Overview of the Regional Carbon Sequestration Partnerships Program

WESTCARB 2007 Annual Business Meeting

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Office of Fossil Energy

Technological Carbon Management Options

Pathways for Reducing GHGs -CO_2

Reduce Carbon Intensity

- Renewables
- Nuclear
- Fuel Switching

Improve Efficiency

- Demand Side
- Supply Side

Sequester Carbon Dioxide

- Enhance Storage in Natural Ecosystems
- Capture and Underground Storage

All options needed to:

- Affordably meet energy demand
- Address environmental objectives

What is Carbon Sequestration?

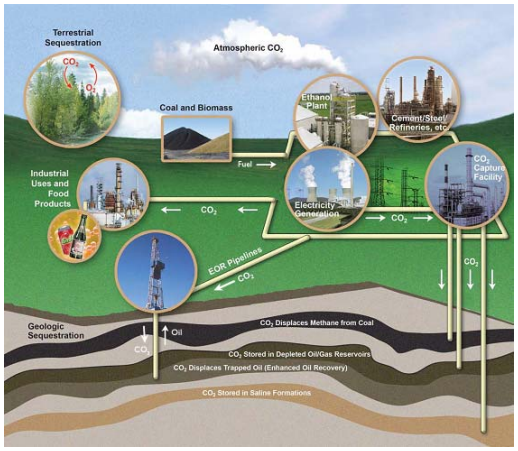
Capture and storage of CO_2 and other Greenhouse Gases that would otherwise be reach the atmosphere…

Capture of CO_2 can occur:

- at point of emission
  - – increases cost of energy 25-80%
  - – transportation requirements
- when absorbed from air by natural ecosystems

Storage locations include:

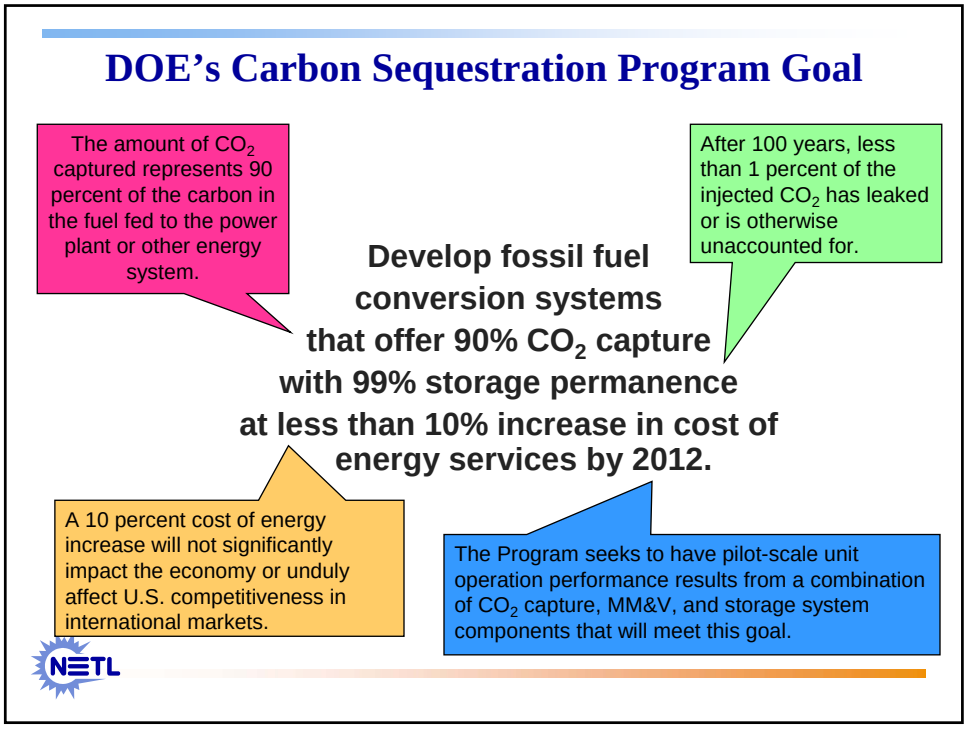
- deep underground formations – *Geologic Sequestration*
- trees, grasses, soils, or algae – *Terrestrial Sequestration*



