Carbon Capture and Sequestration (CCS)

An Overview of the Opportunities and Challenges

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Today’s Talk

• Climate Problem- Why CCS is essential?
• About the Technology
• Potential Risks
• Key Challenges
• WRI CCS project
Carbon Management Challenge

Gap Analysis: Sources of Mitigation

- CCS
- Coal to Gas Substitution
- Nuclear
- Renewable Energy
- Efficiency
- Emissions

Emissions to the Atmosphere

Trajectory needed for 550 ppm

Business as usual

Billion Tonnes of CO2 per Year

Source: Jae Edmonds, PNNL
Energy from Coal

- Twice as CO$_2$ intensive as natural gas
- Relatively cheap and abundant
- Not yesterday’s fuel – we use it to meet over half of our electricity needs in the U.S.
Electric Power Fuel Variations

Source: IEA, World Energy Outlook 2006
What is CCS?

**Geological Storage Options for CO₂**

1. Depleted oil and gas reservoirs
2. CO₂-driven enhanced oil recovery
3. Deep saline formations
4. Deep unmineable coal seams
5. CO₂-driven enhanced coal bed methane recovery
6. Deep saline filled basalts formations and other formations

IPCC 2005
Diverse CO₂ Source Candidates

1,715 Large Sources
Total Annual Emissions = 2.9 GtCO₂

1,053 electric power plants

259 natural gas processing units
126 petroleum refineries
105 cement kilns
44 iron & steel foundries
38 ethylene plants
34 ethanol production plants
30 hydrogen production
19 ammonia refineries
7 ethylene oxide plants
Potential CO\textsubscript{2} Storage Sites

3,900+ Gt CO\textsubscript{2} Capacity within 230 Candidate Geologic CO\textsubscript{2} Storage Reservoirs

- 2,730 Gt CO\textsubscript{2} deep saline formations
- 900 Gt CO\textsubscript{2} offshore DSFs
- 240 Gt CO\textsubscript{2} basalt formations
- 35 Gt CO\textsubscript{2} depleted gas fields
- 30 Gt CO\textsubscript{2} ECBM
- 12 Gt CO\textsubscript{2} EOR

Batelle, 2006
Key Challenge: Economics


1. Natural gas processing facility with EOR
2. Large coal-fired plant with deep saline injection
3. Large gas plant with deep saline injection

Will Storage be Permanent?

• “For well-selected, designed and managed geological storage sites…the fraction [of CO₂] retained…is very likely to exceed 99% over 100 years and is likely to exceed 99% over 1,000 years.”
  – IPCC Special Report on CO₂ Capture and Storage
Potential Risks

**Local**

- **Groundwater quality degradation**
  - $\text{CO}_2$ and geochemical reaction products
  - Brine or gas displacement, including dissolved or separate phase hydrocarbons
- **Ecosystem degradation**
  - Terrestrial & aquatic plants and animals
- **Public safety**
  - $\text{CO}_2$ exposure during operations or due to leakage from surface and subsurface facilities
- **Structural damage**
  - Induced seismicity
  - Differential land surface subsidence or inflation

**Global**

- Release of $\text{CO}_2$ to the atmosphere may undermine $\text{CO}_2$ mitigation benefits further adding to global warming

Adapted from Wilson, Johnson, et al 2003.
Forming Public Views on CCS

• Local (NUMBY) concerns
  – H&S, property values, cost sharing
• National debate
• Perceived vs. actual risk
• Low awareness of climate change and energy issues/options
  – Importance of successful initial projects

Effects of natural CO$_2$ release in Mammoth Lakes, CA
Current Projects

• Three large scale projects
  – Sleipner: Undersea saline formation off Norway (since 1996)
  – Weyburn: US-Canada partnership, enhanced oil recovery
  – In Salah: depleted natural gas reservoir in Algeria

• DOE regional partnerships
  – Phase Two: 25 small scale projects
  – Phase Three: 7 large scale tests
    • Importance of stressing reservoirs

*Dakota Gasification Plant
Source: NETL*
Key Considerations for Safe and Effective Projects

- Site selection and characterization – most important
- Monitoring, Measurement, and Verification (MMV) during and after injection
- Defining liability and financial responsibility
- Inventory and accounting of stored CO$_2$
- Public understanding and acceptability
- Good policy driver
WRI Project on CCS

- WRI’s mission
- **Objective:** develop guidelines for how CCS projects are done
- Ensure that sequestration is **safe** and **effective**
- Strength through diverse stakeholders
  - Power, oil & gas, financial, research, federal, state, NGO, legal
  - Transparent process
Anticipated Outcomes

• Adaptable guidelines covering entire process chain
  – Capture, transport, site selection, operation, closure, and long-term care
• Begin testing guidelines in field demonstrations in 2008
• Inform regulations and industry “best practice”
Summary

• CCS may be a crucial bridging technology
  – Meet energy needs while reducing GHGs
• Technology largely exists, but policy and regulatory gaps need to be filled.
• Large-scale demonstration projects essential
• High standards necessary

website: carboncapture.wri.org