

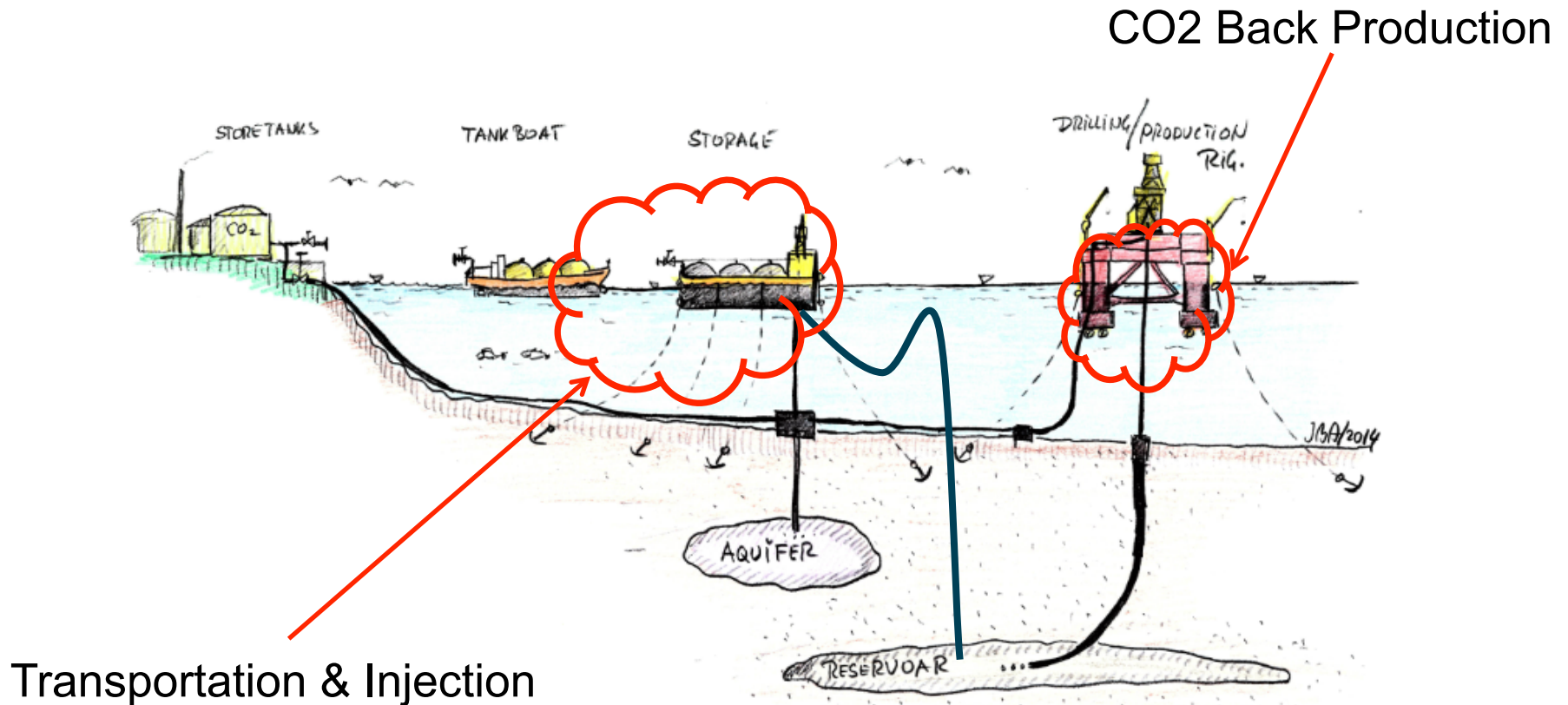
# Status & Next Steps Offshore CO<sub>2</sub> EOR

DOE – OED: CO<sub>2</sub> Storage Task Group Meeting

Bergen, 9<sup>th</sup> of May 2016

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# Main Areas That Differ Offshore to Onshore



