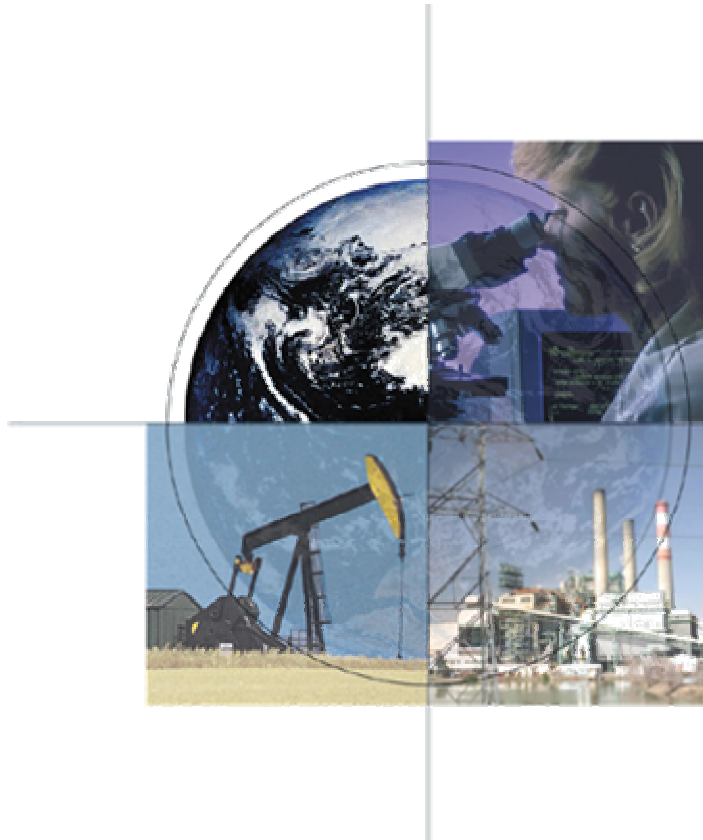


U.S. DOE Field Efforts Sequestering CO₂ in Geologic Formations



*SPE 2003 Eastern
Section Meeting of AAPG*

*September 6 - 10, 2003
Pittsburgh, Pennsylvania*

Scott M. Klara - National Energy Technology Laboratory

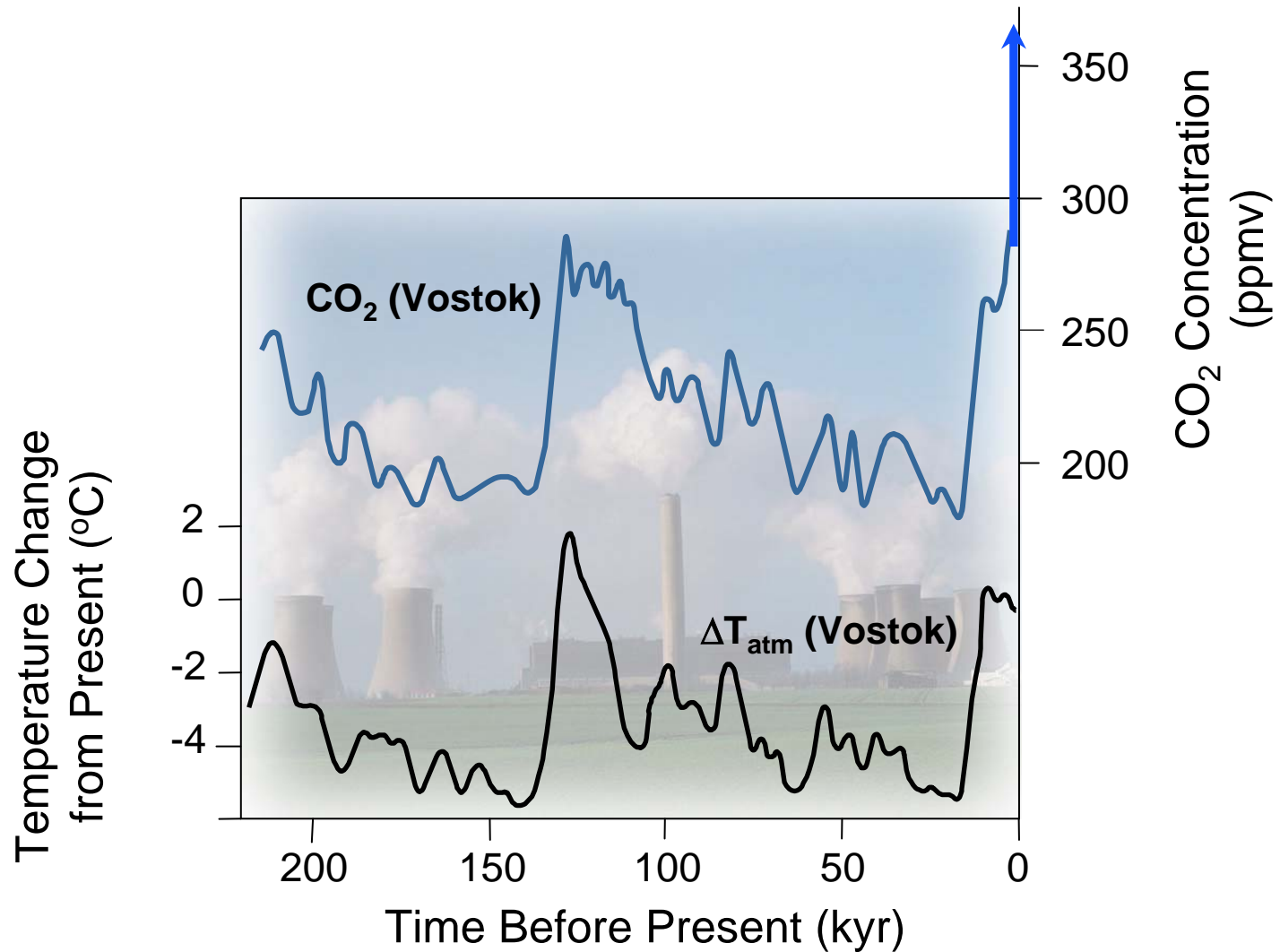


What's All The Fuss About?



