



NATIONAL ENERGY TECHNOLOGY LABORATORY

October 17, 2012

Bakersfield, CA



WESTCARB 2012 Business Meeting

Presenter: Bruce Brown, PG

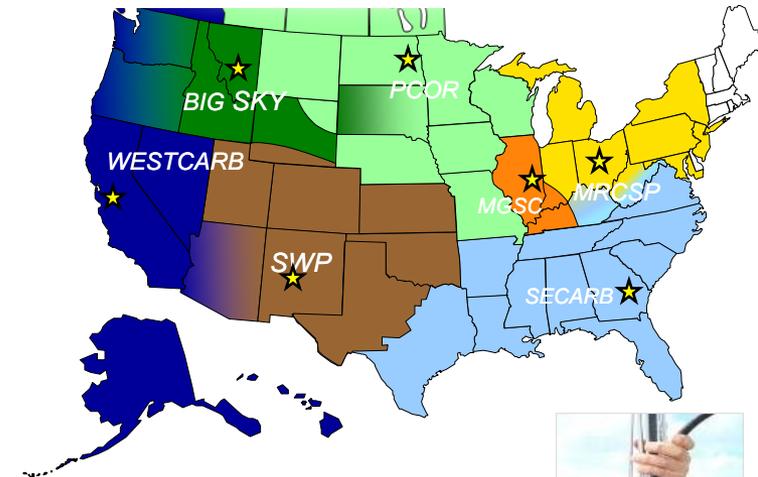
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United States Department of Energy, National Energy Technology Laboratory,



Overview

- **DOE Carbon Storage Program**
 - CCUS
 - Program Goals
- **Core R&D**
- **Infrastructure**
 - Regional Partnerships
- **Best Practices Manuals (BPM)**
as products
- **Other knowledge sharing products**
- **Summary**

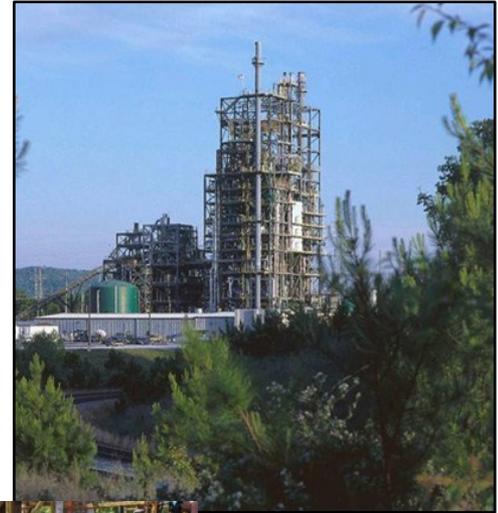


Core Program Components

Office of Coal and Power R&D

Total FY 2012 Funding ~ \$333 Million

- **Carbon Capture - \$68.9 Million**
- **Carbon Storage - \$115.4 Million**
- **Advanced Energy Systems- \$99.9 Million**
 - Advanced Combustion Systems - \$15.9 Million
 - Gasification - \$39 Million
 - Turbines - \$15 Million
 - Fuel Cells - \$25 Million
 - Fuels - \$5 Million
- **Cross Cutting Research - \$49.1 Million**



The Carbon Storage Program

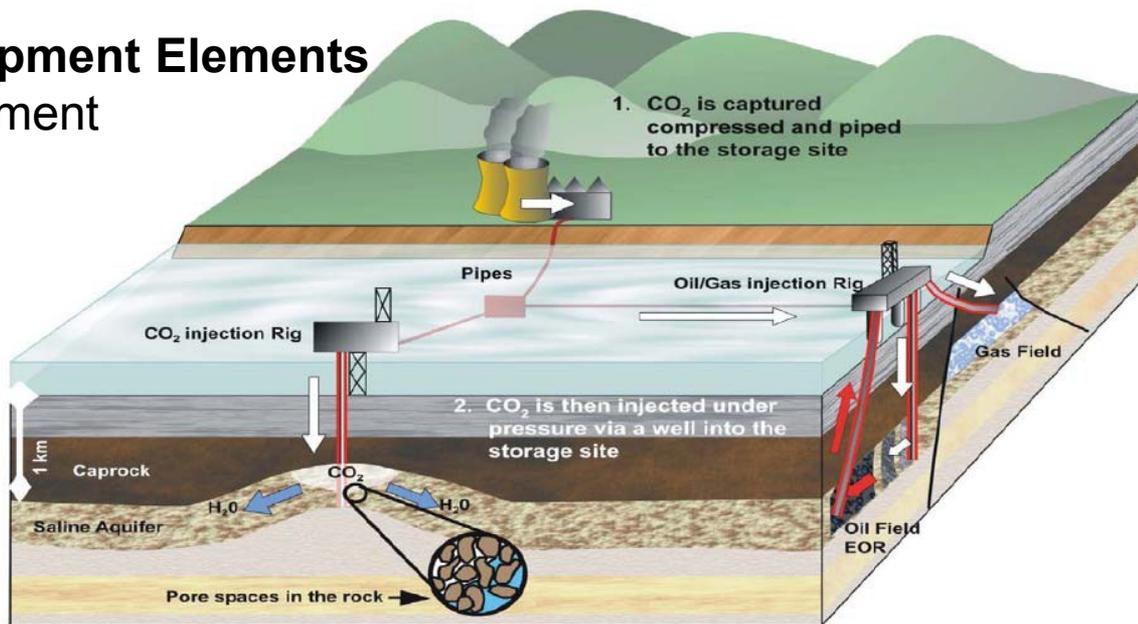
U.S. DOE's R&D Program to Develop Infrastructure for Carbon Storage

Carbon Storage Program

- Implemented by DOE's Office of Fossil Energy and managed by NETL
- Focused on CO₂ capture, separation and storage to reduce GHG emissions without adversely affecting energy use or hindering economic growth
- NETL needs a technology portfolio of safe, cost-effective, GHG capture, transport and storage technologies that will be available for commercial deployment

Three Key Technology Development Elements

1. Core Research and Development
2. Infrastructure
3. Global Collaborations



CO₂ Utilization

Putting the “U” in CCUS

- **Lack of Climate legislation**
- **Low Natural Gas Prices**
- **Regulations Impacting New Coal Fired Power Plants**
- **High Oil Prices**
- **Demands a near term business case for deployment**



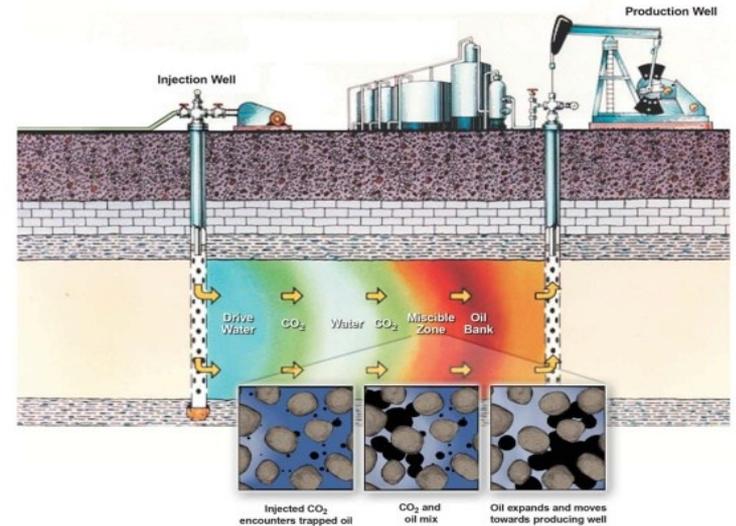
Drivers for Storage in EOR/EGR Opportunities

Economic Benefits

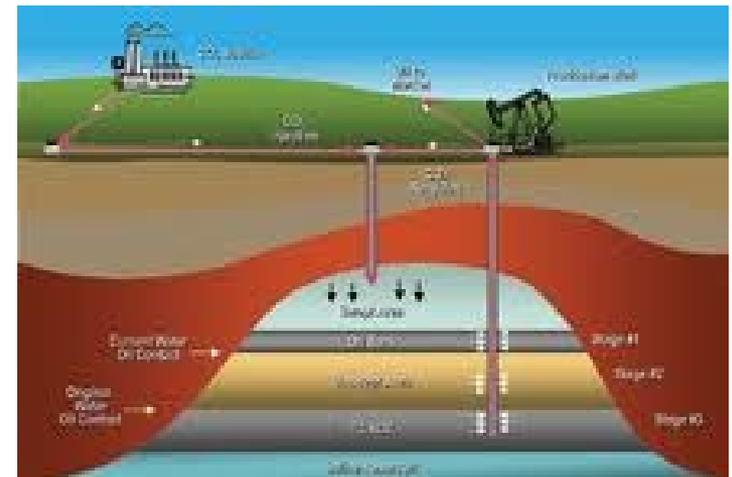
- Produce an additional 60 billion bbl of oil
- Balance trade deficit by over \$3.5 trillion
- Create more than 600,000 new jobs

