NATIONAL ENERGY TECHNOLOGY LABORATORY

Presentation to

WESTCARB Annual Meeting

October 19, 2010

Sacramento, CA

DOE's Carbon Sequestration Program

Dawn Deel, PMP
Sequestration Project Manager

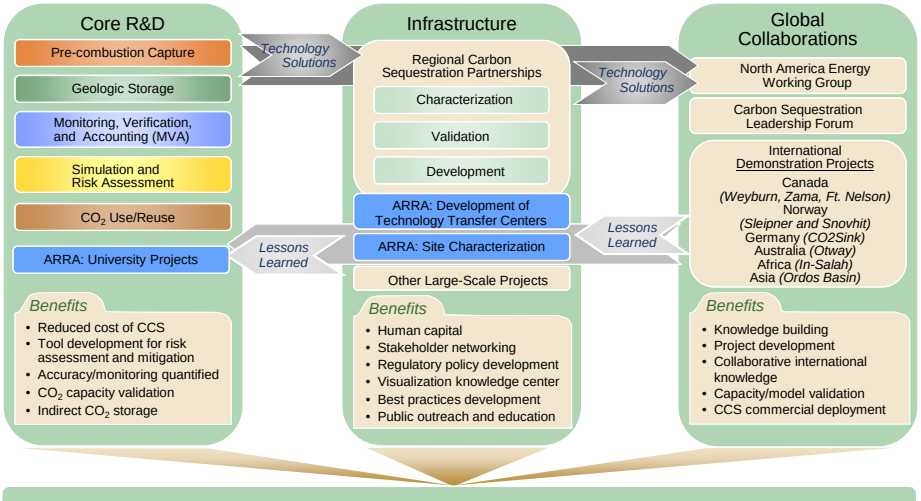
Overview

- Sequestration Program Updates
- Fossil Energy ARRA Portfolio
- National Risk Assessment Partnership
- RCSP - Validation Field Tests
- RCSP - Large Scale CO_2 Storage Projects
- Summary

Sequestration Program Updates

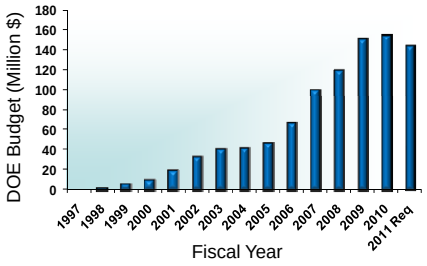
U.S. DEPARTMENT OF ENERGY • OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

CARBON SEQUESTRATION PROGRAM with ARRA Projects

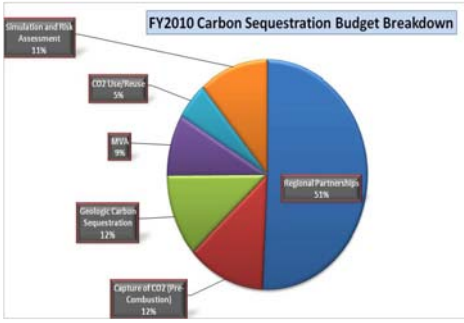


Sequestration Program Total Funding

Program Statistics 2010 (no ARRA funding included)



Strong industry support
~ 39% cost share on projects



Diverse research portfolio

~ 100 Active R&D Projects

Consolidated National Labs Work

+ 60 ARRA Projects

+21 awards in FY10

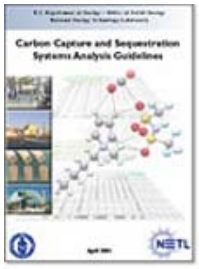
Pre-Combustion CO_2 Capture Goals

By 2020, have available for <u>demonstration</u>, advanced CO_2 capture technologies that achieve:

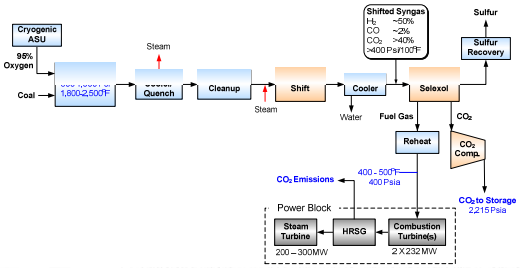
90% CO_2 capture

< 10% increase in COE

Set by Systems Analyses



Evaluated by Systems Analyses



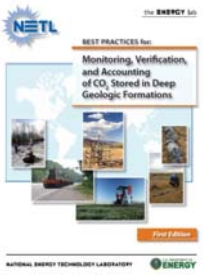
Advanced Geologic Storage Goals

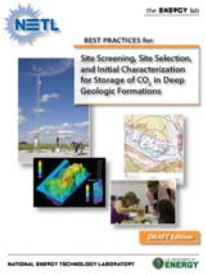
By 2020, have available for demonstration, advanced storage technologies and protocols which allow capacity to be estimated within +/- 30% and account for 99%+ of the injected CO_2 in the formations

