the ENERGY lab

PROJECT FACTS

Carbon Sequestration

Plains CO_2 Reduction Partnership—Development Phase – Large Scale Field Tests

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 Regional Carbon Sequestration Partnership (RCSP) initiative, to determine the best approaches for capturing and permanently storing carbon dioxide (CO_2), a greenhouse gas (GHG) which may 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 RCSPs include more than 350 organizations, spanning 43 states and four Canadian provinces.

The RCSP initiative is being implemented in three phases. The Characterization Phase began in September 2003 with the seven 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 tests in the seven regions. Presently, activities in the Development Phase (2007-2017) are proceeding as an extension of 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 tests 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 projects in North America.

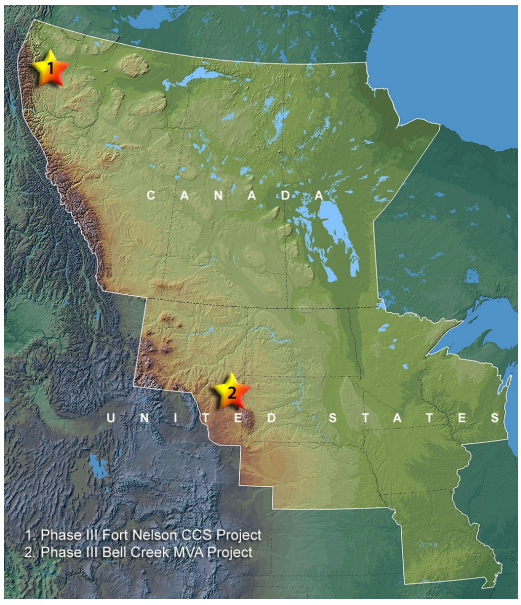

Figure 1. Location of Phase III Sites in the PCOR Partnership Region

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U.S. DEPARTMENT OF ENERGY

PARTNERS

Abengoa Bioenergy New Technology, Inc.
Air Products and Chemicals, Inc.
Alberta Department of Energy
Alberta Innovates - Technology Futures
ALLETE
Ameren Corporation
American Coalition for Clean Coal Electricity
American Lignite Energy (ALE)
Apache Canada Ltd.
Baker Hughes Oilfield Operations, Inc.
Basin Electric Power Cooperative
Biorecro AB
Blue Source, LLC
BNI Coal, Ltd.
British Columbia Ministry of Energy, Mines, and Petroleum Resources
Carbozyme, Inc.
Computer Modelling Group, Inc.
Dakota Gasification Company
Ducks Unlimited, Inc.
Eagle Operating, Inc.
Eastern Iowa Community College District
Enbridge Inc.
Energy & Environmental Research Center (University of North Dakota)
Energy Resources Conservation Board/ Alberta Geological Survey
Environment Canada
Excelsior Energy Inc.
Great Northern Project Development, LP
Great River Energy
Hess Corporation
Huntsman Corporation
Indian Land Tenure Foundation
Interstate Oil and Gas Compact Commission (IOGCC)
Iowa Department of Natural Resources – Geological Survey
Lignite Energy Council
Manitoba Geological Survey
Marathon Oil Company
MEG Energy Corporation
Melzer Consulting
Minnesota Power
Minnkota Power Cooperative, Inc.
Missouri Department of Natural Resources
Missouri River Energy Services
Montana Department of Environmental Quality
Montana-Dakota Utilities Company
National Commission on Energy Policy
Natural Resources Canada
Nebraska Public Power District
Nextant, Inc.

The Plains CO_2 Reduction (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, and Wyoming, and the Canadian provinces of Alberta, British Columbia, Manitoba, and Saskatchewan. The PCOR Partnership received support from more than 80 organizations. The nine states in the PCOR Partnership account for about 13 percent of total U.S. CO_2 emissions from stationary sources. The region offers significant potential for sequestration in limestone, sandstone, and unmineable coal seams, as well as 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 projects for the Development Phase, also known as Phase III (Figure 1). For the Bell Creek demonstration project, the PCOR Partnership is working with a commercial partner to evaluate the efficacy of developing a robust and practical monitoring verification, and accounting (MVA), risk management, and simulation project associated with a commercial-scale injection of CO_2 for the purpose of simultaneous enhanced oil recovery (EOR) and storage of CO_2. The project, which will be conducted in the Bell Creek oil field in Powder River County, southeastern Montana, will provide insight regarding the impact of miscible CO_2 flood tertiary recovery on oil production and successful CO_2 storage within a sandstone reservoir in the Cretaceous Muddy Formation. The Bell Creek project will be a significant opportunity to develop a set of cost-effective MVA protocols for large-scale CO_2 storage associated with an EOR operation.

The Fort Nelson project will inject into a saline formation deep underground more than one million metric tons (approximately 1.1 million tons) of sour CO_2 (mixture of CO_2 and hydrogen sulfide [H_2S]) per year captured from one of the largest gas processing plants in North America. The sour CO_2 will be compressed and transported approximately 9 miles (15 kilometers) in a supercritical state via pipeline to the target injection location. The target zone is the Devonian-age Elk Point carbonate rock (limestone and dolomite) formation located in relatively close proximity to the gas plant at a depth of >7,200 feet (2,195 meters).

