OFFSHORE OIL AND GAS INFRASTRUCTURE RE-USE IN THE GULF OF MEXICO

DARSHAN SACHDE, PHD
KATHERINE DOMBROWSKI, P.E.
JOE LUNDEEN, P.E.
RAY MCKASKLE, P.E.
Trimeric Corporation
DARRELL DAVIS (Consultant)
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Background

• Evaluation of Infrastructure Re-use has been a focus of Gulf of Mexico Partnership for Offshore Carbon Storage (GoMCarb)

• GoMCarb focus = identify gaps, challenges, needs, bigger picture trends

• Momentum building in the region for real projects
Motivation: Source-Sink Matching

CO₂ Sources > 400k t/yr
~75 within 50 miles of coastline in Texas
Size of dot = CO₂ emissions

Data from EPA GHGRP 2017
Motivation: Existing Infrastructure

Lack of new infrastructure

Inventory for Re-use Decreasing?

Active Inventory Circa 2017

<table>
<thead>
<tr>
<th></th>
<th>Cumulative Installed</th>
<th>Decommissioned</th>
<th>Active</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 400 ft</td>
<td>6,933</td>
<td>5,025</td>
<td>1,908</td>
</tr>
<tr>
<td>&gt;400</td>
<td>121</td>
<td>24</td>
<td>97</td>
</tr>
<tr>
<td>Total</td>
<td>7,054</td>
<td>5,049</td>
<td>2,005</td>
</tr>
</tbody>
</table>

Source: Kaiser and Narra, LSU Center for Energy Studies; Offshore Magazine, March 2018
Motivation: Existing Infrastructure

Active structures in water depth less than 400 ft, 1942-2017E.

<table>
<thead>
<tr>
<th>Year</th>
<th>Active Structures</th>
<th>Cumulative Installed</th>
<th>Cumulative Decommissioned</th>
</tr>
</thead>
<tbody>
<tr>
<td>1942</td>
<td>1,000</td>
<td>1,000</td>
<td>0</td>
</tr>
<tr>
<td>1947</td>
<td>2,000</td>
<td>3,000</td>
<td>2,000</td>
</tr>
<tr>
<td>1952</td>
<td>3,000</td>
<td>6,000</td>
<td>4,000</td>
</tr>
<tr>
<td>1957</td>
<td>4,000</td>
<td>10,000</td>
<td>6,000</td>
</tr>
<tr>
<td>1962</td>
<td>5,000</td>
<td>15,000</td>
<td>10,000</td>
</tr>
<tr>
<td>1967</td>
<td>6,000</td>
<td>20,000</td>
<td>12,000</td>
</tr>
<tr>
<td>1972</td>
<td>7,000</td>
<td>25,000</td>
<td>15,000</td>
</tr>
<tr>
<td>1977</td>
<td>8,000</td>
<td>30,000</td>
<td>18,000</td>
</tr>
<tr>
<td>1982</td>
<td>9,000</td>
<td>35,000</td>
<td>20,000</td>
</tr>
<tr>
<td>1987</td>
<td>10,000</td>
<td>40,000</td>
<td>22,000</td>
</tr>
<tr>
<td>1992</td>
<td>11,000</td>
<td>45,000</td>
<td>24,000</td>
</tr>
<tr>
<td>1997</td>
<td>12,000</td>
<td>50,000</td>
<td>26,000</td>
</tr>
<tr>
<td>2002</td>
<td>13,000</td>
<td>55,000</td>
<td>28,000</td>
</tr>
<tr>
<td>2007</td>
<td>14,000</td>
<td>60,000</td>
<td>30,000</td>
</tr>
<tr>
<td>2012</td>
<td>15,000</td>
<td>65,000</td>
<td>32,000</td>
</tr>
<tr>
<td>2017</td>
<td>16,000</td>
<td>70,000</td>
<td>34,000</td>
</tr>
</tbody>
</table>

- **Lack of new infrastructure**
- **Inventory for Re-use Decreasing?**

• What is the practical **scale** of the opportunity for re-use?

• What are risks/benefits/incentives for re-use?

• What are the **challenges** to assessing re-use?

