PROJECT facts

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

Sequestration

10/2007

PLAINS CO_2 REDUCTION PARTNERSHIP — DEPLOYMENT PHASE

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Background

As part of a comprehensive effort to assess options for sustainable energy systems, the U.S. Department of Energy has selected seven Regional Partnerships through its seven Regional Carbon Sequestration Partnership Program to determine the best approaches for capturing and permanently storing carbon dioxide (CO_2), a greenhouse gas that can contribute to global climate change. The Partnerships are made up of state agencies, universities, private companies, national laboratories, and nonprofit organizations that form the core of a nationwide network helping to establish the most suitable technologies, regulations, and infrastructure needs for carbon sequestration. Altogether, the Partner-ships include more than 350 organizations, spanning 41 states, two Indian nations, and four Canadian provinces.

Figure 1. Location of deployment sites in the PCOR Partnership region.

The Regional Partnerships' initiative is being implemented in three phases. The Characterization Phase began in September 2003 with the Partnerships working to develop the necessary framework to validate and potentially deploy carbon sequestration technologies. In June 2005, work transitioned to the Validation Phase, a four-year effort focused on validating promising CO_2 sequestration opportunities through a series of field demonstrations in the seven regions. Presently, activities in the Deployment Phase (2008-2017) are extending the work completed to date and will demonstrate that CO_2 capture, transportation, injection, and storage can be achieved safely, permanently, and economically at a large scale. These demonstrations will promote understanding of injectivity, capacity, and storability of CO_2 in the various geologic formations identified by the Partnerships. Results and assessments from these efforts will help in the commercialization efforts for future sequestration demonstrations in North America.

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PCOR PARTNERS (PHASE I–III)

- U.S. Department of Energy
- University of North Dakota Energy & Environmental Research Center
- Advanced Geotechnology, a division of Hycal Energy Research Laboratories, Ltd.
- Air Products and Chemicals, Inc.
- 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
- Environment Canada
- Excelsior Energy Inc.
- Fischer Oil and Gas, Inc.
- Great Northern Power Development, LP
- Great River Energy
- Hess Corporation
- Interstate Oil and Gas Compact Commission

The Plains CO_2 Reduction Partnership (known as the PCOR Partnership), led by the University of North Dakota's Energy & Environmental Research Center (EERC), includes all or part of the states of Iowa, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota, Wisconsin, Wyoming and the Canadian provinces of Alberta, British Columbia, Manitoba, and Saskatchewan. The PCOR Partnership includes over 70 organizations. The 9 states in the PCOR Partnership account for about 15 percent of U.S. total CO_2 emissions from stationary sources. The region offers significant potential for sequestration in limestone, sandstone, and unmineable coal seams, as well as in depleted oil and gas reservoirs. Of particular interest is the use of CO_2 for enhanced oil recovery (EOR) in tandem with sequestration.

Project Description

Project Summary

The PCOR Partnership is planning two CO_2 sequestration demonstrations (see Figure 2) for the Deployment Phase (Phase III). The Williston Basin demonstration will transport a minimum of 450,000 tonnes (500,000 U.S. tons) of CO_2 per year from Basin Electric Power Cooperative's Antelope Valley Station, an existing conventional coal-fired power plant in central North Dakota, and inject it into an oil reservoir located in western North Dakota or eastern Montana. This demonstration will simultaneously achieve two objectives—EOR and sequestration of CO_2.

Figure 2. Pump jack on an oil well in the Williston Basin.

The Fort Nelson project will utilize approximately 1.6 million tonnes (1.8 million U.S. tons) of CO_2 per year, captured from one of the largest gas-processing plants in North America. The CO_2 will be compressed and transported in a supercritical state via pipeline to the target injection location. While a specific saline formation and injection location have not yet been chosen, it is anticipated that the target zone will be a brine-saturated carbonate rock formation located in northeastern British Columbia.

Injection Site Description

The specific host site for the injection wells for the Williston Basin demonstration will be determined during the first year of the Deployment Phase. Discussions with likely partners indicate that several western North Dakota and eastern Montana oil fields may be appropriate locations to host large-volume sequestration demonstration of the PCOR Partnership Deployment Phase. The specific host site for the injection wells for the Fort Nelson demonstration has not yet been determined but will likely be located in northeastern British Columbia.

