

PROJECT facts

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

Carbon Sequestration

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PLAINS CO₂ REDUCTION PARTNERSHIP— VALIDATION PHASE

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 (CO₂), 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 CO₂ sequestration opportunities through a series of field tests in the seven Partnership regions.

Description

The Plains CO₂ Reduction (PCOR) Partnership is a diverse group of public and private sector stakeholders working together to better understand the technical and economic feasibility of capturing and storing CO₂ emissions from stationary sources in the central interior of North America. The PCOR Partnership is managed by the Energy & Environment Research Center (EERC) at the University of North Dakota, and is one of seven Regional Partnerships funded by DOE and a broad range of project sponsors. The region generates about 12 percent of U.S. CO₂ emissions from major stationary sources. The PCOR Partnership region has abundant geologic sink opportunities. Under the PCOR Partnership Characterization Phase (2003–2005), key reservoir characterization data were gathered for over 1,900 oil fields in the oil-producing states and provinces of the region. Three saline formations that cover large portions of the region were also evaluated in the Characterization Phase, and several more have been identified for evaluation in the Validation Phase. The region's major coal fields have also been evaluated for CO₂ sequestration potential.

The PCOR Partnership region also contains many opportunities for terrestrial sequestration of CO₂. Terrestrial sinks include agricultural lands (e.g., croplands, grasslands, and rangelands), forestlands, wetlands, and peat bogs. Forested areas within the PCOR Partnership region total more than 302 million acres, agricultural lands (both farmland and rangeland) total more than 402 million acres, the Prairie Pothole Region (PPR) includes 30.9 million acres of wetlands, and the region contains more than 106 million acres of peat bogs. While the amount of carbon that can be sequestered terrestrially is species- or location-dependent, gross estimates of sequestration capacity can be made by applying known sequestration rates to the available acreages.



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Alberta Energy and Utilities Board
Alberta Energy Research Institute
Alberta Geological Survey
ALLETE
Ameren Corporation
American Lignite Energy (ALE)
Apache Canada Ltd.
Basin Electric Power Cooperative
Bechtel Corporation
Blue Source, LLC
BNI Coal, Ltd.
British Columbia Ministry of
Energy, Mines, and Petroleum
Resources
Carbozyme, Inc.
Center for Energy and Economic
Development (CEED)
Chicago Climate Exchange
Dakota Gasification Company
Ducks Unlimited Canada
Ducks Unlimited, Inc.
Eagle Operating, Inc.
Eastern Iowa Community College
District
Enbridge Inc.
Encore Acquisition Company
Energy & Environmental Research
Center (University of North
Dakota)
Environment Canada
Excelsior Energy Inc.
Fischer Oil and Gas, Inc.

Primary Project Goal

The overall goal of the PCOR Partnership Validation Phase is to develop a core of local technical expertise and experience to facilitate future CO₂ sequestration efforts in both subsurface and terrestrial settings in the PCOR Partnership region by technology validation through several relatively small field tests.

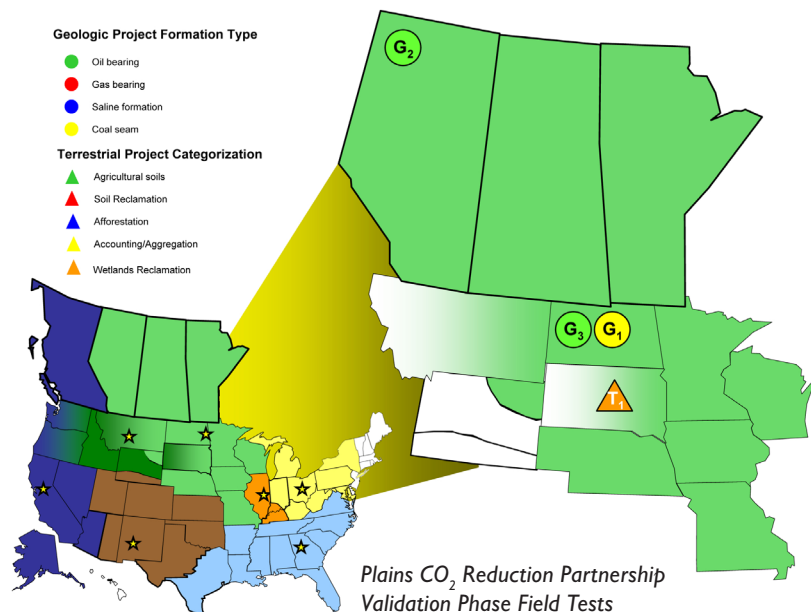
Objectives

- Continue to assess regional carbon sequestration opportunities.
- Develop and implement field tests.
- Evaluate the feasibility of selected commercial-scale carbon sequestration technologies.
- Assess storage capacity, CO₂ permanence, economics, risk, public acceptance, and societal and monetary benefits.
- Provide outreach and education for CO₂ sequestration stakeholders and the general public.

