PROJECT facts

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

Carbon Sequestration

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# SOUTHWEST REGIONAL PARTNERSHIP FOR CARBON SEQUESTRATION—VALIDATION PHASE

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## Background

The U.S. Department of Energy (DOE) has selected seven Partnerships, through its Regional Carbon Sequestration Partnership (RCSP) Program, to determine the best approaches for capturing and permanently storing carbon dioxide ($CO_2$), a greenhouse gas (GHG) which can contribute to global climate change. The Partnerships are made up of state agencies, universities, private companies, and nonprofit organizations that form the core of a nationwide network helping to establish the most suitable technologies, regulation, and infrastructure needs for carbon sequestration. The Partnerships include more than 350 organizations, spanning 41 states, three Indian nations, and four Canadian provinces. The RCSPs are developing the framework needed to validate and deploy carbon sequestration technologies. They will evaluate and determine which of the numerous sequestration approaches are best suited for their specific regions of the country and are studying possible regulatory and infrastructure requirements that will be needed should policy and economics indicate that sequestration be deployed on a wide scale. The Validation Phase (2005–2009) of the Partnership Program is focused on validating promising $CO_2$ sequestration opportunities through a series of field tests in the seven Partnership regions.

## Description

The Southwest Regional Partnership for Carbon Sequestration (SWP), led by the New Mexico Institute of Mining and Technology, Socorro, New Mexico includes the states of Colorado, Oklahoma, New Mexico, Utah, and portions of Arizona, Kansas, Texas, and Wyoming. The SWP is conducting five field tests – three geologic and two terrestrial – all at various stages of planning and execution, and each designed to validate the most promising carbon sequestration technologies and infrastructure concepts. The field tests represent a variety of carbon sink targets, including enhanced oil recovery (EOR) with carbon sequestration, enhanced coal bed methane (ECBM) production with carbon sequestration, and geologic sequestration tests combined with terrestrial tests.

In the Southwest Region, over 95 percent of anthropogenic $CO_2$ emissions result from fossil fuel combustion, with about half of these emissions from power plants. Geologic storage options include coal seams (2.1 billion metric tons of minimum storage potential), natural gas and depleted and marginal oil fields (21.7 billion metric tons minimum storage potential), and deep saline formations (73.3 billion metric tons of minimum storage potential). One option the Partnership is exploring is the viability of supplanting the $CO_2$ currently produced from natural $CO_2$ reservoirs, used for enhanced oil and natural gas recovery, with anthropogenic $CO_2$ from power plants. The presence of $CO_2$ pipelines that bridge $CO_2$ sources and potential $CO_2$ sinks may improve the viability of this possibility. Although terrestrial $CO_2$ sequestration appears to be a viable alternative in several parts of the Southwest Region, low rainfall in some areas decreases the relative terrestrial storage capacity, limiting the applications of this option.

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## PARTNERS

Advanced Resources International (ARI)

Applied Sciences Lab

Arizona Geological Survey

Arizona State University

Blue Source, LLC

Center for Energy & Economic Development (CEED)

Chevron

Colorado Geological Survey

Colorado School of Mines

Colorado State University

ConocoPhillips

Dine College

Electric Power Research Institute (EPRI)

Gas Technology Institute (GTI)

Intermountain Power Agency

Interstate Oil and Gas Compact Commission (IOGCC)

KinderMorgan $CO_2$ Company, L.P.
Los Alamos National Laboratory

Navajo Nation

Navajo Nation Oil and Gas Company

New Mexico Bureau of Geology

New Mexico Environmental Department

New Mexico Institute of Mining and Technology

New Mexico Oil and Gas Association (NMOGA)

New Mexico Oil Conservation Division

## Primary Project Goal

Develop an optimum sequestration strategy for the Southwest, subject to the constraints unique to the region (such as water availability), identify the available technologies on which to base the strategy, determinie technology gaps, and carry out field tests of sequestration options.

## Objectives

- Conduct multiple field pilot tests to validate the most promising sequestration technologies and infrastructure concepts in different parts of the region, including three geologic pilot tests and two terrestrial pilot programs.
- Develop risk mitigation procedures for the sequestration tests.
- Optimize monitoring, mitigation and verification (MMV) protocols for each test.
- Conduct effective outreach and communication to stakeholders and the general public.

## Geologic Sequestration Opportunities

The Southwest Region is rich in geologic sinks, including depleted oil and natural gas fields, saline formations, and coal beds. EOR using $CO_2$ has been conducted in the region for over 30 years. Several hundred miles of $CO_2$ pipelines through the region provide access to $CO_2$ near many candidate project sites. The SWP test pilot scale injections are being deployed in two types of geologic sinks, piggy-backing upon commercial projects.