Technical Benefits

- Store over 20GT of CO₂
- Develop infrastructure to support transition to future saline storage
- Validate storage and monitoring technologies
- Facilitate knowledge sharing between the oil and storage industry to improve performance
- Potentially increase reserves of storage capacity and natural gas in coal and shale formations



Business as usual EOR Operations (WAG)



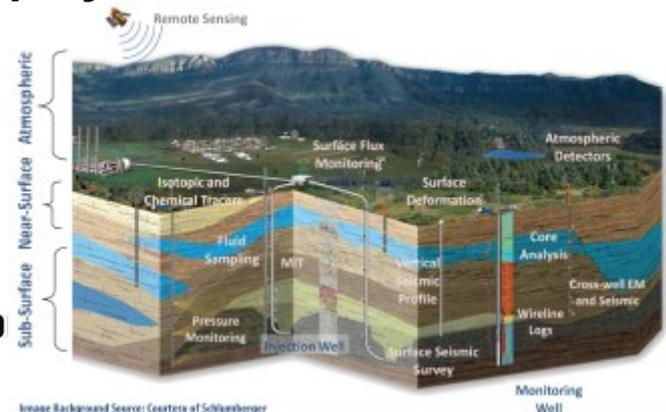
Next Generation Storage/EOR Operations

CCUS Goals

Keeping R&D on Track

Deliver technologies & best practices that validate:

- < 10% increase in COE with CCS at 90% capture (pre-comb.)
- < 35% increase in COE with CCS at 90% capture (post- & oxy-comb.)
- > 90% CO₂ capture
- **99% storage permanence****
- **Validate that capacity is sufficient and where we need it**
- **Validate Formation Classes & maximum storage efficiency**
- **Promote infrastructure for wide scale deployment**
- **Enhance domestic oil & gas production**



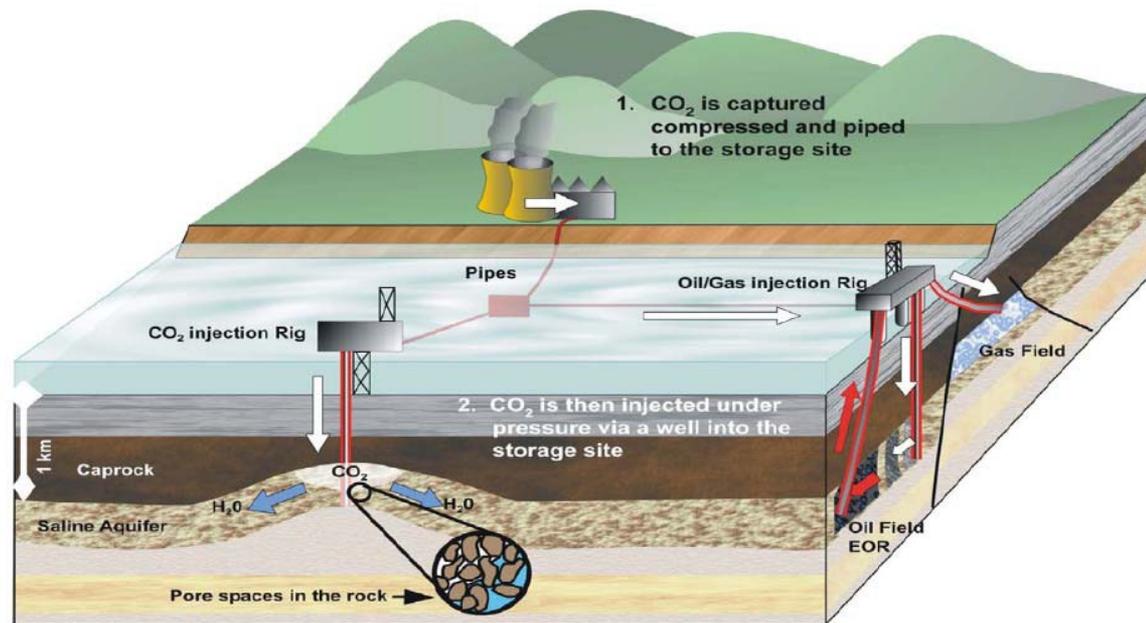
The Carbon Storage Program

U.S. DOE's R&D Program to Develop Infrastructure for Carbon Storage

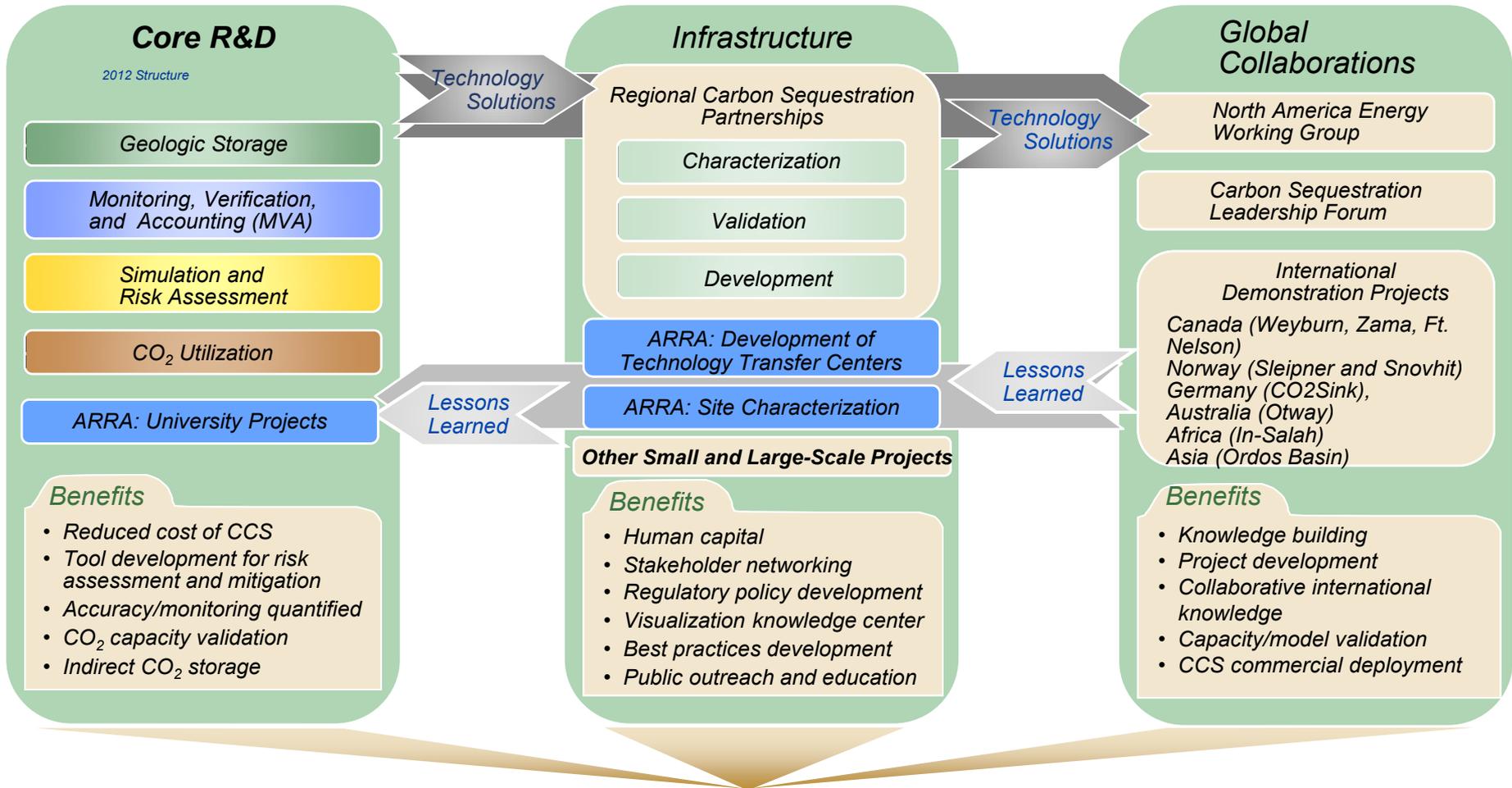
Three Key Technology Development Elements