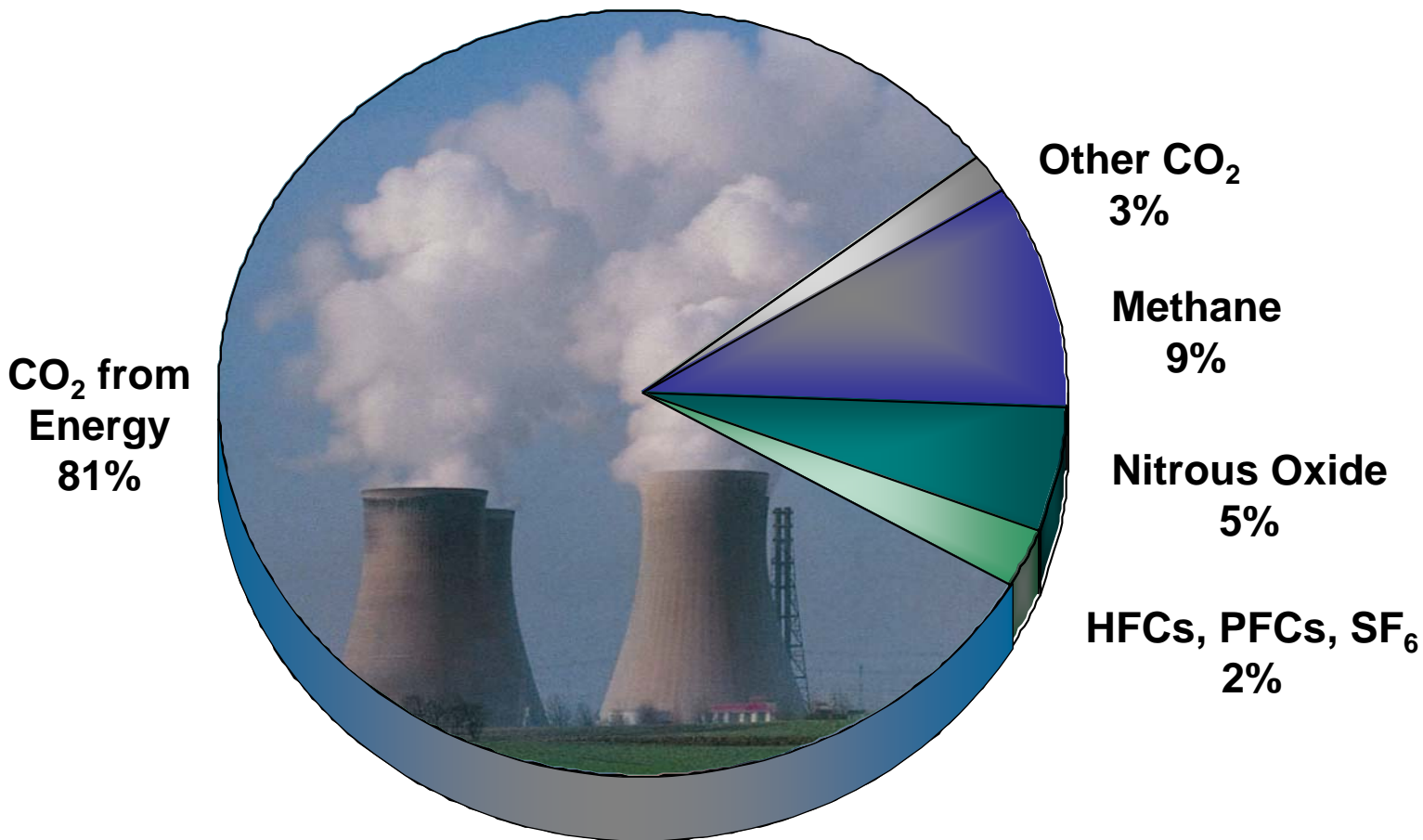
CO₂ Concentrations On The Rise

(~280 ppm to 370 ppm over last 100 years)



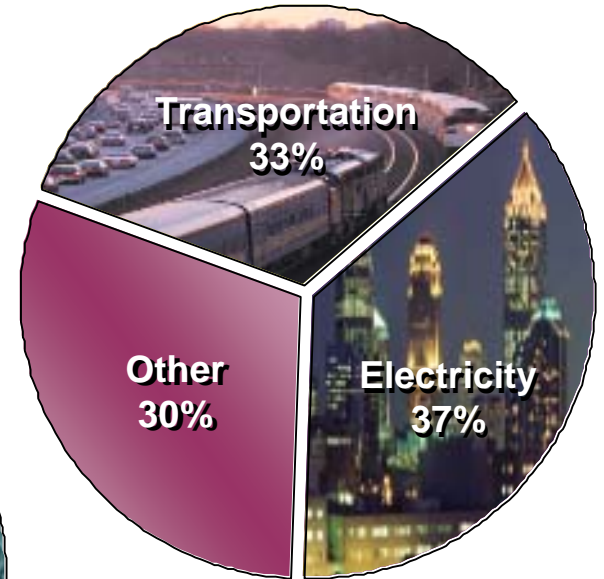
