Status
CSLF TASK FORCE ON OFFSHORE CO$_2$-EOR

Enabling Large-scale CCS using Offshore CO$_2$
Utilization and Storage Infrastructure Developments

Lars Ingolf Eide

2$^{nd}$ International Workshop on Offshore CO$_2$ Geologic Storage
Beaumont, Texas, USA
19-20 June, 2017
The main purposes of the Task Force were to highlight:

- Main differences between offshore and onshore CO₂-EOR
- Issues that are different between offshore CO₂-EOR and pure offshore CO₂ storage
- Technical solutions that will benefit both pure offshore CO₂ storage and offshore CO₂-EOR

All based on existing, although not necessarily published, information.
Timeline

- November 2015, Ministerial Meeting of CSLF, Riyadh, Saudi Arabia
  - Offshore CO$_2$-EOR selected as topic for a new task force
- CSLF Mid-Year Meeting 2017: Presented draft of final report
- September 2017: Final report ready
- CSLF Annual Meeting 2017: Present final report
## Task Force Members and contributors

<table>
<thead>
<tr>
<th>Member state</th>
<th>Persons</th>
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<tbody>
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# Report outline and structure (1)

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<tr>
<th>Chapter title</th>
<th>Content</th>
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<tr>
<td>Introduction</td>
<td>Intro. of CSLF, motivation for doing offshore CO$_2$-EOR, TF mandate</td>
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<tr>
<td>Review of offshore CO$_2$-EOR storage</td>
<td>How CO2-EOR works, difference onshore vs offshore and EOR vs storage, global potential, economics</td>
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<tr>
<td>Insights from Lula Project</td>
<td>Reservoir, development strategy, materials, completion, production units/topside facilities, WAG pilot</td>
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<tr>
<td>Approaches for enabling offshore CO$_2$-EOR</td>
<td>Smart solutions, using late-life infrastructure, using isolated satellite projects, residual oil zone (ROZ), reservoir modelling and numerical simulation</td>
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<tr>
<td>Emerging technical solutions for offshore CO$_2$-EOR and storage</td>
<td>Topside solutions, subsea solutions, novel technologies, mobility control</td>
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Report outline and structure (2)

<table>
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<tbody>
<tr>
<td>Supply chain issues</td>
<td>Considerations, pipelines, ships, initiating new systems, case studies</td>
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<tr>
<td>Monitoring, verification and accounting for offshore CO₂-EOR</td>
<td>Roles and expectations, EOR vs storage, onshore vs offshore, transition from EOR to storage</td>
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<tr>
<td>Regulatory requirements for offshore CO₂ utilization and storage</td>
<td>Scene-setting, examples of national regulatory requirements, differences EOR and storage, regulations on transition EOR to storage</td>
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<td>Summary of barriers</td>
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<tr>
<td>Recommendations for overcoming barriers</td>
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Potential and economics

- Potential updated with available sources
  - Incremental oil production: 114,000 million bbl
  - Stored CO$_2$: $\approx 41$ GT

- Economics
  - Discuss some key parameters
  - Cash flow fictitious example
Lula Project

- Reservoir well suited for miscible gas EOR
- CO$_2$ content in gas $\approx$ 11%
- Extensive reservoir characterization
- Robust and flexible development strategy
- Careful choice of topside solution and materials
- Membranes used for CO$_2$ separation
- WAG solution with six producers, two WAG injectors, one CO$_2$ injector
- No major operational or reservoir problems
- Monitoring with downhole pressure gauges and tracers
Approaches for enabling offshore CO$_2$-EOR

- Using late-life oilfield infrastructure
- Using oilfield satellite projects
- Focusing CO-EOR on the residual oil zone (ROZ)
- Reservoir modelling: Issues particular to CO2-EOR
  - Phase behaviour
  - Reactions with rocks
  - Multiphase flow in porous media
  - Oil instability
Emerging technical solutions - Subsea solutions

• Subsea systems could provide an attractive basis for economically feasible offshore CO₂-EOR gas separation system

• Report
  – Reviews previous solutions
  – Describes and discusses subsea processing building blocks
  – Describes potential new CO₂/HC separation technologies
  – Describes alternative power production

Courtesy Aker Solutions
Illustration of subsea zero emission offshore power generation and CO₂ separation concept

(Courtesy Aker Solutions)
Mobility control (next generation EOR technology)