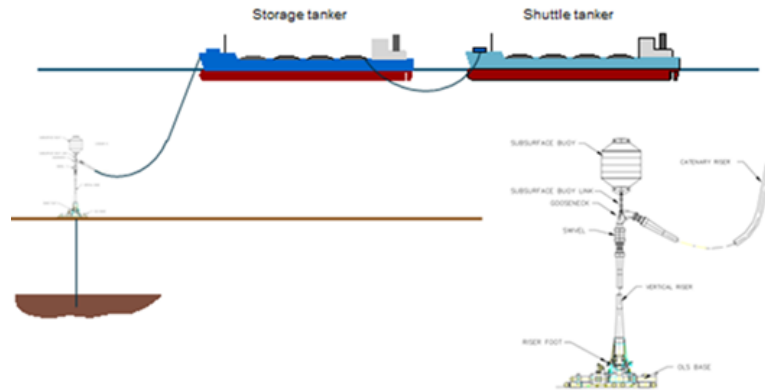
# Challenges Related to Offshore CO2 EOR

- No CO<sub>2</sub> supply chain established – limited availability – ***assumed need for big volumes over time***
- Non-optimized well locations
- No existing pipelines
- Facilities and wells not corrosion resistant
- ***Limited weight and space available for topsides separation***
  - ***Extremely costly retrofits or additional installations***
- High cost of CO<sub>2</sub> at wellhead
- Higher cost level than onshore
  - Offshore operation costs
  - ***Loss of production due to shut down in retrofit period***
- Logistics between onshore CO<sub>2</sub> source and offshore

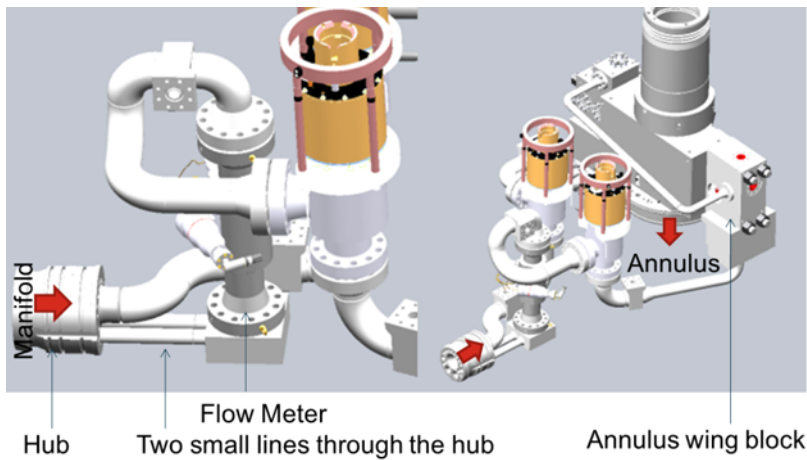


# Offloading & Injection Systems

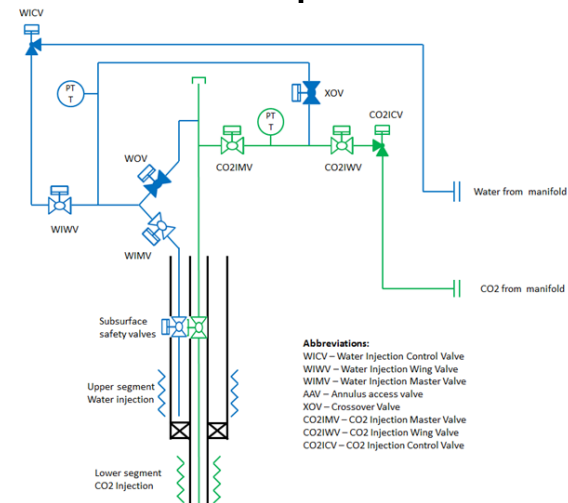
Offshore off/unloading  
& injection



XMT Adaption



## Well Completion



# Available Subsea Processing Building Blocks

- ✓ Subsea multiphase cooler
- ✓ Subsea gas compressor
- ✓ Subsea gas/liquid separator
- ✓ Subsea liquid/liquid separator
- ✓ Subsea de-sanding equipment
- ✓ Subsea produced water de-oiling equipment
- ✓ Liquid pump
- ✓ Multiphase pump
- ✓ Subsea control systems
- ✓ Subsea power solutions

