Global Opportunities for Offshore CCS: Assessing Offshore Storage on Continental Shelves

International Workshop on Offshore Geological CO₂ Storage
Austin, Texas
April 19-20, 2016

Dr. Tip Meckel, Research Scientist
Gulf Coast Carbon Center

TEXAS Geosciences
Bureau of Economic Geology
Jackson School of Geosciences
The University of Texas at Austin
Three motivating messages:

1. For CCS to be a technology with significant atmospheric benefit on desired timelines, rapid and broad global deployment needed.
   • 6 Gt by 2050 (6,000 ‘Sleipners’)
   • 2/3 of CCS potential will need to come from non-OECD countries (IEA)
   • Natural gas likely to be associated with many projects.

2. The global offshore continental shelves broadly represent the largest near-term storage for Gigaton-scale CCS.
   • CCS ‘sweet spots’ – source-sink match, ownership; thick, sand-prone, young (ductile seals), low stress.
   • **How assess storage potential?**

3. Focus needs to be on capacity assessment, knowledge transfer, and deployment of demonstration- and industrial-scale projects.
   • **This workshop!**
Figure from World CO₂ emissions from consumption of energy, US EIA
Select Industrial CCS Projects

- Sleipner, Snohvit – North Sea
- In-Salah - Algeria
- Gorgon, NW Shelf Australia (15% CO₂)
- Lula – CO₂/EOR

World Gas Reserves

- Approximately 40% (2600 Tcf) are estimated to be sour

Gas quality problems are holding back investment

~2% production growth annually (IEA); international market

To the degree that our energy future includes large gas fields, it includes CO₂ management.

Table 12.2 World proven sour gas reserves, end - 2006

<table>
<thead>
<tr>
<th>Region</th>
<th>High H₂S only (tcm)</th>
<th>High CO₂ only (tcm)</th>
<th>High H₂S and CO₂ (tcm)</th>
<th>Total (tcm)</th>
<th>% of total reserves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexico &amp; Latin America</td>
<td>0.3</td>
<td>1.1</td>
<td>0.3</td>
<td>1.7</td>
<td>21</td>
</tr>
<tr>
<td>Europe</td>
<td>0.1</td>
<td>0.7</td>
<td>0.3</td>
<td>1.1</td>
<td>19</td>
</tr>
<tr>
<td>Former Soviet Union</td>
<td>0.8</td>
<td>10.1</td>
<td>7.3</td>
<td>18.2</td>
<td>34</td>
</tr>
<tr>
<td>Africa</td>
<td>0.0</td>
<td>0.5</td>
<td>0.5</td>
<td>1.0</td>
<td>8</td>
</tr>
<tr>
<td>Middle East</td>
<td>2.6</td>
<td>0.4</td>
<td>40.9</td>
<td>44.0</td>
<td>60</td>
</tr>
<tr>
<td>Asia-Pacific</td>
<td>0.3</td>
<td>4.4</td>
<td>2.3</td>
<td>7.1</td>
<td>46</td>
</tr>
<tr>
<td>World</td>
<td>4.2</td>
<td>17.2</td>
<td>51.6</td>
<td>73.1</td>
<td>43</td>
</tr>
</tbody>
</table>

Note: Excludes North America. High H₂S is more than 100 parts per million; high CO₂ is more than 2%. Source: Bourdarot (2007).

Source: US EIA
The global offshore continental shelves broadly represent the largest near-term storage for Gigaton-scale CCS.
Very large regional static capacity estimates
Static Regional Capacity
Texas Example

- NETL Methodology
- 40,000 sq. km.
- 3,300 logs
  - Tops, net sand, porosity
- 172 Gt total (TX State Waters)
Geologic Characterization: What is typical? What is notable?

- Temperature (°F) & Pressure (psi)
- Fluid Density (g/cm³)
- Depth (ft)
- Depth (km)
- Porosity
- Log₁₀ Permeability (Log₁₀ mD)

Gas reservoirs

Distribution of Properties of 6,206 Gas reservoirs

- Mean = 27
- Mean = 2.23 (169 mD)

Frequency

Sand Thickness (meters)

Frequency

Oil (MMBBL), Gas (BCF), Water (MMBBL), Water Inj (MMBBL), Gas Inj (BCF)
Gas field Characterization: What is typical? What is notable?

Gas Field Static Replacement Capacity

Depleted gas fields are major opportunity and part of solution
Injection Simulation: Theoretical/analytical, Numerical

Analytical = Expectations  
Numerical = Sensitivity

Which models lead to **undesirable** outcomes?  
How can you avoid those scenarios?
Capacity Refinement

Increased certainty of storage potential

Increasing cost of storage

Estimated CO₂ Storage Capacity vs. Refinement

Matched Capacity
Practical Capacity
Effective Capacity
Theoretical Capacity

Refinement (cost, time)

Estimated Storage Capacity (MegaTonnes)

Maximum
Mean
Minimum

1.45 years
2.35 years
2.95 years
3.55 years
4.05 years

$3.31 million
$5.01 million
$7.42 million
$9.93 million
$12.46 million

$21.84 million
$23.25 million
$23.65 million
$23.32 million
$23.25 million
Liwan 3-1 Field, Baiyun Sag
4-6 Tcf
Oligocene/Miocene clastics
55 sq km closure
36 m net gas pay
Geologic Similarities/Differences

- Deeper rift sequence (‘CCS Basement’) overlain by prograding fluvial/deltaic/shelf systems.
  - Thick, sand-prone (+/- CO₃), young (limited diagenesis?)
- Regional unconformities, flooding surfaces (Global vs. relative SL change)
- Basement faults, overburden growth structures.
  - Fault seal, migration routes.
- Subsidence history: monotonic, punctuated, uplift?
  - Compaction, fluid pressure
- Provenance (sediment composition)
Basin Petroleum Systems and CCS

- Broad indication of basin fluid performance (if charged)
  - Reservoirs, faults, topseals, migration routes.
- Sequence Stratigraphy effective ‘tool’ for understanding basin geology.
- The question of rates: geologic vs. engineered.
  - North Sumatra Basin or Gulf of Mexico?
- Engineering: Re-commissioning of infrastructure
  - Best for HC = best for CCS?
- Hazards of generalizing
- Reservoirs vs. Overburden
High-resolution 3D seismic data for overburden characterization and 4D monitoring
Data forces us to think very hard about things like faults.
Focus needs to be on capacity assessment, knowledge transfer, and deployment of demonstration- and industrial-scale projects.
Three motivating messages:

1. For CCS to be a technology with significant atmospheric benefit on desired timelines, rapid and broad global deployment needed.
   - 6 Gt by 2050 (6,000 ‘Sleipners’)
   - 2/3 of CCS potential will need to come from non-OECD countries (IEA)
   - Natural gas likely to be associated with many projects.

2. The global offshore continental shelves broadly represent the largest near-term storage for Gigaton-scale CCS.
   - CCS ‘sweet spots’ – source-sink match, ownership; thick, sand-prone, young (ductile seals), low stress.
   - How assess storage potential?

3. Focus needs to be on capacity assessment, knowledge transfer, and deployment of demonstration- and industrial-scale projects.
   - This workshop!