



the **ENERGY** lab

PROJECT FACTS
Carbon Storage – RCSP

Southeast Regional Carbon Sequestration Partnership—Validation Phase

Background

The U.S. Department of Energy Regional Carbon Sequestration Partnership (RCSP) Initiative consists of seven partnerships. The purpose of these partnerships is to determine the best approaches for permanently storing carbon dioxide (CO₂) in geologic formations. Each RCSP includes stakeholders comprised of state and local agencies, private companies, electric utilities, universities, and nonprofit organizations. These partnerships are the core of a nationwide network helping to establish the most suitable technologies, regulations, and infrastructure needs for carbon capture, utilization, and storage (CCUS). The RCSPs include more than 400 distinct organizations, spanning 43 states and four Canadian provinces, and are developing the framework needed to validate carbon storage technologies. The RCSPs are unique in that each one is determining which of the numerous CCUS approaches are best suited for their specific region of the country and are also identifying regulatory and infrastructure requirements needed for future commercial deployment. The RCSP Initiative is being implemented in three phases, the Characterization Phase, Validation Phase, and Development Phase. In September 2003, the Characterization Phase began with the seven partnerships working to determine the locations of CO₂ sources and to assess suitable locations for CO₂ storage. The Validation Phase (2005–2013) focused on evaluating promising CO₂ storage opportunities through a series of small scale field tests in the seven partnership regions. Finally, the Development Phase (2008–2020) activities are proceeding and will continue evaluating how CO₂ capture, transportation, injection, and storage can be achieved safely, permanently, and economically at large scales. These tests are providing tremendous insight regarding injectivity, capacity, and containment of CO₂ in the various geologic formations identified by the partnerships. Results and assessments from these efforts will assist commercialization efforts for future carbon storage projects in North America.

The primary objective of the DOE's Carbon Storage Program is to develop technologies to safely and permanently store CO₂ and reduce Greenhouse Gas (GHG) emissions without adversely affecting energy use or hindering economic growth. The Programmatic goals of Carbon Storage research are: (1) estimating CO₂ storage capacity in geologic formations; (2) demonstrating that 99 percent of injected CO₂ remains in the injection zone(s); (3) improving efficiency of storage operations; and (4) developing Best Practices Manuals (BPMs).

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PARTNERS

Advanced Resources International
AGL Resources
Alabama Oil & Gas Board
Alabama Power Company
Alpha Natural Resources
American Coalition for Clean Coal Energy
American Electric Power
Amvest Gas Resources
Applied Geo Technologies
ARCADIS
Arch Coal
Arkansas Oil and Gas Commission
Association of American Railroads
Augusta Systems, Inc.



U.S. DEPARTMENT OF
ENERGY

PARTNERS (CONT.)

Baker Hughes, Inc.
Big Rivers Electric Corporation
Blue Source
Bluewave Resources, LLC
BP America
Buckhorn Coal Company
CEMEX
Chevron U.S.A., Inc.
Clean Coal Technology Foundation of Texas
Clean Energy Systems, Inc.
Clemson University
CNX Gas
CO₂ Capture Project
Coal Utilization Research Council
Composite Technology Corporation
CONSOL Energy, Inc.
CSX Transportation
Dart Oil & Gas Corporation
Denbury Resources, Inc.
Dominion
Duke Energy
Eastern Coal Council
Edison Electric Institute
Electric Power Research Institute (EPRI)
Energy Services, Inc.
Equitable Production Company (EQT)
Exxon Mobile Production Company
Fibrowatt, LLC
Florida Municipal Electric Association
Florida Power & Light Company
Geological Survey of Alabama
GeoMet, Inc.
Georgia Environmental Facilities Authority
Georgia Forestry Commission
Georgia Power Company
Global CCS Institute
Halliburton
Integrated Utility Service, Inc.
Interstate Oil and Gas Compact Commission
KeLa Energy, LLC
Kentucky Coal Academy
Kentucky Geological Survey
Lawrence Berkeley National Laboratory
Lawrence Livermore National Laboratory
Louisiana Department of Environmental Quality
Louisiana Geological Survey
Marshall Miller & Associates
Massachusetts Institute of Technology
McJunkin Appalachian Oil Field Supply Company
Mississippi Power Company
Mississippi State University
Mowrey Meezan Coddington Cloud