Set by Systems Analyses


Availability analysis of post-combustion carbon capture systems: minimum work input

Evaluated by Systems Analyses





7 NATIONAL ENERGY TECHNOLOGY LABORATORY

Building the Core R&D Portfolio

Core R&D Focus Areas

15 new awards September 2010

9 New Projects March 2009

Capture (Pre-Combustion)
- Membrane
- Solvent-Based
- Sorbent-Based
- Novel Concepts

Geologic Carbon Storage
- Improved Fundamental Understanding
- Technology Development
- Beneficial Use of Produced Water

MVA
- Atmospheric and Remote Sensing
- Near-Surface Monitoring
- Wellbore Monitoring
- Subsurface Monitoring
- Accounting Protocols

10 New Projects September 2009

6 new awards September 2010

CO_2 Utilization
- Conversion of CO_2
- Non-Geologic CO_2 Storage
- Indirect Storage
- Breakthrough Concepts

Simulation and Risk Assessment
- Mathematical Models Development and Verification
- Improved Risk Assessment Protocols

9 New Projects September2009

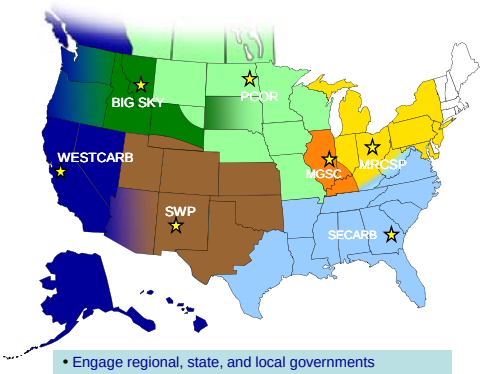
8 NATIONAL ENERGY TECHNOLOGY LABORATORY

Regional Carbon Sequestration Partnerships

Developing the Infrastructure for Wide Scale Deployment

Seven Regional Partnerships

400+ distinct organizations, 43 states, 4 Canadian Provinces



- Engage regional, state, and local governments
- Determine regional sequestration benefits
- Baseline region for sources and sinks
- Establish monitoring and verification protocols
- Address regulatory, environmental, and outreach issues
- Validate sequestration technology and infrastructure

Characterization Phase (2003-2005)

Search of potential storage locations and CO_2 sources	Found potential for 100's of years of storage

Validation Phase (2005-2011)

20 injection tests in saline formations, depleted oil, unmineable coal seams, and basalt

Development Phase (2008-2018+)

9 large scale injections (over 1 million tons each)	Commercial scale understanding	Regulatory, liability, ownership issues

9 NATIONAL ENERGY TECHNOLOGY LABORATORY

Fossil Energy ARRA Portfolio

10 NATIONAL ENERGY TECHNOLOGY LABORATORY

FE ARRA Portfolio
Integrated into Sequestration Program

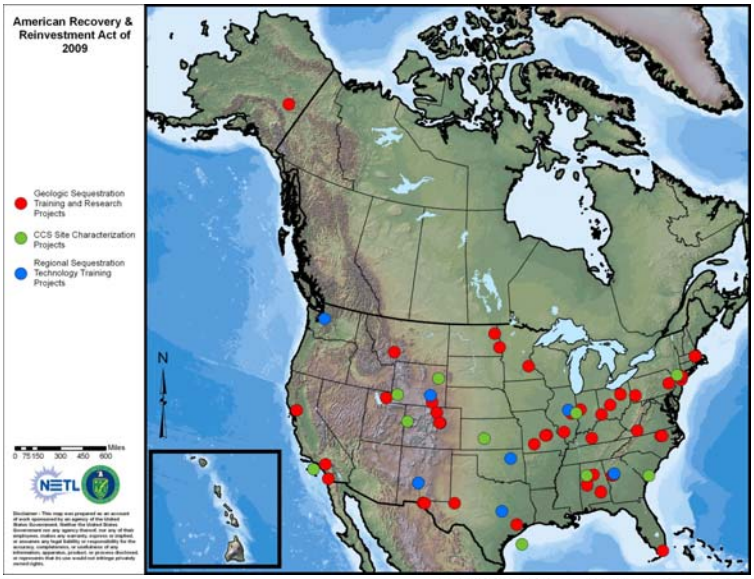
$100* Million Site Characterization ($50M from ICCS)
$20 Million Training and Research