**Paradox Basin, Utah: Aneth EOR-Sequestration Test (G1)**

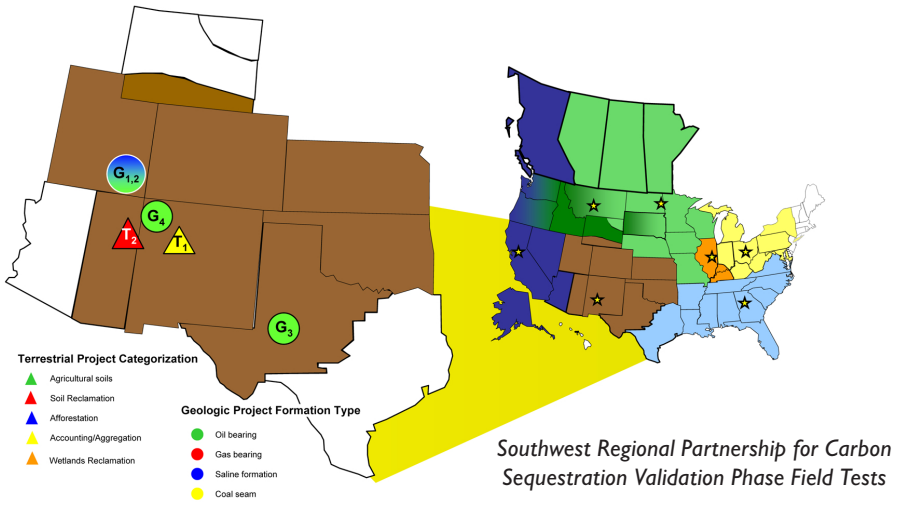
Since August 2007, the SWP has been testing EOR combined with sequestration by injecting a minimum of 150,000 tons of $CO_2$ per year for two years into the Desert Creek and Ismay producing zone, approximately 5,600 to 5,800 feet deep, in the Aneth Oil Field in San Juan County, near Bluff, Utah. The $CO_2$ for this project is sourced from the McElmo Dome; a natural $CO_2$ reservoir located in southwestern Colorado.

Accomplishment Highlights:

- Baseline surface fluxes measured.
- Baseline reservoir groundwater (brine) compositions assessed.
- Three-dimensional (3-D) reservoir model grids assembled.
- Surface and subsurface geological maps and cross-sections refined through new mapping.
- Injection began in August 2007.
- Reservoir tracer testing began in July 2007; analyses are ongoing.
- Vertical seismic array installed; passive seismic monitoring now under way.

**Permian Basin, Texas: SACROC-Claytonville EOR Sequestration Test ($G_2$)**

This test includes a post-audit modeling analysis of injected $CO_2$ for EOR over the last 30 years at the SACROC Unit in the Permian Basin of Texas, in addition to intense MMV analyses of ongoing $CO_2$ injection at SACROC. Results will be used by Kinder Morgan to define an optimized commercial approach to EOR with sequestration in the Claytonville field, a nearby field with similar geology that has not yet been subjected to $CO_2$ injection; Kinder Morgan will begin $CO_2$ injection at Claytonville in 2010. The SACROC pilot represents an opportunity for making $CO_2$ storage history – matching in tandem with large-scale MMV operations during injection of between 900,000 and 1.5 million tons of $CO_2$. The target formations are the Cisco and Canyon Formations within the Horseshoe Atoll Play and the Pennsylvanian Reef/Bank Play.




*Southwest Regional Partnership for Carbon Sequestration Validation Phase Field Tests*

Accomplishment Highlights:

- Baseline surface fluxes measured.
- Baseline reservoir groundwater (bring) compositions assessed.
- 3-D reservoir model grids assembled.
- 3-D reservoir simulations successfully run, using models that are fully parameterized with multiphase flow of oil, $CO_2$, brine, and reactive chemistry.
- Surface and subsurface geologic maps and cross-sections refined through new mapping techniques.
- 3-D reflection seismic survey completed.
- 2-D vertical seismic profile (VSP) completed.

**San Juan Basin, New Mexico: Enhanced Coalbed Methane (ECBM) Sequestration Test (G3)**

The San Juan Basin pilot test will examine ECBM efficacy and degree of CO2 sequestration by injecting 35,000 tons of CO2 form the McElmo Dome into the coals of the Upper Cretaceous Fruitland formation. The project proposes to desalinate produced water from the ECBM pilot and use the water for irrigating a riparian restoration project, forming a combined ECBM/terrestrial sequestration project. The test site is at the San Juan Basin Coal Fairway, near Navajo City, New Mexico. .