Description

The Southeast Regional Carbon Sequestration Partnership (SECARB), led by the Southern States Energy Board (SSEB), represents the 11 southeastern states of Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia, plus counties in Kentucky and West Virginia. Currently, SECARB is comprised of more than 100 partners and stakeholders, representing federal and state governments, industry, academia and non-profit organizations. For the Validation Phase, SECARB has:

- Conducted four field studies in the most promising saline, oil, and coal-bearing formations in the region;
- Surveyed injectivity, capacity, and containment;
- Advanced the state-of-the-art technology in monitoring, verification, and accounting (MVA) techniques and instrumentation;
- Expanded characterization of geologic storage options in the Southeast for future readiness;
- Identified and addressed issues for storage technology deployment;
- Continues fostering local, regional, and national public involvement and education programs.

CO₂ sources, sinks, and transport requirements have been described and entered into a geographical information system. An assessment of public involvement and educational needs is ongoing, and an outreach plan has been developed so that stakeholders can help identify and implement regional CO₂ storage measures. Safety, regulatory, and permitting requirements within the region are being assessed in consultation with regulatory agencies, state public utility commissions, and oil and natural gas commissions. Assessment of ecosystem impacts and an action plan to address impact issues have been developed. MVA requirements are being established, along with protocols for geologic storage.

Primary Project Goal

The primary goal of SECARB is to develop the necessary framework and infrastructure to conduct field tests of carbon storage technologies and to evaluate options and potential opportunities for the future commercialization of carbon storage in the region. The SECARB partners are accomplishing this goal by designing and operating the six field tests across the region. In addition, SECARB continues to characterize the region's geologic storage options, both onshore and offshore; identify barriers and opportunities for the wide-scale construction of pipelines to transport CO₂ for the purposes of storage, EOR, and other commercial uses; monitor Federal and State regulatory and legislative activities; and support local, regional, national, and international education and outreach efforts related to the SECARB and the RCSP initiative.

PARTNERS (CONT.)

National Coal Council
 National Mining Association
 Natural Resource Partners
 Norfolk Southern
 North American Coal Corporation
 North Carolina Department of Commerce
 NRG Energy
 Nuclear Energy Institute
 Oak Ridge National Laboratory
 Old Dominion Electric Corporation
 Peabody Energy
 Penn Virginia Corporation
 Phillips Group, The
 Pine Mountain Oil & Gas, Inc.
 Pocahontas Land Corporation
 Powell River Project
 Praxair
 Progress Energy
 QEA, LLC
 Range Fuels, Inc.
 Rentech, Inc.
 RMS Strategies
 S&ME, Inc.
 Santee Cooper
 SC Public Svc. Authority/Santee Cooper
 SCANA Energy
 Schlumberger Carbon Services
 Shell Exploration & Production
 Shell Oil Company
 South Carolina Electric & Gas Company
 Southern Company
 Southern Natural Gas/El Paso
 Southern States Energy Board
 Susan Rice and Associates, Inc.
 Tampa Electric Company
 Tennessee Valley Authority
 Texas Bureau of Economic Geology
 TXU Corporation (Luminant Energy)
 United Company, The
 University of Alabama
 University of British Columbia
 Virginia Center for Coal and Energy Research
 Virginia Department of Mines, Minerals and Energy
 Walden Consulting
 Winrock International

