WORLD RESOURCES INSTITUTE

Carbon Capture and Sequestration (CCS)

An Overview of the Opportunities and Challenges

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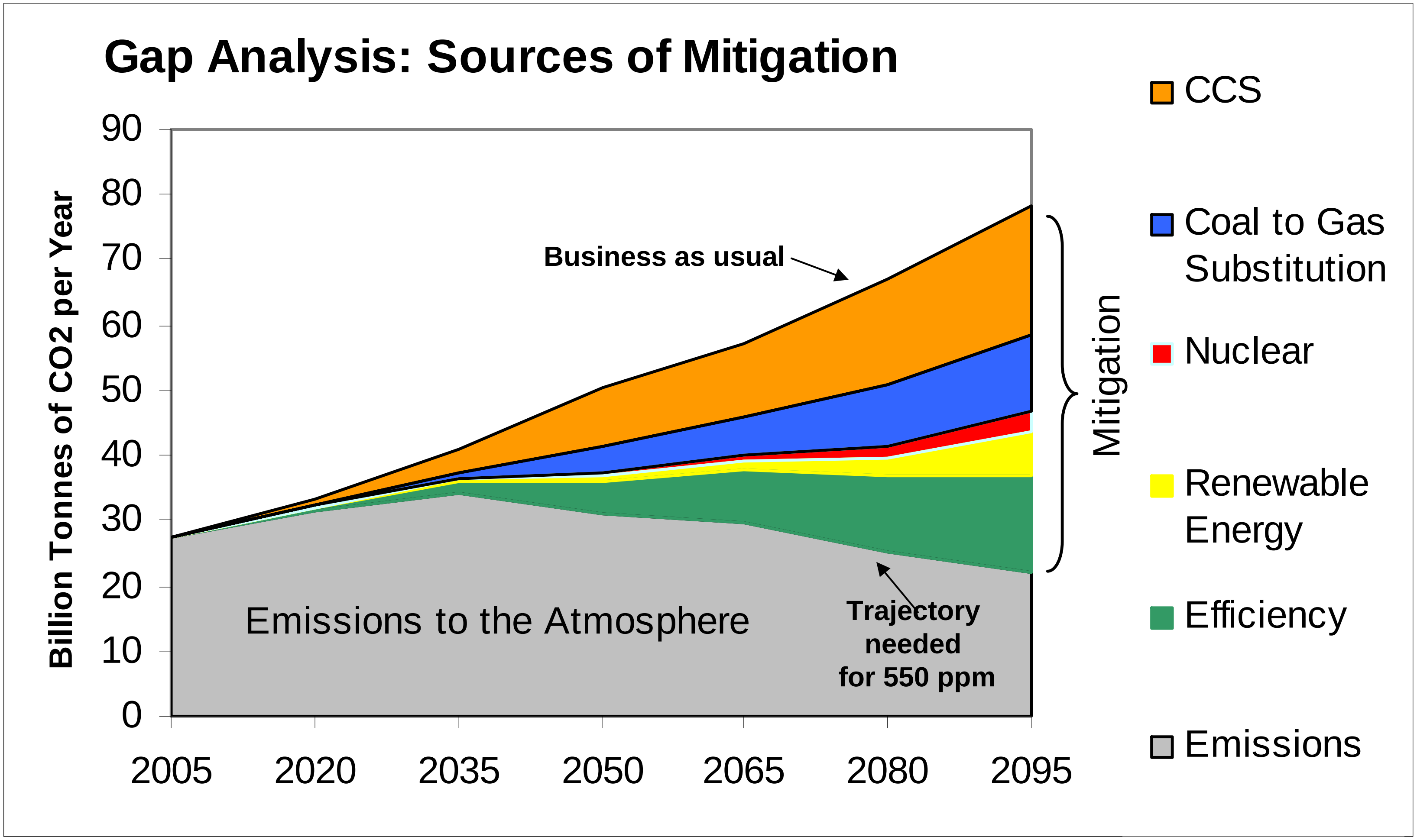
Today's Talk