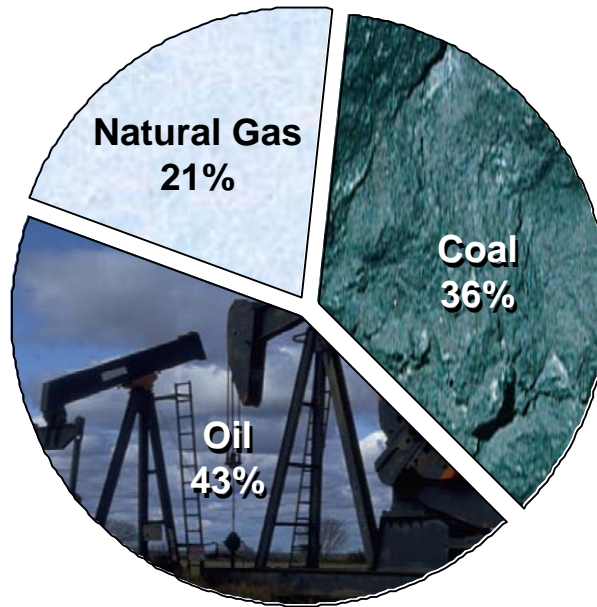
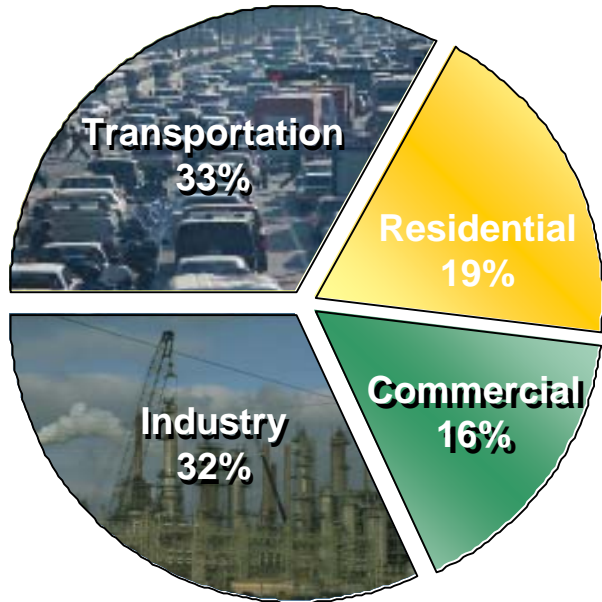
CO₂ & CH₄ - The Primary GHG Contributors