COST

Total Project Value

\$28,872,892

DOE/Non-DOE Share

\$19,753,101 / \$9,119,791

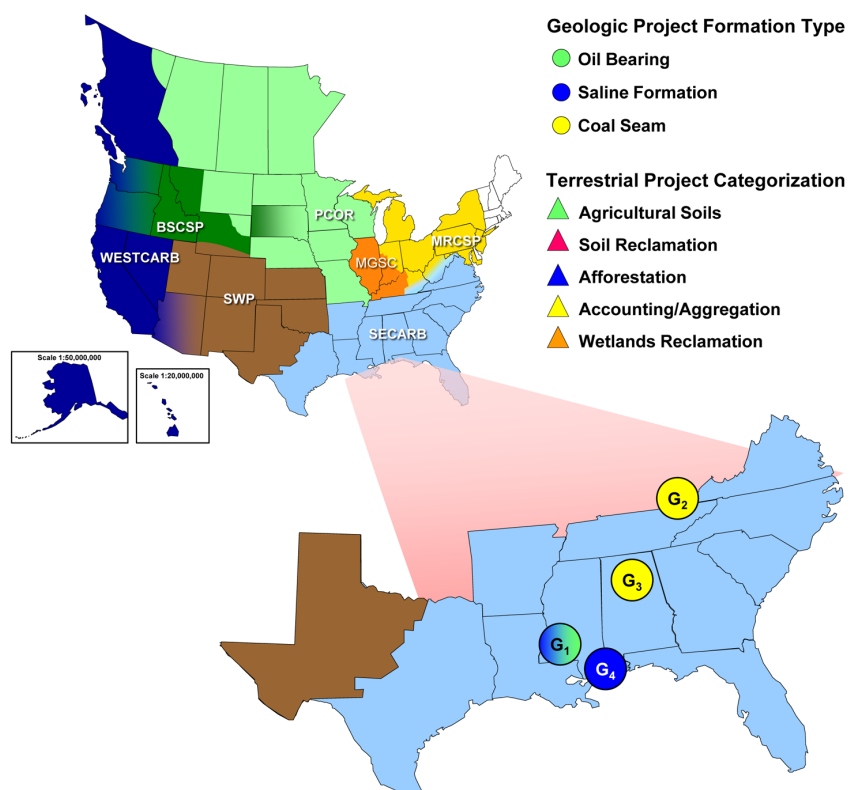
Objectives

SECARB's overall objectives are to develop the necessary framework and infrastructure to evaluate options to:

- Further characterize the region relative to sources, storage resource estimates, CO₂ storage permanence evaluations, transport, and existing and future infrastructure requirements.
- Continue to examine regulations, monitoring, safety, and other issues involved with technology deployment.
- Engage the public and elected officials at all levels in dialogue on the issues and value associated with geologic storage.
- Conduct four small-scale CO₂ injection field tests in the region's deep geologic formations to demonstrate the safety, efficiency, and effectiveness of geologic storage.
- Develop MVA protocols and BPMs that can be effectively applied to commercial-scale operations.

Field Projects

The Validation phase efforts consist of four field validation programs involving geologic storage of CO₂. Two are small-scale coal seam field tests; one in the Black Warrior Basin of Alabama and the second in Virginia. The other two are located in the Gulf Coast region, both in Mississippi, and involve small-scale CO₂ injections into the lower Tuscaloosa Formation. The first is a stacked storage field test in the Cranfield Oil Field near Natchez, and the second is conducted at a coal-fired power plant in Escatawpa, called Plant Daniel. The stacked storage field test in the Cranfield Oil Field near Natchez carried over operations to Phase III as the Early Test.



Geologic Storage Opportunities

SECARB is conducting four geologic storage field tests during the Validation Phase. The information generated allows for further characterization of potential carbon storage options in the Southeast. The “stacked formations,” oil fields overlying deep saline reservoirs along the Gulf Coast, and more specifically in the states of Alabama, Florida, Louisiana, Mississippi and Texas, are a prime target area for geologic CO₂ storage. SECARB’s research estimated 32 billion metric tons of potential storage capacity in the region’s depleted oil and natural gas fields. Coal seams are among the most attractive potential CO₂ storage options occurring in the Southeastern United States, where a prolific coalbed methane industry, which has produced more than 2.3 trillion standard cubic feet (Tscf) of natural gas, is approaching maturity. An estimated 33 billion metric tons of potential storage capacity, at a minimum, exists in the region’s unmineable coal seams. Injection of CO₂ could significantly add to the amount of produced coalbed methane within the region.

