CCS in the IPCC Fourth Assessment

Expert meeting on Financing CCS projects
IEA GHG R&D Programme
London, 31 May 2007
Dr. Leo Meyer, IPCC Working Group III
About IPCC

- Founded 1988 by UNEP and WMO
- No research, no monitoring, no recommendations
- Preferably peer-reviewed literature
- Authors academic, industrial and NGO
- Reviews by Experts *and* Governments
- Policy relevant, but NOT policy prescriptive
- Summary for policymakers: government approval
- Fourth Assessment cycle 2003-2008
Key issues addressed in this presentation

The IPCC Special Report on CCS (2005)
- What is CO$_2$ capture and storage?
- Sources, Capture, transport
- Geological storage, Ocean storage, mineral carbonation
- Maturity of the technologies
- Cost and potential
- Health, safety and environment risks

The IPCC WG III AR4: mitigation of Climate change (2007)
- CCS : transient or expansion;
- CCS readiness of power plants
- New cost and potential estimate in 2030 ; LT potential

‘take home’ messages
CO₂ capture and storage system
Global large stationary CO$_2$ sources with emissions of more than 0.1 MtCO$_2$/year

<table>
<thead>
<tr>
<th>Process</th>
<th>No. of sources</th>
<th>Emissions (MtCO$_2$/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fossil Fuels</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power (coal, gas, oil and others)</td>
<td>4,942</td>
<td>10,539</td>
</tr>
<tr>
<td>Cement production</td>
<td>1,175</td>
<td>932</td>
</tr>
<tr>
<td>Refineries</td>
<td>638</td>
<td>798</td>
</tr>
<tr>
<td>Iron and steel industry</td>
<td>269</td>
<td>646</td>
</tr>
<tr>
<td>Petrochemical industry</td>
<td>470</td>
<td>379</td>
</tr>
<tr>
<td>Oil and gas processing</td>
<td>N/A</td>
<td>50</td>
</tr>
<tr>
<td>Other sources</td>
<td>90</td>
<td>33</td>
</tr>
<tr>
<td><strong>Biomass</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bioethanol and bioenergy</td>
<td>303</td>
<td>91</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>7,887</td>
<td>13,466</td>
</tr>
</tbody>
</table>
Overview of CO$_2$ capture systems
Capture and transport energy requirements

- Additional energy use of 10 - 40% (for same output)
- Capture efficiency: 85 - 95%
- Net CO$_2$ reduction: 80 - 90%
- Assuming safe storage
## Capture energy requirements

<table>
<thead>
<tr>
<th>Power plant (new)</th>
<th>Thermal eff. without capture (LHV), %</th>
<th>Thermal eff. with capture (LHV), %</th>
<th>Increased primary energy use / output electricity %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulverized Coal</td>
<td>41 - 45</td>
<td>30 - 35</td>
<td>24 - 40</td>
</tr>
<tr>
<td>NGCC</td>
<td>55 - 58</td>
<td>47 - 50</td>
<td>11 - 22</td>
</tr>
<tr>
<td>IGCC</td>
<td>38 - 47</td>
<td>31 - 40</td>
<td>14 - 25</td>
</tr>
</tbody>
</table>
Geological storage
Planned and current locations of geological storage
Geographical relationship between sources and storage opportunities

Prospective areas in sedimentary basins where suitable saline formations, oil or gas fields, or coal beds may be found. Locations for storage in coal beds are only partly included. Prospectivity is a qualitative assessment of the likelihood that a suitable storage location is present in a given area based on the available information. This figure should be taken as a guide only, because it is based on partial data, the quality of which may vary from region to region, and which may change over time and with new information (Courtesy of Geoscience Australia).
Geographical relationship between sources and storage opportunities

Global distribution of large stationary sources of CO$_2$ (Based on a compilation of publicly available information on global emission sources, IEA GHG 2002)
Ocean storage
Maturity of CCS technology

- **Research phase** means that the basic science is understood, but the technology is currently in the stage of conceptual design or testing at the laboratory or bench scale, and has not been demonstrated in a pilot plant.

- **Demonstration phase** means that the technology has been built and operated at the scale of a pilot plant, but further development is required before the technology is ready for the design and construction of a full-scale system.

- **Economically feasible under specific conditions** means that the technology is well understood and used in selected commercial applications, such as in case of a favourable tax regime or a niche market, processing at least 0.1 MtCO$_2$/yr, with few (less than 5) replications of the technology.