• What investments & steps are required to make an assessment?

• **FOCUS ON PIPELINES AND PLATFORMS TODAY**

Source: Kaiser and Narra, LSU Center for Energy Studies; Offshore Magazine, March 2018
Pipelines
Pipeline Re-Use: Incentives

- Existing Pipelines: ~20k in federal waters (+ more in state waters)
- New Pipeline Costs
  - Offshore Lines: ~2 – 3x cost of onshore “equivalent”
  - MAJOR CAVEATS
    - Data comparing on- and offshore is almost exclusively for NG lines
    - Large range in costs - highly project and route-specific
- Hidden risks/costs of new pipelines
  - Shore crossing through env. sensitive/challenging geography
  - Routing risks (right of way, new regulatory requirements vs. existing lines)
Pipeline Re-Use: Challenges

• Pressure Rating
  • ANSI Class 600 (working P = 1,480 psig @100 F)
  • ANSI Class 900 (working P = 2,220 psig @100 F)
  • Actual pressure rating of an existing line?
  • Reminder – sCO₂ density + offshore slope = overpressure risk?

• Age
  • Pipeline broker – Up to 85 years usable life
  • Older lines = higher risks (especially out of service lines)

• Condition of Line
  • Corrosion, repairs, thickness, cathodic protection
  • Existing records (or lack thereof) represent essential data

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### Case Inlet Pressure (psig) CO₂ Flow (Mt/yr)

<table>
<thead>
<tr>
<th>Case</th>
<th>Inlet Pressure (psig)</th>
<th>CO₂ Flow (Mt/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Class 900</td>
<td>2,000</td>
<td>~3.2</td>
</tr>
<tr>
<td>Existing Class 600</td>
<td>1,400</td>
<td>~1.8</td>
</tr>
</tbody>
</table>

• 8”, 5-mile pipeline
• P_{Outlet} > 1,200 psig (CO₂ always above P_{Critical})
### Pipeline Screening Results – Federal Water Lines

<table>
<thead>
<tr>
<th>FEDERAL WATERS</th>
<th>Number of Segments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inactive* Line Screening (Near-Term Opportunity)</td>
</tr>
<tr>
<td>Total</td>
<td>20,274</td>
</tr>
<tr>
<td>Service Status (Inactive/Active)</td>
<td>11,195</td>
</tr>
<tr>
<td>8” or larger</td>
<td>2,335</td>
</tr>
<tr>
<td>MAOP &gt; 1000 psig</td>
<td>1,927</td>
</tr>
<tr>
<td>&gt; 2 miles long</td>
<td>951</td>
</tr>
<tr>
<td>Water Depth &lt; 100’</td>
<td>520</td>
</tr>
<tr>
<td>In Service 1980 or later</td>
<td>355</td>
</tr>
<tr>
<td>Key Segments**</td>
<td>11</td>
</tr>
<tr>
<td>Median Diameter</td>
<td>16”</td>
</tr>
<tr>
<td># of Lines MAOP &gt; 1,440 psig</td>
<td>0</td>
</tr>
</tbody>
</table>

*Inactive = Abandoned in place, Proposed abandonment, Out of service

**Key Segments = Come onshore/near-shore (TX, LA)
Pipeline Re-Use: Discussion

• **Scale** of pipeline re-use opportunity limited by size and pressure rating
  • Re-use vs. new is not binary
  • Incremental Capacity: Pair existing with new (reduce total investment)
  • “Phased” Investment: Start-up with existing, build-out new (flexibility)

• What does business model look like for re-use of pipelines?
  • Outright sale of pipelines
  • “Pipeline as a service”: Operators sell “access” to pipelines, potentially provide O&M Support
    • Reduces risks for the project developer (likely increases lifetime cost vs. purchase)

• If CO₂ is transported at lower P, how does offshore compression (incl. access to power) impact economics?
Platforms
Platform Re-Use Overview

• Repurposing platforms for CO₂ storage = offset cost of decommissioning idled platforms (“win-win”)

• High-Level platform re-use criteria
  • Location/proximity to preferred injection site
  • Age/general condition of platform
  • Space on platform
  • Regulatory/legal considerations
    • How does liability/decommissioning responsibility transfer?
Overview of Platforms in GoM

