Geological Storage Capacity in the United States

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Carbon Dioxide Capture and Geologic Storage

Capture → Compression → Pipeline Transport → Underground Injection
Topics

- What formations are suitable for storage?
- Where are they located?
- How much storage capacity is there?
- Conclusions
What Types of Rock Formations are Suitable for Geological Storage?

Rocks in deep sedimentary basins are suitable for CO₂ storage.

Map showing world-wide sedimentary basins

Northern California Sedimentary Basin

Map showing world-wide sedimentary basins

Specific formation types

• Oil reservoirs
• Gas reservoirs
• Saline aquifers
• Deep unminable coal beds

What about CO₂ storage in basalt? This is an unproven technology that is the subject of ongoing research.
### Some Attributes of Effective Storage Sites

<table>
<thead>
<tr>
<th>Overburden</th>
<th>Seal</th>
<th>Storage Formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Known condition of active and abandoned wells</td>
<td>Geographically extensive</td>
<td>Not a source of drinking water</td>
</tr>
<tr>
<td>Presence of secondary seals</td>
<td>Low permeability and high capillary entry pressure</td>
<td>Satisfactory injectivity</td>
</tr>
<tr>
<td>Stable and sealed faults and fractures</td>
<td>Hydrologically isolated from drinking water aquifers</td>
<td>Sufficient storage volume</td>
</tr>
</tbody>
</table>

> ~ 1 km
Capacity Assessment: California

• Screening criteria
  – depth (<800m),
  – presence of porous, permeable sediments,
  – presence of seals,
  – restricted access (parks, Indian lands, military installations)

• Data from literature and well logs

Source: WESTCARB
Oil and Gas Field Capacity Assessment

- 121 fields met depth and miscible EOR criteria
  - 3.4 Gt CO$_2$ storage capacity, using production as a basis
  - Other studies suggest 5.4 billion barrels oil technically recoverable

- 128 gas fields met depth criteria
  - 1.8 Gt CO$_2$ storage capacity
Saline Aquifer Capacity Assessment

Storage Capacity = Size of the “Box” x Fraction of the Pore Space Filled with CO₂
Saline Aquifer Capacity Assessment

<table>
<thead>
<tr>
<th>Basin</th>
<th>Area (&gt; 800 m deep) (sq. miles.)</th>
<th>Average Thickness (ft.)</th>
<th>Average Porosity</th>
<th>Total estimated Pore Volume (cu. ft.)</th>
<th>Total estimated Pore Volume (cu. meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sacramento-San Joaquin basins</td>
<td>18,550</td>
<td>2,000</td>
<td>0.25</td>
<td>258,572,160,000,000</td>
<td>7,321,941,287,906</td>
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<tr>
<td>Los Angeles Basin</td>
<td>1,341</td>
<td>3,000</td>
<td>0.25</td>
<td>28,038,700,800,000</td>
<td>793,966,841,004</td>
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<tr>
<td>Ventura Basin</td>
<td>1,450</td>
<td>3,000</td>
<td>0.24</td>
<td>29,105,049,600,000</td>
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<tr>
<td>Salton Trough</td>
<td>2,559</td>
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<td>0.24</td>
<td>34,243,596,288,000</td>
<td>969,669,749,085</td>
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<tr>
<td>Eel River Basin</td>
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<td>1,500</td>
<td>0.26</td>
<td>1,902,700,800,000</td>
<td>53,878,435,892</td>
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<tr>
<td>Salinas Basin</td>
<td>1,343</td>
<td>1,250</td>
<td>0.28</td>
<td>13,104,241,920,000</td>
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<td>La Honda Basin</td>
<td>268</td>
<td>1,500</td>
<td>0.25</td>
<td>2,801,779,200,000</td>
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<td>Livermore Basin</td>
<td>144</td>
<td>800</td>
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<td>738,666,086,400</td>
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<td>Orinda Basin</td>
<td>296</td>
<td>600</td>
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<td>Cuyama Basin</td>
<td>582</td>
<td>3,000</td>
<td>0.27</td>
<td>13,142,435,328,000</td>
<td>372,151,974,334</td>
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</table>
Approach for Assessing Capacity in Saline Aquifers

Geology
Models
Simulations

Statistics

“Rules of Thumb”

CO₂ Storage Capacity = 1 to 4% Total Pore Volume

¹Values used in the First North American Carbon Sequestration Atlas, 2006
CO₂ Storage Capacity in California

Saline Formation Capacity

Storage Capacity: 75 to 300 GT CO₂
CO₂ Storage Capacity
(Billion Metric Tons)

- Big Sky: 0.8
- MGSC: 0.4
- MRCSP: 2.5
- PCOR: 19.6
- SECARB: 32.4
- SOUTHWEST: 21.4
- WESTCARB: 5.3
- TOTAL: 82.4
Location of Storage Sites in
North America: Saline Aquifers

First North American Carbon
Sequestration Atlas, 2006

CO₂ Storage Capacity
(Billion Metric Tons)
Big Sky   271   1,085
MGSC     29    115
MRCSP    47    189
PCOR     97    97
SECARB   360   1,440
SOUTHWEST 18    64
WESTCARB 97    288
TOTAL    919   3,378

North American Saline Basins
Location of Storage Sites in North America: Coal


CO₂ Storage Capacity
(Billion Metric Tons)

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Storage Capacity* and Validation Test Sites for Phase II

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<thead>
<tr>
<th>Partitions</th>
<th>Field Test Type</th>
<th>Capacity (Gt)</th>
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</thead>
<tbody>
<tr>
<td>Oil&amp;Gas</td>
<td>Oil bearing (9)</td>
<td>19.6</td>
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<tr>
<td>Coal</td>
<td>Gas bearing (1)</td>
<td>0.44</td>
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<tr>
<td>Saline</td>
<td>Saline Formation (10)</td>
<td>97</td>
</tr>
</tbody>
</table>

* Tentative, subject to revision as new information is available (From Dawn DEEL, USDOE)
Capacity Varies Widely by Region

Theoretical capacity estimates range from 50 to over 1,000 times annual emissions (from stationary sources), depending on location.
Summary

- U.S. CO$_2$ Storage Capacity Range: 1,160 to 3,550 billion metric tons
  - > 200 times total annual CO$_2$ emissions
- Potential storage capacity
  - Saline Aquifers >> Coal > Oil and Gas
- Reliability of estimates
  - Oil and Gas >> Saline aquifers > Coal
- Highly uneven distribution of capacity
- Much more work is needed to increase confidence in theoretical and practical storage capacity estimates
- U.S. DOE is working on an update to the National Carbon Sequestration Atlas