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Southeast Regional Carbon Sequestration Partnership
A Southern States Energy Board Carbon Management Program

Background
In 2003, the United States Department of Energy (DOE) issued awards initiating seven Regional Carbon Sequestration Partnerships (RCSP) spanning the United States and portions of Canada. Managed by DOE’s National Energy Technology Laboratory (NETL), the RCSPs currently represent more than 400 state agencies, universities, and private companies, spanning 43 states, three Native American Organizations, and four Canadian provinces. The Southern States Energy Board (SSEB) received an award on October 1, 2003, which established the Board’s overall management and administration of the Southeast Regional Carbon Sequestration Partnership, or SECARB. The geographical region currently includes 13 states and a network of more than 100 stakeholders. The Nation’s leading scientists, university researchers, national laboratories, industrial representatives, environmental organizations, and many others have taken a proactive approach at identifying and characterizing the most promising options for technology deployment and carbon dioxide (CO₂) utilization and storage (CCUS) for the Southeast. The results obtained during these injections will be important to the future commercialization of CCUS technologies and the continued use of fossil fuels as a significant energy source in a manner that is environmentally responsible.

Each of the six SECARB project locations has been locally coordinated by its own field team. The field teams assume responsibility for the technical scope of work, local education and outreach, permitting, monitoring, verification, and accounting (MVA), and maintaining the validation test’s schedule and budget. Each team contributes new information to the continued characterization of the region. In addition, a task is dedicated to integrating field data and filling gaps in regional characterization data sets. Data and tools developed in the Continued Characterization task are incorporated into a relational database and geographic information system (GIS).

All field tests, the continued characterization project, and the cross-cutting functions are designed to support the DOE roadmap by validating technologies and identifying locations throughout the region that could support full-scale CCUS deployment opportunities. Detailed fact sheets for the SECARB projects are available on the SECARB website at www.secarbon.org (see “Projects” tab).

SECARB Program
The SECARB Program is divided into three phases, all of which are funded by DOE and cost-sharing partners. During Phase I (2003-2005) of the program, SECARB completed an initial screening of potential CO₂ sources and terrestrial and geologic sinks for carbon utilization.
and/or storage. The partners developed action plans for small-scale CCUS field demonstrations. SECARB’s Phase II Validation program (2005-2011) implemented the action plans developed in Phase I, and the project teams conducted three small-scale and diverse field tests in four locations. The 10-year Phase III Development program began in 2007 with a goal to develop an integrated CO₂ capture, transportation, and geologic storage project utilizing post-combustion CO₂ captured from a coal-fired power generating facility. Phase III includes two projects; the Early Test and the Anthropogenic Test.

**SECARB Phase II Projects**

**Gulf Coast Stacked Storage Project**

Stacked saline formations along the Gulf Coast are a prime target area for geologic storage of CO₂ and can help the United States reach national emissions reduction targets. SECARB’s research estimates 31 billion metric tonnes (34 billion U.S. tons) of potential storage capacity in the region’s depleted oil and natural gas fields. The goal of this project was to validate the storage capacity of the stacked formations. SECARB’s Gulf Coast Stacked Storage Field Test, managed by the Texas Bureau of Economic Geology, began injecting CO₂ in July 2008 and concluded in 2010. It was the first of the RCSP’s Phase II programs to attain an injection volume of 500,000 metric tons. The site is located in Denbury Resources, Incorporated’s Cranfield oilfield near Natchez, Mississippi.

**Coal Seam Projects (Central Appalachia and Black Warrior Basin)**

Unmineable coal seams are among the most attractive potential CO₂ sinks 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. CO₂ injection in unmineable coal seams can enhance coal bed methane production to help offset storage costs. An estimated 82.1 billion metric tonnes (90.3 billion U.S. tons) of potential CO₂ storage capacity exists in the region’s unmineable coal seams. There are two SECARB Phase II enhanced coal bed methane (ECBM) field tests. The first was managed by Virginia Tech, and CO₂ injection of 1,000 tons was completed in February 2009. This test utilized an existing CNX Gas well located in Russell County, Virginia. The second was managed by the Geological Survey of Alabama, and El Paso Exploration and Production donated a well to the SECARB team for CO₂ injection. Four wells were drilled to monitor reservoir pressure, gas composition, water quality, and the CO₂ plume. The targeted coal seams are in the Pratt, Mary Lee, and Black Creek Coal groups within the upper Pottsville Formation and range from 940 feet to 1,800 feet in depth and from 1 foot to 6 feet in thickness. Two hundred and forty (240) tons of CO₂ was injected between June 15 and August 31, 2010. The site is located near Tuscaloosa, Alabama.
CO₂ injection at the Central Appalachian Coal Seam Project site in Russell County, Virginia.

