CO2 Storage
Challenges to the Iron and Steel Industry

John Gale
General Manager
IEA Greenhouse Gas R&D Programme

Steel Institute VDEh Auditorium
Düsseldorf, Germany
8th-9th November 2011
Storage portfolio

- **Technical studies on key issues**
- **International research network series**
  - Learning's from R&D projects and pilot injection projects
    - Modelling of injected CO2
    - Monitoring of injected CO2
      - Monitoring Tool
    - Well bore integrity
    - Risk Assessment
    - Environmental Impacts/Natural Analogues
- **What have we learnt from early commercial CCS projects**
Geological Storage Of CO$_2$

*Injection of a supercritical fluid into the pore spaces of permeable rocks (geological reservoirs)*

- Reverse of oil and gas production
- Oil industry has been injecting fluids into geological reservoirs to assist oil production for many years
- CO2-EOR has been practised in North America since the mid 1980’s
- Storing natural gas in depleted oil and gas fields and deep saline aquifers since 1990’s
The reservoir comprises a reservoir and seal pair
In general a reservoir / seal pair consist of:
- Porous and permeable “reservoir” rock that can contain (a mixture of) gas and liquid
Rocks with porosity of typically 5-30% of volume of the rock
Overlain by a “seal” (non permeable rock) layer
Typical seal permeability is < 0.001 md
How Does the CO₂ Stay Underground?

**Structural Trapping**
- CO₂ moves upwards and is physically trapped under the seals

**Residual storage**
- CO₂ becomes stuck between the pore spaces of the rock as it moves through the reservoir

**Dissolution**
- CO₂ dissolves in the formation water

**Mineralisation**
- The CO₂ can react with minerals in the rock forming new minerals
Commercial Application of CCS (to date)

- **Sleipner**: 1Mt/y CO₂
  - 1996
- **Weyburn**: 2.5 Mt/y CO₂
  - 1998
- **In-Salah**: 1.2 Mt/y CO₂
  - 2002
- **Snohvit**: 0.7Mt/y CO₂
  - 2004
- **Gorgon**: 4Mt/y CO₂
  - 2008

**Pipelines**
- **Sleipner**: 350km overland pipeline
- **Gorgon**: 160km subsea pipeline

**Timeline**

- 1996
  - 1998
  - 2000
  - 2002
  - 2004
  - 2006
  - 2008
  - 2010
  - 2012
  - 2014
  - 2016
  - 2018
Industry considerations

• Need for CCS in steel industry highlighted in global policy studies

• Core business is making steel
  • Same dilemma faced by power sector

• Is there a business case for CCS?
  • Probably not – no price on CO2

• Industry has no experience of transport and storage – same as power sector

• Ideally would like a storage company to handle out of gate storage
  • No market therefore no such companies currently exist
Infrastructure considerations

- Each site will be site specific
- Need a gas gathering system?
  - More than one stack
  - Central capture plant or multiple?
  - Experience from refining industry
- Shipping versus pipelines
  - Site approximate to harbours
  - Experience from projects like ROAD in Rotterdam
Experience to date

Experience from demonstration projects in power sector

- Need to start storage assessments early
- Highest source of project risk
- Large up front cost, which you may lose
  - Who pays for those costs and takes the risks?
- Who undertakes work? – geological surveys or geoengineering contractors
- Biggest issue regarding public acceptance
  - Security of storage issues
Storage Resource

World Emissions

- Highly Prospective Areas
- Prospective Areas
- Non-Prospective Areas

Emission Locations (kT CO₂ per year):
- 1 - 1000
- 1000 - 5000
- 5000 - 10000
- 10000 - 15000
- 15000 - 50000
Storage Resource Issues

**USA & Europe**
- Good storage potential
- Europe – off shore
- USA – on shore
- Competition from other sectors – power sector
- Need to consider transmission network to reservoirs
- Are there suitably large reservoirs?

**Asia**
- Limited storage potential in region
- Transport to other regions – shipping
- Competition from other sectors – power sector
- Need to consider transmission network to distribution terminal
- Are there suitably large reservoirs?
Moving up in scale

- Injection rates on the order of 10 MtCO$_2$/year for many sites;
- CCS infrastructure will need to be of the same scale as that of the current petroleum industry;
  - Management of reservoir pressures (water production) to avoid fracturing, seismic events and impact on resources (both groundwater, petroleum).
  - Need to optimise storage process by:
    - Multi-well injection schemes;
    - Enhancement of dissolution and residual trapping mechanisms to maximise effective storage capacity (co-injection of brine/CO$_2$).
Definition of Injectivity:

- The ability of a geological formation to accept fluids by injection through a well or series of wells.

Many factors effecting injectivity, but primary is bottom-hole pressure, surpassing this pressure limit is likely to lead to migration and leakage.

- Bottom-hole pressure influenced by:
  - Injection rate,
  - Permeability,
  - Formation thickness,
  - $\text{CO}_2$ / brine viscosity,
  - Compressibility.
Existing Injection Strategies

• Snøhvit, Norway, LNG Project.
  • 0.75 Mt/yr CO2 injected through single well into DSF below Jurassic gas reservoir
  • Single well injection, considerable upscale necessary to analogise with commercial CCS projects of the future

• Gorgon, Australia, Offshore Natural Gas Production,
  • Produced gas approx. 14% CO2, removed from gas stream, compressed and transported via 12km pipeline to storage site.
  • Anticipated 9 injector wells, in 3 groups
  • Budget contingency allows for additional wells if necessary.
  • 4.9 Mt/yr CO2 injected, with total projected storage of 125 Mt CO2
  • Water production wells also planned to maximise control of plume, and manage reservoir pressures
Pressure Maintenance - Gorgon Proposal

- 4 water producers
- 9 CO₂ injectors
Conclusions to date

• Pressure build-up is most influential factor on injectivity and storage potential,
• Pressure management will therefore prove a vital element of injection strategies,
• Large scale demonstrations will enhance knowledge and understanding.
• The pure size of future CCS projects might provide unexpected new challenges.
Largest on shore project in planning

Belchatów CCS Project

- 250MW post combustion capture slip stream
- Storage in onshore deep saline formation

858MWe Power Plant near Lodz in Poland
Bełchatów issues

- **Site characterisation programme, 5 years and €7 million**
- **Proposed reservoir is a deep saline aquifer**
  - Area of Karst on top causing seismic issues
  - Inject and monitor in flanks
- **Public opposition to seismic acquisition**
- **Plume could extend 20km**
  - Need a compensation mechanism to cover plume spread
Summary

- **Technology development issues**
  - 10 - 20 years to introduce new technology into industry sectors
  - Technical issues to resolve with oxy blast furnace technology
  - Alternative hot metal production for CCS also under evaluation

- **Transmission**
  - Steel facilities near sea shore/estuaries
    - Large volumes of gas to be transported
    - Multiple stacks, collection/distribution infrastructure required
    - Pipeline or ship transport?

- **Scale**
  - We could be looking at 8 to 30 Mt/CO2/y produced
  - Need large reservoirs to accept this volume of CO2
  - Largest CCS injection so far Gorgon, Australia 4 Mt/y
  - Looked at potential for injection up to 10Mt/y so far
Thank You

Further details can be found at:
www.ieaghg.org
www.ghgt.info