Description of Geology

The Williston Basin is a relatively large, roughly circular, intracratonic basin with a thick sedimentary cover in excess of 16,000 feet. It underlies several hundred thousand square miles of parts of North Dakota, South Dakota, Montana, and the Canadian provinces of Manitoba and Saskatchewan. The Williston Basin is considered to be tectonically stable. The stratigraphy of the area is well studied, especially in those intervals that are oil producers. The geometry of the Williston Basin is fairly symmetrical with gently dipping slopes. Thus, in the absence of a structural and/or a hydrodynamic rapping mechanism, the migration of a low-gravity fluid like CO_2 will be expected to move up the dip along the stratigraphic trap,

toward the flanks of the basin (see Figure 3). Also, accumulation of hydrocarbons in the hundreds of oil fields scattered throughout the basin provides evidence of the presence of structural and/or hydrodynamic trapping mechanisms in the area in addition to the prevailing stratigraphic traps.

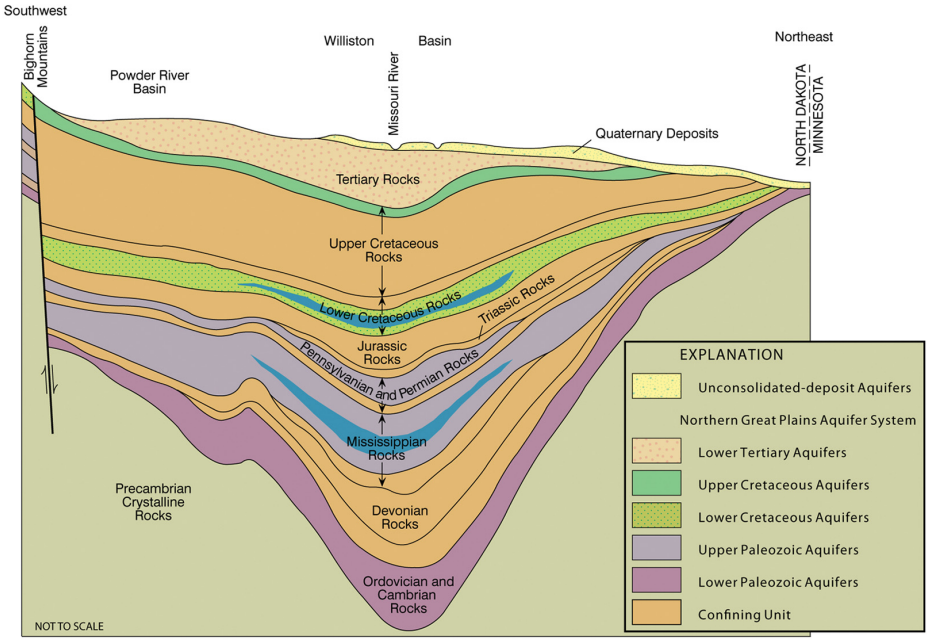

Figure 3. Generalized cross section of the Williston Basin.

Dakota. No historically known earthquakes have occurred in the vicinity of any of the oil fields being considered.

While specific saline formations and injection locations have not yet been chosen for the Fort Nelson demonstration, it is anticipated that the target zone will be a carbonate rock formation located in relatively close proximity to the Fort Nelson gas plant (<50 miles). The thickest and most comprehensive seal for the carbonate rock formations under consideration will be provided by the massive and extensive shales of the Fort Simpson Formation, which is characterized by low permeability and high geomechanical strength. This cap provides a very competent seal for underlying brine-saturated formations. The cumulative average thickness of the Fort Simpson Formation is approximately 500 meters, and in some areas the thickness can be in excess of 1000 meters. The Fort Simpson Formation is laterally extensive, underlying thousands of square miles. Secondary seals also exist above the Fort Simpson Formation, the most competent and massive being the Banff Formation, which is predominantly shale and is not less than 100 feet thick in the Fort Nelson area.