1. Core Research and Development (Basic R&D)
2. Infrastructure (Field Testing)
3. Global Collaborations

Together, these elements address technological and economic challenges

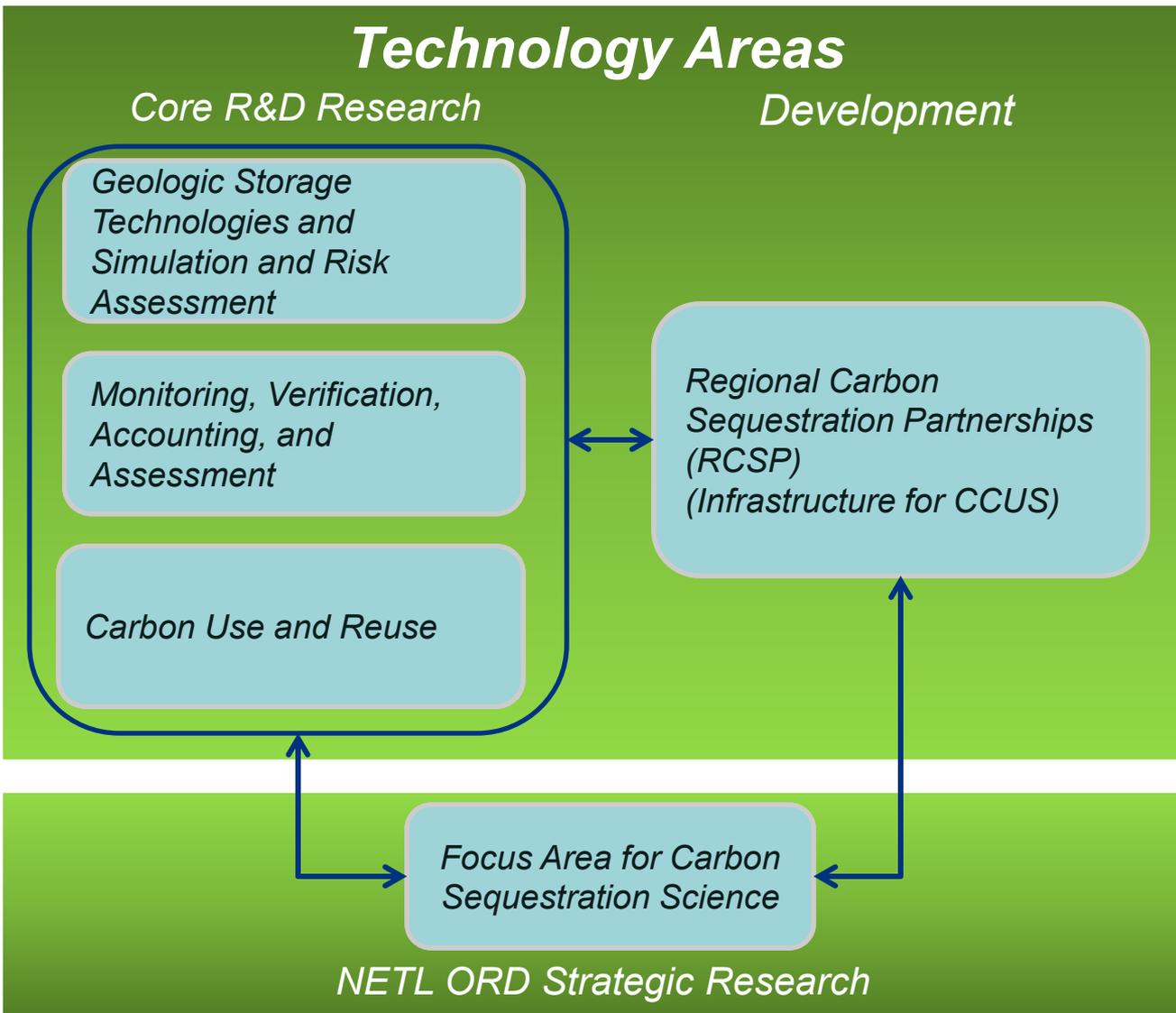


CARBON STORAGE PROGRAM *with ARRA Projects*



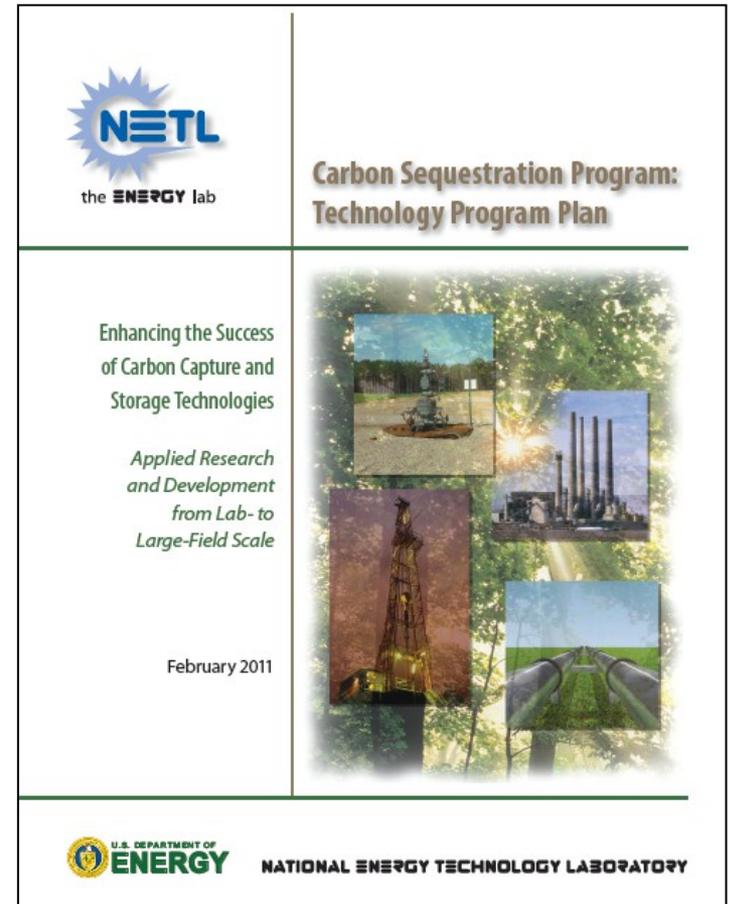
Demonstration and Commercialization Carbon Capture and Storage (CCS)