United States Greenhouse Gas Emissions
(Equivalent Global Warming Basis)



All Fossil Fuels & Energy Sectors Contribute CO₂ Emissions

United States Carbon Dioxide Emissions
(By Source & Sector)

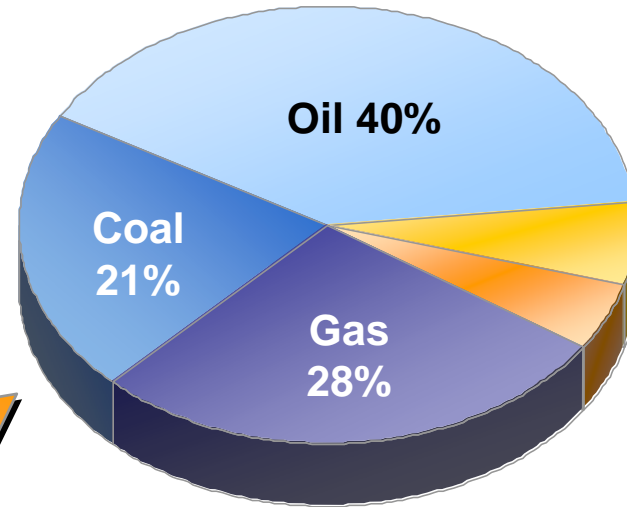
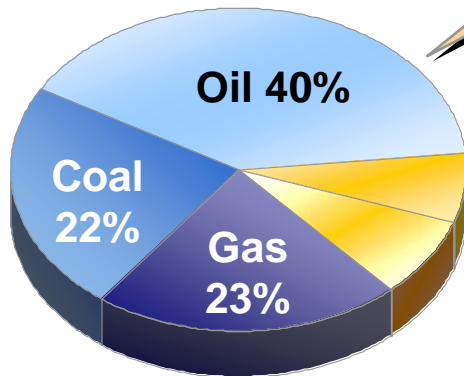


Fossil Energy - America's Energy Foundation

1999

96.1 Quads

Fossil fuels provide 85% of energy (67% of electricity)



2020

127.0 Quads

By 2020, reliance on fossil fuels could grow to 90%



Enter....