+++

Subsea process system  
building blocks

Production XT

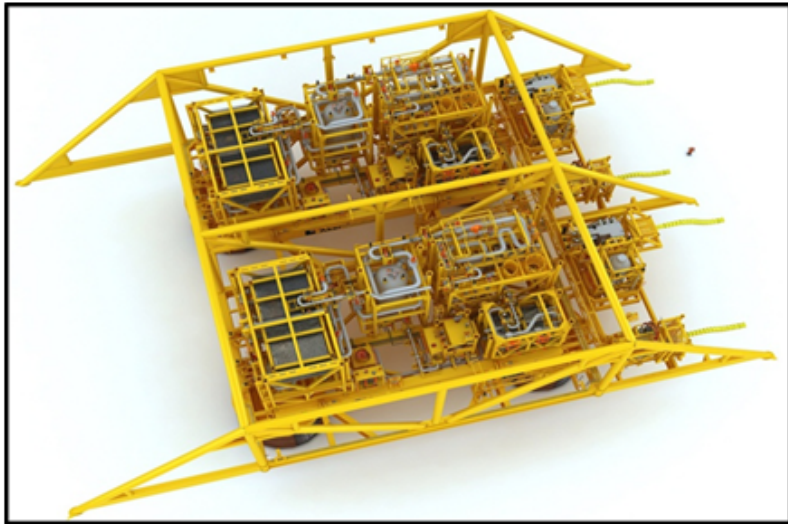
Injection XT





# Two Important Subsea Building Blocks

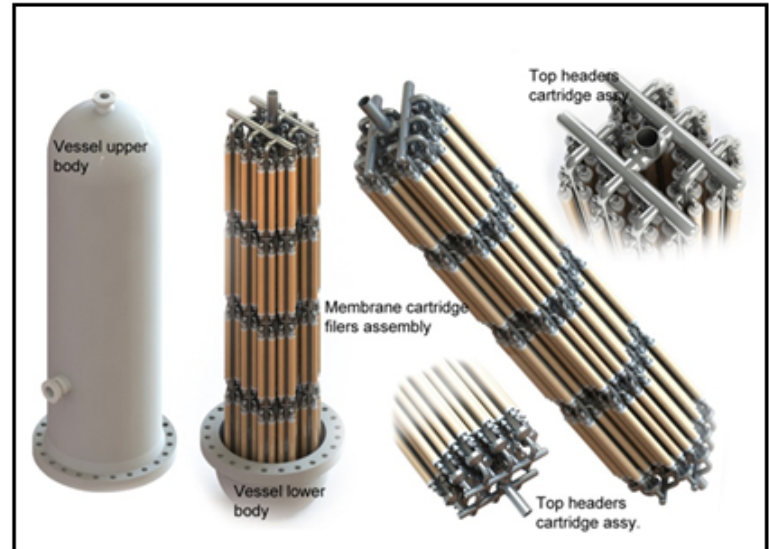
## Compression System



### 2010 – 2015 Asgard:

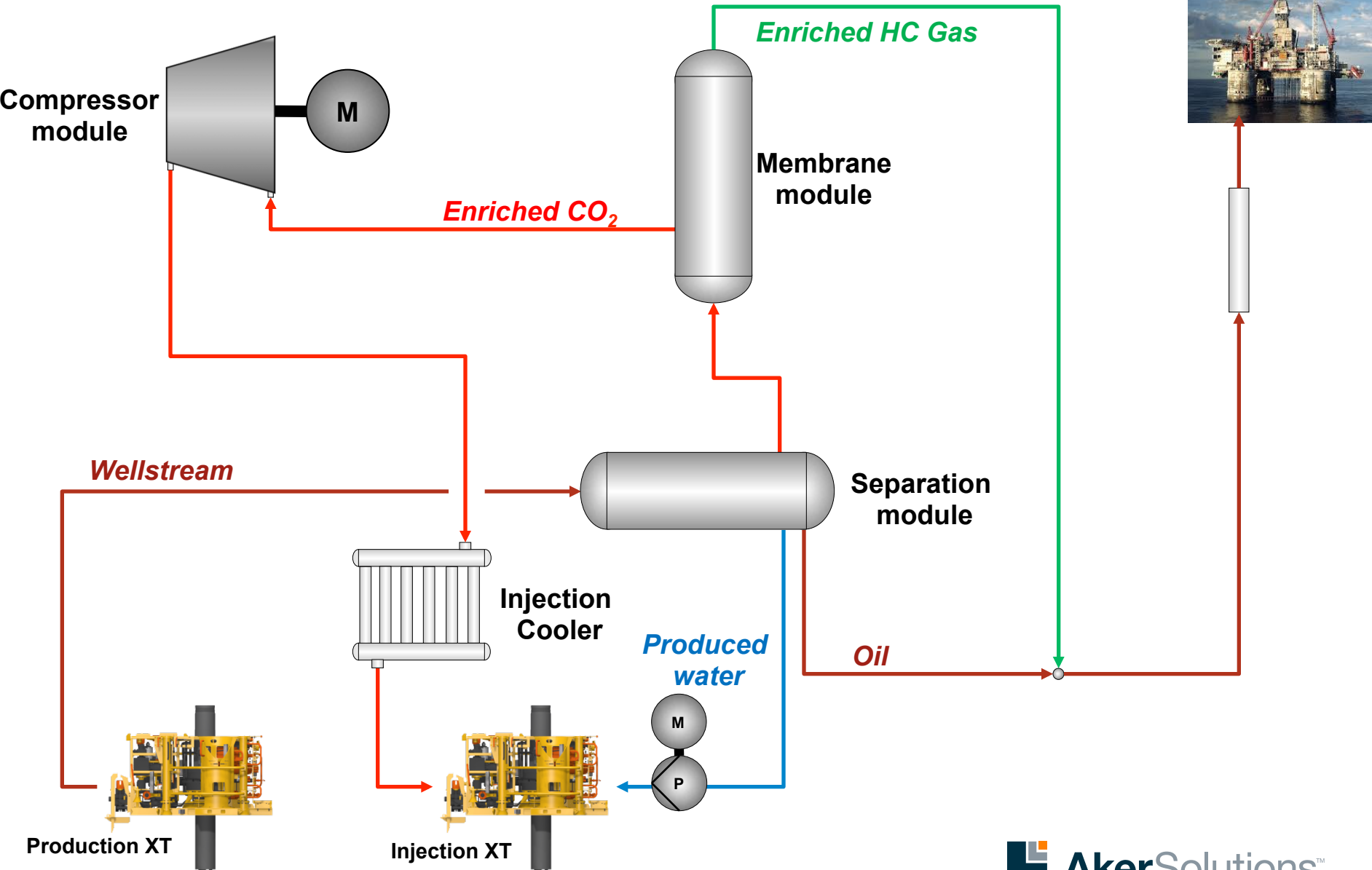
- 21 MSm<sup>3</sup>/d flow rate
- 2 x 11.5 MW compressor power