2012 Carbon Storage Program

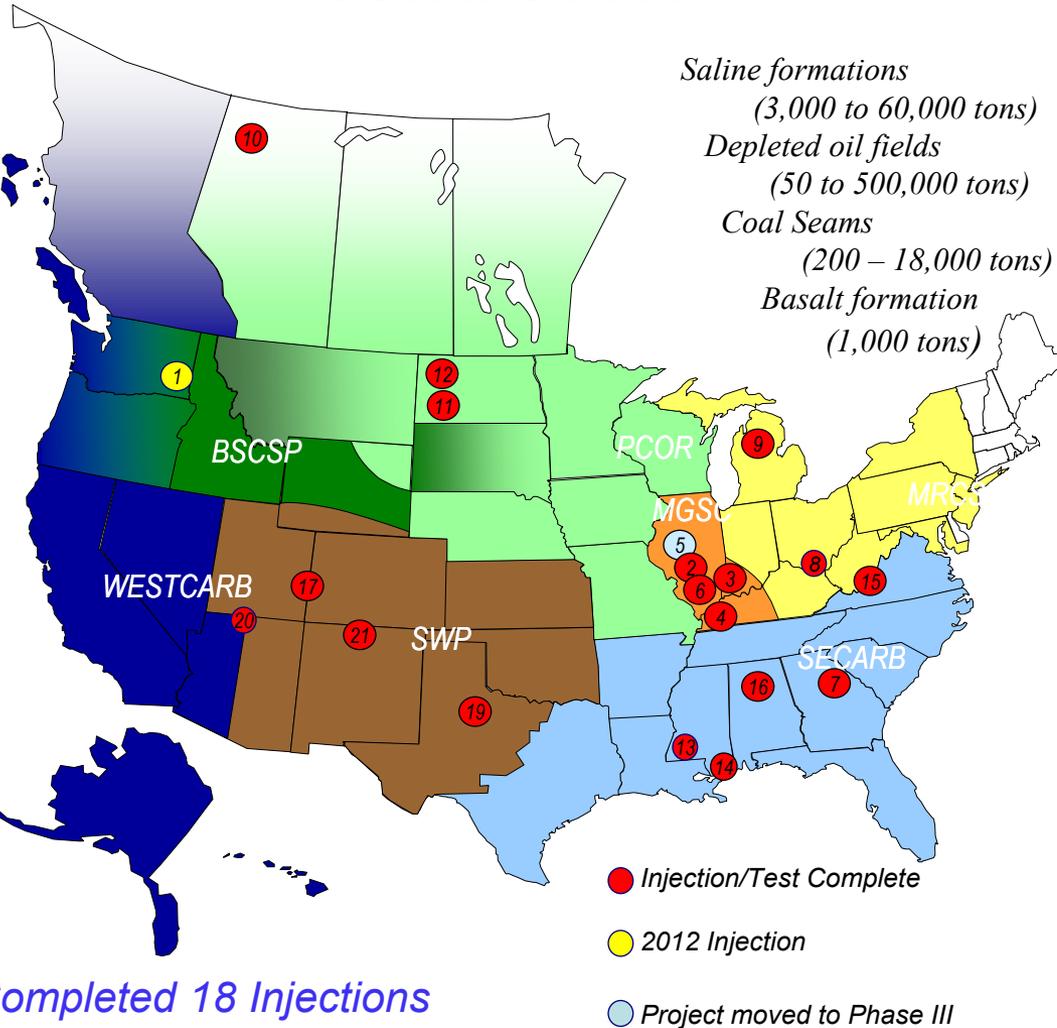


Carbon Storage CCUS Program Plan

- Available in Fall 2012
- Prioritization of R&D Goals
- 2nd Generation Technologies
 - Near and mid-term (2020)
- Transformational Technologies
 - Long-term (2030)



Small-Scale Geologic Field Tests

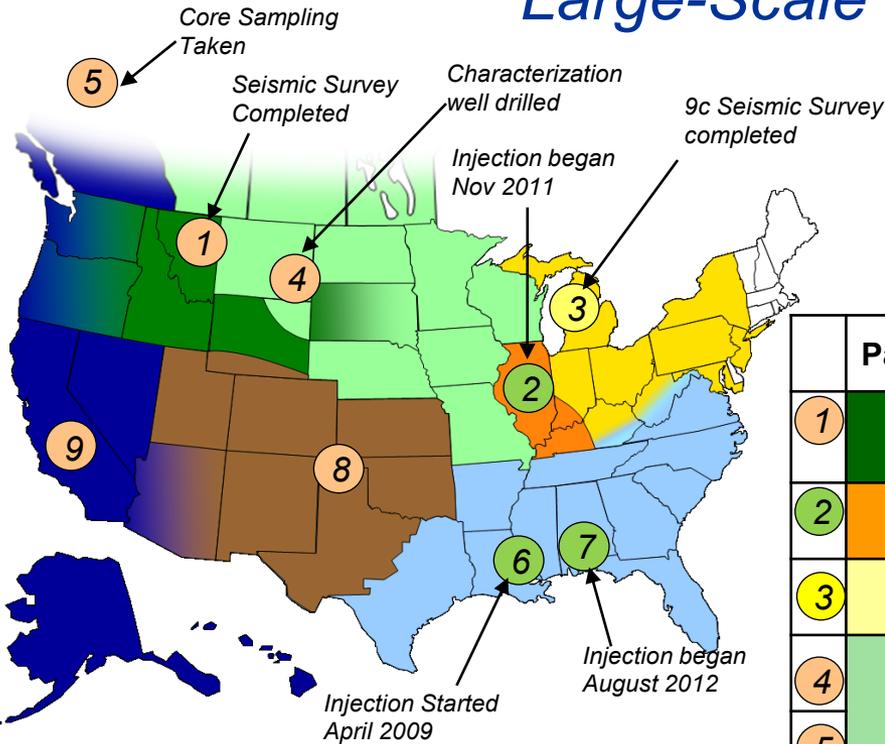


Completed 18 Injections
Over 1.35 M Tons injected

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

RCSP Phase III: Development Phase

Large-Scale Geologic Tests



- ✓ Large-volume tests
- ✓ Two projects currently injecting CO₂
- ✓ Remaining injections scheduled 2012-2015

	Partnership	Geologic Province	Target Injection Volume (tonnes)
1	Big Sky	Nugget Sandstone	1,000,000
2	MGSC	Illinois Basin-Mt. Simon Sandstone	1,000,000
3	MRCSP	Michigan Basin-Niagaran Reef	1,000,000
4	PCOR	Powder River Basin-Bell Creek Field	1,500,000
5		Horn River Basin-Carbonates	2,000,000
6	SECARB	Gulf Coast – Cranfield Field- Tuscaloosa Formation	3,200,000
7		Gulf Coast – Paluxy Formation	250,000
8	SWP	Regional CCUS Opportunity	1,000,000
9	WESTCARB	Regional Characterization	

- Injection Ongoing
- 2012 Injection Scheduled
- Injection Scheduled 2013-2015

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

Southeast Regional CS Partnership Cranfield Site Large-Scale Project (Early Test)

Target Formation

- Lower Tuscaloosa

CO₂ Source

- Jackson Dome (natural source) delivered via Denbury Resources' Sonat CO₂ pipeline

CO₂ Injection Amount (Current)

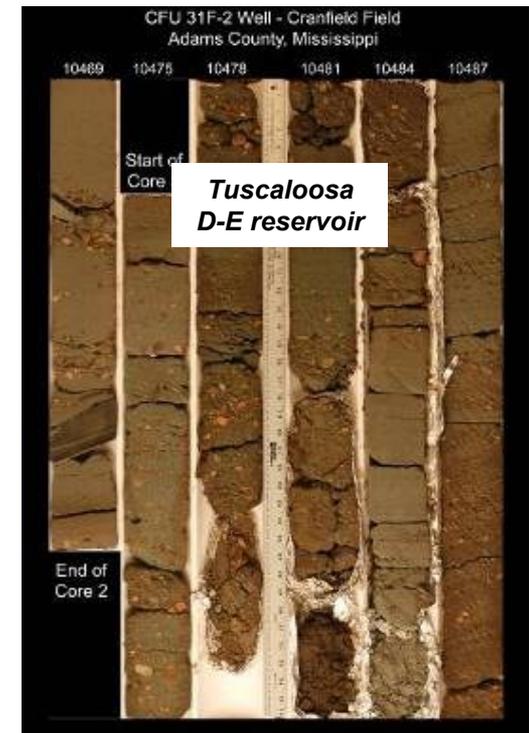
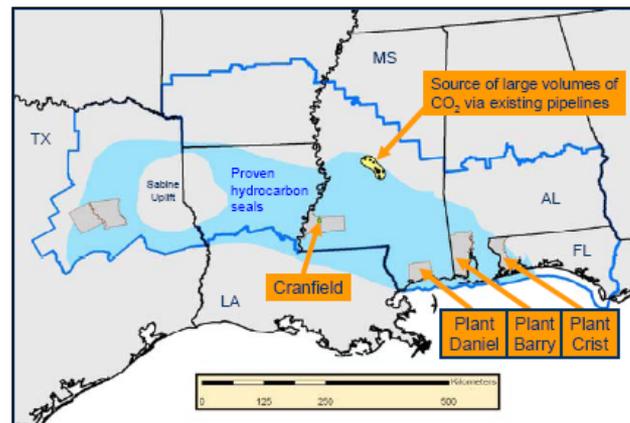
- > 3.4 million metric tons (P3 only)
- > 3.8 million metric tons (combined P2 and P3)

Current Status

- Injection began on 04/01/2009
- Injection rate was ~ 432 metric tons/day, now < 100 metric tons/day

MVA

- 4-D geophysics (VSP, ERT)
- Geochemical (U-Tube sampling)
- Field pressure monitoring
- Distributed Temperature
- Wireline logging



Southeast Regional CS Partnership

Plant Barry Site Large-Scale Project

Largest fully integrated PC plant capture and saline storage project in the U.S.