Field validation tests that will demonstrate three sequestration scenarios of significant scale and designed to verify the proposed concepts are under way. The PCOR Partnership Characterization Phase (2003–2005) results have indicated enormous potential for sequestration in strata suitable for enhanced oil recovery (EOR). EOR projects are especially compelling as field validation tests since the PCOR Partnership's regional opportunity is large, and the economics are favorable. The information generated on sink capacities and permanence; monitoring, mitigation, and verification (MMV); CO₂ transport; economics; risk; public acceptance; and societal benefits that will result from the proposed sequestration/EOR tests, makes them ideal activities for the Validation Phase.

Accomplishments

The PCOR Partnership is conducting three geologic sequestration validation field tests and one wetland terrestrial sequestration investigation. The field trials involve storage of CO₂ and comprehensive monitoring of depleted oil and natural gas reservoirs, unmineable coal seams, and wetland restoration and management. These activities, along with continued regional characterization and integration with other RCSPs, are providing a firm technical foundation for the PCOR Partnership's large-scale Deployment Phase tests (initiated in September 2007) and for future commercial-scale deployment of carbon capture and storage (CCS) in the region.



Lignite in North Dakota Field Validation Test

A maximum of 400 tons of CO₂ at a drilling depth of approximately 1,600 feet will be injected into unmineable lignite seams of the Williston Basin to determine the suitability of these strata for both CO₂ sequestration and coalbed methane production. The test is located in Burke County, North Dakota, and will determine whether long-term contact with CO₂ affects the physical stability and gas storage capacity properties of lignite and the hydrodynamic properties of the seam. Lignite coal seams in North Dakota may have the capacity to store 380 million tons of CO₂ and the potential to produce 1.1 trillion cubic feet (Tcf) of methane.

Accomplishment Highlights:

- Drilling of one CO₂ injection well and four monitoring wells were completed in a five-spot pattern during the summer of 2007.
- A 30-foot core was retrieved (including 20 feet of cap rock) for geophysical and geochemical analysis.
- Gas samples from the wells have been obtained and are being analyzed for methane content and to provide baseline for MMV.
- Preliminary results from data analysis indicate the existence of multiple coal seams with sufficient areal extent and low-permeability clay layers above and below the target seam. The targeted coal seam (~1,100 ft) was selected as the best candidate for CO₂ injection.
- The project will be featured in an upcoming production of the Public Broadcasting Service series NOVA and TV Tokyo, America.

Zama Field Validation Test

The field validation test being conducted at Apache Canada's Zama oil field in Alberta, Canada, is evaluating the potential for geologic sequestration of CO₂ in an acid gas stream that also includes high concentrations of hydrogen sulfide (H₂S) for the concurrent purposes of CO₂ sequestration, H₂S disposal, and EOR. Approximately 230,000 tons of CO₂ and 80,000 tons of H₂S will be stored in the oil field over the lifetime of the commercial project at a drilling depth of 5,500 feet. The target formation is a carbonate pinnacle reef structure of the Middle Devonian Keg River Formation – one of the hundreds of such structures within the Zama subbasin. The project is providing insight regarding the impact of high concentrations of H₂S on sink integrity, MMV, and EOR productivity within a carbonate formation. It is anticipated that the EOR operations will yield 180,000 - 276,000 barrels of incremental oil recovery per year.

Accomplishment Highlights:

- Injection of acid gas into the test formation began December 2006.
- Over 12,000 tons of acid gas (~4,800 tons CO₂) has been injected as of January 2008.
- In March 2007, the Zama field validation test was recognized by the Carbon Sequestration Leadership Forum for the MMV strategy employed at the site.

Williston Basin EOR Field Test

The Williston Basin demonstration test will evaluate the potential for geological sequestration of CO₂ in a deep carbonate reservoir for the dual purpose of CO₂ sequestration and EOR. Characterization studies indicate that the oil fields of the Williston Basin may have over 1 billion tons of CO₂ storage capacity. Additionally, the volume of incremental oil that could be produced from Williston Basin oil fields has been estimated to be approximately 1 billion barrels. With the Deployment Phase project now under way, results of the Validation Phase activities will be used to support the large-scale deployment project.

A maximum of 5,000 tons of CO₂ will be injected into a target formation that will likely be in either the Devonian Duperow Formation or the Mississippian Madison Group, at depths of 10,000 - 12,000 feet. Potential sources of CO₂ being

PARTNERS (cont.)