Source of CO_2

For the Williston Basin demonstration, CO_2 will be obtained from Basin Electric Power Cooperative's Antelope Valley Station, a lignite-fired facility in western North Dakota. The power plant will be retrofitted with a system that can capture CO_2 from the flue gas. The CO_2 will be compressed and transported by pipeline as a supercritical fluid. The Fort Nelson demonstration will utilize CO_2 from the Spectra Energy Fort Nelson natural gas-processing plant in northwestern British Columbia. The CO_2 will be captured using an existing amine-based acid gas removal system; it will then be dried, compressed, and transported by pipeline as a supercritical fluid. Its composition will be approximately 85 percent CO_2 and 15 percent hydrogen sulfide.

PCOR PARTNERS (cont.)

- 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
- North Dakota Petroleum Council
- North Dakota State University
- Otter Tail Power Company
- Petroleum Technology Research Centre
- Petroleum Technology Transfer Council
- Prairie Public Television
- Pratt & Whitney Rocketdyne, Inc.
- Ramgen Power Systems, Inc.
- RPS Energy
- Saskatchewan Industry and Resources
- SaskPower
- Schlumburger
- Shell Canada Energy
- Spectra Energy

PCOR PARTNERS (cont.)

Strategic West Energy Ltd.

Suncor Energy Inc.

Tesoro Refinery (Mandan)

University of Alberta

University of Regina

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

$135,586,059

DOE/Non-DOE Share

$67,000,000 / $68,586,059

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Injection Operations

For the Williston Basin demonstration, the injection strategy will be developed in cooperation with the commercial EOR partner. Since the oil fields being considered have undergone secondary recovery, injection strategies have already been established at demonstration sites, which should facilitate a more rapid engineering and permitting process for CO_2 injection. For the Fort Nelson demonstration, Spectra Energy will install significant infrastructure to transport the supercritical CO_2 to the injection site, including construction of acid gas compressors, a dehydration system, a pipeline for the acid gas stream, and an acid gas pump. The specific host site for the injection wells for the Fort Nelson demonstration has not yet been determined, but will likely be located within 50 miles of the chosen gas-processing plant. The target injection formation will be at a depth of between 6500 and 7500 feet. Formations in this depth range will be at a temperature and pressure that will ensure the injected CO_2 remains in a supercritical state.

Simulation and Monitoring of CO_2

An emphasis on cost-effectiveness and integration with routine oil field activities is the driving philosophical basis for developing the modeling, monitoring, and verification (MMV) plan that will be implemented as part of the Deployment Phase demonstrations. MMV techniques used will include the following: pressure monitoring, fluid sampling (oil, gas, water), pressure and geochemical monitoring of overlying formations, downhole geophysical monitors (passive microseismic and/or tiltmeters), surface CO_2 measurements, ion chemistry and isotopes of sampled fluids, and tracer (e.g., perfluorocarbons) monitoring.

Goals and Objectives

The PCOR Partnership's overall goal is to validate the information and technology developed under the Characterization and Validation Phases relative to research and field activities, public outreach efforts, and regional characterization. Specific objectives include:

- Conduct a successful Williston Basin demonstration to verify and validate the concept of utilizing the region's large number of oil fields for large-scale injection of anthropogenic CO_2, resulting in incremental oil production.
- Conduct a successful Fort Nelson demonstration to verify and validate the concept of utilizing the region's carbonate saline formations for large-scale injection of anthropogenic CO_2.
- Gather characterization data that will verify the ability of the target formations to meet the goal of storing 50 percent of the region's point source CO_2 emissions for the next 100 years.
- Advance the regulatory and permitting framework.
- Provide a demonstration bed for developing technologies related to CO_2 sequestration.
- Develop a method to monetize carbon credits for CO_2 sequestered in geologic formations.

Benefits to the Region

The PCOR Partnership region emits approximately 500 million tonnes (550 million U.S. tons) of CO_2 yearly from large stationary sources in the region. Over the course of 100 years, it is assumed that approximately 50 to 55 billion tonnes (55 to 60 billion U.S. tons) of CO_2 will be generated by large stationary sources. The results of regional sink characterization activities conducted under the Characterization and Validation Phases indicate that oil fields and saline formations in the region have the capacity to store nearly 28 billion tonnes (31 billion U.S. tons) and 455 billion tonnes (500 billion U.S. tons) of CO_2, respectively, which is greater than 50 percent of the anticipated regional emissions over the next 100 years, assuming a static emissions profile.