements
## JDR TRACK RECORD

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<tr>
<th>Renewable Energy</th>
<th>Power &amp; Subsea Pumping</th>
<th>Intervention &amp; Workover</th>
<th>Subsea Control</th>
<th>Complex Projects</th>
</tr>
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<tbody>
<tr>
<td><strong>UK</strong>&lt;br&gt;Dong Energy Racebank 140km, first award under FA</td>
<td>Brunei Shell Champion B23 13km of Composite Power Umbilicals</td>
<td>US Chevron Jack St, Malo Rigless, Riserless IWOCS</td>
<td>Australia Apache Van Gogh Dynamic &amp; Static Umbilicals</td>
<td><strong>UK</strong>&lt;br&gt;London Array Worlds Largest OW Farm – over 200km</td>
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<td><strong>Germany</strong>&lt;br&gt;RWE Nordsee One 70km, Aluminium Cores</td>
<td><strong>UK</strong> Marathon West Brae 13km Power Umbilicals</td>
<td><strong>Norway</strong> Statoil Aasgard 10 IWOCS Systems including Reelers</td>
<td><strong>Nigeria</strong> ENI Abo 12 Deepwater Steel Tube umbilical</td>
<td><strong>Angola</strong> Total Egina Largest IWOCS order in the Industry</td>
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<tr>
<td><strong>UK</strong> Statoil Dudgeon 95km Inter-Array Cables</td>
<td>Gabon Total Anguille 60km Subsea Power Cables</td>
<td><strong>Angola</strong> Total Kaombo 14 IWOCS Umbilicals, Jumpers &amp; Reelers</td>
<td><strong>Australia</strong> Santos Fletcher Finucane 60km Umbilicals &amp; Power Cables</td>
<td><strong>China</strong> CNOOC Liuhua 4-1 ESP &amp; Production Control Umbilicals</td>
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<td><strong>UK</strong> Wave Hub Worlds Largest Wave Test Centre</td>
<td>UAE Adma-Opco Sarb 58km Subsea Power Cables</td>
<td><strong>China</strong> Husky Energy Liwan Largest IWOCS System ever supplied</td>
<td><strong>Qatar</strong> QP Wellhead Umbilicals 2,413m Platform to Platform</td>
<td><strong>Denmark</strong> Wintershall Ravn 18km Hybrid Steel Tube Umbilical</td>
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REGIONAL BASES, MANUFACTURING EXCELLENCE

JDR serves its international offshore oil and gas customers with its well-equipped and strategically located facilities. Over the last four years we have invested over £30m in state-of-the-art manufacturing capabilities.

**Hartlepool, Victoria Dock**

A world-class quayside manufacturing site strategically located alongside a North Sea port. A 20,000m² site, commissioned in 2009 for SPJU, SPF and REC manufacture. Highly flexible production set-up with capability in ultra-long length cables & umbilicals.

**Littleport**

Engineering design, project management, research and development, NWGC production and manufacture of specialist components and Subsea Production Umbilicals, and Power Cables up to 100 tonnes. The facility provides specialist testing facilities.

**Brazil**

In 2014 JDR opened a Product and Installation Services facility in the bustling port city of Macael. More than 80% of Brazilian oil is moved to this port in some way. At the facility, JDR performs assembly, integration and testing of umbilicals, cables, reeplers and associated packages.

**Houston Service Centre**

Assembly, integration and testing of umbilicals, reeplers and associated packages. Houston-based project management and engineering support is available for projects in the Gulf of Mexico, as well as offshore commissioning, testing and repair work.
JDR PRODUCT APPLICATIONS

1. Conventional MOCOC umbilical and reeler
2. Self-spooling oceanic MOCOC umbilical and reeler
3. Dynamic subsea production umbilical (DPU)
4. Dynamic subsea power cables (SPC)
5. Shallow-platform subsea power cable (SPC)
6. Thermoplastic Hydraulic Flying Lead (HFL)
7. Steel Tube Flying Lead (STFL)
8. 33 kV Static Intra-Array Cable
9. 72 kV Export & Intra-Array Cable
10. 72 kV Dynamic Export and Dynamic Intra-Array Cable
Inter Array Cabling supplied on:
Greater Gabbard (2010)
London Array (2011)
Meerwind (2013)
Sandbank (2015)
Nordsee One (2015)
Rampion (2016)
Veja Mate (2016)
Race Bank (2016)

Galloper (2017)
Beatrice (2017)

Currently, Offshore Wind represents 75% of our activity
INTER ARRAY WIND FARM CABLE SUPPLIERS 2010 -2016