Carbon Sequestration

“Pathways to GHG Stabilization”



Technological Carbon Management Options

Reduce Carbon Intensity

- Renewables
- Nuclear
- Fuel Switching

Improve Efficiency

- Demand Side
- Supply Side

Sequester Carbon

- Capture & Store
- Enhance Natural Sinks

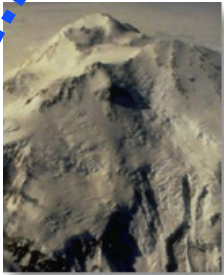
All options needed to:

- Affordably meet energy demand
- Address environmental objectives



Approaches to Sequester Carbon

Capture and Storage



Unmineable
Coal Seams



Ocean Uptake



Depleted Oil /
Gas Wells,
Saline Reservoirs



Mineral
Carbonation

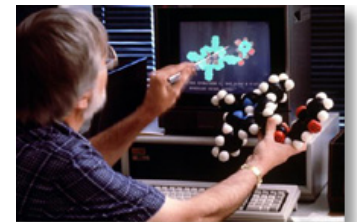


Iron or Nitrogen
Fertilization of
Ocean

Enhance Natural Processes



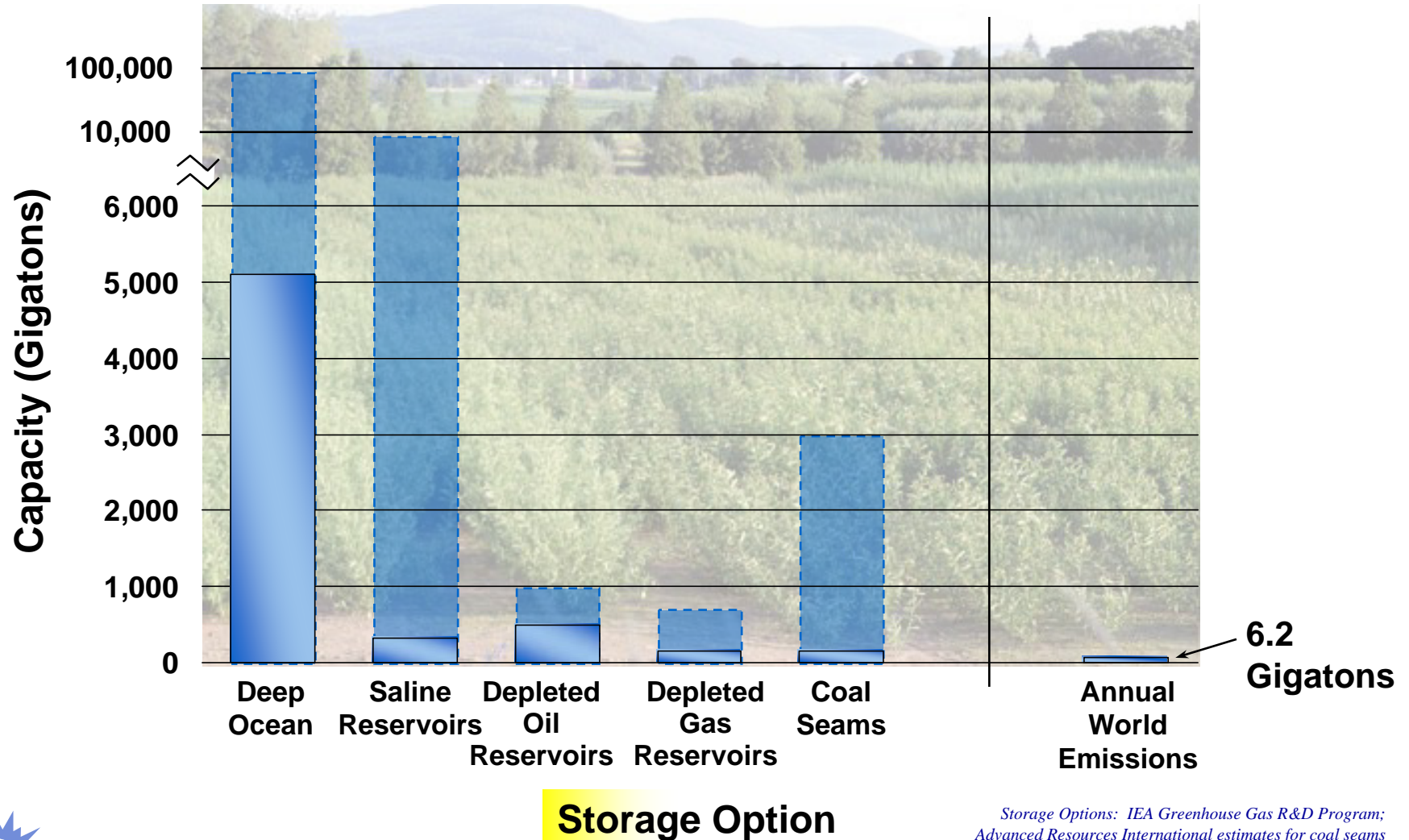
Forestation



Enhanced
Photosynthesis



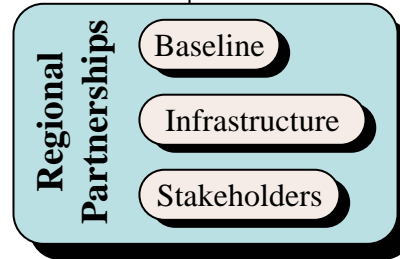
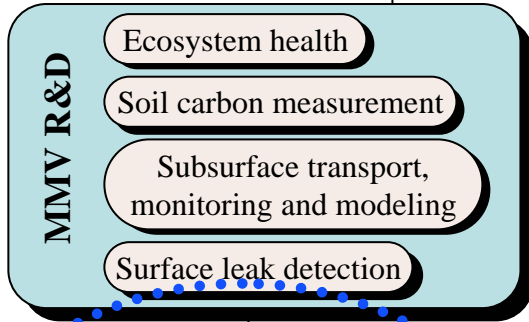
Large Potential Worldwide Storage Capacity



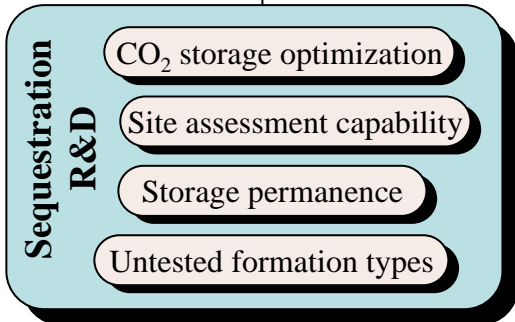
Storage Options: IEA Greenhouse Gas R&D Program;
Advanced Resources International estimates for coal seams
World Emissions: International Energy Outlook 2000, Table A10

Carbon Sequestration Roadmap

Regulatory Approval and Compliance, Acceptance in GHG Trading Context



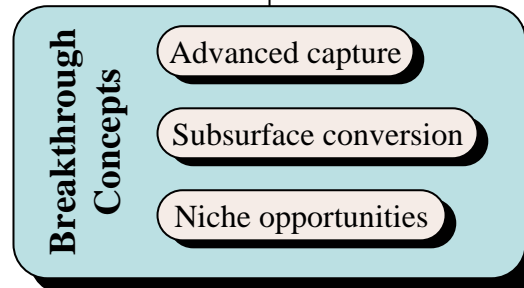
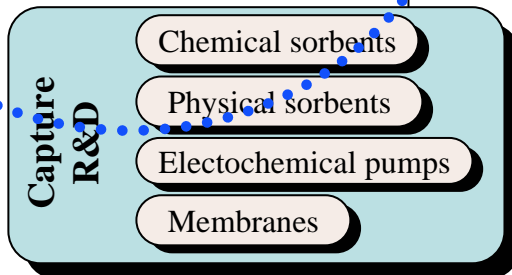
Sequestration Field Tests