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

Carbon Management Challenge

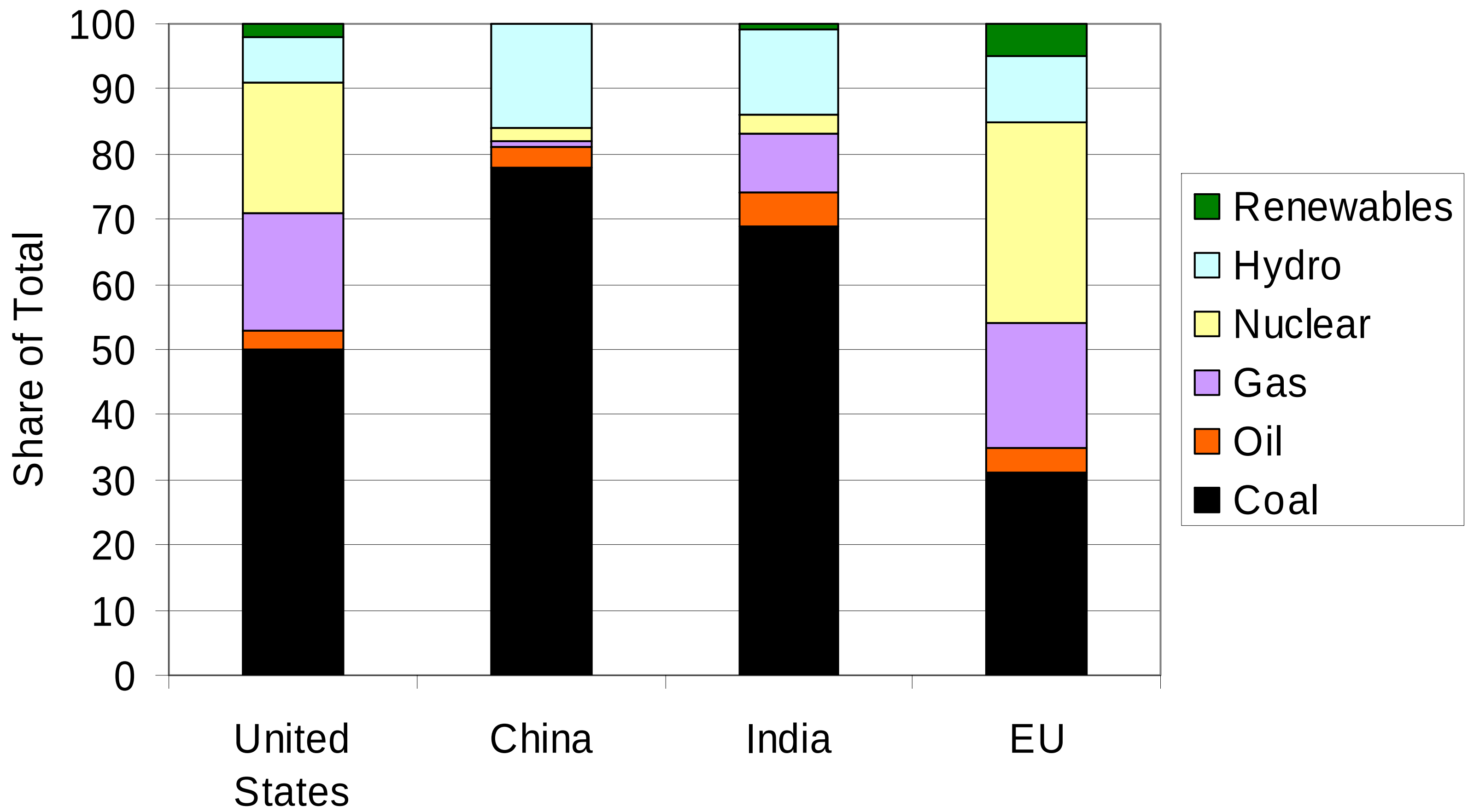


Source: Jae Edmonds, PNNL

Energy from Coal