Objectives	FOAs	Results
Promote technology; support economic recovery; produce jobs	Site Characterization & Promising Geologic Formations for CO_2 Storage	10 New Large Geologic Site Characterizations
	Geologic Sequestration Training & Research	43 University Training & Research Coop Agreements
Logical extension of FE coal program activities	Regional Sequestration Technical Training	7 New Regional Sequestration Training Centers

Projects awarded Nov- Dec 2009

11 NATIONAL ENERGY TECHNOLOGY LABORATORY

ARRA Project Location



12 NATIONAL ENERGY TECHNOLOGY LABORATORY

National Risk Assessment Partnership

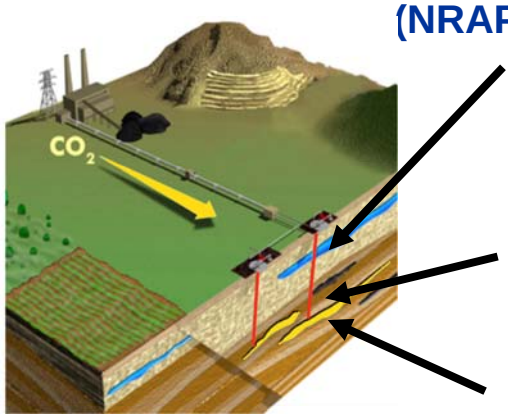
All Potential Risks Are Being Studied

- **Environmental Risks**
  - Increases atmospheric CO_2
  - Accumulation of CO_2 pockets on earth
  - Migration into other strata and contamination of fresh water
  - Leakage of CO_2 into a marine environment
  - Damage to nearby hydrocarbon resources
  - Displacement of underground fluids
  - Initiation of seismic activity

- **Health and Safety Risks**
  - Human and animal exposure can lead to asphyxiation
  - NIOSH defines CO_2 as a nontoxic, inert gas that displaces oxygen
  - Work hazard

- **Economic Risks**
  - Enhanced oil recovery is a commercially proven process
  - Additional research needed
  - Liability
  - Operational considerations

National Risk Assessment Partnership (NRAP)



Lawrence Berkeley National Lab
Lawrence Livermore National Lab
Los Alamos National Lab
National Energy Technology Lab (lead)
Pacific Northwest National Lab

Outside of the Reservoir

- **Strategic monitoring for the site (during injection and post closure)**
- **Potential impacts of CO_2 release**
- **Protection of subsurface resources (groundwater, minerals, etc.)**

Seal

- **Seal characterization**
- **Seal (and wellbore) integrity over time**
- **Mitigation strategies**

Reservoir

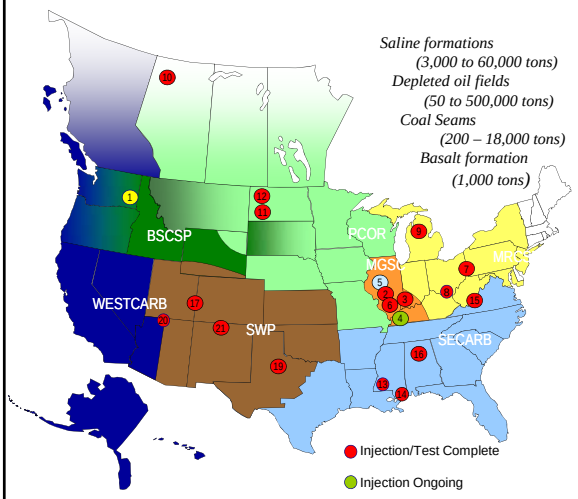
- **Strategic site characterization**
- **Capacity & injectivity over time**
- **Plume movement in reservoir (CO2, brine, pressure front)**
- **Impacts from introducing CO2 into the reservoir**

