Global Status of CCS
Do we have a full portfolio?

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IEA Greenhouse Gas R&D Programme

IENE Seminar
The Prospects for CO₂ Capture and Storage in Greece
December 17, 2009, Kozani, Greece
Introduction

- Briefly introduce IEA GHG
- What we need to demonstrate CCS
- Discuss what we have learnt to date
- Look at the forward agenda for CCS.
IEA Greenhouse Gas R&D Programme

• A collaborative research programme founded in 1991
• Aim: Provide members with definitive information on the role that technology can play in reducing greenhouse gas emissions.

• Producing information that is:
  ➢ Objective, trustworthy, independent
  ➢ Policy relevant but NOT policy prescriptive
  ➢ Reviewed by external Expert Reviewers
  ➢ Subject to review of policy implications by Members

• Activities: Studies (>150); R&D networks :- Wells, Risk, Monitoring, Oxy, Capture, Biofixation; Communications (GHGT9, IJGGC, etc); facilitating and focussing R&D and demonstration activities
• Funding approx 2 million €/year (2.6 million $/year).
Contracting Parties and Sponsors

IEA Greenhouse Gas R&D Programme

StatoilHydro
Statkraft
Schlumberger
RWE
Repsol YPF
JGC
Global CCS Institute

VATTENFALL
ALSTOM
B&W
BG GROUP
bp
CEZ GROUP
Chevron
ConocoPhillips

TOTAL
United Kingdom
Canada
Germany
France
China

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Portfolio Approach Required

- Need to ensure all technical combinations are tested and assured
  - All fossil fuels tested in combinations
  - All capture technology options tested and components assured
  - Transmission options tested
  - Likely range of geological storage options tested and geological range assessed
- How can this best be achieved?
What Do We Need To Demonstrate?

- Power Plants
  - 3 main capture technologies
    - Post Combustion
    - Precombustion IGCC
    - Oxyfuel
  - Transport
    - Pipeline
    - Sea borne – regional & Maritime?
- Storage
  - Cover all the options?
- Industry
  - Capture at cement plant
  - Capture at iron & steel
  - Capture at Ammonia plant
  - Capture at Refineries
  - Capture at smelting plant
  - Capture at oil and gas processing plant
Capture & Storage Technical Status

Sleipner capturing and injecting 1Mt/y CO₂ since 1996

Weyburn capturing and injecting 1Mt/y CO₂ since 2000

Rangeley injecting 3 Mt/y CO₂ since 1996

In-Salah capturing and injecting 1Mt/y CO₂ since 2004

Total Anthropogenic CO₂ captured and injected currently 7Mt/y

Snøhvit capturing and injecting 0.7Mt/y CO₂ since 1996
Capture and Transport Technical Status

Pipeline network to capture and supply 1.2Mt/y CO2 by 2010

Permian Basin, 3000km pipeline network operating since mid 80’s

Long distance transport of CO2 by pipeline is established technology

Snohvit 160km Sub sea pipeline

Weyburn 300km transboundary pipeline
What have we learnt to date - projects?

- Review current operational large-scale CCS projects
  - Assess learning from projects
  - Identify gaps in the global CCS project portfolio
- Focus on projects relevant to full-commercial scale operation
  - Includes:
    - Large-scale pilot
    - Demonstration
    - Commercial
  - Excludes
    - Small and medium pilot
    - Lab scale
- Define criteria – Identify projects – Collect information - Analyse
Criteria for large-scale operational projects

- Indicative criteria defined for ‘large-scale operational projects’
- Was, or had been, operational by the end of 2008, and either:-
  - Captured over 10,000 tCO₂ per year from a flue gas
  - Injected over 10,000 tCO₂ per year with the purpose of geological storage with monitoring
  - Captured over 100,000 tCO₂ per year from any source
  - Coal-bed storage of over 10,000 tCO₂ per year
- Commercial CO2-EOR was excluded unless there was a monitoring programme to provide learning
- Did not need to be fully integrated
- Added term ‘large-scale operational’ to IEA GHG Projects Database
### Projects identified