- **Mature market** means that the technology is now in operation with multiple replications of the commercial-scale technology worldwide.
Maturity of CCS technology

- **Research phase**
  - Mineral carbonation
  - Ocean storage

- **Demonstration phase**
  - Oxyfuel combustion
  - Enhanced Coal Bed Methane

- **Post-combustion**
  - Gas and oil fields
  - Saline formations

- **Pre-combustion**
  - Transport
  - Industrial separation

- **Industrial utilization**
  - Enhanced Oil Recovery

- **Economically feasible under specific conditions**
  - Mature market
Costs

Two ways of expressing costs:

• Additional electricity costs
  – Energy policymaking community

• CO₂ avoidance costs
  – Climate policymaking community

Different outcomes:

0.01 - 0.05 US$/kWh

20* - 270 US$/tCO₂ avoided
(with EOR: 0*– 240 US$/tCO₂ avoided)

* low-end: capture-ready, low transport cost, revenues from storage: 360 MtCO₂/yr
## CCS component costs

<table>
<thead>
<tr>
<th>CCS component</th>
<th>Cost range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capture from a power plant</td>
<td>15 - 75 US$/tCO₂ net captured</td>
</tr>
<tr>
<td>Capture from gas processing or ammonia production</td>
<td>5 - 55 US$/tCO₂ net captured</td>
</tr>
<tr>
<td>Capture from other industrial sources</td>
<td>25 - 115 US$/tCO₂ net captured</td>
</tr>
<tr>
<td>Transportation</td>
<td>1 - 8 US$/tCO₂ transported per 250km</td>
</tr>
<tr>
<td>Geological storage</td>
<td>0.5 - 8 US$/tCO₂ injected</td>
</tr>
<tr>
<td>Ocean storage</td>
<td>5 - 30 US$/tCO₂ injected</td>
</tr>
<tr>
<td>Mineral carbonation</td>
<td>50 - 100 US$/tCO₂ net mineralized</td>
</tr>
</tbody>
</table>
Economic potential

- Cost reduction of climate change stabilisation: 30% or more
- Most scenario studies: role of CCS increases over the course of the century
- Substantial application above CO\textsubscript{2} price of 25-30 US$/tCO\textsubscript{2}
- 15 to 55% of the cumulative mitigation effort worldwide until 2100
- 220 - 2,200 GtCO\textsubscript{2} cumulatively up to 2100, depending on the baseline scenario, stabilisation level (450 - 750 ppmv), cost assumptions
Storage potential

• **Geological storage**: likely at least about 2,000 GtCO$_2$ in geological formations
  "Likely" is a probability between 66 and 90%.

• **Ocean storage**: on the order of thousands of GtCO$_2$, depending on environmental constraints

• **Mineral carbonation**: can currently not be determined

• **Industrial uses**: Not much net reduction of CO$_2$ emissions
Health, safety, environment risks

- **In general**: lack of real data, so comparison with current operations
- **CO$_2$ pipelines**: similar to or lower than those posed by hydrocarbon pipelines
- **Geological storage**:
  - appropriate site selection, a monitoring program to detect problems, a regulatory system, remediation methods to stop or control CO$_2$ releases if they arise:
  - comparable to risks of current activities (natural gas storage, EOR, disposal of acid gas)
Health, safety, environment risks

- **Ocean storage:**
  - pH change
  - Mortality of ocean organisms
  - Ecosystem consequences
  - Chronic effects unknown

- **Mineral carbonation:**
  - Mining and disposal of resulting products
  - Some of it may be re-used
CCS in the Fourth Assessment Report of IPCC WG 3 2007 (1)

• IPCC 2005: expansion towards 2100
• IEA 2006: CCS is ‘transitional’, peaking at 2050 and declining thereafter
• CCS and biomass could return CO2 conc below 450 ppm
CCS in the Fourth Assessment Report of IPCC WG 3 2007 (2)

• ‘Make power plants CCS-ready if rapid deployment desired’
• Significant pre-capital investments not justified
• Detailed reports not yet published
# CCS in the Fourth Assessment Report of IPCC WG 3 2007 (3)

## Global potential reduction and costs for CCS in 2030

<table>
<thead>
<tr>
<th>Power plants with CCS</th>
<th>Share %</th>
<th>Avoided emissions (GtCO2/y)</th>
<th>Costs US$/tCO2</th>
<th>Costs USct/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>6</td>
<td>0.49 (3%)</td>
<td>22-42</td>
<td>2-4</td>
</tr>
<tr>
<td>Gas</td>
<td>6</td>
<td>0.22 (1%)</td>
<td>43-79</td>
<td>1.3-2.4</td>
</tr>
</tbody>
</table>
Long term economic potential
‘Take home messages’

1. Potential 15 - 55% of mitigation effort to 2100, but no silver bullet - portfolio needed to address climate change

2. Reduce overall mitigation costs (30%) by increasing flexibility in achieving greenhouse gas emission reductions

3. Energy requirements still considerable (10-40%)

4. No substantive deployment unless CO$_2$ market price over 25-30 USD/tonne CO$_2$ to offset costs

5. Risks comparable to current industrial activities, but more experience needed
THANK YOU FOR YOUR ATTENTION!

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