How to select the separation solution to maximize the economics of a subsea development
Maximize the value proposition

\[ NPV(i) = \sum_{i}^{N} \left( oil\ price(i) \cdot oil\ rate(i) \cdot \frac{CAPEX(i) - OPEX(i) - TAX(i)}{(1+r)^t} \right) \]

- Maximize production
- Minimize intervention cost
- Maximize availability
- Minimize power & utilities
- Minimize future changes
- Minimize topside (scope and modification)
- Minimize risk
- Minimize execution time
- Minimize installation cost
Selection Principles

\[ NPV(i) = \sum_{i}^{N} \frac{\text{oil price}(i) \times \text{oil rate}(i) - \text{CAPEX}(i) - \text{OPEX}(i) - \text{TAX}(i)}{(1+r)^i} \]

- **Low Cost**
  - Simple system
  - Optimized Installation

- **High Maturity**
  - Low technical risk
  - Low development cost

- **High Availability**
  - Robustness
  - Flexibility
  - Simplicity

Maximized Asset Value
Deep waters – down to 1000-1500m

<table>
<thead>
<tr>
<th>Cost optimization</th>
</tr>
</thead>
<tbody>
<tr>
<td>- No reject stream</td>
</tr>
<tr>
<td>- Simple control system (large volume)</td>
</tr>
<tr>
<td>- Large, heavy</td>
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</tbody>
</table>

<table>
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<tr>
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<tr>
<td>- Field Proven</td>
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<tr>
<td>- Robust</td>
</tr>
<tr>
<td>- Flexible</td>
</tr>
<tr>
<td>- Good slug handling</td>
</tr>
<tr>
<td>- Infinite turndown</td>
</tr>
<tr>
<td>- Large operational envelope</td>
</tr>
</tbody>
</table>

Maximized Asset Value

- ~99.8% uptime
Ultra Deep Water Challenges

What is the limit?

Depends on

- Design Pressure
  - Shut-in pressure
  - External pressure
  - Subtracting external pressure
- Vessel diameter

Max design pressure (barg) vs. vessel ID (mm),
\[ t_{\text{max}} = 150 \text{ mm}, \text{ material: P500 (EN)} \]
Solutions for Ultra Deep Water

Option 1: Parallelisation:

**Cost optimization**
- Increased complexity
- Extra equipment, structure...
- Extra installation requirements

**High Maturity**
- Field Proven
- Reduced technical risk

**High Availability**
- Robust & flexible
- Parallel trains

Maximised Asset Value
Solutions for Ultra Deep Water

Option 2: Introduce G forces => Compact equipment

**Gas Unie**
- Based on field proven solution, similar system solution
- High allowable gas load up
- Less slug capacity

**GLCC**
- Installed subsea
- Less slug capacity
- Requires fast acting control system

**System combining Inline Equipment**
- System tested
- Increase system complexity
- Less slug capacity
- Requires fast acting control system

Maximized Asset Value
Solutions for Ultra Deep Water

Option 3: MultiPipe

- Developed through engineering and CFD
- Proof of concept in lab at low and high pressure
- Ongoing qualification

**Cost optimization**
- Low complexity
- Large footprint
- Extra installation requirements

**Lower Maturity**
- Under development (prototype tested, TRL3)
- Gravity separation well known

**High Availability**
- Slug tolerant
- High turndown

Maximized Asset Value
Summary

• A generic methodology has been presented – does not remove need for case specific study

• Economic attractiveness does not only depend on low hardware cost

\[
NPV(i) = \sum_{i=1}^{N} \frac{\text{oil price}(i) \times \text{oil rate}(i) - \text{CAPEX}(i) - \text{OPEX}(i) - \text{TAX}(i)}{(1+r)^i}
\]

• Use of field proven equipment when feasible helps to bring costs down

• Getting to more challenging areas as deep water, new technologies have to be cost effective
  • Technologies are available
  • Economic attractiveness often suffer from high financial penalty accounting for technical risk