Saline formations are the primary CO₂ geologic storage options for the SECARB region because of the extensive formations that underlie many of the power plants in the region. Research by the SECARB estimated a low-end potential storage quantity of 919 billion metric tons in saline formation in the region. Work performed during the Characterization Phase showed that saline formations with favorable storage potential underlie Alabama, Florida, Louisiana, Mississippi, East Texas, and Tennessee.

Gulf Coast Stacked Storage Project (G1)

The Gulf Coast Stacked Storage project demonstrates the concept of phased use of subsurface storage volume. This storage approach combines the early use of CO₂ for EOR followed by subsequent injection into associated saline formations. This results in both short- and long-term benefits, as there is the immediate commercial benefit of EOR as a result of the injection of CO₂ (offsetting infrastructure development costs), followed by large volume, long-term storage of CO₂ in saline-bearing formations. The field test is being conducted in the lower Tuscaloosa Formation in the Cranfield unit, located in southwestern Mississippi, at a depth of 10,300 feet. This one year Validation Phase study includes a large-volume injection into the brine-bearing formations down dip of the oil ring during the Development Phase.

Accomplishment Highlights:

- Initiated injection of CO₂ for the storage/EOR activity on July 15, 2008. As of March 2009, approximately 627,744 metric tons of CO₂ have been injected.
- Completed site baseline characterization, including analysis of 200 existing wireline logs, new open-hole logs, core, and a new three-dimensional seismic survey. Results from the baseline characterization indicated that the site was well-suited for CCUS operations.
- A plugged and abandoned production well, Ella G. Lees #7, was reentered to a depth of 10,300 feet and has been instrumented as a dedicated monitoring well, with real-time pressure and temperature read-outs to assess the progress of the CO₂.
- Conducted a logging program in nearby producer wells to measure evolution of pressure and movement of fluids as reservoir pressure builds. Additional monitoring includes daily tracking well-head pressures, pressure memory gauges and dip-in pressures, and fluid composition changes measured with Schlumberger’s Reservoir Saturation Tool (RST) in an area around the initial injection and observation well. To date, monitoring indicates that CO₂ remains within the storage reservoir and EOR operations are also proceeding within the field.
- Conducted soil gas studies at abandoned and plugged wells for baseline identification. This will continue as part of the monitoring program. Time lapse surface soil gas monitoring at plugged and abandoned wells documents no changes in soil gas from pre to post-injection.

Central Appalachian Basin Coal Test (G2)

This test validates storage opportunities in the unmineable coal seams of the Central Appalachian Basin, a northeast-to-southwest-trending basin encompassing 10,000 square miles in southwestern Virginia and southern West Virginia. The principal area of investigation includes portions of five counties in Virginia (Buchanan, Dickenson, Russell, Tazewell and Wise) and four counties in West Virginia (Fayette, McDowell, Raleigh and Wyoming), however the specific injection location is in Russell County, Virginia. The project evaluated the injection of more than 900 metric tons of CO₂ into multiple coal seams of the Pocahontas Formation and Lee Formation at depths ranging between 1,400 and 2,200 feet. The project also included coalbed methane (CBM) recovery operations, adding economic value to the project. The primary project objective was to demonstrate geologic storage in unmineable Appalachian coals as a safe and permanent method to mitigate GHG emissions.

Accomplishment Highlights:

- Accomplished injection of approximately 900 metric tons of CO₂ from January 15, 2009 to February 9, 2009.
- Completed a detailed regional assessment of the potential Central Appalachian Basin carbon storage resources.
- Performed and finalized a comprehensive suite of production maps for the active CBM wells in the Central Appalachian Basin. Furthermore, preliminary reservoir modeling on the test site has been completed.
- Completed site selection of a donated CNX Gas CBM well, along with the initial reservoir modeling, site permitting, and well design for the field test site.
- Post-injection monitoring activities have verified the CO₂ has remained in the coal seams, but gas analysis has shown that the injected tracer is present in the off-set producing CBM wells. Long term monitoring of the flowback is finished.



