CO$_2$ for EOR from Coal Gasification

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PetroChina-RIPED (Research Institute of Petroleum Exploration and Development) and BP seminar on “Exploration of CO$_2$-Contaminated Natural Gas and CO$_2$ Storage and Integrated Utilization of Resources”
Beijing, 24-25 April 2007
Carbon Mitigation Initiative at Princeton, 2001-2010

Carbon Capture

Carbon Storage

YEAR SEVEN: FINAL FUNDING IN HAND

“An environmental problem”

Carbon Science

Carbon Policy

$21,150,000 funding from BP and Ford, plus new BP increment. 2
CMI Carbon Capture Group

Personnel
Williams
Socolow
Kreutz
Larson
Consonni (Milan)
Li (Tsinghua)
Post-docs
Students

Tools (plant design and simulation)
Aspen Plus
“GS” (Politecnico di Milano)

Core Research
Catalyzing early commercialization of CCS
Coal gasification systems;
  Power or synfuels production
Biomass gasification systems
  Power or synfuels production
  Co-gasifying with coal
Sustainable feedstocks
  DF-x collaboration (advanced capture, low-rank coals)
  Polygeneration of electricity and synfuels (with Tsinghua)
  Baseload wind (with natural gas)
  H₂ and DME combustion
Coal Gasification Systems for Liquid Fuels or H₂ Production ➔ Low Cost CO₂

- CO₂ is natural by-product of fuels production.
- For example, SASOL Fischer-Tropsh plants in S. Africa vent ~20 million t/yr of nearly pure CO₂.
- Capturing the CO₂ at such plants for EOR use can be done with low incremental cost
  - Capture cost is essentially the cost of CO₂ drying and compression (< $10/tCO₂).
  - CO₂ pipeline transport adds $5-10/tCO₂ (depending on distance and flow volume).
Fischer-Tropsch and Electricity Co-Production with CO₂ Capture

~100 kWh electricity per tCO₂ for compression to 150 bar.
Coal-H$_2$ Production with CO$_2$ Capture

Note: China is world’s largest producer of H2 from coal today.
Coal-IGCC with CO₂ Capture

CO₂ capture less costly for IGCC than for pulverized coal steam-electric plants.
Extensive Experience in USA with CO$_2$ Transport For EOR

Total pipelines: ~ 3000 km
One EOR Project Uses CO$_2$ By-Product of Coal Gasification for Synthetic Natural Gas Production

- Great Plains Synfuels plant (Beulah, North Dakota) capacity of 170 million cubic feet/day methane from 18,500 tons of lignite ➔ 200 million ft$^3$/day of nearly pure CO$_2$.
- Operating since 1984.
- 95 million ft$^3$/day CO$_2$ being sold (since 2000) to Encana Corporation for CO$_2$-EOR at the Weyburn oil field in Saskatchewan, Canada.
- CO$_2$ is transported 205 miles to the CO$_2$-EOR site via pipeline.
**Cost Of CO₂ Capture in Generating Electricity -- Existing Technology ($ per tonne of CO₂)**

<table>
<thead>
<tr>
<th>Technology</th>
<th>Representative Value</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>New natural gas combined cycle plant</td>
<td>44</td>
<td>33 - 57</td>
</tr>
<tr>
<td>New pulverized coal plant</td>
<td>29</td>
<td>23 - 35</td>
</tr>
<tr>
<td>New coal IGCC plant</td>
<td>20</td>
<td>11 – 32</td>
</tr>
<tr>
<td>Existing pulverized coal plant</td>
<td>None indicated</td>
<td>31 - 56</td>
</tr>
</tbody>
</table>

Source: IPCC Special Report on Carbon Dioxide Capture and Storage, 2005

IGCC CO₂ costs likely to fall faster with experience than cost of CO₂ from pulverized coal plants..

Assessment of USA CO$_2$-EOR Potential (done by ARI, 2005)

<table>
<thead>
<tr>
<th>Basin/Area</th>
<th>30-yr levelized economic CO$_2$-EOR potential (10$^6$ barrels/day)</th>
<th>Princeton estimates for capacity of coal gasification systems that could provide the CO$_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>IGCC ($G_{W_e}$)</td>
</tr>
<tr>
<td>Alaska</td>
<td>0.70</td>
<td>7.8</td>
</tr>
<tr>
<td>California</td>
<td>0.30</td>
<td>4.4</td>
</tr>
<tr>
<td>Gulf Coast</td>
<td>0.21</td>
<td>3.3</td>
</tr>
<tr>
<td>Mid-Continent</td>
<td>0.57</td>
<td>5.9</td>
</tr>
<tr>
<td>North Central</td>
<td>0.058</td>
<td>0.7</td>
</tr>
<tr>
<td>Permian</td>
<td>0.99</td>
<td>14.9</td>
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<tr>
<td>Rockies</td>
<td>0.22</td>
<td>3.1</td>
</tr>
<tr>
<td>Texas, East/Central</td>
<td>0.79</td>
<td>9.4</td>
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<tr>
<td>Williston</td>
<td>0.046</td>
<td>0.6</td>
</tr>
<tr>
<td>Lousiana offshore</td>
<td>0.40</td>
<td>7.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4.28</strong></td>
<td><strong>57.3</strong></td>
</tr>
</tbody>
</table>

- Estimates are for “state-of-the-art” CO$_2$ EOR [~0.2 tCO$_2$ (fresh) per EOR barrel].
- Each GW of coal-IGCC electricity capacity supports ~13x10$^6$ bpd EOR production.
- Each barrel of FT liquid production supports ~2 bbls EOR production.