- 300 m water depth
- 40 km step-out distance
- Topsides Variable Speed Drives, Circuit breakers and UPS
- Delivered by Aker Solutions

## Compact membrane packing



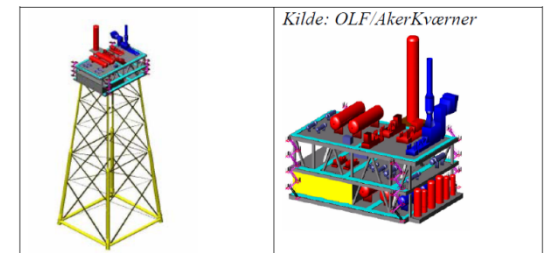
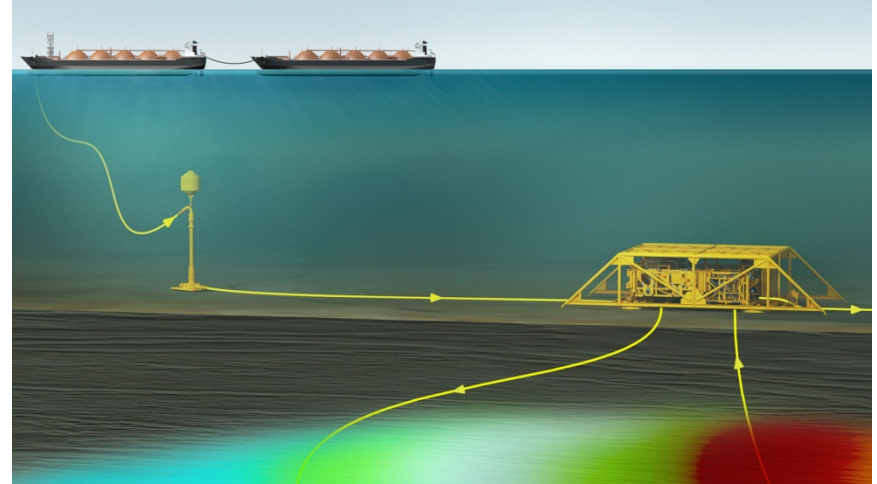
- Onshore stacking not feasible subsea
- Compact packing arrangement developed by AKSO