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Plant Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bellingham Cogeneration Facility</td>
<td>IFFCO CO2 Recovery Plant – Aonla</td>
</tr>
<tr>
<td>CASTOR Project</td>
<td>Prosint Methanol Plant</td>
</tr>
<tr>
<td>Great Plains Synfuel Plant</td>
<td>Rangely CO2 Project</td>
</tr>
<tr>
<td>IMC Global Soda Plant</td>
<td>Schwarze Pumpe</td>
</tr>
<tr>
<td>In Salah</td>
<td>SECARB - Cranfield II</td>
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<tr>
<td>K12-B</td>
<td>Shady Point Power Plant</td>
</tr>
<tr>
<td>Ketzin Project</td>
<td>Sleipner</td>
</tr>
<tr>
<td>MRCSP - Michigan Basin</td>
<td>Snohvit LNG Project</td>
</tr>
<tr>
<td>Nagaoka</td>
<td>SRCSP - Aneth EOR-Paradox Basin</td>
</tr>
<tr>
<td>Otway Basin Project</td>
<td>SRCSP - San Juan Basin</td>
</tr>
<tr>
<td>Pembina Cardium Project</td>
<td>Sumitomo Chemicals Plant</td>
</tr>
<tr>
<td>Petronas Fertilizer Plant</td>
<td>Warrior Run Power Plant</td>
</tr>
<tr>
<td>IFFCO CO2 Recovery Plant - Phulpur</td>
<td>Weyburn</td>
</tr>
<tr>
<td>Chemical Co. “A” CO2 Recovery Plant</td>
<td>Zama EOR Project</td>
</tr>
</tbody>
</table>

*Capture over 100ktCO₂*

*Injection over 10ktCO₂ for storage*

*Monitored EOR over 10ktCO₂*

*Capture over 10ktCO₂ from flue gas*

*Coal bed storage over 10ktCO₂*
Project Locations

Capture over 100ktCO₂
Injection over 10ktCO₂ for storage
Monitored EOR over 10ktCO₂
Capture over 10ktCO₂ from flue gas
Coal bed storage over 10ktCO₂

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Extent of coverage - Capture

- 13 plants capturing CO$_2$ from combustion processes
  - 11 post-combustion
  - 1 pre-combustion
  - 1 oxyfuel
- 9 projects source CO$_2$ from industrial processing (Natural gas separation, ammonia, LNG, hydrogen production)
- Multiple fuels represented
  - Hard coal
  - Lignite
  - Natural Gas
  - Industrial processes
- Over 10Mt of CO$_2$ captured per year
Extent of coverage - Transport

• Pipeline
  • Single sink source pipelines
  • Multiple source-multiple sink pipeline networks
• Truck
• Cross-border transport
• Transport over 860km
## Extent of coverage vs ZEP project matrix

<table>
<thead>
<tr>
<th>Archetype 1</th>
<th>Lignite/co-firing with Biomass</th>
<th>Pre-combustion, variant A</th>
<th>Cross-border pipeline</th>
<th>Offshore depleted oil &amp; gas field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Archetype 2</td>
<td>Gas</td>
<td>Post-combustion, variant A</td>
<td>Pipeline</td>
<td>Offshore structural deep saline aquifer</td>
</tr>
<tr>
<td>Archetype 3</td>
<td>Hard Coal</td>
<td>Oxy-fuel, variant A</td>
<td>Ship</td>
<td>Offshore open deep saline aquifer</td>
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<tr>
<td>Archetype 4</td>
<td>Hard Coal</td>
<td>Post-combustion, variant A</td>
<td>Pipeline</td>
<td>Offshore depleted oil &amp; gas field</td>
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<tr>
<td>Archetype 5</td>
<td>Lignite</td>
<td>Oxy-fuel, variant B</td>
<td>Pipeline</td>
<td>Offshore structural deep saline aquifer</td>
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<tr>
<td>Archetype 6</td>
<td>Hard Coal</td>
<td>Pre-combustion, variant B</td>
<td>Pipeline</td>
<td>Offshore depleted oil &amp; gas field</td>
</tr>
<tr>
<td>Archetype 7</td>
<td>Hard Coal</td>
<td>Post-combustion, variant B</td>
<td>Pipeline</td>
<td>Offshore open deep saline aquifer</td>
</tr>
</tbody>
</table>

