Potential for EOR to kick-start early projects CCS projects

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Three key messages

1. CO$_2$-flood enhanced oil recovery (CO$_2$-EOR) is a technically proven and well understood process that is applied commercially today.

2. CO$_2$-EOR results in storage of CO$_2$, however the emissions reduction benefit is dependent on design of the project and the policy environment.

3. There are barriers to designing and operating a CO$_2$-EOR project as part of a CCS project that need to be resolved for CO$_2$-EOR to play a role in reducing emissions.
CO$_2$-EOR: Using CO$_2$ to improve oil recovery

Source: McCoy, 2008
How does CO₂ improve oil recovery?

- Two types of CO₂-EOR processes exist:
  - *Immiscible*: injected CO₂ displaces oil from the reservoir and drives it towards production wells
  - *Miscible*: injected CO₂ forms a single-phase mixture with the oil, effectively reducing the density and viscosity of the oil, improving ability of the oil to flow

- *Miscible* CO₂-EOR tends to recover more oil than *immiscible*, but uses less CO₂ per barrel
  - The type of CO₂-EOR process depends on reservoir pressure and oil composition (MMP)

- Majority of projects are *miscible* CO₂-EOR projects
Increased oil production from the Weyburn Unit under miscible CO$_2$-EOR

Around 30,000 bbl/day total production, over 20,000 bbl/d due to CO$_2$-EOR

Figure: Cenovus Energy/Malcolm Wilson, PTRC
An upwards trend for US miscible projects and production from CO$_2$-EOR

Data: Oil & Gas Journal, 2010
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The boundaries used to assess emissions from CO$_2$-EOR matter

- Khoo & Tan, 2006: >0 t CO$_2$ avoided/net t CO$_2$
- Aycaguer et al., 2001: 0.14 t CO$_2$ avoided/bbl Oil
- Suebsiri et al., 2006: 0.35 t CO$_2$ emitted/bbl Oil

Figure: Jaramillo et al, 2009
Cradle-to-grave emissions from CO₂-EOR are positive

Jaramillo et al., 2009
For net storage, >0.62 net t CO₂/bbl oil
Emissions can be reduced through displacement

<table>
<thead>
<tr>
<th>Marginal Barrel Displaced (kg CO2e/bbl)</th>
<th>Marginal Generation Displaced (kg CO2e/MWh)</th>
<th>Emissions Reduction Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Average Consumption-USA (529)</td>
<td>Current Average Generation-USA (652)</td>
<td>Project 1 Project 2 Project 3 Project 4</td>
</tr>
<tr>
<td>71%</td>
<td>68%</td>
<td>70%</td>
</tr>
<tr>
<td>Canadian In-Situ SCO (600)</td>
<td>Uncontrolled IGCC (894)</td>
<td>140%</td>
</tr>
<tr>
<td>87%</td>
<td>75%</td>
<td>83%</td>
</tr>
<tr>
<td>Saudi Arabian Light (521)</td>
<td>Uncontrolled IGCC (894)</td>
<td>94%</td>
</tr>
<tr>
<td>41%</td>
<td>38%</td>
<td>40%</td>
</tr>
<tr>
<td>Carbon-free Electricity (0)</td>
<td>-8%</td>
<td>-10%</td>
</tr>
</tbody>
</table>

McCoy et al, 2010
Important observations from past life-cycle assessment research

1. Emissions depend on boundaries:
   a) Including emissions from oil production makes business-as-usual (BAU) CO$_2$-EOR a net emitter
   b) Changes to design and operation of BAU CO$_2$-EOR could decrease the CO$_2$ footprint

2. If energy-related emissions that would otherwise be produced from an equivalent system are displaced, CO$_2$-EOR reduces emissions

3. Emissions reduction efficiency is a function of energy displacement and CO$_2$ utilization
   a) Displacement of CO$_2$-intensive power and oil results in a larger emissions reduction than would otherwise occur
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## Attributes of CO₂-EOR operations necessary for qualification as storage

<table>
<thead>
<tr>
<th>Technology</th>
<th>Energy Policy</th>
<th>Climate Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Law and regulation to enable CO₂-EOR as a oil recovery process&lt;br&gt; • Regulation to ensure that CO₂-EOR is undertaken safely for humans and the environment</td>
<td>• Measurable emissions reduction goals and accompanying policy&lt;br&gt; • Laws and regulation enabling CO₂-EOR as climate change mitigation option&lt;br&gt; • Accounting rules that accurately award credit for emissions avoided</td>
</tr>
<tr>
<td>• Increase net CO₂ utilization through changes to design and operation (?)&lt;br&gt; • Monitoring, measurement, and verification of similar stringency to that applied to saline aquifers&lt;br&gt; • Abandonment to ensure long-term retention of stored CO₂</td>
<td></td>
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</table>
Numerous planned CCS projects rely on CO$_2$-EOR

Data: GCCSI Project Database, 7 Nov. 2011
Barriers to private investment in CO₂-EOR

<table>
<thead>
<tr>
<th>BAU CO₂-EOR</th>
<th>CO₂-EOR for Climate Change Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Low valued investment option in IOC portfolios</td>
<td>• Those for BAU CO₂-EOR, PLUS:</td>
</tr>
<tr>
<td>• Lack of low cost CO₂ for injection in many places</td>
<td>• No return on additional cost for storage</td>
</tr>
<tr>
<td>• Competition with other EOR processes</td>
<td>• Cost for monitoring, measurement, and verification</td>
</tr>
<tr>
<td>• Mismatch in business cases for capture versus injection</td>
<td>• Cost for ensuring long-term containment</td>
</tr>
</tbody>
</table>

Can incentive policies address these issues? 
If so, how?
Objectives CO$_2$-EOR analysis at the IEA

1. A clear understanding of the global potential for CO$_2$-EOR to contribute to emissions reductions
2. Identification of unique considerations that need to be addressed to achieve emissions reductions
3. Identification and understanding of gaps and barriers that prevent development of projects
4. Sound recommendations for member countries to enable CO$_2$-EOR as climate policy option
IEA working paper on CO$_2$-EOR as storage

1. A brief history of enhanced oil recovery
2. Objectives
3. Business as usual enhanced oil recovery
   a. Process details and applicability
   b. Conventional economics
   c. Global potential for oil production
   d. The emissions balance
   e. Legal and institutional framework
4. Enhanced oil recovery for storage
   a. Engineering the EOR process for storage
   b. Accounting for emissions reductions from EOR
   c. Global potential for oil production and storage
   d. Legal, regulatory requirements
5. Necessary attributes of EOR for storage
6. Barriers to enhanced oil recovery as storage
IEA-OPEC dialogue on CO$_2$-EOR as storage

- The Kuwait Petroleum Company hosted a joint IEA-OPEC workshop on February 7-8 in Kuwait City

- Four objectives:
  1. Review CO$_2$-EOR technology, its potential benefits and the technical considerations, challenges and risks for turning CO$_2$-EOR into CO$_2$ storage
  2. Share lessons learned from some of the existing CO$_2$-EOR projects and from past experiences
  3. Gain deeper insight into the commercial and economic aspects for CO$_2$-EOR as CO$_2$ storage
  4. Identify areas of mutual interest for a possible follow-up workshop
Questions?

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