Overcoming Barriers to Carbon Capture and Storage (CCS)

- **Capture Costs**
  - – Capital Investments
  - – Increases in COE
- **Lack of Infrastructure**
- **Regulatory Requirements**
- **Public Acceptance**
- **Human Capital Resources**

- **DOE/FE—NETL Sequestration Program is overcoming these barriers through:**
  - – Core R&D
  - – Technology/Infrastructure Development
  - – Government/Industry Partnerships
  - – International Collaborations


DOE's Carbon Sequestration Program Goal
The amount of CO_2 captured represents 90 percent of the carbon in the fuel fed to the power plant or other energy system.
After 100 years, less than 1 percent of the injected CO_2 has leaked or is otherwise unaccounted for.
Develop fossil fuel conversion systems that offer 90% CO_2 capture with 99% storage permanence at less than 10% increase in cost of energy services by 2012.
A 10 percent cost of energy increase will not significantly impact the economy or unduly affect U.S. competitiveness in international markets.
The Program seeks to have pilot-scale unit operation performance results from a combination of CO_2 capture, MM&V, and storage system components that will meet this goal.
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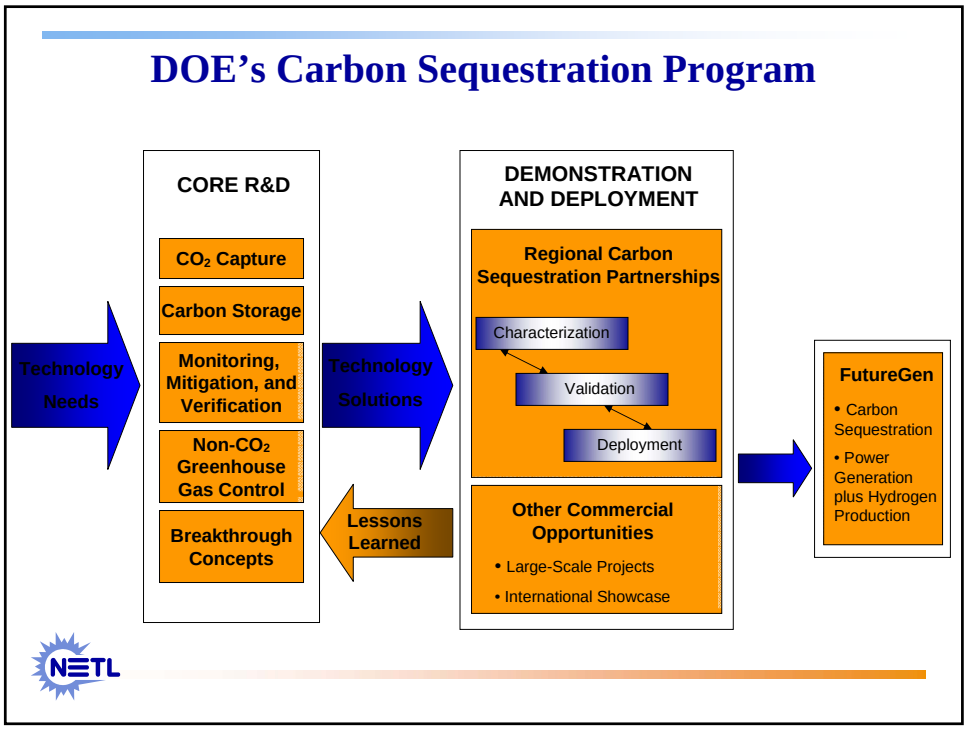
DOE's Carbon Sequestration Program
CORE R&D
CO_2 Capture
Carbon Storage
Monitoring, Mitigation, and Verification
Non-CO_2 Greenhouse Gas Control
Breakthrough Concepts
Technology Needs
Technology Solutions
Lessons Learned
DEMONSTRATION AND DEPLOYMENT
Regional Carbon Sequestration Partnerships
Characterization
Validation
Deployment
Other Commercial Opportunities
• Large-Scale Projects
• International Showcase
FutureGen
• Carbon Sequestration
• Power Generation plus Hydrogen Production
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Summary of Core R&D Capture Activities