15 NATIONAL ENERGY TECHNOLOGY LABORATORY

Validation Field Projects

16 NATIONAL ENERGY TECHNOLOGY LABORATORY

Small-Scale Geologic Field Tests



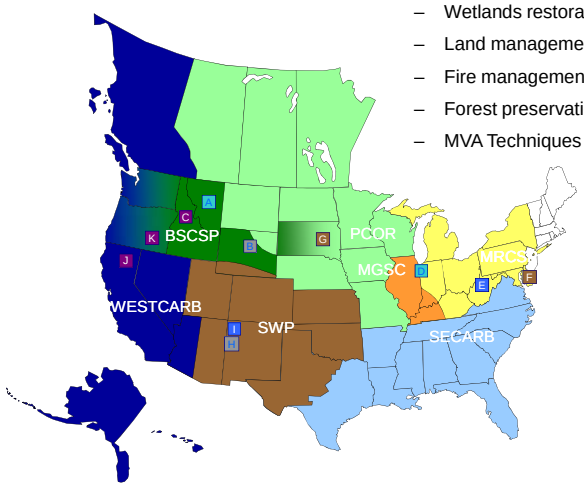
Completed 17 Injections

Over 1.35 M Tons injected

RCSP	Formation Type	Geologic Province
Big Sky	Saline 1	Columbia Basin
MGSC	Oil-bearing 2 3 4 Saline 5 Coal seam 6	Illinois Basin
MRCSP	Saline 7 8 9	Cincinnati Arch, Michigan Basin, Appalachian Basin
PCOR	Oil-bearing 10 11 Coal seam 12	Keg River, Duperow, Williston Basin
SECARB	Oil-bearing 13 Saline 14 Coal seam 15 16	Gulf Coast, Mississippi Salt Basin, Central Appalachian, Black Warrior Basin
SWP	Oil-bearing 17 18 Coal seam 19	Paradox Basin, Aneth Field, Permian Basin, San Juan Basin
WESTCARB	Saline 20	Colorado Plateau

Terrestrial Sequestration Field Tests

- Tree-plantings
- No-till farming
- Wetlands restoration
- Land management: grasslands, grazing lands
- Fire management
- Forest preservation
- MVA Techniques



Terrestrial Project Categorization

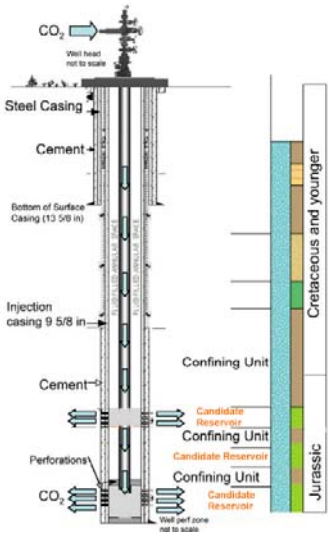
- Agricultural soils
- Soil Reclamation
- Afforestation
- Accounting/Aggregation
- Wetlands Reclamation

Large Scale Storage Projects

RCSP Development Phase

Strive to Attain the Following Goals

- **Validate Geologic Storage**
  - Injectivity and Capacity
  - Storage Permanence
- **Develop Monitoring Methodologies**
  - Areal Extent of Plume and Leakage Pathways Mitigation
- **Develop from Experience**
  - Risk Assessment Strategies
  - Best Practices for Industry
- **Support Regulatory Development**
- **Engage in Public Outreach and Education**



RCSP Development Phase

Scaling Up Towards Commercialization

Fiscal Year										
2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018

Stage 1.
Site selection and characterization
Permitting and NEPA compliance;
Well completion and testing;
Infrastructure development.

Scale up is required to provide insight into several operational and technical issues that differ from formation to formation

Stage 2.
CO_2 procurement and transportation;
Injection operations; Monitoring activities.

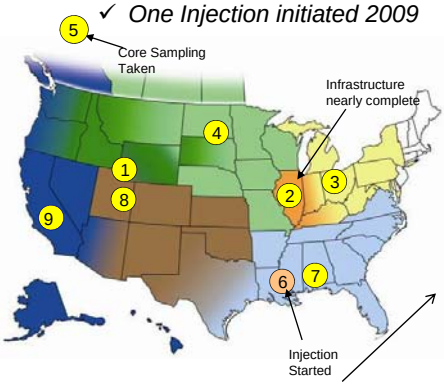
Stage 3.
Site closure; Post-injection monitoring; Project assessment.

