Carbon Capture and Sequestration for Greenhouse Gas Control

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Take-Home Messages

• Technology is commercially available to remove over 90% of the CO₂ from industrial gas streams.
• As a climate mitigation strategy this technology is currently expensive.
• R&D can substantially lower the cost of CO₂ capture at large sources such as electric power plants.
• Storing the captured CO₂ underground in geological formations appears to be the most viable and inexpensive method of carbon sequestration. However, . . .
• The environmental and social acceptability of geologic sequestration still must be demonstrated.
• If successfully developed, CCS can play an important role in reducing the cost of climate stabilization.
Why the Interest in Carbon Capture and Sequestration (CCS)?

*CCS technology may be a way to:*

- Have your cake and eat it: use fossil fuels without CO$_2$ emissions
- Minimize the overall cost of reducing greenhouse gas emissions
- Provide a bridge to a more sustainable energy future

Schematic of CO$_2$ Capture and Storage System

Coal or Natural Gas → Air or Oxygen → Energy Conversion Process → CO$_2$ Capture → CO$_2$ Transport → CO$_2$ Storage (Sequestration) → Useful Products (Electricity, Fuels, Chemicals, Hydrogen)
CO₂ Capture Technology is Commercially Available

Current industrial applications include:
- Enhanced oil recovery (EOR)
- Fertilizer production
- Soda ash
- Food processing
- Hydrogen production
CO₂ Capture at a Coal-Fired Power Plant
(Shady Point, Oklahoma)

Scale of CO₂ Capture Applications

<table>
<thead>
<tr>
<th>Application</th>
<th>Current</th>
<th>Proposed</th>
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<tbody>
<tr>
<td>EOR</td>
<td>1200</td>
<td>150</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>Soda Ash</td>
<td>800</td>
<td></td>
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<tr>
<td>Food-grade</td>
<td>320</td>
<td></td>
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<tr>
<td>Sleipner West Gasfield, Norway</td>
<td>3000</td>
<td></td>
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<tr>
<td>500MW Coal-based Powerplant</td>
<td>9600</td>
<td></td>
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Source: ABB Lummus
**CO₂ Transport and Storage**

- Hundreds of miles of CO₂ pipeline transport are already in use (mainly for enhanced oil recovery)
- Large-scale storage (sequestration) of CO₂ is now being demonstrated in Norway and Canada
- There is substantial on-going research to better assess the feasibility and cost of alternative CO₂ sequestration methods

**CO₂ Sequestration Options**

- Geologic Sequestration
  - Deep saline reservoirs
  - Depleted oil and gas wells
  - Unmineable coal seams
- Ocean Sequestration
- Terrestrial Sequestration
- Other Novel Concepts
Weyburn Field Project

- Will store CO$_2$ at the Weyburn oil field in Saskatchewan, Canada, after use for enhanced oil recovery (EOR)
- CO$_2$ source is the Great Plains Synfuels Plant in Beulah, North Dakota (a coal gasification plant)
- Transport of CO$_2$ via a 325 km (200 mi) pipeline built and operated by the Dakota Gasification Company
- Will sequester 14 million tons of CO$_2$ over the life of the project
How Much Does CCS Cost?

- The cost of CO₂ capture and sequestration depends strongly on the assumptions that are made -- there is no single “right answer”
- Several different cost measures are in use, which can be a source of confusion
- The next slide shows typical values and ranges for current CCS technologies and the options they compete with for electric power generation

Cost of Alternative Options
Key R&D Needs

- Reduce the capital and operating costs of CO₂ separation and capture
- Determine the environmental acceptability of CO₂ storage (sequestration) methods
- Evaluate the true cost of alternative sequestration methods

Major R&D Initiatives

- U.S. Department of Energy
  - Carbon Sequestration Program
- Other Federal Agency Programs
- CO₂ Capture Project
  - Consortium of: BP, Chevron, ENI, Norsk Hydro, Pan Canada, Shell, Suncor, Statoil, Texaco
Some Research Questions

- How do alternative CO₂ capture and storage options compare in terms of performance, emissions and cost?
- What are the uncertainties and technological risks of different options?
- What are the priorities and payoffs of R&D to reduce key uncertainties and to reduce costs?
- What is the potential role of CO₂ capture and sequestration in achieving climate policy objectives at the lowest cost?

Conclusions

- Carbon capture and sequestration technology is a potentially important player in GHG control
- Its role will be shaped largely by:
  - The stringency of future emission reduction requirements for greenhouse gases
  - The success of R&D efforts to lower the costs of CO₂ capture and sequestration
  - Public acceptance of sequestration as an approach to greenhouse gas control