Injection operations at the Central Appalachian Coal Seam site in Russell County, Virginia.

Black Warrior Basin Coal Test (G3)

As in the Central Appalachian Basin, the objectives of the Black Warrior Basin test were to determine if storage of CO₂ in mature CBM reservoirs is a safe and effective method to mitigate GHG emissions and to determine if sufficient injectivity exists to efficiently drive CO₂-enhanced coalbed methane (ECBM) recovery. The test occurred in the Blue Creek Coal Degassing Field near Tuscaloosa County, Alabama. An existing CBM well was utilized for injection into the Black Creek, Mary Lee, and Pratt coal zones of the Pennsylvanian-age Pottsville Formation, and three monitoring wells were drilled and instrumented. The three coal seams depths range from 1,000-2,000 feet. Two hundred and fifty-two (252) metric tons of CO₂ were injected at the site in Tuscaloosa County, Alabama, in June–August 2010.



Injection operations at the Black Warrior Basin Coal Seam site near Tuscaloosa, Alabama

Accomplishment Highlights:

- CO₂ injection complete in the Black Creek and Mary Lee coal seams, with 252 metric tons injected in June through August of 2010.
- Completed assessment of storage opportunities in coal of the Black Warrior Basin and southern Appalachian thrust belt.
- Selected test site in the Black Warrior Basin in the Blue Creek Field.
- Completed project design documents for the site.
- Pre-injection monitoring activities complete in June 2010. Results indicated that the site was suitable for ECBM recovery operations.
- Developed a vigorous technology transfer and outreach program and instituted it through the internet, publications, and presentations at technical and non-technical meetings.

Saline Reservoir Field Test: The Mississippi Test Site (G4)

The primary objective of this project was to locate and evaluate suitable saline formations for storage of CO₂ in close proximity to large coal-fired power plants along the Mississippi Gulf Coast. The target formation for this field test is the Lower Tuscaloosa Massive Sand Unit in Jackson County, Mississippi. The test included building detailed geological and reservoir maps to further assess the test site and conducting reservoir simulations to estimate injectivity, storage resources, and long-term fate of injected CO₂. Injection of 2,740 metric tons of CO₂ at depths exceeding 9,500 feet has taken place at Mississippi Power Company's Plant Daniel, a 2,000-MW facility, located near Escatawpa, Mississippi.



Drilling rig at Mississippi Test Site

Accomplishment Highlights:

- Developed a plan to conduct the storage project on the grounds of the Plant Daniel Electric Generating Facility, approved in April 2006 by Mississippi Power Company.
- Received a Class V Experimental Well injection permit from the Mississippi Department of Environmental Quality (MDEQ) and drilling permits for injection and observation wells from the Mississippi Oil and Gas Board.
- Completed monitoring and observation wells at Plant Daniel in spring 2008.
- Initiated baseline soil flux and groundwater monitoring in September 2007 prior to CO₂ injection.
- Conducted vertical seismic profile (VSP) survey in December 2008 for post-injection comparison to the baseline VSP conducted in April 2008.
- Completed injection of 2,740 metric tons of CO₂ in October 2008.

Benefits

The work supported by the SECARB partnership supports DOE's Carbon Storage Program by promoting the development of better estimations of carbon storage capacity and CO₂ storage permanence, in addition to the framework and infrastructure necessary for the deployment of carbon storage technologies and validating those technologies through field tests. Lessons-learned and information generated from SECARB's Validation Phase testing helps make CO₂ storage operations more efficient, and provides options and potential opportunities for regional CO₂ storage in the Gulf Coast and helps determine that long-term storage can be done safely, permanently, and economically.