Pathways
- Post-combustion
- Pre-combustion
- Oxy-combustion
- Optimized engineering

Technologies
- Absorption
- Adsorption
- Membranes
- Chemical looping
- Oxygen-fired Combustion

System Analyses

Researching Cost-Effective Technologies for CO_2 Capture

Summary of Storage R&D Activities

Terrestrial Storage Sinks
- Mined Lands
- Agricultural Soils
- Afforestation

Geologic Storage Sinks
- Oil and Gas Bearing Formations
- Saline Formations
- Unmineable Coal Seams
- Oil and Gas Rich Shales
- Basalts

Research Pathways
- Trapping mechanisms
- Modeling
- Well integrity
- Tree planting
- Soil reclamation
- No-till farming
- Afforestation

Technologies to Cost-Effectively Store CO_2 in Geologic Formations and Terrestrial Systems

Monitoring, Mitigation, and Verification

Providing accurate accounting of stored CO_2 and high level of confidence that the CO_2 will remain sequestered permanently

Geologic Formations

- **CO_2 fate and transport models – simulating underground conditions that influence behavior of CO_2**
- **Plume tracking – map injected CO_2 and track its movement**
- **CO_2 leak detection – critical measurements of whether CO_2 is escaping from storage reservoir**
- **Mitigation- steps to be taken to arrest the flow of CO_2 and mitigate the impacts**

Terrestrial Ecosystems

- **Organic matter measurement – reducing cost for measuring carbon in terrestrial ecosystems and analyzing soil samples**
- **Soil carbon measurement – automated technologies for measuring soil carbon**
- **Modeling – extrapolating results of carbon uptake activities from random samples to entire plots for estimating net increase in carbon**

Non-CO_2 Greenhouse Gas Mitigation

Mitigation of non-CO_2 GHGs is integrated with energy production, conversion, and use

Pathways

- **Landfill Gas**
  - Methane oxidation
    - Bacterial tarp
  - Methane/CO_2 separation
    - Use of landfill gas for ECBM
  - Methane generation control
    - Water and microbe management
- **Coal Mine Methane**
  - Methane oxidation
    - Catalytic oxidation
  - N_2/methane separation
    - Thermal swing adsorption

Breakthrough Concepts

Breakthrough concepts is the portion of the core R&D portfolio devoted to revolutionary and transformational approaches to carbon sequestration

Pathways

- **Advanced CO_2 Separation**
  - Hydrogen selective silica membrane
  - Dual function membrane
  - Design of CO_2 adsorbents
  - Solvents for CO_2 capture
  - Novel membranes
- **Advanced Subsurface Technologies**
  - Carbonate sediments below the sea floor
  - Mineral dissolution kinetics
  - Mineral carbonation

Regional Carbon Sequestration Partnerships

westcarb.org	California Energy Commission http://www.westcarb.org/
Southwest Regional Partnership on Carbon Sequestration	New Mexico Institute of Mining and Technology http://www.southwestcarbonpartnership.org/
BIGSKYCARBON SEQUESTRATION PARTNERSHIP	Montana State University http://www.bigskyco2.org/
The Plains CO_2 Reduction Partnership PCOR	University of North Dakota, Energy & Environmental Research Center http://www.undeerc.org/pcor/
MGSC	University of Illinois, Illinois State Geological Survey http://www.sequestration.org/
MRCSP	Battelle Memorial Institute http://www.mrcsp.org/
Southeast Regional Carbon Sequestration Partnership	Southern States Energy Board http://www.secarbon.org/

Characterization Phase

- **24 months (2003-2005)**
- **7 Partnerships (41 states)**

Validation Phase

- **4 years (2005 - 2009)**
- **Field validation tests**
  - 25 Geologic
  - 11 Terrestrial