Integration of CO₂ Capture and Storage

Commercial Ready Sequestration Systems

Pilot-scale CO₂ Capture Tests



Integration of CO₂ Capture with SO_x, NO_x, and Hg Control

2002

2015



Issues: *Sequestration*

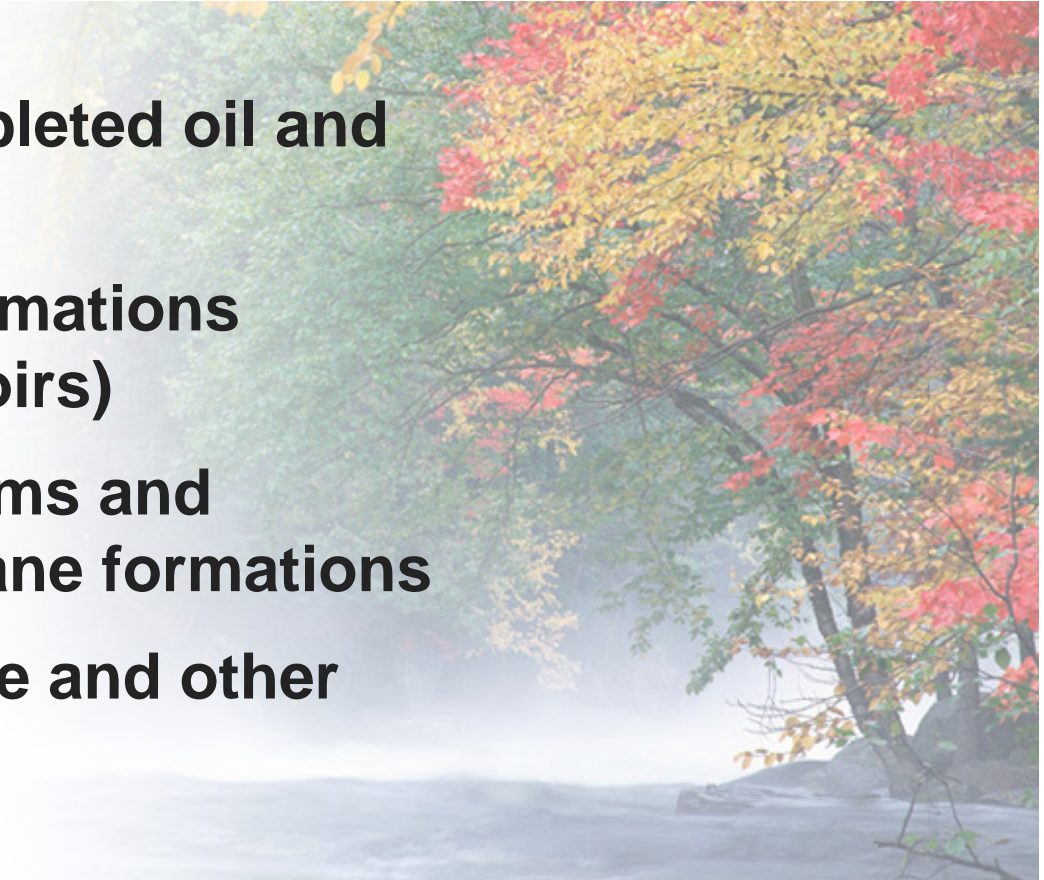
- Health, safety, and environmental risks
- Permanence and large-scale verification
- Capacity evaluation
- Infrastructure
- Uncertain regulatory frameworks
- Protocols for identifying amenable storage sites

- Direct CO₂ storage
- Enhanced natural sinks



Sequestration in Geologic Formations Builds on a Strong Industry Experience Base

- Active and depleted oil and gas reservoirs
- Deep brine formations (saline reservoirs)
- Deep coal seams and coalbed methane formations
- Devonian shale and other formations



Studying Natural Gas Storage and Natural CO₂ Analogs in Geologic Formations

- Provides experience and demonstrates the feasibility of the geologic trapping mechanisms for use in sequestering CO₂ emissions
- Reservoir *Examples:*
 - McElmo Dome
 - Bravo Dome
 - St John's Field