MHI KS1 amine process

UIC Class V permit with Class VI requirements

Target Formation

- Upper Paluxy Formation

CO₂ Source

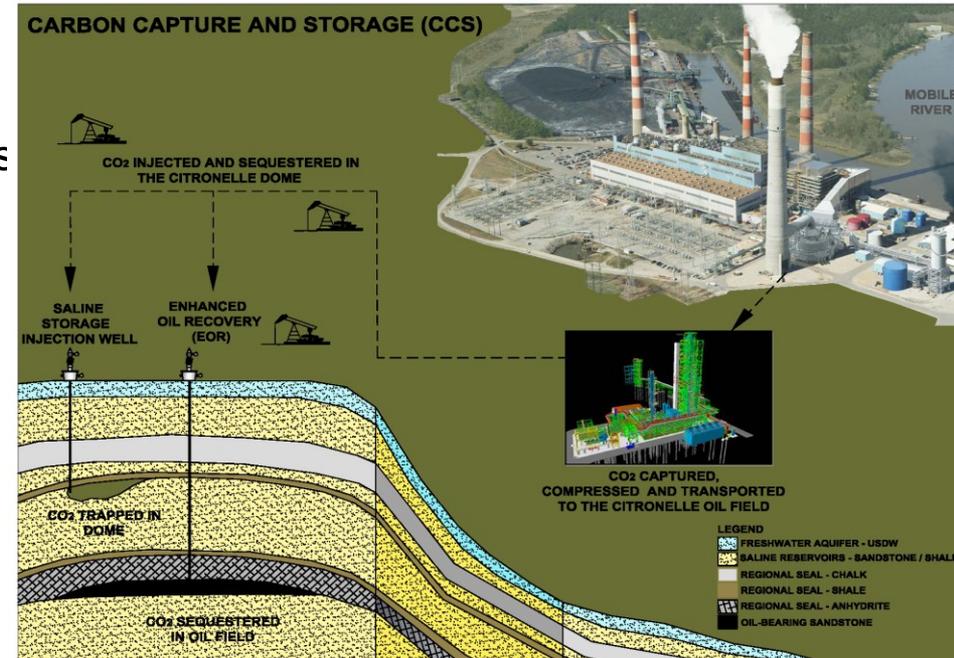
- Southern Company's Plant Barry Power Station

CO₂ Injection Amount

- ~ 250,000 metric tons over 2 years (August 2012)

Current Status

- Characterization well drilled January 2011
- Final Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) signed March 2011
- Pipeline construction completed (November 2011)
- Injection well drilling completed (December 2011)
- UIC Class V Injection well permit (July 2012)
- CO₂ injection started August 20, 2012. >13,000 metric tons to date



Midwest Geological Sequestration Consortium

Decatur Site Large-Scale Project

Target Formation

- Mt. Simon Sandstone

CO₂ Source

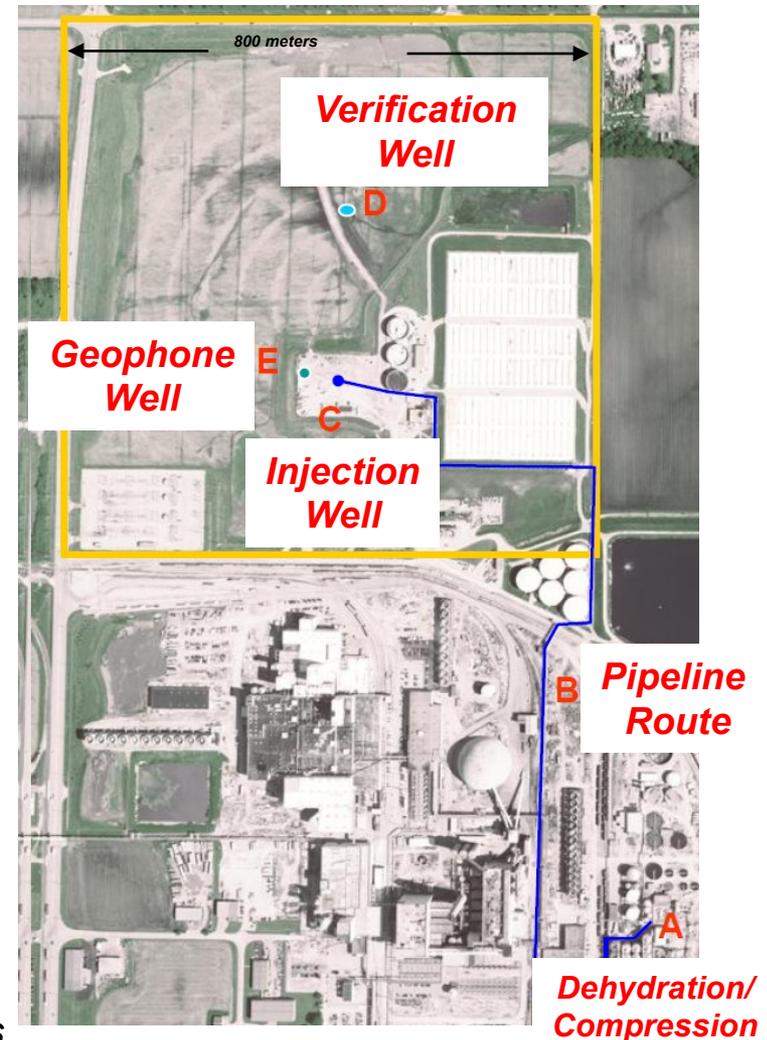
- ADM's Ethanol Production Facility

CO₂ Injection Amount

- 1 million metric tons over 3 years (Nov 2011)

Current Status

- Completed 4 square mile 3D seismic survey
- Completed drilling injection well, groundwater monitoring wells, geophone well, and verification well.
- CO₂ Pipeline installed and connected to injection wellhead.
- Installed all subsurface monitoring equipment.
- Completed commission of compression/dehydration facility
- Completed baseline fluid samples from verification well.
- Completed satellite interferometry (InSAR) baseline imaging data collection.
- UIC Permit finalized in March, 2011. Approval from IEPA to begin injection granted November 4, 2011.
- As of mid-October 2012 cumulative CO₂ injection volume is over 280,000 metric tons



Midwest Regional CS Partnership

Michigan Site Large-Scale Project

Target Formation

- Niagaran Reef

CO₂ Source

- Core Energy provider per Natural Gas Processing Facility

CO₂ Injection Amount

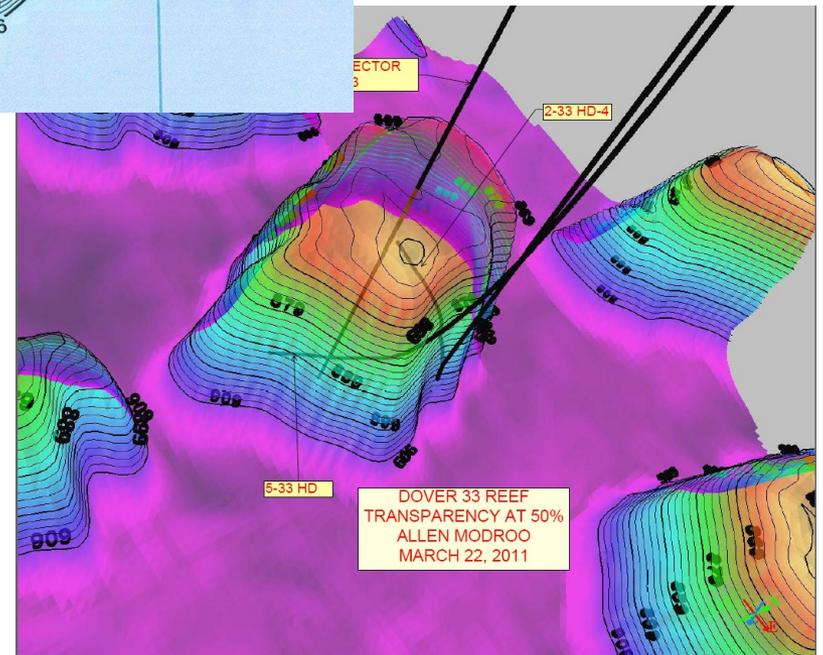
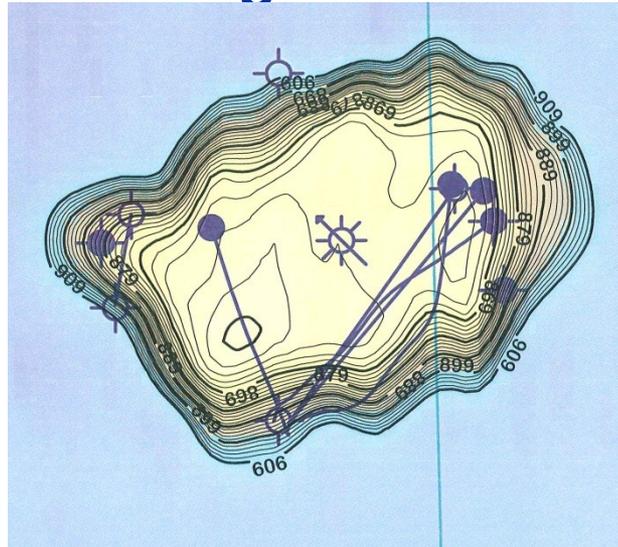
- Two under existing production
 - Completed production
 - New Production
- 1 million metric tons over 4 years
 - Injection anticipated to begin 2012