- **Demonstrated in operational large projects**
- **Not demonstrated in operational large projects**

Porosity Range of large Injection Projects

- Sleipner
- Rangeley
- Snohvit
- Weyburn
- In-Salah

Porosity (%) vs. Project Locations

Min, Typical, Max values for each project.
Extent of coverage - storage

- Data from 13 CO₂ injection projects
- CO₂ has been injected into:
  - Unconsolidated sand bodies offshore (Sleipner)
    - Porosity 37%
  - Both tight sandstone and carbonate reservoirs on shore (In-Salah & Weyburn)
    - Porosities down to 10%
  - Depths ranging from 800 to >3000m
Extent of coverage – injection wells

• Some injection problems identified
  • No insurmountable problems
• Injection wells
  • Single well - Sleipner
  • Multiple distributed wells – Weyburn
  • Both new and existing wells used
Summary

• Projects underway to date have demonstrated:
  • Range of capture options at 1 MT/y scale in power sector and some industry sectors.
  • Pipeline transport of CO₂
  • That injection into a wide range of geological formations is feasible
• This data set is going to expand
New Commercial Scale Developments

- US Regional Carbon Sequestration Programme
  - 9 planned 1Mt/year projects to start before 2011
    - Many are integrated projects

- Planned Aquifer projects in Canada could add 6-8Mt/y CO₂ captured and stored by 2012

Total Anthropogenic CO₂ captured and injected could increase to at least 24Mt/y by 2012

Source: Alberta Research Council

Source: NETL
Planned and Proposed Integrated Demos.
(illustrative as of June 2008)
Integrated Demonstration Plant Initiatives

- European Commission in 2007 set out a plan for 10-12 demonstration plants
  - Draft Storage Directive
  - Programme to monitor demonstrations
- IEA Recommendations to G8
  - Need for 20 demonstration plants by 2020
  - Endorsed by G8 at Hokkaido Summit in Spring 2008
- GCCSI established in 2009 to progress uptake of 20 demonstration projects globally by 2020
IEA CCS Roadmap

Technology Roadmap
Carbon capture and storage
The rationale for CCS

• Without new policies, global emissions increase by 130% by 2050, leading to a 4-7°C temperature rise
• CCS provides one-fifth of the needed CO₂ reductions in 2050
• Without CCS, cost of stabilization rises by 70%
• CCS is the only low-carbon solution for gas/coal, cement, and iron & steel sectors
The ETP BLUE Map Scenario
**CCS deployment in the BLUE Map Scenario**

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Projects</th>
<th>MtCO2/year Captured</th>
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</thead>
<tbody>
<tr>
<td>2010</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2015</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>2020</td>
<td>1000</td>
<td>1000</td>
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<td>2025</td>
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<tr>
<td>2045</td>
<td>6000</td>
<td>6000</td>
</tr>
<tr>
<td>2050</td>
<td>7000</td>
<td>7000</td>
</tr>
</tbody>
</table>

There is an ambitious growth path for CCS from 2010 to 2050.

*Technology Roadmap: Carbon capture and storage*
An ambitious growth pathway

OECD regions must lead in demonstrating CCS, but the technology must quickly spread to the rest of the world.
Thank You!

Happy to take any questions!

For more information on CCS attend:

GHGT-10
19th-23rd September 2010,
Amsterdam, The Netherlands

www.ghgt.info