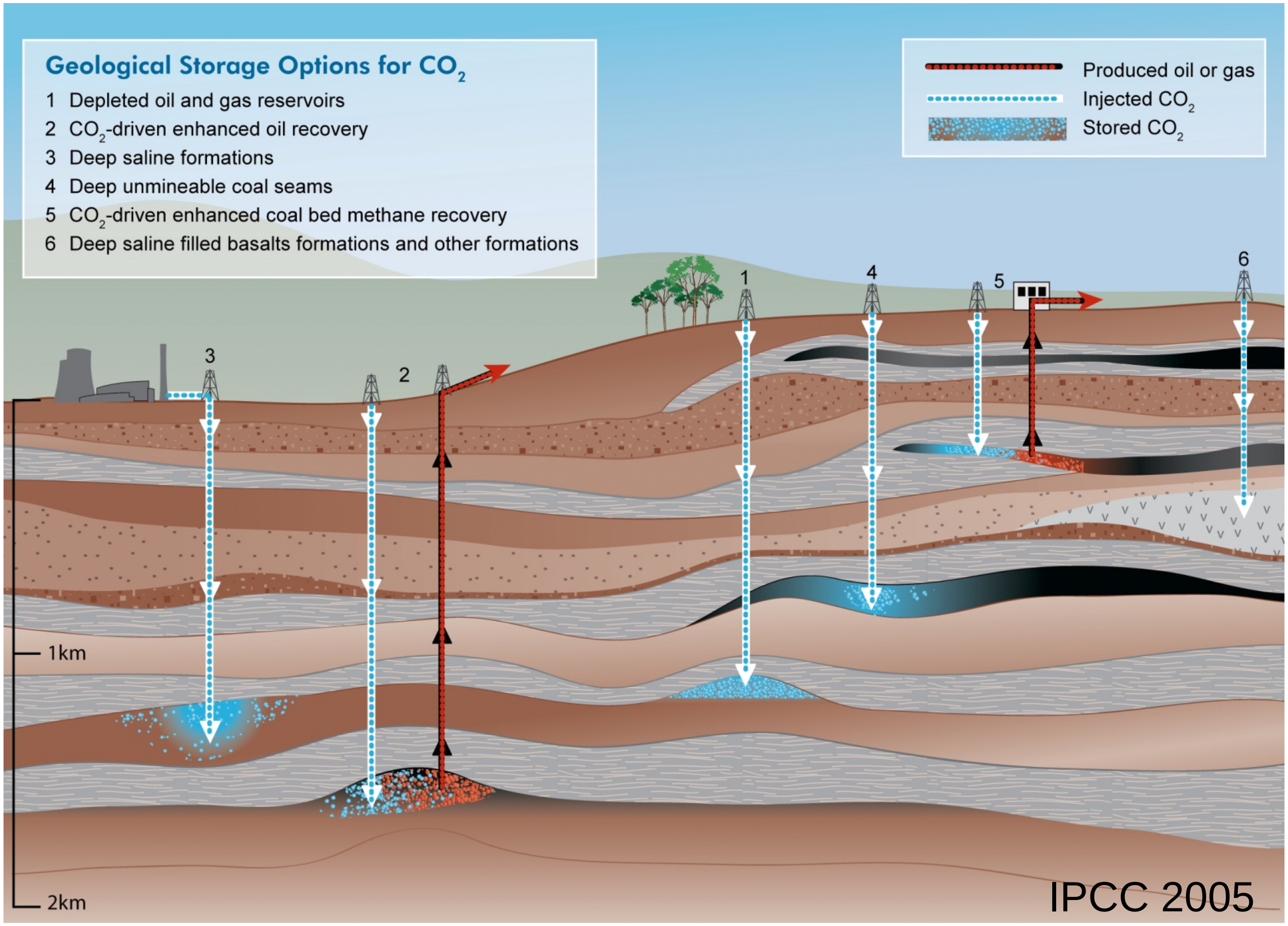
- Twice as CO_2 intensive as natural gas
- Relatively cheap and abundant
- Not yesterday's fuel – we use it to meet over half of our electricity needs in the U.S.