- Caisson
- Well Protector
- Fixed Leg Platform
- Compliant Tower
- Mini Tension Leg Platform
- Tension Leg Platform
- SPAR Floating Production
- Mobile Production Unit
- Semi Submersible Floating Production
- FPSO

From bsee.gov
Overview of Platforms in GoM

<table>
<thead>
<tr>
<th>Structure Type</th>
<th>% of Total (~1,850)</th>
<th>Average Depth (ft)</th>
<th>Average Age (years)</th>
<th>Re-Use for Drilling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caisson</td>
<td>24.6%</td>
<td>41</td>
<td>39</td>
<td>No</td>
</tr>
<tr>
<td>Well Protector</td>
<td>0.7%</td>
<td>53</td>
<td>84</td>
<td>No</td>
</tr>
<tr>
<td><strong>Fixed Leg Platform</strong></td>
<td><strong>71.9%</strong></td>
<td><strong>131</strong></td>
<td><strong>41</strong></td>
<td>Yes</td>
</tr>
<tr>
<td>Compliant Tower</td>
<td>0.2%</td>
<td>1,467</td>
<td>28</td>
<td>Yes</td>
</tr>
<tr>
<td>Mobile Production Unit</td>
<td>0.1%</td>
<td>2,200</td>
<td>13</td>
<td>No</td>
</tr>
<tr>
<td>Mini Tension Leg Platform</td>
<td>0.2%</td>
<td>3,024</td>
<td>20</td>
<td>Yes</td>
</tr>
<tr>
<td>Tension Leg Platform</td>
<td>0.8%</td>
<td>3,378</td>
<td>19</td>
<td>Yes</td>
</tr>
<tr>
<td>SPAR Floating Production</td>
<td>1.0%</td>
<td>4,380</td>
<td>17</td>
<td>Yes</td>
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<tr>
<td>Semi Submersible Floating Production</td>
<td>0.6%</td>
<td>5,695</td>
<td>22</td>
<td>Yes</td>
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<tr>
<td>FPSO</td>
<td>0.1%</td>
<td>8,930</td>
<td>9</td>
<td>No</td>
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</table>
# Overview of Platforms in GoM

The map illustrates the distribution of platforms in the Gulf of Mexico (GoM) with the maximum water depth being 1,353 feet. The table below provides a detailed overview of the different types of platforms, their percentage of the total, average depth, average age, and whether they are re-used for drilling:

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<td>8,930</td>
<td>9</td>
<td>No</td>
</tr>
</tbody>
</table>
Platforms

• Texas State Waters:
  • 95% of platforms (of 89 total) = inactive
  • Minimal detailed data (no age, water depth, inspect. records)

• Federal Waters:
  • 1,800+ platforms offshore TX (8%) & LA (92%)
  • High-level data (inspection reports in some cases)

• Age:
  • SME: Beyond 30 years, structural integrity risk rises
  • Important Standards/Best Practices
    • API RP 2A 9th Ed (1977): “100-year return period conditions”
    • MMS – From 1988 on, enhanced inspection requirements

• Critical information such as structural integrity, topsides space, etc. requires contact with operators
Platforms – Are Incentives Aligned?

CCS Project Developer: Minimize cost while managing risk

ASSET OWNER: Avoid decommissioning liability

Government/Public: Mitigate asset liability, ideally re-use
Conclusions
Summary

• **Pipelines:**
  • **Scale** of pipeline re-use opportunity limited by size and pressure rating
  • Re-use vs. new is not binary
    • Incremental Capacity: Pair existing with new (reduce total investment)
    • “Phased” Investment: Start-up with existing, build-out new (flexibility)
  • Existing right-of-way, existing routes have inherent value
  • Are there different business models to de-risk pipeline re-use?

• **Platforms:**
  • Limited stock of “newer” platforms (mostly in deeper waters)
  • Fixed platforms are most common, span large range of water depth – needs more investigation
  • Platform re-use unlikely to drive a project (vs. reservoir, pipeline, wells)
  • Are incentives aligned for re-use?