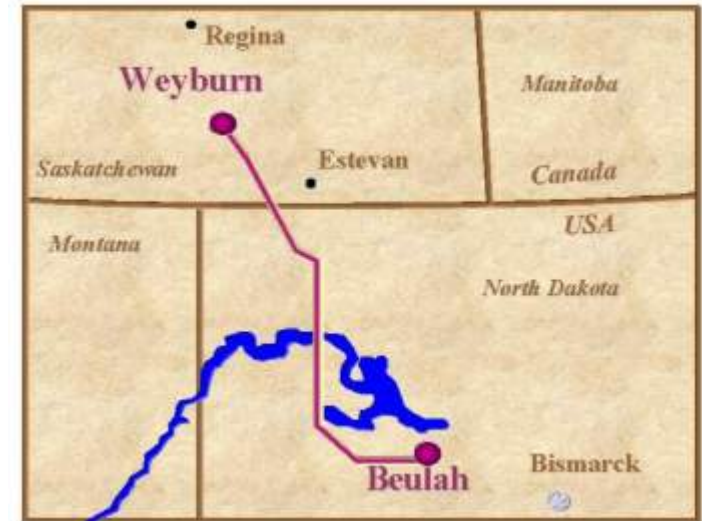


Large Field Demonstrations

(1 Million TPY CO₂, ~ 150 MW Coal Power Plant)

Weyburn CO₂ EOR Project

- Pan Canadian Resources
- 204-mile CO₂ pipeline from Dakota Gasification Plant
- 130M barrels oil over 20-year project



Sleipner North Sea Project

- Statoil
- Currently monitoring CO₂ migration
- \$80M “incremental cost”
- \$35/ ton CO₂ tax



Texas Field Test

Saline Aquifer – Frio Formation

- Drilling new well by year's end at depth ~5000 ft near Houston, Texas
- Characterizing formation using seismic, logging and reservoir modeling techniques
- Investigating injectivity, safety, capacity & permanence
- Plan to inject 3000 tons CO₂ & extensively monitor



Participants: Texas BEG, TARC, BP, Schlumberger, Sandia, LBNL, LLNL, ORNL, NETL



West Virginia Field Test

Saline Aquifer – Mt. Simon Sandstone

- Completed new well to 9172 ft in New Haven, West Virginia
- Characterizing formation using seismic, logging and reservoir modeling techniques
- Developing comprehensive monitoring plan
- Investigating injectivity, safety, capacity & permanence
- No current plans for CO₂ injection



Participants: Battelle, AEP, PNNL, BP, OCDO, Schlumberger, OGS, WVU

New Mexico Field Test

Depleted Oil Reservoir

- Injected 2100 tons of CO₂ over two months
- Six month soak of CO₂
- Currently tracking CO₂ plume using seismic and reservoir modeling techniques
- Plan to prepare best practice guidelines for injection, monitoring & verification
- West Pearl Queen reservoir near Roswell, New Mexico



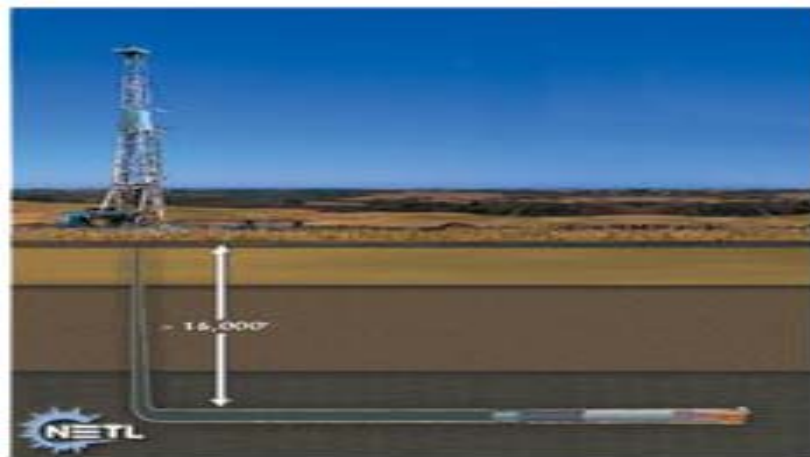
Participants: Strata, Pecos, NMTech, Sandia, LANL, NETL



West Virginia Field Test

Coal Formation - Enhanced Coalbed Methane Recovery

- Demonstrate CO₂ enhanced coal seam methane production using slant hole drilling
- Demonstrate permanence of CO₂ sequestration & value added methane recovery
- Coal seam 1200-1300 ft deep & about 4 feet thick
- Up to 26,000 tons of CO₂ to be injected
- Marshall County, West Virginia



Participants: CONSOL & Subsidiaries



Questions ?