Deployment Phase

- **10 years (2008-2017)**
- **Seven large volume injection tests**

Characterization Phase Accomplishments

Characterized opportunities for capture and storage of carbon dioxide in North America

Developed National Carbon Sequestration Atlas and Geographic Information System (NatCarb)

Completed regulatory review and gap analysis – IOGCC Report 2005

Public outreach

- Documentary of Carbon Sequestration
- Focus groups used to gauge public opinion
- Outreach materials - websites and fact sheets

Developed regional action plans for regulatory permitting, MMV, outreach, and project implementation

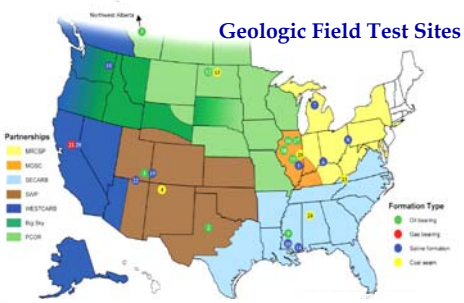
Identified promising opportunities for validation phase

Validation Phase Field Tests

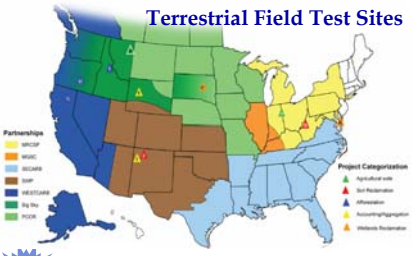
Geologic Tests (25 injection tests)

- Validating geologic formation capacities
- Validating injectivity
- Monitoring mitigation and verification technologies (reservoir modeling)
- Permitting requirements
- Public outreach and perception
- Testing formation seals
- Investigating well bore construction methods

Geologic Field Test Sites



Terrestrial Field Test Sites



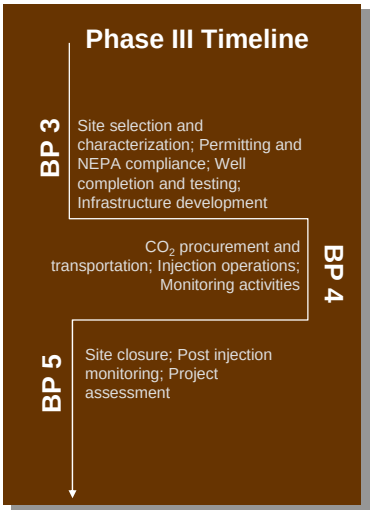
Terrestrial Tests (11 field tests)

- Tree-plantings
- No-till farming
- Wetlands restoration
- Land management: grasslands, grazing lands
- Fire management
- Forest preservation
- Monitoring, mitigation, and verification technologies
- Accounting protocols for trading markets (CCX)

Deployment Phase

Scaling Up Towards Commercialization

- **FY 2008-2017 (10 years)**
- **Several Large Volume Sequestration tests in North America (3 have been awarded)**
- **Injection rates from 250,000 to 1 million tons per year for several years**
- **Scale up is required to provide insight into several operational and technical issues in different formations**



Deployment Phase

Sources and Sinks

- **Sources**
  - Anthropogenic
  - High purity industrial vents
  - Natural vents
- **Transportation**
  - Pipeline
  - Truck and Rail (cost prohibitive)
- **Sinks**
  - Geologic formations representative of region: EOR and Saline
  - Competent seals
  - Capacity and availability is high

Deployment Phase

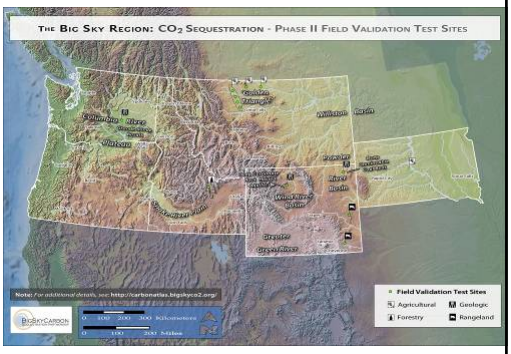
Outcomes

- **Site characterization requirements**
- **Storage resource (moving towards capacity) assessment**
- **Design criteria**
  - Injection wells
  - Regional monitoring, mitigation, and verification program
  - Site Closure
- **Permitting requirements**
- **Validate reservoir and risk assessment models**
- **Accelerate public outreach**
- **Best practice manuals**