Current Status

- Completed preliminary geologic assessment of Otsego County area
- Completed Environmental Assessment (EA) Process
- Completed 3D Seismic Survey

MVA Plans

- 4DSeismic
- Passive Seismic
- Geochemical sampling
- Surface flux measurements



Plains CO₂ Reduction Partnership

Bell Creek Site Large-Scale Project

Target Formation

- Colorado Group/Muddy Sandstone Formation

CO₂ Source

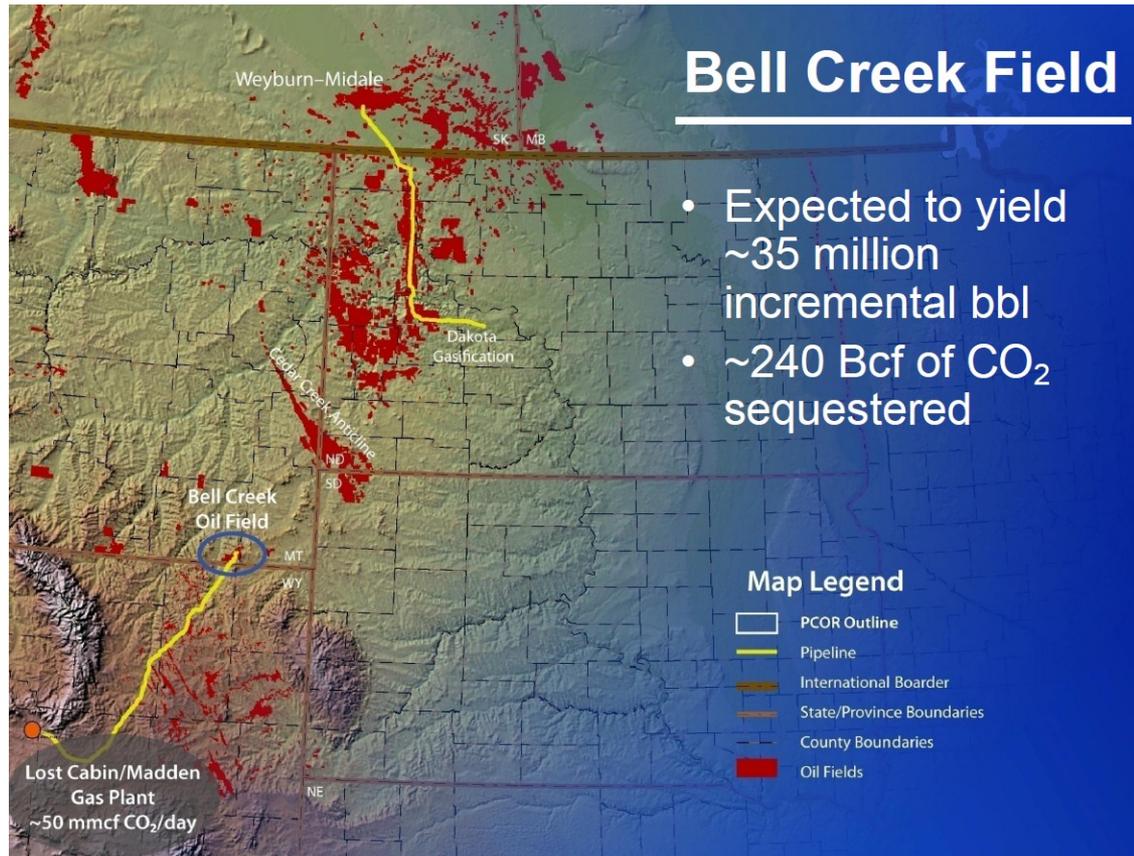
- Lost Cabin/Madden Gas Plant operated by Conoco Phillips

CO₂ Injection Amount

- As much as 1 million tons/year
- Injection anticipated early 2013

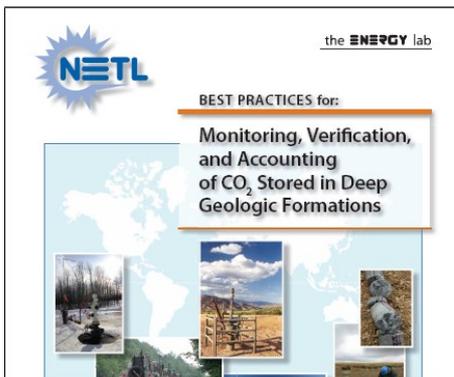
Current Status

- Working with commercial partner (Denbury Resources Inc.)
- Developing integrated modeling and MVA plan
- Completed installation of the monitoring well



CCS Best Practices Manuals

Critical Requirement For Significant Wide Scale Deployment - Capturing Lessons Learned



Best Practices Manual	Version 1 (Phase II)	Version 2 (Phase III)	Final Guidelines (Post Injection)
Monitoring, Verification and Accounting	2009/ 2012	2016	2020
Public Outreach and Education	2009	2016	2020
Site Characterization	2010	2016	2020
Geologic Storage Formation Classification	2010	2016	2020
**Simulation and Risk Assessment	2010	2016	2020
**Carbon Storage Systems and Well Management Activities	2011	2016	2020
Terrestrial	2010	2016 – Post MVA Phase III	

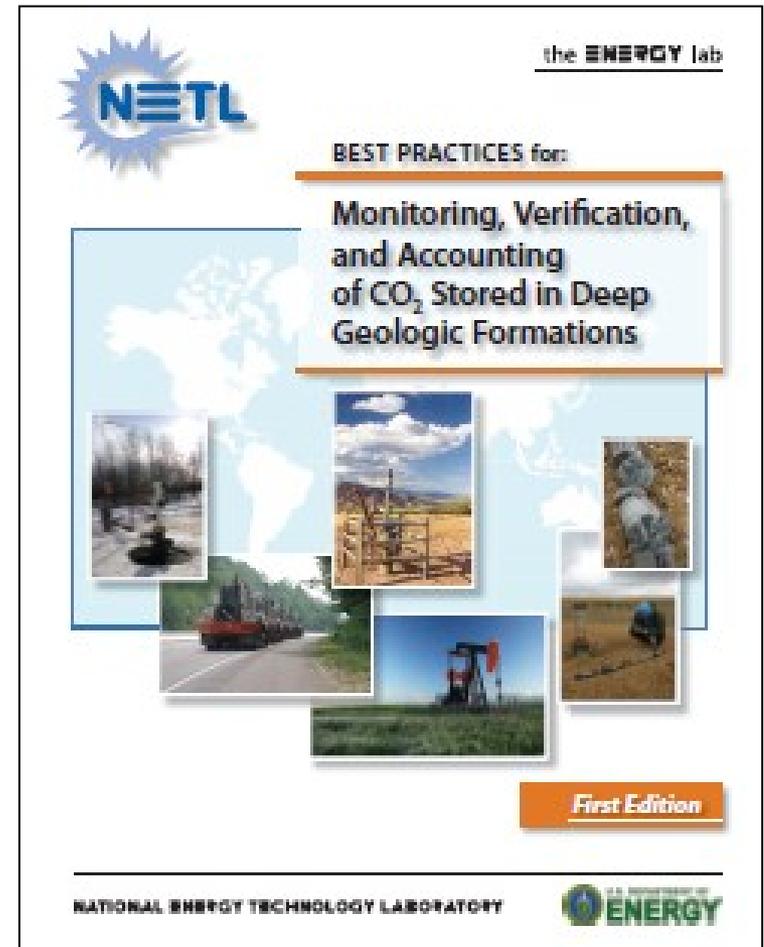
***Regulatory Issues will be addressed within various Manuals*