Europe at a Glance: 30-36kV Cable Manufacturers

Market share since 2010

Source: 4C Offshore
<table>
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<tr>
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<th>Offshore Oil &amp; Gas</th>
<th>Offshore Wind</th>
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<tbody>
<tr>
<td>Established Supply Base?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Lots of Competition?</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Pressure on Cost Reduction?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Risk Averse End Clients?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Construction &amp; Weather Risk?</td>
<td>Yes</td>
<td>Yes</td>
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## SIMILARITIES & DIFFERENCES - 2

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<tr>
<td>Hydrocarbon Explosion Risk?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Subsidy on Construction?</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Subsidy on Production?</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Market size controlled by governments?</td>
<td>Yes and No</td>
<td>Yes</td>
</tr>
<tr>
<td>Growth?</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Typical Project Size</td>
<td>Decreasing</td>
<td>Increasing</td>
</tr>
<tr>
<td>Repeat operations?</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Water Depth?</td>
<td>Deep</td>
<td>Shallow</td>
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TECHNOLOGICAL CHALLENGES IN OFFSHORE WIND

• Cost reduction
• Cost reduction
• Cost reduction

Expectation is costs reduce towards being a subsidy free industry

2 current innovations:
• To reduce overall cost is increasing voltage from 33kV to 66kV
• Floating Wind – Dynamic Cables
64 turbine field, 8 strings of 8 turbines

250MW Windfarm with 3 or 4 MW turbines
500MW WINDFARM WITH 7 OR 8MW TURBINES

- 33kV
- 66kV

Export Cables
Collector Cables
Inter-Turbine Cables

7 o 8 MW Wind Turbine
66kV BENEFITS OVER 33kV

- Array cable length reduction (circa 20%-30%, depending on site layout)
- Less weight and length of cable to make and install
- OSS platform/transformer - size & weight reduction, simplification
- These benefits outweigh increased unit costs of higher voltage cable/terminations/switchgear
66kV (72.5kV) AC CABLE & SYSTEM ELECTRICAL TYPE TESTING

- Extension to higher electrical stress at 66 kV demonstrated by JDR in cable type testing.

- 66 kV cable type test approval to IEC60840, CIGRE 623 & 490 completed including coilable cable, factory flexible joint, connectors, repair joints. All successfully completed.

- Full-scale 66 kV accelerated wet-age testing performed in saline conditions at 3Uo 500 Hz for 3000 hrs

- COLLABORATION with ORE Catapult HV Laboratory at Blyth was a very important enabler

- Weibull assessment of step-break down results gives a lifetime prediction of > 40 years at operating stress

- Qualified for next offshore wind farms up to 66 kV

- Suitable for larger WTG power and for floating offshore wind
FLOATING WIND DEVELOPMENT

- Dynamic Power Cables required, rather than static
- Typ 100m water depth
- Similarities with FPSO mooring lines, risers and umbilicals
- Demonstrator Projects done in Norway and Japan
- First larger scale project is in Scotland (Hywind)
OPERATIONS & MAINTENANCE OF ARRAY CABLES

- Cable itself is designed to be maintenance free, although there may be reburial work required after scour/seabed movement

- Increased role of condition monitoring (e.g. Distributed Temperature Sensing to identify unburied cable areas)?

- Cable Repairs – repair joint kits supplied with cables and spare cable lengths supplied too, so replace or repair options available.

- Marine spread is likely to be repair bottleneck – potential role for call off agreements

- If an array cable fails or is damaged (e.g. by an anchor, jack up etc) then either replace whole link or repair

- Experience to date is that damage is much more likely during installation phase than operations phase

- JDR has not had a single fault in service reported on any array cable supplied by JDR to data

- As sector assets mature – end of life prediction/replacement programmes? (as per land cables)
SUMMARY

- Offshore Wind has many similarities to Offshore Oil & Gas, but very different emphasis (e.g. multiple operation industrialisation)

- Cost reduction drives market, this requires innovation

- Establishing a track record is key – demonstrator projects are very important to help supply chain show technical readiness

- JDR’s success in offshore wind is the result of:
  - Early involvement in UK Demonstration Project to give track record
  - Listening to the challenges developers have in their harsh offshore applications
  - Working collaboratively across the supply-chain to solve these challenges
  - Developing leading technology, working in partnership to ensure success
  - Executing well, continually improving and growing world leading capabilities

- 66 (72.5 max) kV AC wet-design cables are a viable alternative to conventional cable types, reducing cost and offering reliable performance

- Floating Offshore Wind will also need cost reduction
Thank you

UNITED KINGDOM | UNITED STATES | WEST AFRICA | THAILAND | SINGAPORE | GERMANY | BRAZIL

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