Electric Power Fuel Variations

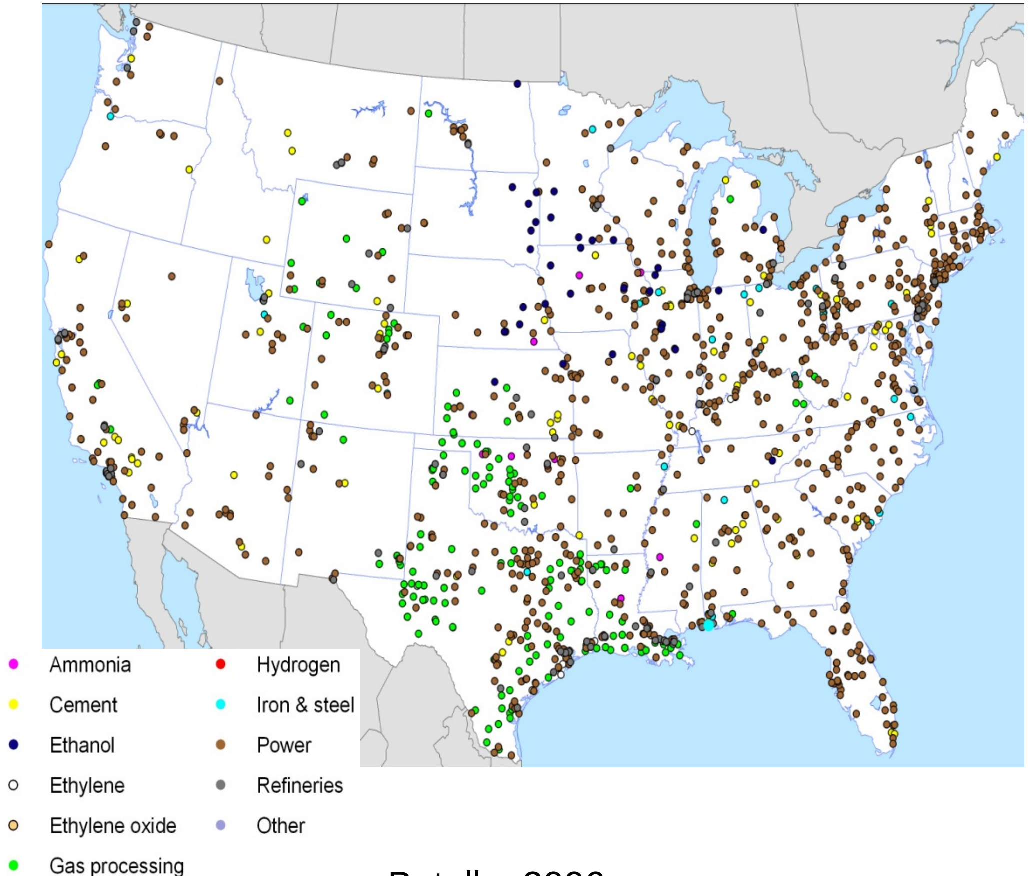


Source: IEA, World Energy Outlook 2006

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
Produced oil or gas
Injected CO2
Stored CO2
1
2
3
4
5
6
1km
2km
IPCC 2005

