Subsea Processing, A Holistic Approach to Marginal Field Development

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Prospects for Subsea Processing

- Subsea Processing Technology is Maturing for Field Developments
- Gained wide Acceptance in the Offshore Industry
- Huge Benefits to develop Marginal Fields
- Techno-Economic barriers hindering Field developments can be Broken
Technology Gaps

- Quality of Separation is less than that for Topsides
- Compression Technology under Development and Qualification Testing
- Current Boosting Technology cannot cover 80Km
- Controls and Power Transmission needs to be Improved for Greater Step-out Distance
Fundamental Building Block for Subsea Processing

FULL SUBSEA PROCESSING

- Sand handling
- Separation
- Compression
- Boosting
- Re-injection

Wellfluids -> Sand handling -> Separation (gas, water, oil) -> Compression -> Boosting -> Re-injection

Receiving Facility
### Design Life for Subsea Processing

Subsea Systems Designed to Operate above 25 years

<table>
<thead>
<tr>
<th>Systems</th>
<th>Depth (m)</th>
<th>Design Life (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Troll Pilot Subsea</td>
<td>349</td>
<td>25</td>
</tr>
<tr>
<td>Tordis SSBI</td>
<td>210</td>
<td>26</td>
</tr>
<tr>
<td>Tyrihans RSWI</td>
<td>270</td>
<td>25</td>
</tr>
<tr>
<td>Gulffaks Gas Compression</td>
<td>135</td>
<td>20</td>
</tr>
<tr>
<td>Asgard Gas Compression</td>
<td>260</td>
<td>30</td>
</tr>
</tbody>
</table>
Field was considered Marginal due to Technological/Economic reasons

ESP's was used, offered more benefits over Hydraulic Submersible Pumps
Economic Evaluation of Marginal Field (Otter Field)

Daily Production Profiles in 10,000 barrels over the Field life

Total Production

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### Booster Stations along step out Routes

**Typical Field Developments Step-out Distance**

<table>
<thead>
<tr>
<th>Field</th>
<th>Depth (m)</th>
<th>Distance (km)</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>King</td>
<td>1700</td>
<td>29</td>
<td>2007</td>
</tr>
<tr>
<td>ETAP - Machar</td>
<td>84.5</td>
<td>35.2</td>
<td>1999</td>
</tr>
<tr>
<td>Otter</td>
<td>185</td>
<td>21</td>
<td>2002</td>
</tr>
<tr>
<td>Tyrhians</td>
<td>270</td>
<td>31</td>
<td>2009</td>
</tr>
</tbody>
</table>

**Proposed Boosting Options with Multiple Booster Stations**

[Diagram of proposed boosting options with multiple booster stations.]

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Equipment Manufactured is Installed and Produced till abandoned

Then Equipment is Retrieved, Refurbished as necessary

Moved onto another Field and Installed again
Simultaneous Production Method

Produce each Field Separately and Simultaneously with:

5 FSUs

5 FSPSs

Other Equipment re-used in other Developments or sold/rented out as Asset

The Profit yielding years of the Simultaneous Method end after only 5 years
Combination Method

- This combines both IPRR and Simultaneous Method
- 2 FSUs are acquired instead of 5
- First FSU is used to produce 3 of the 5 Fields
- Second FSU is used to produce the remaining 2 Fields
- Both begin at the same time with IPRR applied
### Simultaneous Method, Combinational and IPRR Comparison

<table>
<thead>
<tr>
<th>Descriptions</th>
<th>SM</th>
<th>Combinational</th>
<th>IPRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Time (yrs)</td>
<td>5</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>Average Annual Profit ($M)</td>
<td>246</td>
<td>131</td>
<td>74</td>
</tr>
<tr>
<td>Total Profit ($M)</td>
<td>1230</td>
<td>1969</td>
<td>1848</td>
</tr>
<tr>
<td>Initial CAPAX ($M)</td>
<td>2230</td>
<td>892</td>
<td>446</td>
</tr>
<tr>
<td>Internal Rate of Return (%)</td>
<td>55</td>
<td>220</td>
<td>414</td>
</tr>
</tbody>
</table>
Derivable Results

Critical Elements for Marginal Field Development:

- Increase Recovery up to about 60% of Reserves
- Reduce OPEX due to
  - Less Energy required for Pumping
  - Reduced Production Time
- Materials

Reduction of total Production Time by Subsea Boosting

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Developing Remote Offshore Marginal Fields

- Adopting a Holistic Approach in developing this Fields
- Group Fields into Clusters
- Use FSPS with Long distance Pipeline and IPRR
- Apply FSPS with Floating Platform and IPRR
Operating Oil Companies

Easier to Raise the lower sum (IPRR)

Takes 25 years to Complete .........., too long for Small Companies

Best Method is to Combine both IPRR and SM

Combinational Method with 15 years, most Commercial Option
Conclusions

Subsea Processing Breaks the Techno-Economic Barriers Hindering Developments

Technical Analysis Reveal Enormous Advantages derivable

Increased Recovery and Reduced OPEX have been Established

Industry will benefit Significantly from Subsea Processing Technology
The Authors would wish to Acknowledge all Resources particularly Otter Field Development (TOTAL) and Africa Oil & Gas Report, accredited to this Presentation.

THANK YOU

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