Cost efficient subsea tie-back development concept in 1000m water depth and mitigation of hydrate challenges.

Ole Heggdal
Subsea tie-back to existing jacket platform

- Gas & Condensate field at 1000 m
- Distance to host 30 km at 150 m
- Plateau gas production 400 mmscfd
- Peak water production: 300 bpd
- Base case dual production flowlines 2x12"
- Single line 16” opportunity
- Limited host weight and utilities capacity
Hydrate Management Concept Selection

Case 1: Continuous MEG injection and regeneration (MEG)
Case 2: Direct Electrical Heating (DEH)
Case 3: Trace Heated Pipe-in-Pipe (ETH PiP)
Case 4: Production water bundle (PWB)
Case 5: Low dosage hydrate inhibitors (LDHI)
Selection Criteria

• Topside modifications and constructability
• Operability and Robustness
• Technology feasibility
• HSE
• CAPEX / OPEX
Topside study – Module size / weights

- Weight capacity for new tie-back < 2000 tonnes

Topside size/weight

Operating weight [tonnes]  
Dry weight [tonnes]  
Volume [m3]  
Topside capacity [tonnes]
Hydrate mitigation – Power consumption

- Continuous electrical [MW]
- Intermittent electrical [MW]
- Heating medium [MW]
- Cooling medium [MW]
- Life of field electricity consumption [GWhrs]

Cases:
- Case 1: MEG
- Case 2: DEH
- Case 3: ETH PiP
- Case 4: PWB
- Case 5: LDHI
## Subsea study

<table>
<thead>
<tr>
<th></th>
<th>Case 1 - MEG</th>
<th>Case 2 - DEH</th>
<th>Case 3 – ETH PiP</th>
<th>Case 4 - PWB</th>
<th>Case 5 - LDHI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operability</strong></td>
<td>Minimum flow restrictions (MEG storage)</td>
<td>Re-heat one flowline at the time</td>
<td>Low power consumption</td>
<td>Cold spots at joints</td>
<td>Logistics/OPEX Impact on flow Sub-cooling limitations Shut-in/ shutdown</td>
</tr>
<tr>
<td><strong>Installability</strong></td>
<td>1 off 6” MEG supply line</td>
<td>Flowline insulation + heating cable</td>
<td>Availability of reeling vessels</td>
<td>Distance to manufacturing site Complex installation scope</td>
<td>Negligible SURF impact</td>
</tr>
<tr>
<td><strong>Technical feasibility</strong></td>
<td>Field proven</td>
<td>Field proven</td>
<td>Lack of track record</td>
<td>Challenging for deep water &gt; 400m</td>
<td>Production chemistry specific</td>
</tr>
<tr>
<td><strong>HSE</strong></td>
<td>Power consumption</td>
<td>No specific challenges</td>
<td>No specific challenges</td>
<td>No specific challenges</td>
<td>Toxicity Biodegradability</td>
</tr>
</tbody>
</table>

**Preferred** | **Acceptable** | **Not acceptable**
CAPEX Comparison

Case 1 MEG
Case 2 DEH
Case 3 ETH PiP

Dual flowline additional cost
Flowlines & Heating CAPEX
Topside & modifications CAPEX

Reduced CAPEX
Direct Electrical Heating: Concept

Purpose: Increase/maintain temperature in flowline above hydrate, wax or ice appearance temperature, either by intermittent or continuous heating.
# DEH Track Record worldwide