# Advanced Subsea Processing (ASP) Unit



# Offshore CO2 EOR Challenges - Mitigations

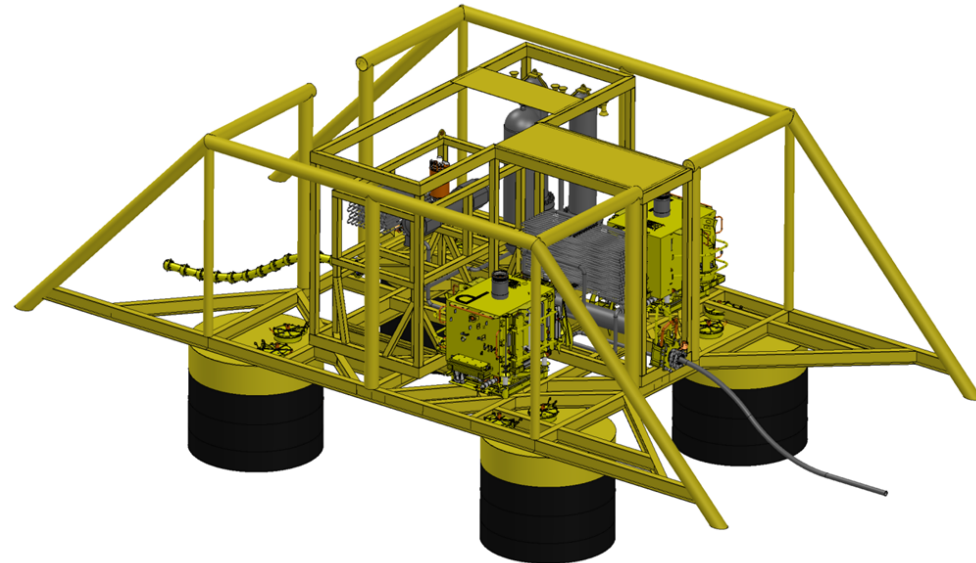
- No CO2 supply
  - **Pipeline**
  - **Ship supply**
- Space limitations on platforms
  - **Subsea installation**
- Weight limitations
  - **Subsea installation**
- Power availability
  - **Less power needed than gas injection, heavier fluid**
- Corrosion issues
  - **13% Cr needed – standard for subsea wells**
- High cost when modifications done topsides
  - **Short/no downtime with subsea installation**
- HSE concern by sudden topside release
  - **No issue subsea**