Dr. Jack Pashin, GSA, explaining the pressure gauges and gas sampling lines at the 1-South monitoring well.

Photo taken on April 28, 2010, by Kimberly Sams Gray of SSEB.
These projects focus on coal seams with high methane content and unmineable coal seams in the vicinity of existing coal fields extending from the Appalachian Range, southwesterly into the Black Warrior Basin, and towards the Gulf Coast. The objectives for the Coal Seam Projects include the following milestones.

- These field tests demonstrated injection for ECBM in the southeastern United States and investigated associated storage in unmineable coal seams.
- A breakthrough concept for storing a full range of coal-fired power plant emissions was investigated.

**Saline Reservoir Field Test**

Saline formations are the primary CO$_2$ geologic storage option for the SECARB region because of the extensive saline formations that underlie many of the power plants in the region. SECARB’s research estimated 1,440 billion metric tonnes (1,584 billion U.S. tons) of potential storage in saline formations 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.

Mississippi Power Company’s Victor J. Daniel coal-fueled power plant was the host site of SECARB’s Saline Reservoir Field Test, which was managed by the Electric Power Research Institute. Injection operations were conducted from October 2-28, 2008.

*Open House education and outreach event during CO$_2$ injection operations at the Saline Reservoir Test Center Project at Mississippi Power Company’s Plant Daniel in Escatawpa, Mississippi.*

*Photo taken on October 15, 2008 by Kimberly Sams Gray of SSEB.*
SECARB Phase III Projects

Early Test

The Early Test is located in Cranfield, Mississippi. The SECARB project team took advantage of ongoing CO\textsubscript{2}-enhanced oil recovery (CO\textsubscript{2}-EOR) efforts by the field operator, Denbury Onshore, LLC. Research was conducted in four areas: (1) the High Volume Injection Test area (HiVIT); (2) the Detailed Area of Study (DAS); (3) the Geomechanical Test area; and (4) the near surface observatory. Following release of a Finding of No Significant Impact on March 17, 2009, Phase III injection started on April 1, 2009, at the HiVIT area and in December 2009 at the DAS. In August 2009, the team met a milestone of monitoring an injection of more than one million tonnes of CO\textsubscript{2}. In November 2009, the SECARB Early Test was recognized by DOE for furthering CCS technology and meeting G-8 goals for deployment of 20 similar projects by 2010 ([DOE Techline](#)). The Early Test is the fifth project worldwide to reach this CO\textsubscript{2} injection volume and the first in the United States. The project team monitored the storage of over 5.3 million tonnes of CO\textsubscript{2} at this site. The project was discontinued on April 30, 2015, though Denbury’s commercial operations continues.

Monitoring/Observation Well (CFU 31-F2 #1), located at the SECARB Phase III Detailed Area of Study in Cranfield, Mississippi. Note the various tools on the well, indicating the multiple MVA tools being deployed at the site.

*Photo taken on April 10, 2010, by KimberlySams Gray of SSEB.*
Knowledge gained from the Early Test is being applied at the Anthropogenic Test. This project established the world’s first fully integrated CCS project utilizing anthropogenic, or man-made, CO₂ from a coal-fueled power plant. Under separate funding, the CO₂ was captured at Alabama Power Company’s James M. Barry Electric Generating Plant located in Bucks, Alabama. The CO₂ was transported 12 miles by pipeline and permanently stored within the deep, saline Paluxy Formation at the Citronelle oilfield operated by Denbury. CO₂ injection began in August 2012 and ended in September 2014. In October 2013, the project achieved a milestone of over 100,000 metric tons of CO₂ injected. Over 114,000 tonnes of CO₂ have been injected and stored at the site. The SECARB team is applying proven and experimental MVA technologies to monitor CO₂ movement in the subsurface during the post-injection site closure phase of the project.

According to the U.S. DOE, the project "will help demonstrate the feasibility of carbon capture, utilization and storage (CCUS), considered by most energy experts as an important option for meeting the challenge of helping to reduce atmospheric CO₂ emissions linked to potential climate change." CO₂-EOR is a primary business driver for commercial CCUS deployment. An integrated system like the Anthropogenic Test is representative of the technical and business arrangements necessary for CO₂-EOR operations utilizing anthropogenic CO₂ sources.

Left to right: CO₂ capture unit at Plant Barry; CO₂ pipeline; and CO₂ injection well at Citronelle oilfield.

