‘Subsea Water Treatment and Injection – tailored water quality for EOR’

Seabox™ and SWIT™ -
‘More oil out of new and old reservoirs!’

FORCE seminar, NPD
14 February 2017
Overview

• Big Picture – importance of water
• Everything starts with the reservoir...
• Technology – a very different approach

• Value proposition – flexibility, reduced / delayed cost, increased oil recovery
• New solutions – new opportunities - examples
• Summary
Global Water Injection Volumes

- As oil fields mature, they require more water injection to sustain oil production.

- The global requirement for water injection is expected to double or tripple over the next 10 years.

- New technical solutions are essential to be able to meet these demands in a cost effective and HSE friendly way.

- SWIT™ technology may become a game changer in this picture.

Source: Rystad Energy research and analysis, Rystad Energy UCube.
Micro Displacement Efficiency, Sweep and Enhanced Recovery Methods

**Figur 2.12** Ressursoversikt for de 25 største oljefeltene, solgte mengder, reserver og gjenværende olje uten nye tiltak.

Source: NPD, ressurs rapport 2014
Importance of clean water
- with the right chemical composition
Technology fundamentals
Solids Removal – What each equipment item is doing

1) Chlorination
2) Settlement
3) Radicals
4) Suspended Solids (Re-generable)
5) Dissolved (ionic) Solids (Non re-generable)

SOLIDS SPECTRUM

100μ 10μ 1μ 0,1μ 0,01μ 0,001μ 0,0001μ

Suspended
Dissolved

Normal / Fractured
Matrix
Low Sulphate / Low Salinity

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Membrane Lifetime

Findings from JIP Phase IV
<table>
<thead>
<tr>
<th>Flooding Regime</th>
<th>Water Flooding</th>
<th>Matrix Flooding</th>
<th>Low Salinity Low Sulfate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>Electrochlorination Solids Settlement HRG treatment</td>
<td>Micro Filtration (MF)</td>
<td>Reverse Osmosis (RO)</td>
</tr>
<tr>
<td>Sediment Size (μm)</td>
<td>≤ 24</td>
<td>≤ 0,1</td>
<td>NA</td>
</tr>
</tbody>
</table>

Seabox™ + Micro Filtration (MF) + RO or Nano membranes

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SWIT™ system

- **Membrane feed pump**
  - 2,0 x 2,5 x 6,0 (m)
  - 20 t

- **Nano- / Reverse Osmosis**
  - 2,8 x 5,3 x 7,8 (m)
  - 20 t

- **Seaboxx**
  - 8 x 8 x 7 (m)
  - 47 t

- **Microfiltration**
  - 4,2 x 4,6 x 6,4 (m)
  - 30 t

- **Structure**
  - 21 x 21 x 10 (m)
  - 200 t

20,000 bpd low salinity / sulfate free solution
Optimize recovery and reduce uncertainty

FIG 4.10: NEW IOR TECHNOLOGY TYPICALLY OPTIMIZES OIL AND GAS VOLUMES OR REDUCES THE UNCERTAINTY OF THE VOLUME ESTIMATE, BOTH ARE CENTRAL IN DECISION MAKING.

- Project not sanctioned: low volume or high cost/risk
- Project sanctioned
- Project terminated
- Px0: x0% probability of higher volume

New technology:
- Increase volume
- Reduce cost
- Reduce uncertainty

Source: OG21 – National technology strategy for the 21th century
Smaller volumes per reservoir and well
Importance of Dynamic data – and Flexibility

Source: Oil & Gas Portal, oil-gasportal.com
Example: Gullfaks (and Tampen area)

Source: Statoil
Seabox™ and SWIT™ benefits

Restrictions and limitations with topside solutions
- Restriction in number of available well slots
- Restriction in drilling reach from the topside
- Difficulty in achieving optimal flood regime
- Limited weight and space capacity topside

The Solution: Moving water injection to the seabed

- Seabox and SWIT provide all required treatment and WI capacities on the seabed
- Flexibility with Seabox and SWIT allows for optimization of sweep and recovery of main field
- Seabox and SWIT simplify process and reduce overall capex and opex related to new WI capacity
- Stand alone from topside and distributed approach allow for increased reach, added flexibility and deferred investment
SWIT™ technology – Value Proposition
Operational & Economical Benefits Compared to Topside WI Solution

**HSE**
- 15-20% less power / emissions
- No liquid chemicals use or handling
- No human exposure to chemicals

**Recovery benefits**
- Improved recovery (adaptable ‘real time’ drainage strategies)
- Improved sweep (well locations & spacing, water quantity)

**Regularity benefits**
- No rotating or moving parts
- Redundancy installed
- Favorable & more stable seabed conditions

**Production benefits**
- Drilling - WI wells decoupled from production wells (less time to plateau, platform rig dedicated to production)
- WI can run independently from platform shutdowns
- Less risk of souring

**OPEX benefits**
- Reduced power consumption
- Reduced offshore manning (remote operation – 5 year maint. intervals)
- Reduced chemical consumption and supply logistics

**CAPEX benefits**
- Reduced investments on topsides infrastructure
- Reduced cost to get water to injection zone (shorter wells, no HP pipelines)
- CAPEX deferment (WI installed as / when required) - increased NPV
Seabox™ «Dump flood»

$$\Delta P_{\text{water}} = \Delta P_{\text{water}} > P_{\text{reservoir}}$$
Seabox™ with subsea pump, when required
Complete SWIT™ for special water qualities
Subsea Water Treatment and Injection

SEABOX 40 + INJECTION PUMP

SWIT Modules installed onto the flowbase

Estimated dimensions: 15 x 11 x 9.5 m
Estimated weight in air: 140 t
Water Treatment and Injection for Matrix Flooding

Capacity: 40 000 bpd
Water Treatment with Sulfate Removal and Low Salinity, and Injection

Capacity: 20 000 bpd (sulfate free and low sal water)
Everything starts with the reservoir....
Subsea Water Treatment and Injection - *Solutions for IOR and EOR*

Source: Ministry of Petroleum and Energy
Summary

• Seabox™ and SWIT™ allow for new ways to develop fields and improve existing, to reduce cost and emissions and to improve recovery

• The stand alone and distributed solution provides complete flexibility – allowing improved reservoir management and reduced total risk

• Simplification and superior water quality give high reliability

• Full range of systems and capabilities currently under construction

• Available now with 12 months delivery time