Accomplishment Highlights:

- Baseline surface fluxes measured
- Baseline reservoir groundwater (brine) compositions assessed
- 3-D reservoir model grids assembled and simulations underway
- Tiltmeter array surveyed and being installed

## Terrestrial Opportunities

Terrestrial carbon capacity in the Southwest Region is limited by low average annual precipitation and yearly variability in precipitation. Even in systems managed for carbon storage, wet years followed by a series of dry years may result in a net carbon flux out of the system. There is limited opportunity to increase carbon storage on rangelands because most areas are at a relatively stable equilibrium given land use history and management. Much of the desert grassland and shrub land areas with less than 12 inches of annual precipitation are subject to loss of cover and exposure

## PARTNERS (cont.)

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Oklahoma Gas and Electric
Oklahoma Geological Survey
Oklahoma State University
PacifiCorp
NM Petroleum Recovery Research Center (PRRC)
Public Service Company of New Mexico (PNM)
Resolute Natural Resources Company
Sandia National Laboratories
Southern Cal Edison Electric Service
Texas A&M University
Texas Bureau of Economic Geology
Tucson Electric Power Company
U.S. Department of Agriculture
University of Oklahoma
University of Utah
Utah Automated Geographic Reference Center (AGRC)
Utah Division of Air Quality
Utah Division of Oil, Gas, & Mining
Utah Energy Office
Utah Geological Survey
Utah State University
Waste-Management Education & Research Consortium (WERC)
Western Governors' Association
Xcel Energy
Yates Petroleum Corporation

## COST

**Total Project Value**
$17,299,083

**DOE/Non-DOE Share**
$12,696,283/4,602,800

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to wind and water erosion. Retaining soil carbon levels in these ecosystems will require active restoration practices that are challenging given current technologies. Two demonstration projects are proposed.

**Southwest Regional Terrestrial Pilot Test (T1)**

The rterrestrial pilot test will develop a carbon reporting and monitoring system that functions consistently across hierarchical scales and is compatible with the existing technology underlying the DOE's Energy Information Administration Voluntary Reporting of Greenhouse Gases (1605b) Program. Within this system, the project will: (1) develop improved technologies and systems for direct measurement of soil and vegetation carbon at reference sites selected within the region; (2) develop remote sensing and classification protocols to improve mesoscale (km2) soil and vegetation carbon estimates; (3) construct ecological process (State and Transition) models that reflect soil/vegetation changes resulting from current land use and land use associated with implementation of programs to sequester carbon or reduce carbon losses; and (4) develop a regional inventory and decision support tool. The value-added products of the test will be new carbon credits and increased land productivity.

Accomplishment Highlights:

- Applied pattern recognition technology to remotely sensed imagery to classify rangeland plant communities.
- Identified soil/vegetation combinations that have a high uncertainty levels in the initial model runs and acquired soils for testing for calibrating the model.
- Completed initial tests of laser induced breakdown spectroscopy (LIBS) as a laboratory and field base measurement technology.

**Terrestrial Riparian Restoration Project (T2)**

This project proposes to desalinate produced water from the San Juan Basin ECBM pilot and use the water for irrigating a riparian restoration project, forming a combined ECBM/terrestrial sequestration project. The test site will be the San Juan Basin Coal Fairway, near Navajo City, New Mexico, and involve such value-added products as new carbon credits, improved water quality, and improved ecological conditions.

Accomplishment Highlights:

- This project is scheduled to run in tandem with the Partnership's ECBM project in the San Juan Basin

## Benefits

This project will benefit the United States by providing a comprehensive assessment of the sources and potential sinks for $CO_2$ in the Southwest region. This data can be integrated with the data from other partnerships to provide a database covering the entire nation. The data generated by the field tests will provide information to evaluate potential commercial-scale sequestration projects in the Southwest. Some value-added benefits of the project include enhanced recovery of oil, natural gas, and coalbed methane. Methane is adsorbed in coals, and $CO_2$ can replace the methane and release it for recovery. Part of the value-added benefits for oil, natural gas, and methane recovery is that some of the cost of $CO_2$ storage is mitigated by the revenue from sale of the recovered hydrocarbons. Currently, all such enhanced resource recovery operations use $CO_2$ drawn from natural $CO_2$ reservoirs. If all enhanced recovery operations in the southwestern United States were to use power-plant generated $CO_2$ rather than natural $CO_2$, it is estimated that the region would see at least a 10 percent reduction in greenhouse gas intensity. Finally, another value-added benefit for the region is a potential increase in carbon credits. Test results will be critical to the development of DOE's FutureGen Initiative which will produce both hydrogen and electricity from a highly efficient and technologically sophisticated coal-fired power plant with virtually no emissions.