- CO₂ mobility control important offshore due to large well spacing
- Use increased miscibility oil and CO₂
- CO₂ foam a potential remedy for fingering etc that reduce volumetric sweep and effectiveness of injection
- Will increase oil recovery as well as CO₂ storage
- International cooperation needed
- Up-scaling from laboratory to onshore and offshore pertains major issue

WHY TEXAS?
- CO₂ is commercially available
- Foam as mobility control
- Up-scaling; major challenge in oil recovery
- Fraction of costs of off-shore field tests
- Fast results: short inter-well distances
- 30 years experience in Texas on CO₂ EOR
- 4D seismic establishes a field laboratory
Conclusions emerging technologies

- Significant and promising technologies for reducing the cost of separating CO₂ from production fluids in CO₂-EOR operations are under development and, to some degree, testing.

- Compact sub-sea equipment for CO₂ processing and mobility control using CO₂ foam appear to have large potential when it comes to reducing CAPEX and OPEX for CO₂-EOR projects.
CO₂ supply chain issues

- No technical barriers to CO₂ infrastructure for offshore EOR
- Optimisation will bring costs down
- Some system parts need qualification
- Barriers are commercial and political in nature
MVA

- Offshore CO₂-EOR is much less mature than onshore CO₂-EOR and offshore dedicated CO₂ storage.
- Will have different risk profiles that require special considerations when designing an MVA programme for offshore CO₂-EOR.
- A range of monitoring technologies applied in the two other settings are applicable also to offshore CO₂-EOR.
- The review did not identify any technical barriers for proper monitoring of offshore CO₂-EOR fields.
Regulatory requirements

• In all regions considered here, it appears that CO₂ EOR activities can be regulated under existing oil and gas regulation.

• However, to demonstrate long-term storage, or seeking incentives (such as carbon credits), the same challenges as transitioning from CO₂-EOR to CO₂ storage onshore are met.

• In general, transitional requirements do not exist.
Summary of barriers and recommendations (1)

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<th>Barrier</th>
<th>Recommendation</th>
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<tr>
<td>Access to sufficient and timely supply of CO₂</td>
<td><strong>Increase the pace in deployment of CCS.</strong> A prerequisite for offshore CO₂-EOR, needs attention at high political level. Slow deployment may lead to missed windows of opportunity for CO₂-EOR, as the effect of CO₂-EOR reduces with maturity. There are few, if any, developed sources of CO₂ close to the offshore fields amenable to CO₂-EOR</td>
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<td><strong>Start planning regional hubs and transportation infrastructures for CO₂.</strong> Building the networks will require significant up-front investments and the coordination of stakeholders, including industries, business sectors and authorities that will have to work together. The activities will include CO₂ capture at regional clusters of power and industrial plants, transportation of the CO₂ to hubs and to the individual receiving fields, and injection management</td>
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Summary of barriers and recommendations (2)

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<tr>
<td>Lack of business models, also for offshore CO$_2$-EOR</td>
<td><strong>Develop business models for offshore CO$_2$-EOR.</strong> Establishing offshore CO$_2$ networks will create many interdependencies and commercial risks concerning both economics and liabilities. Risk- and cost-sharing will be needed. The literature has a few examples that provide some thoughts, but these need to be matured. The business models must include fiscal incentives, e.g. in term of taxes or tax rebates</td>
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<td>High investment costs, CAPEX and additional operational costs, OPEX; needs for modifications</td>
<td><strong>Support RD&amp;D to develop new technologies.</strong> CAPEX and OPEX are significant due to needed modifications and additional equipment on the platforms to separate CO$_2$ from the produced oil and gas and to make existing wells and pipes resistant to CO$_2$ corrosion. New technologies can reduce the need for modifications and new equipment, for example better mobility control or sub-surface separation systems. Use of existing pipelines may also be a way to keep investment costs down</td>
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Summary of barriers and recommendations (3)

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<tr>
<td>Lack of regulatory requirements in many jurisdictions, e.g. on monitoring the CO₂ in the underground</td>
<td><strong>Continue to develop regulations specific to offshore CO₂-EOR.</strong> Regulations should include monitoring the CO₂ in the underground, both during and particularly after closure and guidelines for when the field transfers into a CO₂ storage site. While not being a barrier in itself, monitoring will require different considerations compared to offshore CO₂ storage and to onshore CO₂-EOR</td>
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Next steps

- Polish document, e.g. with help from professional technical editor
- June 30, 2017: Final review by Task Force
- November 1, 2017: Final report presented to CSLF
Thank you for the attention!