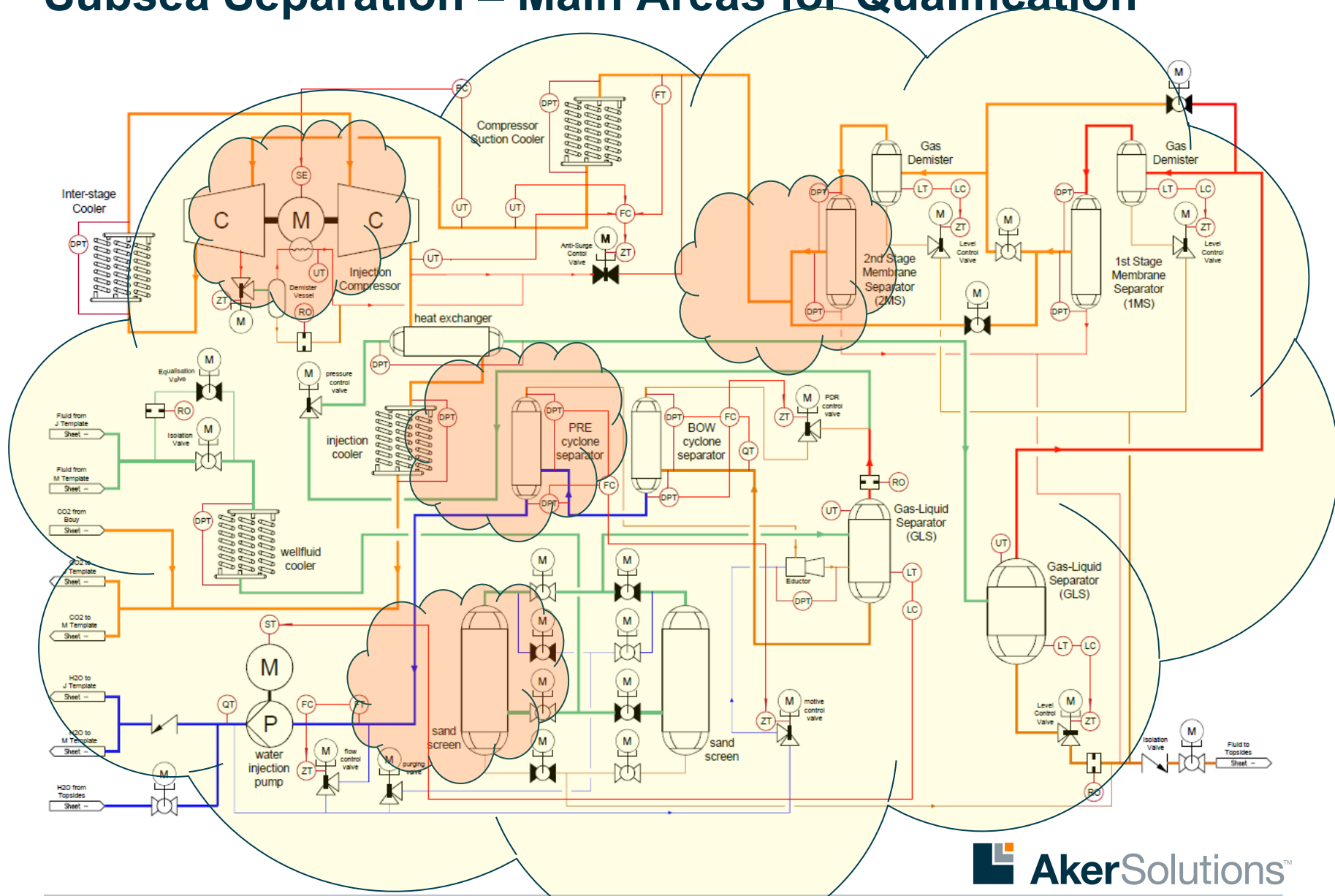


# Other Aspects Subsea Technology Concept

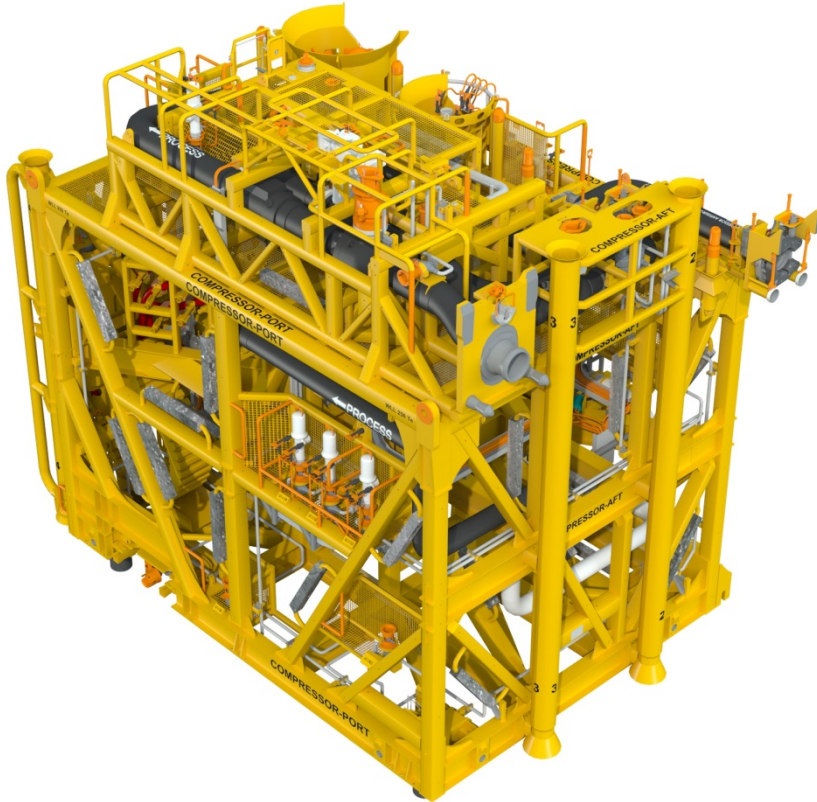
- Reduced installation costs – subsea separation
- Overlap of EOR production with conventional oil production
- Small subsea facilities serving segments in large reservoir
- Facilities available for injection of CO<sub>2</sub> for permanent storage as a final CCS stage
- Retrievable modules –  
limited operational time - reuse