• Decommissioning “best practices” not always followed. Urgency to identify assets before abandonment.
Thank You

- Acknowledgements:
  - Darrell Davis (Consultant) led efforts for pipeline and platform screening
    - davisdw58@hotmail.com
  - UT BEG for data analysis support
  - Trimeric Corporation
    - www.trimeric.com
  - Darshan Sachde
    - darshan.sachde@trimeric.com
Backup Slides
Pipeline Re-use Workflow

1. **Public Data Review**
   - Contact Owners, Public Records: Negligible Investment

2. **Pursue Evaluation?**
   - **No** → **New Line**
   - **Yes** → **Line Inspection**

3. **Line Inspection**
   - **No**
     - **Divers**: Est: $250k for 10 days
     - **SMART Pig**: Est: $150k < 25 miles
   - **Yes** → **Acceptable Integrity?**

4. **Acceptable Integrity?**
   - **No** → **New Line**
   - **Yes** → **Line Testing**

5. **Line Testing**
   - **Cathodic Protection Survey**: Est: $250k ~15 miles
   - **Pressure Test**: Est: $175k

6. **Repair/Reuse?**
   - **No** → **New Line**
   - **Yes** → **Permitting & Regulatory**

7. **Permitting & Regulatory**
   - **Total Investment (excl. repairs, permits): ~$750k+**
Pipeline Screening Results – Federal Active Lines

**Pipeline Size Distribution - Active Lines**

- Median Diameter = 21”

**Pipeline Pressure Distribution - Active Lines**

- >1,440 psig = 10 lines

**Note:**
- Out of Service Median Size = 16”

**Note:**
- Out of Service Lines >1,440 psig = 0
Pipeline Screening Results – Federal Out of Service

• Limited stock of large pipelines
  • ~23% ≥ 8 inches
  • 41% of this subset are 8” lines

• Class 600 pipelines are most common
  • 61% of all pipelines at least 1440 psig

• Nearly half of pipelines meeting size and pressure screen are active
  • Recent (last 10 years) common practice: fill abandoned lines w/ uninhibited seawater.

• Less than half (46%) of lines meet the age criteria (< 40 years)

<table>
<thead>
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<th>Number of Segments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>20,274</td>
</tr>
<tr>
<td>8” or larger</td>
<td>4,614</td>
</tr>
<tr>
<td>Max Operating Pressure &gt; 1000 psig</td>
<td>3,875</td>
</tr>
<tr>
<td>Not in Service</td>
<td>1,927</td>
</tr>
<tr>
<td>&gt; 2 miles long</td>
<td>951</td>
</tr>
<tr>
<td>Water Depth &lt; 100’</td>
<td>520</td>
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<td>355</td>
</tr>
<tr>
<td>Key Segments*</td>
<td>11</td>
</tr>
</tbody>
</table>

*Key Segments = Come onshore & terminate near state waters offshore
Pipeline Opportunity: Texas State Waters

Light blue lines are abandoned lines which are 8” or greater

Source: Prepared by Darrell Davis for Trimeric Corporation
Platforms – Federal Waters

Oil and Gas Platforms Installed in Federal Waters off of the Texas Coast

- Total Platforms = 136
- Installed After 1977 = 113
- Installed After 2000 = 41

Oil and Gas Platforms Installed in Federal Waters off the Louisiana Coast

- Total Platforms = 1,671
- Installed After 1977 = 1,023
- Installed After 2000 = 371
Platforms – CO₂ Topsides Requirements

- **General Equipment**: Valving, instrumentation, filters, pig receivers, piping manifold, heaters
- **Drill new CO₂ injection wells**
  - Weight of a drilling rig or need a separate jack-up rig for drilling
  - Need open slots for injections wells or re-use existing wells
- **Booster compression/pumping (in some cases)**
  - Additional topsides weight, space, power requirements
- **Materials compatibility**:
  - Supercritical CO₂ is a solvent, P, T considerations
- **Do cost-savings of re-purposing vs. new-build hold up after modifications?**
- **More detailed engineering studies will be needed to**:
  - Assess the integrity and useful life of specific platforms
  - Assess modifications to the topsides for CO₂ injection
  - Understand the cost of a new platform