STRATEGIC ANALYSIS OF CCS APPLICATIONS IN THE INDUSTRIAL PROCESSES SECTOR
Dale Seymour, Senior Vice President, Strategy
CSLF Financing Task Force Roundtable on the Commercial and Financial Structuring of Commercial Scale Projects with CCS
Washington D.C. 6 April 2010
WWW.GLOBALCCSINSTITUTE.COM
CCS: A ROADMAP TO 2050

Urgent need for early confidence to deploy CCS post 2020 at the scale necessary to make a difference – key role for large scale demonstration

Source: IEA, CCS Roadmap
## DESIRED PORTFOLIO VS COMMITMENTS

<table>
<thead>
<tr>
<th>Category</th>
<th>What's required</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Funding levels</td>
<td>US$15-20bn</td>
<td>18-21bn committed</td>
</tr>
<tr>
<td>Timing</td>
<td>Demonstration projects operational by 2016-17, design and construction by 2013-15</td>
<td>All projects currently in planning or design phase</td>
</tr>
<tr>
<td>Size and number of projects</td>
<td>26 Demonstration projects by 2020 ranging from</td>
<td>Funds spread over a large number of smaller projects</td>
</tr>
<tr>
<td></td>
<td>• Powerplants: 0.6-1.6 mt CO2/pa</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Industry: 0.7-3 mt CO2/pa</td>
<td></td>
</tr>
<tr>
<td>Geography</td>
<td>Spread over North America, Europe and Asia</td>
<td>Minimal funding in any developing countries</td>
</tr>
<tr>
<td>Industry/application</td>
<td>Spread of project technologies in Coal, gas and industry</td>
<td>Large focus on EOR, very few projects in industry (steel and cement)</td>
</tr>
</tbody>
</table>
# CCS FUNDING CHALLENGES

<table>
<thead>
<tr>
<th>Category</th>
<th>Challenges</th>
</tr>
</thead>
</table>
| Funding Volume                    | • Level of support  
• Portfolio mix                                                              |
| Funding Models                    | • Limited funding models in use  
• Large capital intensive procurement                                         |
| Finance and risk allocation       | • CCS projects are large  
• First of a kind risks are always high  
• Magnitude and nature of risks limit traditional financing vehicles        |
| Commercial Issues                 | • Appropriate contract structures across entire CCS chain difficult  
• Integrated projects projects may compound project risk of any individual element |
INSTITUTE – DRIVING FORWARD

Policy

GCCSI Outcomes

Delivery

Strategy
INSTITUTE RESPONSES

- Making available objective data
- Providing project qualification advice
- Establish project funds with multilateral development banks
- Co-ordinating support and technical advice
- Influencing flexible fund approaches such as CCS in CDM
INDUSTRIAL PROCESSES AND THE APPLICATION OF CCS
CCS APPLIED TO INDUSTRIAL PROCESSES REPRESENTS 45% OF CAPTURED CO2 BY 2050

Global installed CCS by sector - 2050

Source: EIA CCS Roadmap 2009, BLUE Map scenario (estimated data)
IPCC IDENTIFIED ENHANCED OIL RECOVERY AS EARLY OPPORTUNITY

- IPCC define *early opportunities* as projects that [are likely to] “involve CO₂ of less than 50 km, coupled with CO₂ storage in a value-added application such as EOR.” Early opportunities here includes longer transport distances and lower purity sources (e.g. cement)

- IEA/CSLF mandated to assess CCS ‘early opportunities’ by G8 leaders. Reported in 2007
<table>
<thead>
<tr>
<th>Industry</th>
<th>Demonstration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Generation</td>
<td>106</td>
</tr>
<tr>
<td>Gas Processing</td>
<td>19</td>
</tr>
<tr>
<td>Fertiliser production</td>
<td>11</td>
</tr>
<tr>
<td>Coal to Liquids/Gas</td>
<td>3</td>
</tr>
<tr>
<td>Oil Refining</td>
<td>2</td>
</tr>
<tr>
<td>Oil/Gas Recovery</td>
<td>15</td>
</tr>
<tr>
<td>CO2 Sequestration</td>
<td>14</td>
</tr>
<tr>
<td>Chemical Production</td>
<td>8</td>
</tr>
<tr>
<td>Mining</td>
<td>7</td>
</tr>
<tr>
<td>Iron and Steel</td>
<td>3</td>
</tr>
<tr>
<td>Not Categorised</td>
<td>19</td>
</tr>
</tbody>
</table>

51% of all demonstration projects are in power generation.
INDUSTRIAL PROCESS - STATUS

- Power Generation: 106 projects, 41 demonstration, 65 integrated
- Gas Processing: 19 projects, 13 demonstration, 6 integrated
- Fertiliser production: 11 projects, 4 demonstration, 7 integrated
- Coal to Liquids/Gas: 3 projects, 3 demonstration, 0 integrated
- Oil Refining: 2 projects, 2 demonstration, 0 integrated
- Oil/Gas Recovery: 15 projects, 15 demonstration, 0 integrated
- CO2 Sequestration: 14 projects, 14 demonstration, 0 integrated
- Chemical Production: 8 projects, 0 demonstration, 8 integrated
- Mining: 7 projects, 0 demonstration, 7 integrated
- Iron and Steel: 3 projects, 0 demonstration, 3 integrated
- Not Categorised: 19 projects, 2 demonstration, 17 integrated

~50% of planned commercial scale projects are in industrial sectors.