Diverse CO_2 Source Candidates



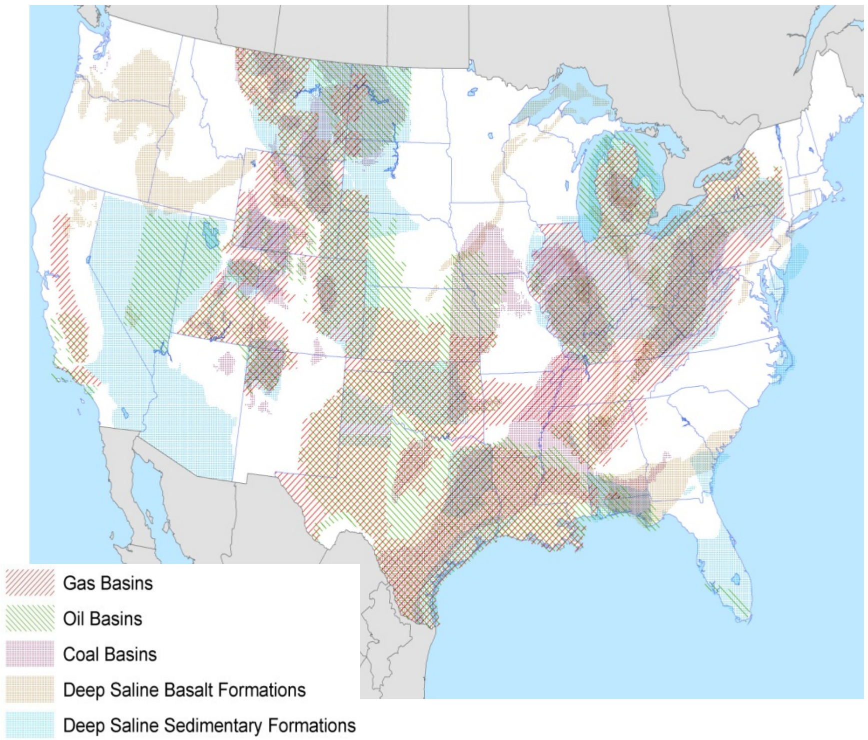
Batelle, 2006

1,715 Large Sources
Total Annual Emissions = 2.9 $GtCO_2$

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_2 Storage Sites

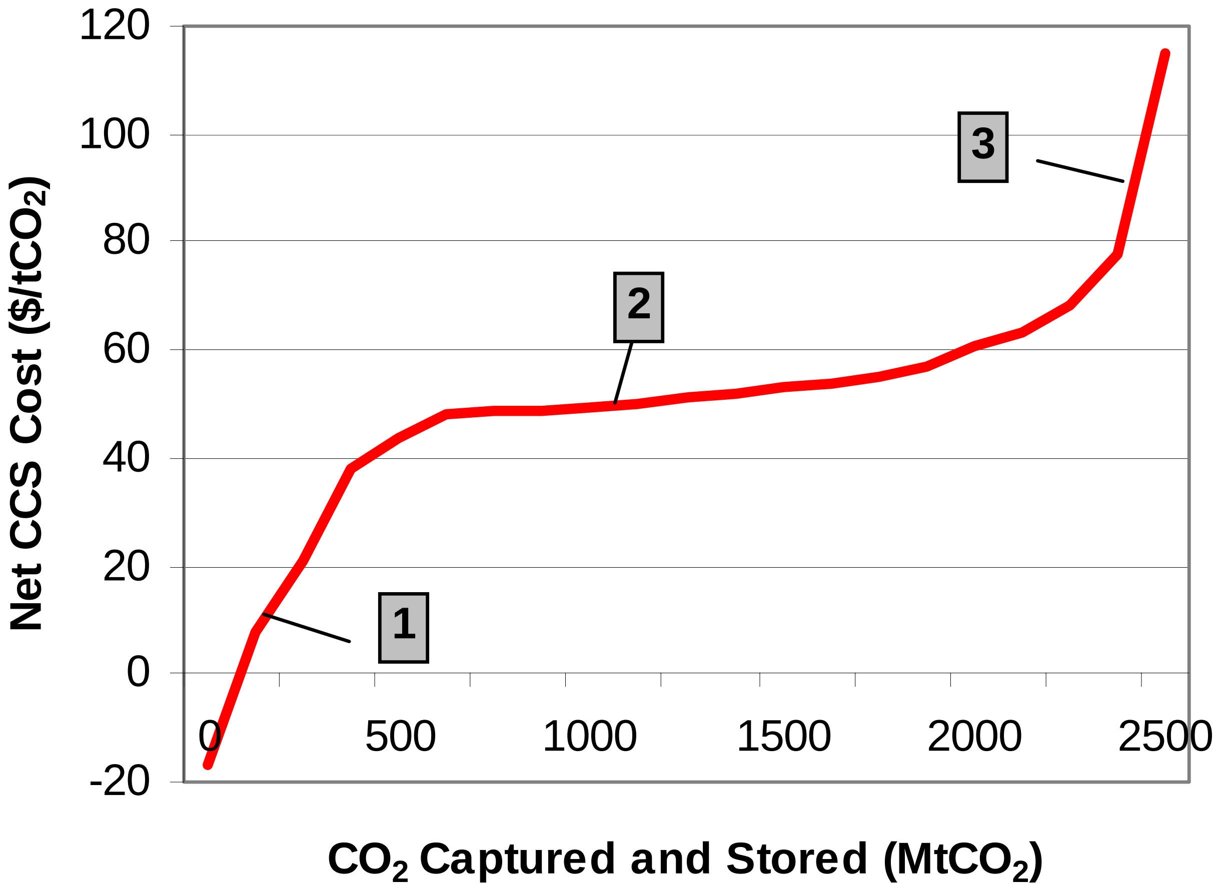


3,900+ Gt CO_2 Capacity within 230 Candidate Geologic CO_2 Storage Reservoirs

2,730 Gt CO_2	deep saline formations
900 Gt CO_2	offshore DSFs
240 Gt CO_2	basalt formations
35 Gt CO_2	depleted gas fields
30 Gt CO_2	ECBM
12 Gt CO_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**

Source: Battelle, Carbon dioxide capture and storage, 2006.

Will Storage be Permanent?

- "For well-selected, designed and managed geological storage sites…the fraction [of CO_2] retained…is *very likely* to exceed 99% over 100 years and is *likely* to exceed 99% over 1,000 years."
  - – IPCC Special Report on CO_2 Capture and Storage

Potential Risks

<u>Local</u>

- Groundwater quality degradation
  - 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
  - CO_2 exposure during operations or due to leakage from surface and subsurface facilities
- Structural damage
  - Induced seismicity
  - Differential land surface subsidence or inflation

<u>Global</u>

- Release of CO_2 to the atmosphere may undermine 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 project are done
- Ensure that sequestration is <u>safe</u> and <u>effective</u>
- 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