Big Sky Regional Carbon Sequestration Partnership

Montana State University, Bozeman

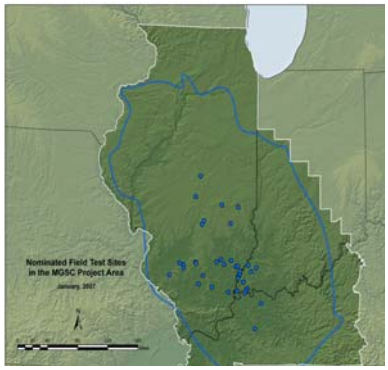
- **Partnership covers 6 states (Montana, Idaho, South Dakota, Wyoming, Eastern Oregon and Washington)**
- **60 Partners**
- **Extensive Reactive Carbonate and Basalt Formations**
- **Geologic Sequestration Tests**
  - Pilot injection (SW Wyoming)
  - Kevin Dome characterization study (north central Montana)
  - Basalt characterization (eastern Washington)
- **Several Terrestrial field tests planned**
  - No-till agriculture
  - Reforestation
  - Rangeland restoration



Midwest Geological Sequestration Consortium

Illinois State Geological Survey

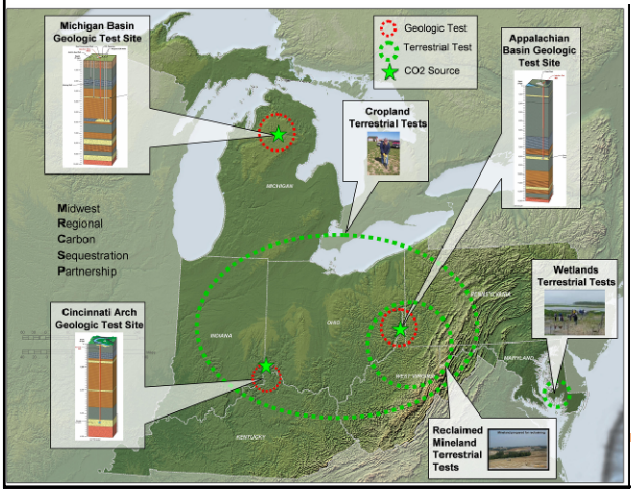
- **Covers Illinois Basin, Illinois, Kentucky, and Indiana**
- **Value added products**
- **Six field tests proposed within the Illinois Basin**
  - EOR
  - ECBM
  - Deep saline
- **Conducting structural characterization using seismic assessments**
- **Injected at Huff and Puff site**



Midwest Regional Carbon Sequestration Partnership

Battelle Laboratories

- **Covers 8 states: Indiana, Kentucky, Maryland, Michigan, New York, Ohio, Pennsylvania, and West Virginia**



- **30 Partners**
- **Geologic Field Tests**
  - Appalachian Basin
  - Cincinnati Arch
  - Michigan Basin
- **Injection expected in Michigan Nov 07**

Plains CO_2 Reduction Partnership

UND, Energy and Environmental Research Center

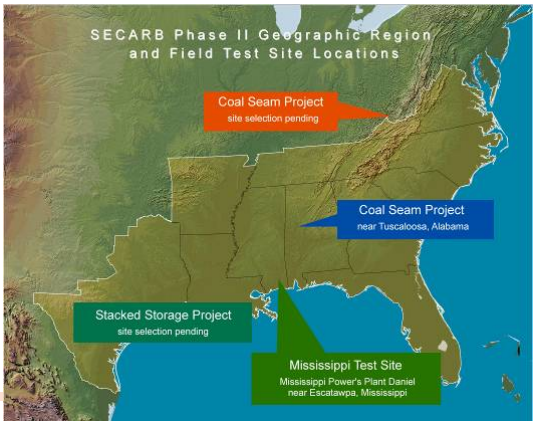
- **Partnership covers 9 states** (Montana, North Dakota, Minnesota, Wisconsin, South Dakota, eastern Wyoming, Nebraska, Iowa, and Missouri) **and 3 Canadian Provinces** (eastern British Columbia, Saskatchewan, and Alberta)