But majority of planned integrated projects in power.
SELECTED MARGINAL ABATEMENT COSTS BY VOLUME ACCORDING TO PROJECT TYPE

CCS-relevant emissions by 2030

% regional emissions, ranked in order of abatement cost

Coal Power/China
Coal Power/ North America, Europe & Middle East
Iron & Steel/Europe
Iron & Steel/Oceania

Theoretically feasible CCS-relevant emissions (MtCO2 pa)

1. Includes ammonia, ethanol, ethylene oxide, gas processing, hydrogen
Source: BCG
MARGINAL ABATEMENT COST CURVE
KEY MESSAGES

• CCS deployment should be pursued across a variety of geographies and project types
  – Coal fired power in China, Europe and North America
  – Gas processing in Asia and the Middle East
  – Iron and steel in Europe and Oceania
  – However options for India and other regions still need to be pursued on an emissions basis
COSTS BY INDUSTRY

- Fertilizer: $18/tonne
- Natural Gas: $19/tonne
- Cement Kiln: $50/tonne
- Blast Furnace: $52/tonne
- Oxy-combustion: $66/tonne
- IGCC: $81/tonne
- Post-Combustion: $91/tonne
- NGCC: $112/tonne
Production cost increases for industrial processes are significantly less than for power generation.

<table>
<thead>
<tr>
<th>Process</th>
<th>Avoided CO2 cost ($/tonne)</th>
<th>Production cost increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilizer</td>
<td>3%</td>
<td>18</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>1%</td>
<td>19</td>
</tr>
<tr>
<td>Cement Kiln</td>
<td>36%</td>
<td>50</td>
</tr>
<tr>
<td>Blast Furnace</td>
<td>18%</td>
<td>52</td>
</tr>
<tr>
<td>Oxy-combustion</td>
<td>60%</td>
<td>66</td>
</tr>
<tr>
<td>IGCC</td>
<td>74%</td>
<td>81</td>
</tr>
<tr>
<td>Post-Combustion</td>
<td>82%</td>
<td>91</td>
</tr>
<tr>
<td>NGCC</td>
<td>43%</td>
<td>112</td>
</tr>
</tbody>
</table>

Source data: Worley Parsons
INDUSTRIAL PROCESSES...
LOW HANGING FRUIT

• Cheaper to finance
• Lower increases in production costs for industrial processes compared to power generation
• Lower cost option than power generation to increase learning from projects
• Alternative to way to address barriers to:
  – Storage
  – Regulatory issues
  – Managing risks
CAPITAL COSTS FOR INDUSTRIAL PROCESSES
LOWER OVERALL PROJECT COSTS FOR CCS

**Gas Processing-**
$18\text{tonne/CO}_2^*$
- Capture & compression: 35%
- Transport: 21%
- Storage: 44%

*Cost of CO2 avoided, based on NOAK project*

**Cement & Steel**
$47\text{tonne/CO}_2^*$
- Capture & compression: 77%
- Transport: 7%
- Storage: 16%

*Cost of CO2 avoided, based on NOAK project*

For power generation: Total costs for CCS significantly more expensive. Capture & compression represents 82% of capital costs. Storage represents 11% of capital costs.
CHALLENGES AND THE WAY FORWARD

• Level of uncertainty for project costs
  ➢ Design analyses not formulated so costs will vary significantly
  ➢ At the study level estimates can vary by 30%

• Cost estimates increase in accuracy as project moves through development phases
  ➢ FEED stage estimates within 15% accuracy
  ➢ Define stage within 15% accuracy

• Challenges still remain from financing perspective
  ➢ Managing the various risks such as construction, operation, storage
  ➢ What is the quantum of risk? Who is best placed to manage the risks?

• Additional policy challenge for industrial processes where products are export orientated

• Issues around a CO₂ price signal, liability and transboundary transport
STRATEGIC FRAMEWORK
MOVING THE CCS AGENDA FORWARD

- **2015 outcomes**
  - Relevant CCS demonstration projects underway

- **2020 outcomes**
  - Directly contribute to development of 20 demonstration projects
  - IEA proposed 100 projects globally

- **2050 outcomes**
  - A significant contribution to reducing greenhouse gas emissions
  - CCS an integral part of the suite of options to limit global temperature increases to 2 degrees
  - 3000 projects globally (IEA)
275 PROJECTS IDENTIFIED WORLDWIDE

Total - 275

- Completed - 34
- Cancelled or delayed - 26
- Input withheld - 2
- Active or planned - 213
- Commercial scale - 101
- Integrated - 62
32% of all active or planned projects are in the industrial sector.

Power sector is very active, however there are no commercial scale integrated operational plants in this sector. Gas and Oil Processing utilise CO₂ separation for the normal process and there are a number of operational CCS projects utilising these facilities as capture plants.

Very minimal activity in other large emitting industries such as Iron, Steel, Cement and Aluminium production.
62 COMMERCIAL SCALE INTEGRATED PLANTS- ACTIVE OR PLANNED STAGE IDENTIFIED

Project type

- Gas processing
- Coal to liquids
- Oil refinery
- Aluminium and steel
- Power plant related

Industrial processes:
- 7 gas processing projects
- 2 coal to liquids projects
- 3 oil refinery projects
- 1 includes steel and aluminium smelter

Source: Worley Parsons
VARIANCE OF STORAGE

• Capture costs for some industrial processes are not a key capital cost, will focus costs on storage
  ➢ CO2 separation included in design of gas processing, ammonia production

• Variance in storage costs will be key issue for industrial processes
  ➢ Represent a larger portion of costs

• Financial risks and liabilities for storage need to be better understood if industrial projects are to move forward