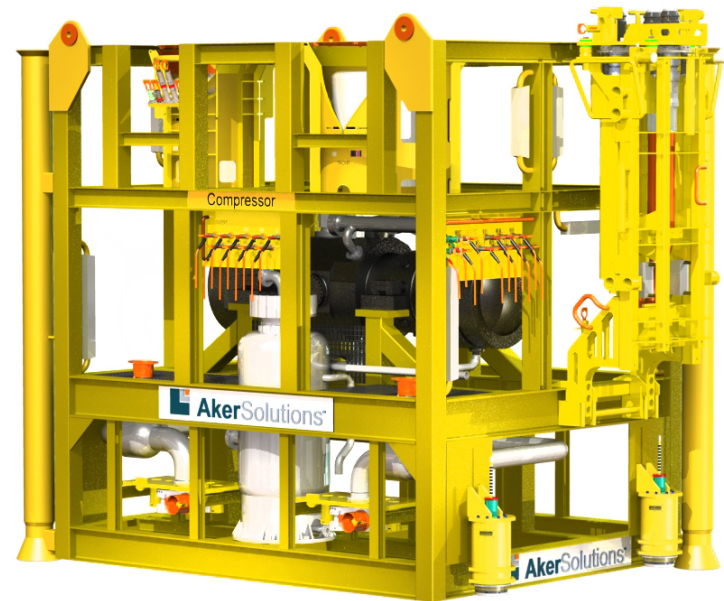
# Subsea Separation – Main Areas for Qualification



# Asgard Compressor Module – Single Motor-Compressor



Original design

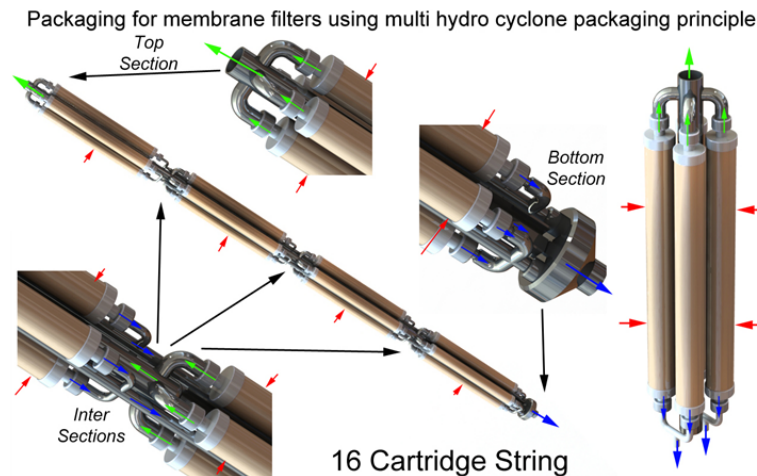
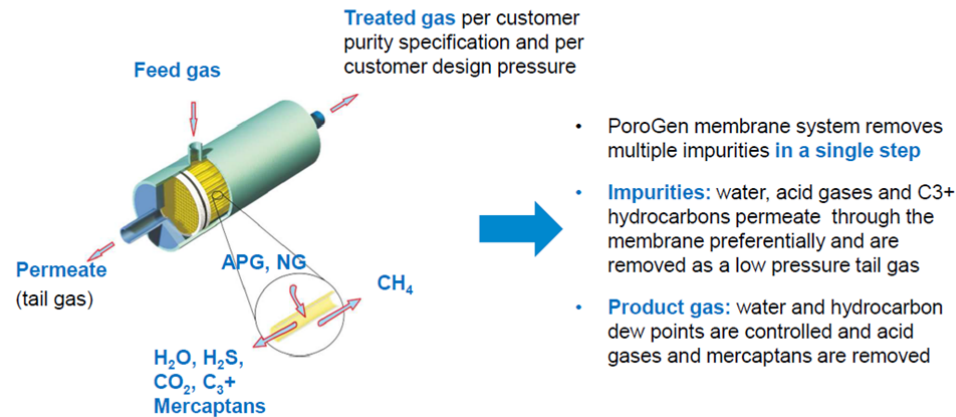


Modified, lighter design

# Qualification Membrane Bulk Separation of CO<sub>2</sub>

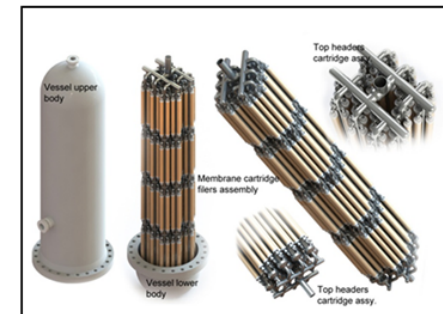
- Preferable subsea conditions outside regular operational window