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

Monitoring, Verification, and Accounting of CO₂ Stored in Deep Geologic Formations

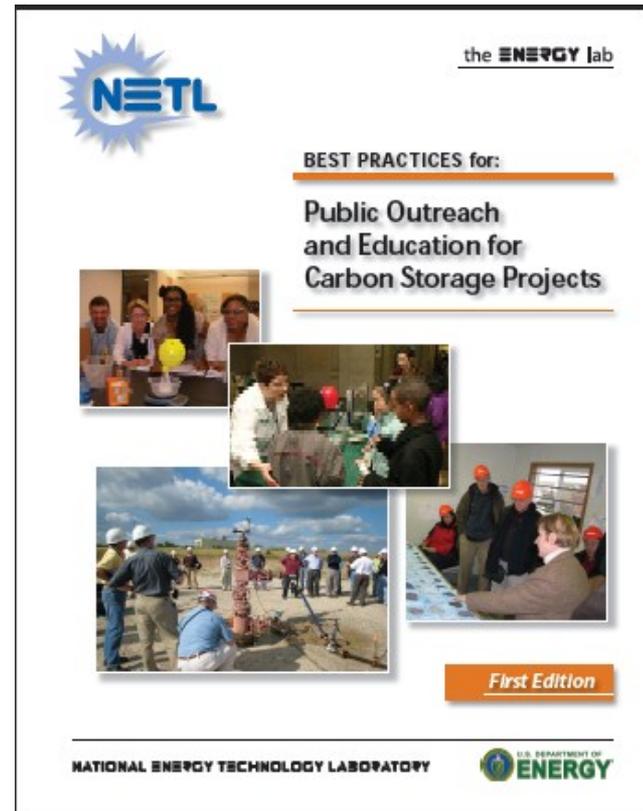
- **Based on DOE Supported and leveraged monitoring activities**
 - RCSP Program
 - Core R&D
 - International Projects
 - Industrial applications
- **Regulatory requirements and associated monitoring needs**
- **35 Technologies divided into:**
 - Primary
 - Secondary
 - Additional
- **Updated 2012**



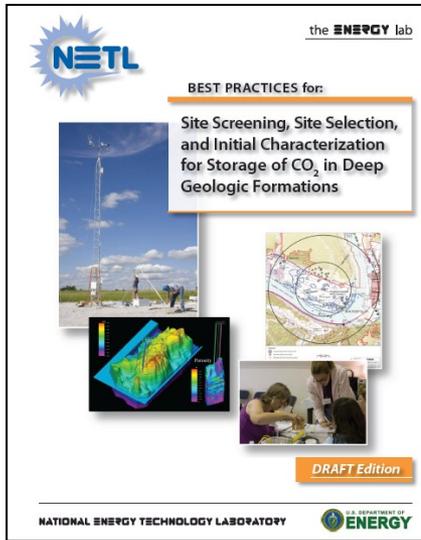
Public Outreach and Education for Carbon Storage Projects

Focused on project developers providing 10 Best Practices based on practical RCSP experience

- **Do your homework**
 - Integrate outreach with project management
 - Establish an outreach team
 - Identify stakeholders
 - Conduct and apply social characterization
- **Develop plans and materials**
 - Develop plan tailored to community
 - Develop key messages
 - Tailor materials to audience
- **Implement, Assess and Refine**



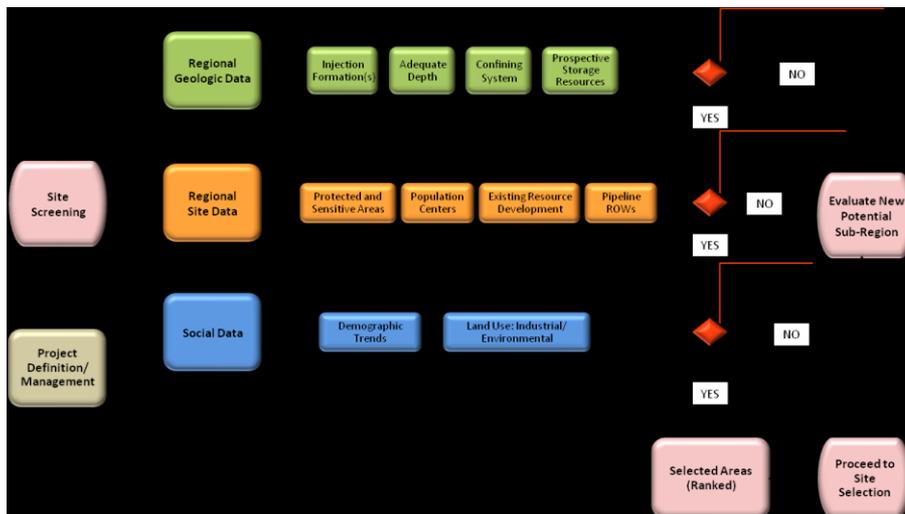
Site Screening, Site Selection, and Initial Characterization



Petroleum Industry	CO ₂ Geological Storage
Reserves	Capacity
On Production	Active Injection
Approved for Development	Approved for Development
Justified for Development	Justified for Development
Contingent Resources	Contingent Storage Resources
Development Pending	Development Pending
Development Unclearified or On Hold	Development Unclearified or On Hold
Development Not Viable	Development Not Viable
Prospective Resources	Prospective Storage Resources
Prospect	Qualified Site(s)
Lead	Selected Areas
Play	Potential Sub-Regions

Prospective Storage Resources	
Project Sub-class	Evaluation Process
Qualified Site(s)	Initial Characterization
Selected Areas	Site Selection
Potential Sub-Regions	Site Screening

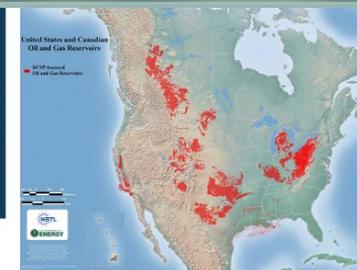
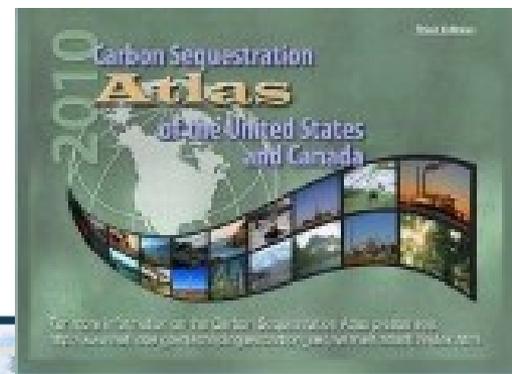
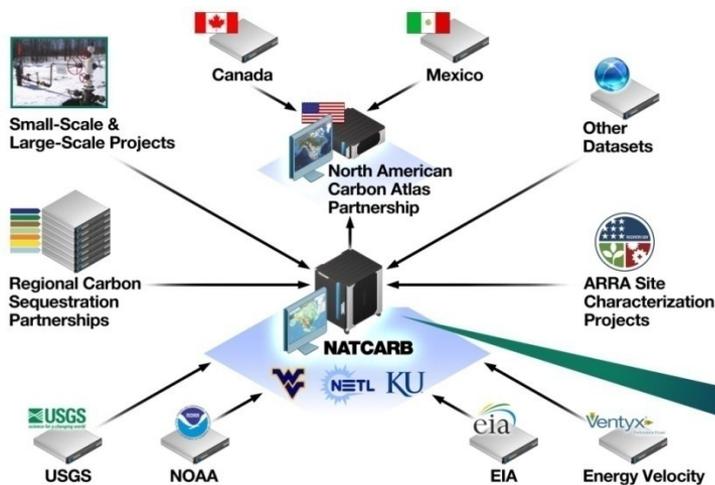
- Integrating Exploration Phase evaluation processes into one consistent (industry standard) framework, terminology and guidelines for communicating “project” related storage estimates
- Framework integrates processes and lessons learned from RCSP field projects into the Classification
- Provide stakeholders and greater sequestration community process and guidelines for site evaluation