- **70 partners**
- **Geologic Demonstrations**
  - Williston Basin, North Dakota. CO_2 injection site for CO_2 sequestration and EOR in deep carbonate (~10,000 ft)
  - Zama, Alberta. acid gas Injection site for CO_2 sequestration and EOR begun
  - Lignite coal in North Dakota. CO_2 injected into an unminable lignite coal seam for CO_2 sequestration and possible ECBM production – Wells completed

Southeast Regional Carbon Sequestration Partnership

Southern States Energy Board

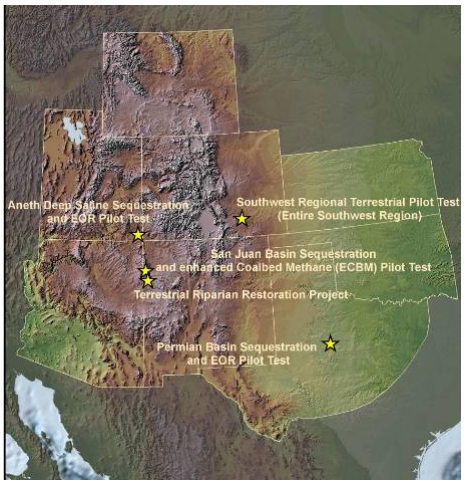
- **Partnership includes Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia**
- **Nearly 30% of national CO_2 emissions from the region**
- **Geologic Sequestration Tests**
  - Two coal bed storage tests in Alabama and Appalachia
  - Stacked storage test along gulf coast – EOR/Saline
  - Deep saline test in Mississippi



Southwest Partnership on Carbon Sequestration

New Mexico Institute of Mining and Technology

- **Partnership covers 8 states: New Mexico, Arizona, Colorado, Oklahoma, Utah, and portions of Kansas, Nevada, Texas, and Wyoming**
- **21 Partners**
- **30 year history of CO_2 EOR and CO_2 transportation**
- **Geologic Sequestration Tests**
  - 2 CO_2 Sequestration/ EOR Recovery Tests in the Paradox and Permian basins
  - 1 Coal bed sequestration and methane recovery test
- **Terrestrial Sequestration**
  - Riparian restoration and regional assessment



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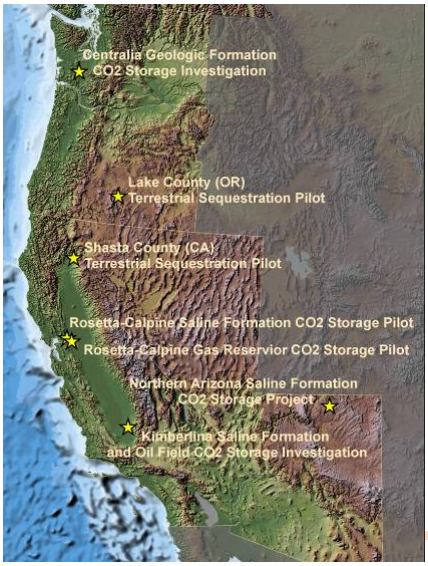
West Coast Regional Carbon Sequestration Partnership

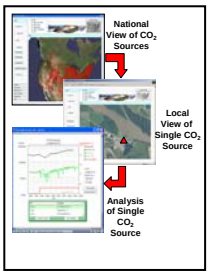
California Energy Commission



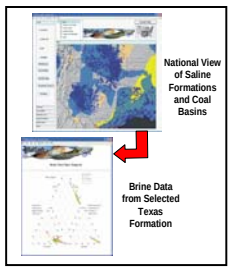
- **Partnership covers 6 states (Arizona, California, Oregon, Washington, Alaska, and Nevada) and 1 Canadian Province (British Columbia)**
- **70 Partners**
- **Long-history of oil/gas production**
- **Geologic Field Tests**
  - Stacked depleted gas and saline formation test (CA)
  - Deep saline injection (AZ)
- **Terrestrial Field Tests**
  - Bio-energy and forest fuel reduction measures

