Translating US CO$_2$-EOR learnings from onshore to offshore

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Talk Outline

• CO₂ Enhanced oil recovery (CO₂-EOR) onshore is mature, safe, and economically viable
• What is needed to translate this to offshore?
• Monitoring storage and accounting as part of CCUS onshore – translation to offshore
• Lifecycle value of EOR as storage
Total United States Enhanced Oil Recovery Production, 1986 - 2010
(Thousand Barrels Per Day)

Source: Oil and Gas Journal, Biennial Enhanced Oil Recovery Project Surveys
What makes CO2-EOR succeed: Screening Tree

**Oil-reservoir database**

- Cumulative production > 1 MMSTB
  - Yes
  - Rejected
  - No

- Minimum miscibility pressure (depth, temp., pressure, oil character)
  - Unknown
  - Rejected
  - Yes

- Reservoir depth > 6000 ft
  - Yes
  - No

**Candidate reservoirs**

- Has reservoir been waterflooded?
  - Yes
  - No
  - Candidate for secondary recovery

- Does reservoir have water-drive mechanism?
  - Yes
  - Rejected
  - No
What makes CO$_2$- EOR succeed
(the hidden issues that may be barriers to offshore)

- Business model – investment for a delayed but sure payout
- Competition with other similar capital-intensive projects
- Non contamination of methane resources
Business model – investment for a delayed but sure payout

– Risk averse deployment (similar to last project)
– Fast deployment once investment decision is made
  • Fast permitting
  • Fast preparation of field and infrastructure
  • Fast processing of reservoir
– Required investment
Fast processing of reservoir

- Comparing onshore and offshore well spacing - link to rate of reservoir processing

Typical 5-spot pattern

400 m 6-15 months CO₂ + oil to producers

Well emplaced from a platform commonly use long laterals

Long laterals more time for CO₂ + oil to reach producers
Competition with other similar capital-intensive projects

• Competition with other types of EOR
  – Methane reinjection
  – Cantarrell N₂ flood

• Other types of investments

• Note that this competition can be mitigated via financial market structure
  – US CO₂ EOR incentives for tertiary recovery
Overview of CO$_2$ Recycle

CO$_2$ and oil come out of solution

Miscible (dissolved) oil-CO$_2$ solution

Brine

Low pressure vessel

Brine

Oil

CO$_2$

High pressure
Recycle

• Onshore field has space for CO$_2$-oil-water separation and CO$_2$ recompression.
• Space and weight on platform is much more limited than onshore

Or Aker Solutions, seafloor facility

Core Energy facility, Michigan
Snøvit solution- applied to CO$_2$ EOR?

Double pipeline, processing done onshore
Competition with Methane Resources

- Methane abundant in offshore reservoirs
- Methane stranded offshore recycled into reservoir for pressure support
- Value of methane avoid damage by contamination by CO$_2$
- Methane damages miscibility
Case study fields: Offshore Gulf of Mexico

Prisca Odbaubau
Decreasing miscibility in oil sands

Offshore GoM oil sands

Percent Miscible

mole % CH4 contamination in CO2

Prisca Odbaubau
## Examples of Integrated CCS Projects

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<th>Capture from</th>
<th>Power production</th>
<th>Industry</th>
<th>Gas Separation</th>
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<td>For disposal</td>
<td>SECARB- Plant Berry Alabama</td>
<td>ADM Ethanol, IL</td>
<td>Sleipner – North Sea</td>
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<td>AEP Mountaineer, West Virginia</td>
<td>Tomakomai-Hokkaido Japan</td>
<td>Snøvit – Barents Sea</td>
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<td>Aquistore, Sask.</td>
<td>Shell QUEST, Alberta</td>
<td>Otway Australia</td>
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<td>For EOR</td>
<td>Boundary Dam, Saskatchewan</td>
<td>Air Products-Port Arthur TX</td>
<td>Many fields in Permian Basin sourced from Val Verde Basin gas, TX</td>
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<td>Kemper - Alabama</td>
<td>Yanchang Ordos, China</td>
<td>Bell Creek, Lost Cabin, WY</td>
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<td>NRG/PetraNova-Houston TX</td>
<td>Coffeeville and Enid OK</td>
<td>Multiple midcontinent US projects</td>
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- **For disposal**
  - Offshore storage
  - Completed

- **Extensive inventory**
  - [Link](https://www.globalccsinstitute.com/projects/large-scale-ccs-projects)

- **Completed projects**
  - Lula Field offshore Brazil
  - Uthmaniyah Saudi Arabia
Conclusions – needs to incentivize Offshore EOR

• Detailed FEED study on infrastructure
  – Move facilities to sea floor

• Additional research on geometry optimization – sweep improvement options

• Reduce risk by support of investment