## Flow Distribution in PEEK-Sep Membrane Module



# Technology Gaps – Future Work

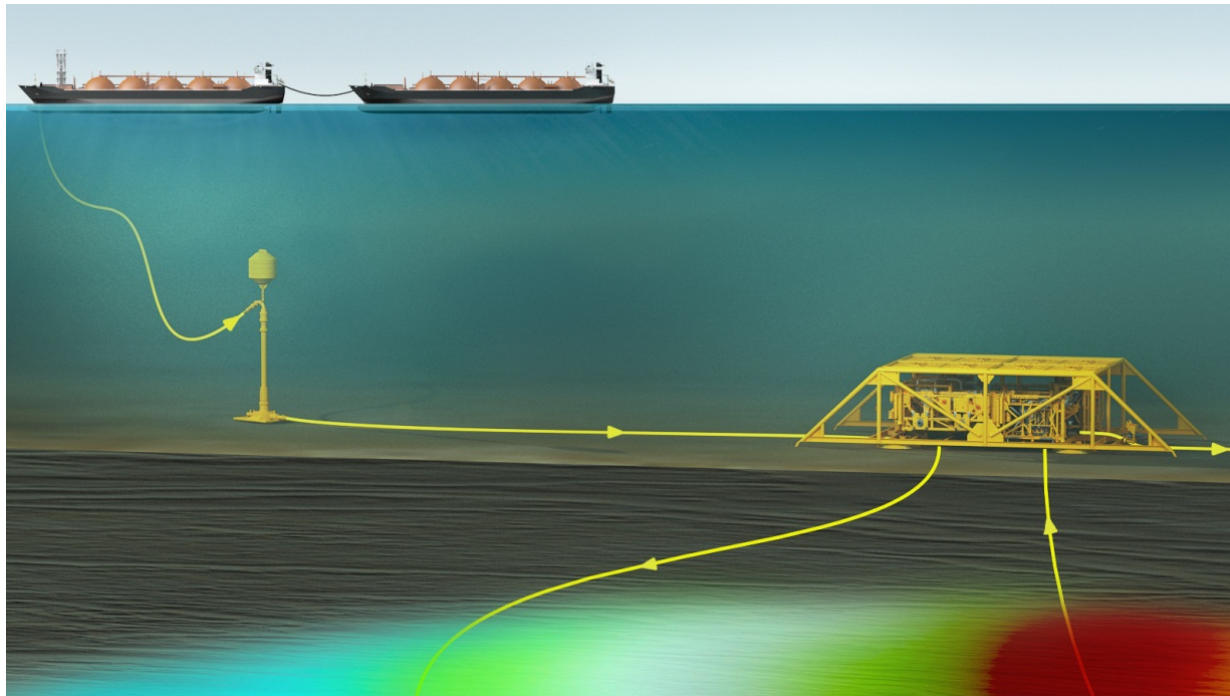
- Injection system qualification
  - Improved thermodynamic and dynamic models, Flow Assurance
  - Injection solutions, XMT, well completions allowing SWAG/WAG and return/reinjection
- Compressor solution
  - Service in wet CO2 environment
  - Low duty range (pilot)
- Compact membrane separation
  - Qualify membrane qualities for relevant operational conditions
  - Qualify compact arrangement for subsea service
- Reservoir simulations
  - Optimize flooding conditions
  - Blow down conditions
- Process design analysis
  - Update process solutions, lay out and cost





# SUMMARY

- A subsea based well separation concept of a CO2 flooded offshore oil reservoir might represent an enabling technical and economical solution to offshore CO2 EOR
- Some systems along the injection chain and processing chain need qualification and further assessment





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# Funding Challenges

- Sort out possibilities within cofunding
  - Learning from projects (all task teams)
    - List projects where funding have worked
  - Opportunities \ limitations: Joint calls etc

# New opportunities, ideas

- CSDC initiative beyond preproject: plan in place, need to continue working issues
- knowledge sharing projects / moderate funding needs
- Workshops («chatham house light») on critical issues-Cooperation\piggy back opportunities (**Need further refinement**)
  - How could co2-eor offshore pilot break barriers? And how to get there...
  - CO2-EOR: Learnings from onshore to offshore....
  - CO2-storage operators workshop on MVA: learnings from large scale project operators (focus on cost efficiency, «what is needed», proven effective, regulatory requirements)
  - Offshore/subsea technology innovation (---like subsea capture technology, power production...)
  - Material selection, CO2 composition etc : for «cross cutting»