(Map courtesy of Advanced Resources International, Inc.)
Complementary Activities

Continued Characterization: Most Promising Geologic Storage Opportunities for CO₂

While the SECARB Phase I project was dedicated to identifying the most promising opportunities for geologic storage of CO₂ in the southeastern United States, characterization efforts continue throughout the life of the program. Within the scope of Phase III, the team has identified an multitude of Cretaceous-age sandstone units (saline reservoirs) of the Paluxy Formation, Washita-Fredericksburg interval, Tuscaloosa Group and Eutaw Formation that are suitable for safe, long-term geologic storage of CO₂. Extensive characterization of core samples taken during well drilling at project sites is a tremendous resource for future CCS project planning.

Outreach and Education

SSEB serves as the lead organization for regional outreach and education activities. This work augments the site-specific education and outreach that the field teams conduct. SSEB provides region-wide and, to the extent requested by DOE, national assistance in public education and outreach. SSEB represents the SECARB partnership in DOE conference calls and forums set up by DOE among the regional partnerships.

Outreach and education are key components of success for all three phases of the SECARB program. Conducting effective public outreach involves listening, sharing information, addressing concerns, and communicating project risks early and often. During the Characterization Phase, an action plan for outreach and education related to small-scale CO₂ utilization and storage field tests was developed.
This action plan has been carried out in Phases II and III and includes SSEB leading the international, national, and regional effort and the individual field teams leading the site specific public outreach activities. Each field site has hosted one or more Open House meetings to engage the local community and future CCS workforce. Knowledge sharing events have been hosted and thousands of presentations have been delivered and posters displayed since the SECARB program began in 2003 to share the details of the SECARB projects' definition, design, implementation, operation, and closeout activities with various audiences. SSEB maintains a website at secarbon.org with current fact sheets, photos of field activities, news, and upcoming, and recent events. Timely updates on project activities are communicated through multiple electronic sources, including social networking.

Legal and Regulatory Analysis

SSEB provides all regulatory and permitting cross-cutting support to the field teams, as required. SSEB also monitors federal and state regulatory and legislative activities and reports significant findings to the field team leads, SECARB stakeholders, and appropriate SSEB members and affiliates. In July 2011, SSEB published Carbon Capture and Sequestration Legislation in the United States of America. This study provides an overview of four key areas identified as necessary elements of a broader comprehensive regulatory framework governing CCS activities. The key areas are Project Authority, Pore Space and CO$_2$ Ownership, Liability and Financing Sources. The publication is available under the Reference tab of the SSEB website (www.sseb.org).

Pipeline Study

The Pipeline Study task was established on June 1, 2009, to identify barriers and opportunities for the wide-scale construction of pipelines to transport CO$_2$ for the purposes of storage, enhanced oil and gas recovery, and other commercial uses. Other objectives are to inform key decision-makers about transportation as it relates to guidelines, legal, regulatory, and liability frameworks for CCS; to facilitate cooperation, collaboration, and communication among key stakeholders involved in pipeline infrastructure planning and development; and to form a basis for continued future planning and communication. The Pipeline Transportation Task Force published its research findings and recommendations on January 31, 2011 (visit www.secarbon.org to download the report). The Interstate Oil and Gas Compact Commission participated with SSEB on the study.
**Offshore Study**

In October 2013, the SECARB partners published a document entitled *Preliminary Evaluation of Offshore Transport and Storage of CO₂* as part of the Phase III program. The report provides basic information and recommendations that will guide regulators, policy makers, legal professionals, and carbon-emitting industries in evaluating the potential for CO₂ storage in sub-seabed geological structures. The report explores geological and technical topics that should be considered to develop and apply a robust legal and regulatory framework that will facilitate the deployment of a successful offshore CCUS project.

The report is available online at [www.secarbon.org](http://www.secarbon.org) under the “Publications and Press” tab. SSEB’s partners in this effort include the Bureau of Economic Geology at The University of Texas at Austin, the Geological Survey of Alabama, the Interstate Oil and Gas Compact Commission, and the Offshore Task Force experts who contributed to the report.

**Commercialization Opportunities**

Early opportunities for commercialization in the Southeast region have been associated with an ability to offset the cost of capturing and storing CO₂. Utilizing CO₂-EOR is the primary candidate for offsetting costs in several SECARB states. Work conducted by SECARB in Gulf Coast formations will assist in expanding CO₂-EOR and ECBM recovery opportunities.

Within the SECARB region, CO₂-EOR is in place in Texas, Louisiana, and Mississippi. CO₂ that is used for EOR is coming from the Jackson Dome, a natural source of CO₂ located near Jackson, Mississippi. Denbury Resources operates a pipeline network that transports Jackson Dome CO₂ to oilfields in the Southeast. As a result, the Denbury pipeline system has the potential for becoming the regional backbone of an integrated source-sink network for CO₂.