National Carbon Sequestration Database and Geographical Information System (NATCARB)

- Relational database and geographic information system (GIS)
- Integrates data from the RCSPs and various other sources
- Provides a National view of the carbon sequestration potential in the U.S. and Canada



CO_2 Sources

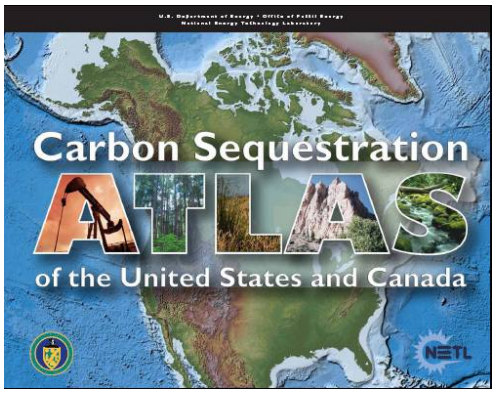


CO_2 Sequestration Site

- Allows users to estimate the amount of CO_2 emitted by sources in relation to geologic formations that can provide safe, secure sequestration sites over long periods of time

Carbon Sequestration Atlas of the United States and Canada

- First version of the Carbon Sequestration Atlas of the U.S. and Canada
- Methodology developed by experts in the U.S. and Canada involved in the Partnerships
- Provides both a National and Regional Summaries of CCS opportunities

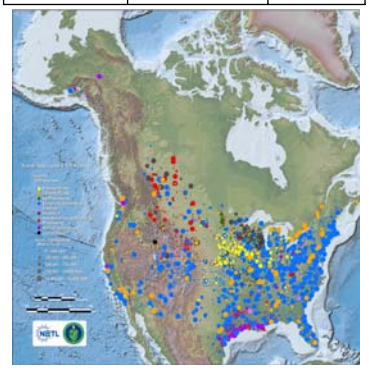


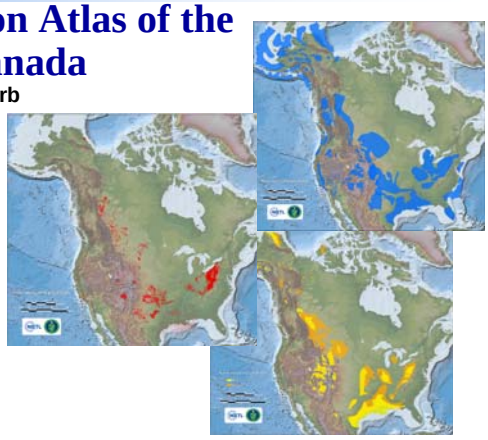
- Development of Atlas II underway (November 2008 release goal)
- Focus of Atlas II is adding new info on basins/formations; documenting procedures; defining storage "resource"

Carbon Sequestration Atlas of the U.S. and Canada

CO_2 Sources Documented in NatCarb

	CO_2 Emission (Million Metric Tons)	Number of Facilities
CO_2 Sources	3,809	4,365





North American CO_2 Storage Potential (Billion Metric Tons)

Sink Type	Low	High
Saline	919	3,378
Unmineable Coal Seams	156	184
Oil and Gas Fields	82	

Benefits of the RCSP Initiative

- **Better understanding of regional opportunities**
  - Match sources and sinks
  - Define scenarios for implementation
- **Test and refine geologic models**
- **Measure fate of CO_2 and compare technologies**
- **Best management practices to address site selection, well design, operations, monitoring, and closeout**
- **Engagement of regional stakeholders**
  - Implement public outreach and education

Additional Information

http://www.netl.doe.gov/technologies/carbon_seq/index.html

Questions ?