<table>
<thead>
<tr>
<th>Field</th>
<th>Åsgard Statoil</th>
<th>Huldra Statoil</th>
<th>Kristin Statoil</th>
<th>Urd Statoil</th>
<th>Tyrihans Statoil</th>
<th>Ormen Lange Statoil</th>
<th>Alve Statoil</th>
<th>Morvin Statoil</th>
<th>Skarv BP</th>
<th>Olowi CNR</th>
<th>Skuld Statoil</th>
<th>Lianzi Chevron</th>
<th>Goliat ENI</th>
<th>Gullfaks Statoil</th>
<th>Shah Deniz BP</th>
<th>Maria Wintershall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe dimension (inches)</td>
<td>10</td>
<td>8</td>
<td>10</td>
<td>12 1/2</td>
<td>18</td>
<td>30</td>
<td>12 1/2</td>
<td>10.5</td>
<td>12</td>
<td>8</td>
<td>14</td>
<td>11</td>
<td>12</td>
<td>8</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Flowline length (km)</td>
<td>6-8.5 (6 flowl.)</td>
<td>16</td>
<td>6-7 (6 flowl.)</td>
<td>9</td>
<td>43</td>
<td>20</td>
<td>16</td>
<td>20</td>
<td>13</td>
<td>4 (3 flowl.)</td>
<td>26</td>
<td>43</td>
<td>8 (2 flowl.)</td>
<td>8.5</td>
<td>3 - 18 (12 flowl.)</td>
<td>26</td>
</tr>
<tr>
<td>Water depth (m)</td>
<td>300</td>
<td>175</td>
<td>370</td>
<td>390</td>
<td>1000</td>
<td>350</td>
<td>300</td>
<td>30</td>
<td>370</td>
<td>1000</td>
<td>330</td>
<td>150</td>
<td>500</td>
<td>370</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U-value (W/m²K)</td>
<td>5</td>
<td>3.5</td>
<td>8</td>
<td>4</td>
<td>4</td>
<td>-</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>4.5</td>
<td>3.5</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>Cable cross section (mm²)</td>
<td>1000</td>
<td>650</td>
<td>1200</td>
<td>1200</td>
<td>1200</td>
<td>1200</td>
<td>1200</td>
<td>1200</td>
<td>1200</td>
<td>1000</td>
<td>1200</td>
<td>1400</td>
<td>1200</td>
<td>630</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>DEH cable rating current/voltage (A/kV)</td>
<td>1500/12</td>
<td>1100/24</td>
<td>1500/12</td>
<td>1400/12</td>
<td>1600/52</td>
<td>3000/52</td>
<td>1300/12</td>
<td>1500/24</td>
<td>1400/12</td>
<td>1300/12</td>
<td>1300/24</td>
<td>1400/52</td>
<td>1300/12</td>
<td>900/12</td>
<td>1300/24</td>
<td>1350/24</td>
</tr>
<tr>
<td>Rated power (MW)</td>
<td>1-1.5</td>
<td>2</td>
<td>1.5-1.6</td>
<td>2.3</td>
<td>10</td>
<td>8</td>
<td>2.4</td>
<td>4</td>
<td>2.2</td>
<td>0.9*3</td>
<td>4</td>
<td>9</td>
<td>1.2*2</td>
<td>1.1</td>
<td>0.5 - 2.5</td>
<td>4</td>
</tr>
</tbody>
</table>
Olowi System delivery – a system for continuous operation

- **Operation**: Continuous
- **Heating temp**: 43 degrees C
- **Service life**: 20 years
- **Flowlines**: 3 off, 4 km
- **Dimension**: 10”
- **Coating**: Concrete and armoring
- **Water depth**: 40m
- **Cable**: 1000mm2
- **Voltage**: 6/12 kV
- **Commissioning**: 2009
Goliat DEH – A solution for floater with multiple flowlines

**Delivery**

- 4x 500m feeder cables - 1x1200mm²
- 2x 7,487m piggyback cable - 1x1200mm²
- 1x 1,266m DEH riser cable - 4x1600mm²
Gullfaks DEH – A solution for daisy chained in-line subsea manifolds
DEH Installation
Summary

• This study concludes that DEH is an attractive technical and commercial solution
• DEH is a field-proven and qualified technology, both for intermittent and continuous use
• Reliable and robust system, 16 years in operation with more than 25 off DEH heated flowlines
• Installation friendly system
• Applicable for long step outs and large flow lines
• Aker Solutions provides feasibility studies, field optimization, cost estimates and support from early conceptual and system definition phase to complete DEH system deliveries
The preferred flowline heating system supplier

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