- Great Northern Power Development, LP
- Great River Energy
- Hess Corporation
- Interstate Oil and Gas Compact Commission (IOGCC)
- Iowa Department of Natural Resources — Geological Survey
- Kiewit Mining Group Inc.
- Lignite Energy Council
- Manitoba Hydro
- MEG Energy Corporation
- Melzer Consulting
- Minnesota Geological Survey—University of Minnesota
- Minnesota Pollution Control Agency
- Minnesota Power
- Minnkota Power Cooperative, Inc.
- Missouri Department of Natural Resources
- Missouri River Energy Services
- Montana–Dakota Utilities Co.
- Montana Department of Environmental Quality
- Montana Public Service Commission
- Murex Petroleum Corporation
- National Commission on Energy Policy
- Natural Resources Canada
- Nexant, Inc.
- North American Coal Corporation
- North Dakota Department of Commerce Division of Community Services
- North Dakota Department of Health
- North Dakota Geological Survey
- North Dakota Industrial Commission Department of Mineral Resources, Oil and Gas Division
- North Dakota Industrial Commission Lignite Research, Development and Marketing Program
- North Dakota Industrial Commission Oil and Gas Research Council
- North Dakota Natural Resources Trust

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North Dakota Petroleum Council
North Dakota State University
Otter Tail Power Company
Petroleum Technology Research Centre
Petroleum Technology Transfer Council
Prairie Public Broadcasting
Pratt & Whitney Rocketdyne, Inc.
Ramgen Power Systems, Inc.
RPS Energy
Saskatchewan Industry and Resources
SaskPower
Schlumberger
Shell Canada Energy
Spectra Energy
Strategic West Energy Ltd.
Suncor Energy Inc
Tesoro Refinery (Mandan)
University of Alberta
University of Regina
U.S. Department of Energy
U.S. Geological Survey Northern Prairie Wildlife Research Center
Western Governors' Association
Westmoreland Coal Company
Wisconsin Department of Agriculture, Trade, and Consumer Protection
Xcel Energy

COST

Total Project Value

\$18,142,149

DOE/Non-DOE Share

\$14,374,767 / \$3,767,382

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WEBSITE

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considered for the field test are the Great Plains Synfuels Plant near Beulah, North Dakota, operated by Dakota Gasification Company; a natural gas-processing plant operated in western North Dakota; and an ethanol plant operated in western North Dakota. Evaluations have focused on determining the properties of candidate sites that may be suitable to host the EOR demonstration project, including performing robust reservoir-modeling activities. Construction requirements will include the modification of wells for CO₂ injection and the infrastructure and facilities necessary to transport the CO₂. With respect to injection operations, it is anticipated that CO₂ will be injected into the target zone using a minimum of two injection wells at a rate that is appropriate for pilot-scale EOR operations. Injection is expected to be conducted over about one year of the project beginning in the summer of 2008.

Accomplishment Highlights:

- Reconnaissance-level evaluations were conducted of several reservoirs in the Williston Basin that may be suitable candidates for the injection and MMV activities.
- Geophysical logs were obtained for 100 wells in the Billings Anticline–Dickinson and Nesson Anticline areas.
- Petrophysical models that give a more detailed evaluation of sealing formations and zones of porosity that are not hydrocarbon bearing, were developed for possible fields.

PCOR Terrestrial Field Validation Test

Wetland restoration activities in the PPR will provide the background information needed to determine carbon offsets, develop protocols and standards, and provide a market-based carbon sequestration strategy in the future. The project will consist of a field study for collection of the scientific information necessary to facilitate market development; the identification, development, and application of alternative land use management practices that will result in GHG reductions; and the development of appropriate protocols that will provide the background data needed for the eventual determination of carbon offsets to be sold in voluntary GHG markets. This regional sink opportunity has a capacity to store 135 million tons of CO₂.

Accomplishment Highlights:

- 2007 grassland and wetland sampling efforts were completed at North Dakota and South Dakota sites.
- 75 cores were collected and are presently in storage, and awaiting processing.

The first full season of GHG flux monitoring from cropland, restored wetland, and native prairie wetland catchments was completed in December 2007. The result of these efforts produced the collection of over 4,000 individual gas samples that are currently being analyzed.

Benefits

This project will benefit the United States by providing a comprehensive assessment of the sources and potential sinks for CO₂ in the central interior of North America. The data are being integrated with the data from other partnerships to provide a database covering the entire nation. The project will promote cooperation among stakeholders and help ensure public acceptance of CO₂ sequestration. Analysis of existing EOR projects in the region will also provide valuable data to increase the understanding of this option for CO₂ sequestration.

The PCOR Partnership Validation Phase projects are demonstrating that geologic storage is not just an option for the distant future, but is now being implemented on a large scale for both environmental and commercial reasons. The PCOR Partnership estimates additional oil recovery through regional EOR applications of over 1.4 billion barrels, with a value of approximately \$100 billion at U.S. \$50 per barrel. Overall, based on the geological formations characterized to date, the PCOR Partnership region has the capacity to sequester 97 billion metric tonnes (106.7 billion tons) of CO₂ in saline formations, 19.6 billion metric tonnes (21.56 billion tons) in depleted oil and natural gas fields, and 8 billion metric tonnes (8.8 billion tons) in unmineable coal seams.