RCSP Development Phase – 10+ years (FY 2008-2017+)

RCSP Phase III: Development Phase

Major Milestone - Large-Volume Geologic Field Tests

- ✓ *Nine large-volume tests*
- ✓ *One Injection initiated 2009*




ABOUT NETL
KEY ISSUES & MANDATES
RESEARCH
TECHNOLOGIES
ENERGY ANALYSIS
SOLICITATIONS & BUSINESS
EDUCATION
NEWSROOM
CONTACT NETL

Publications
News Release

Release Date: November 5, 2009

DOE-Sponsored Mississippi Project Hits 1-Million-Ton Milestone for Injected CO_2

Project Helping Further CCS Technology and Meeting G-8 Goals for Deployment

Washington, D.C. —A large-scale carbon dioxide (CO_2) storage project in Mississippi has become the fifth worldwide to reach the important milestone of more than 1 million tons injected. As a result, it is helping to both further carbon capture and storage (CCS) as a mitigation strategy for global climate change and move forward G-8 recommendations for launching 20 projects of this type internationally by 2010.

The project, sponsored by the U.S. Department of Energy's (DOE) Office of Fossil Energy (FE), is located at the Cranfield site in Southwestern Mississippi. It is led by the Southeast Regional Carbon Sequestration Partnership (SECARB), one of seven members of the Regional Carbon Sequestration Partnerships Program (RCSP) managed by the Office of Fossil Energy's National Energy Technology Laboratory (NETL).

MORE INFO
- Learn more about DOE's Regional Carbon Sequestration Partnership Program
- Link to SECARB web site

CCS is a group of technologies for capturing and compressing the CO_2 emitted by power plants or industrial sites; transporting it; and injecting it into suitable permanent storage sites, such as deep underground formations. It has been increasingly recognized by scientists and nations worldwide as an effective way to both reduce CO_2 emissions from existing sources and help avoid future emissions, making it part of a portfolio response to meet atmospheric CO_2 reduction goals. Additionally, the G-8 – of which the United States is a part – has endorsed demonstrating CCS by getting at least 20 industrial-scale projects underway, with the goal of broad deployment of the technology by 2020.

Over 1,000,000 Tons injected at SECARB site

- Injection ongoing
- Injection Scheduled 2011-2015

Note: Some locations presented on map may differ from final injection location

Summary

Collaborations

Regional Partnerships - Working Groups

- **Geologic and Infrastructure**
- **Monitoring**
- **Simulation**
- **Capture and Transportation**
- **GIS and Database**
- **Public Outreach**
- **Economics and Markets**
- **Water**

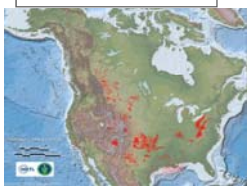
- **Benefits:**
  - Standard approaches (Best Practices)
  - Technology transfer between partnerships and partners

National Atlas Highlights

Hundreds of Years of Storage Potential

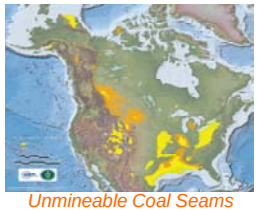
U.S. Emissions ~ 6 GT CO_2/yr all sources

2008 Conservative Resource Assessment



Oil and Gas Fields
*138 GT CO_2 Storage Resource**

Saline Formations
*3,300–12,600 GT CO_2 Storage Resource**



Unmineable Coal Seams
*157-178 GT CO_2 Storage Resource**

- **DOE's Carbon Sequestration Program**
- **DOE's International Collaborations**
- **DOE's National Risk Assessment Partnership (NRAP)**
- **Regional Carbon Sequestration Partnership (RCSP) Activities**
- **Refined CO_2 source estimates and CO_2 storage potential across the RCSP regions**
- **Worldwide CCS projects, CCS regulatory issues**
- **NATCARB's improved databases and GIS system**

*2008 Carbon Sequestration Atlas of the United States and Canada.

Available for download at http://www.netl.doe.gov/technologies/carbon_seq/refshelf/atlasII/atlasII.pdf

Sequestration Programmatic Documents

DOE/NETL Advanced CO_2 Capture R&D Program: Technology Update (September 2010)

- Handbook updates DOE/NETL R&D efforts on advanced CO_2 capture technologies for coal-based power systems
- Report tracks the progress of DOE/NETL pre-combustion, post-combustion, and oxy-combustion technologies for CO_2 capture (prepared by the Existing Plants and Sequestration R&D Programs)

2010 Carbon Sequestration Project Portfolio (August 2010)

- Comprehensive portfolio of all active storage and pre-combustion projects in the sequestration program
- BPMs from Regional Partnerships and other key programmatic documents and papers

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

Visit Our Websites

Office of Fossil Energy
www.fe.doe.gov

NETL
www.netl.doe.gov