***Adapted from SPE_WPC_AAPG_SPEE*

Knowledge Sharing Products

North American Carbon Atlas and NATCARB

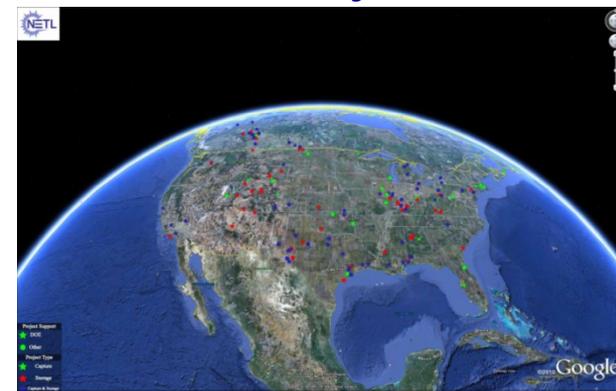


**Oil and Gas Fields
143 GT CO₂
Storage Resource**

ARRA Regional Technology Training



Worldwide CCS Project Database



RCSPs Working Groups

- Geological and Infrastructure
- Monitoring, Verification, Accounting
- Simulation and Risk Assessment
- Capture and Transportation
- GIS and Database
- Water
- Public Outreach and Education

Visit our website: www.NETL.DOE.GOV

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North American Carbon Atlas Partnership

First coordinated effort between Canada, Mexico, and the United States to jointly publish a resource of data and information on CCS technologies, pressing issues, and current progress toward solutions

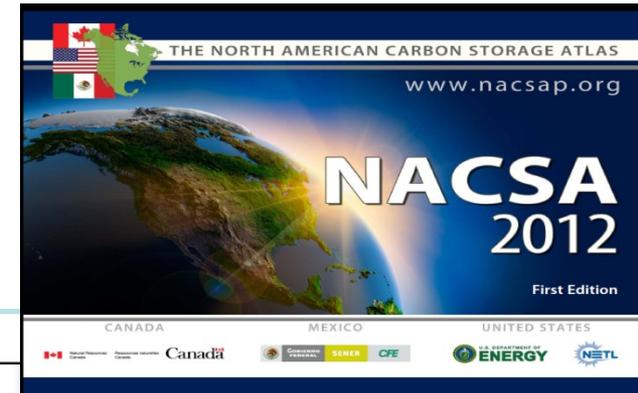
- **NACAP's Objective:**

- Identify, gather, and **share** data of CO₂ sources and geologic storage potential

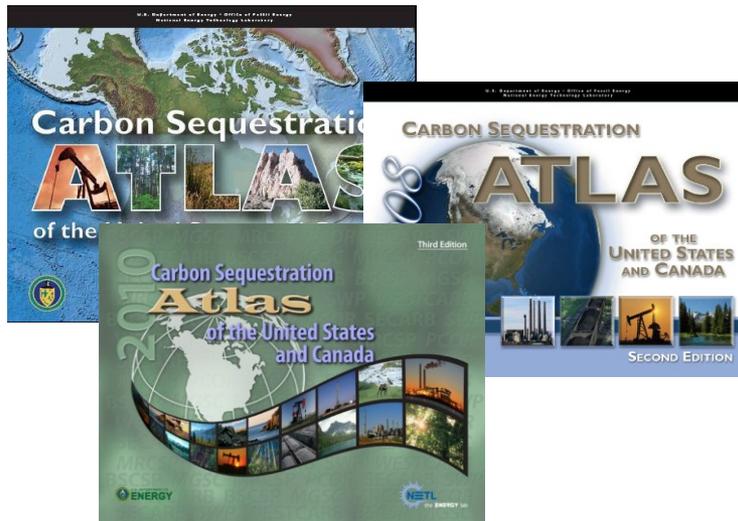
- **Development of this GIS-based CO₂ sources and storage database**

- **3 North American Products:**

- NACSA website (<http://www.nacsap.org/>) – online version of NACSA, links to resources (English, Spanish, and French)



Carbon Sequestration Atlas of the United States and Canada



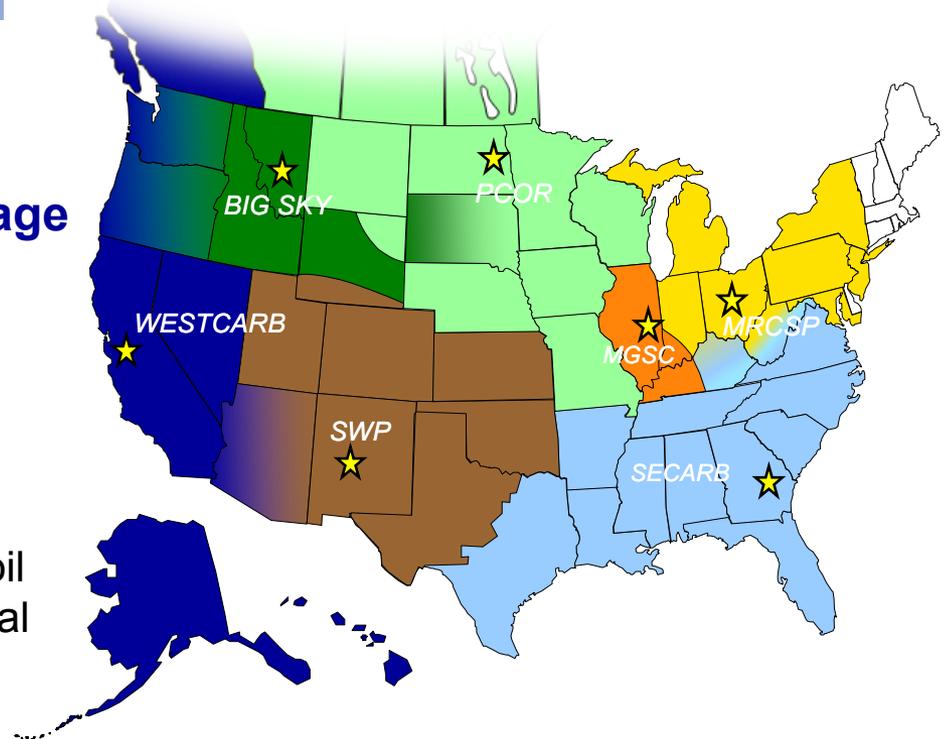
Atlas I - March 2007
Atlas II - November 2008
Atlas III - November 2010

U.S. 2012 Carbon Utilization and Storage Atlas -- ATLAS IV (Nov. 2012)

- Comparison of publically available methodologies for regional and site specific assessments

ATLAS V (Nov. 2014)

- Revised / Improved methodology for oil and gas formations and unconventional reservoirs (shale, unmineable coal, basalts)





Data Exchange for Energy Solutions

- *R&D coordination & collaboration tool*
- *Share information across networks*
 - *Rapid access through one site*
 - *Online access for historical data*
 - *Venue for newly released datasets*
- *Security, database design, and structure leverage DHS system*
- *Built to accommodate both open access and restricted access data*
- *Role-based security allows for groups or “communities” within the system*
- *Future FY13 roll outs will incorporate spatial/mapping tools, displays and other opportunities*

More information on EDX:

<http://www.netl.doe.gov/publications/factsheets/rd/R%26D184%20.pdf>

The screenshot shows the EDX website interface. At the top, there is a navigation bar with links for Home, About, Search, Contribute, My EDX, Contact, and FAQ. A search box is located in the top right corner. The main content area features a large image of an oil rig in a field, with a caption 'Photo courtesy of Devon Energy'. To the right of the image is a 'Welcome to EDX' message and a search section titled '>> Search EDX Now for:' with links for Data, News, People, Organizations, Images, and Video. Below the image is a 'Latest News Items' section with a news item about Shell's Arctic oil spill training. At the bottom, there is a footer with contact information and a 'Rate and contribute data Join Now' button.

Designed for:

- **Fossil & renewable energy researchers**
- **Policy makers**
- **General public**

NATIONAL ENERGY TECHNOLOGY LABORATORY

Now available at: <https://edx1.netl.doe.gov>

For More Information About the NETL Carbon Storage Program

- **NETL website:**

– www.netl.doe.gov

- **Office of Fossil Energy website:**

– www.fe.doe.gov

Reference Shelf

Thank you! Questions?