Injection Site Description

The specific host site for the injection wells needed for the Bell Creek demonstration will likely be determined by the spring of 2012. The specific host site for the injection wells for the Fort Nelson demonstration is located in northeastern British Columbia and approximately 9 miles west of the Fort Nelson gas plant.

Description of Geology

Production from the Bell Creek oil field in southeastern Montana is from stratigraphic traps in the Muddy Sandstone of Early Cretaceous age. These sandstones are 20 to 30 feet thick and are underlain and overlain by organic-rich marine shale. The Bell Creek oil field is an ideal candidate for a CO_2 tertiary recovery project for numerous reasons. The primary reason is its depth of 4,500 feet, which results in temperature and pressure conditions that will maintain the injected CO_2 in a supercritical state and allow for miscibility of the CO_2 in the oil. The secondary reason is Bell Creek's permeability at 900 millidarcies and its porosity, which averages 24%, allowing for high CO_2 injection rates and a fairly rapid production response.

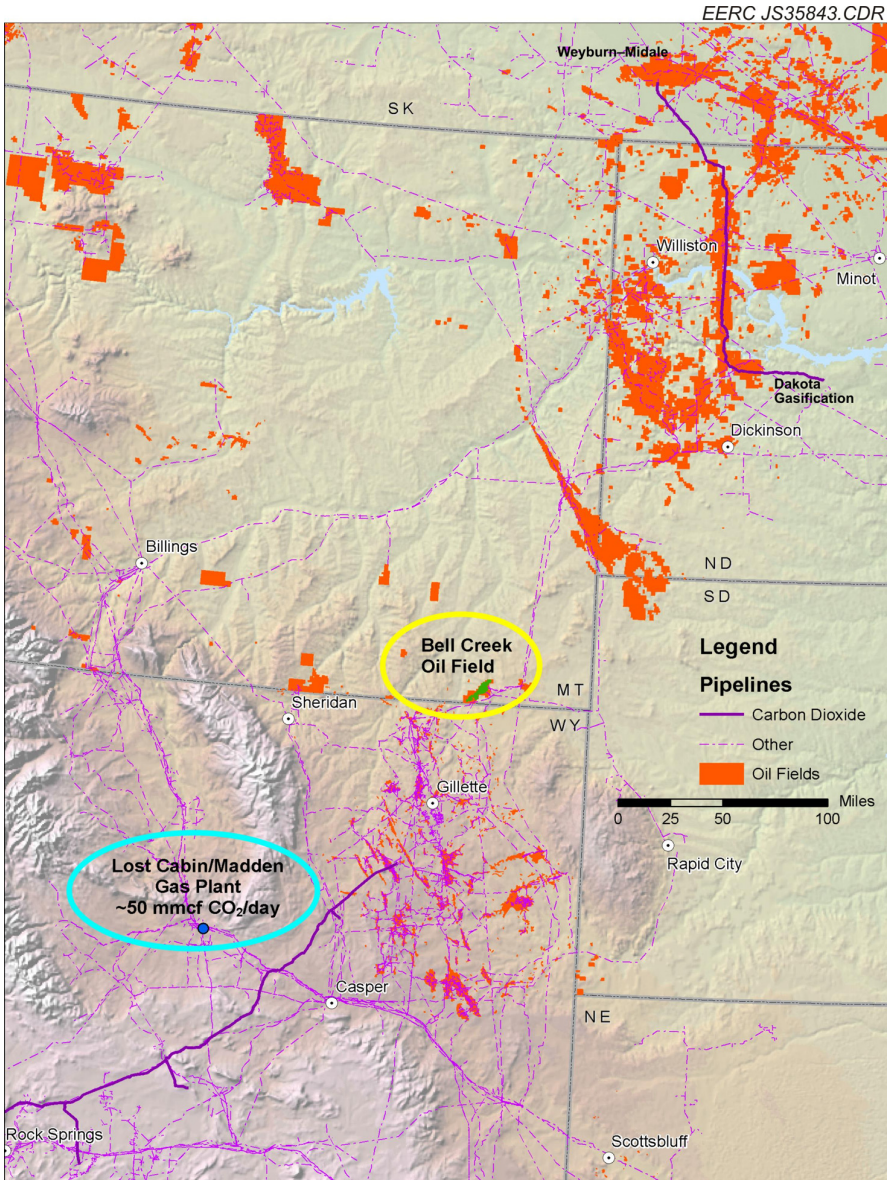

Figure 2. Location of the Lost Cabin Gas Plant and Bell Creek oil field in Wyoming and Montana. The PCOR Partnership Phase III Bell Creek project will be conducted within the PRB.

The target zone for the Fort Nelson injection test is a carbonate rock formation, known as the Elk Point group, located at a depth of > 7200 feet (2195 meters). 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 and Muskwa Formations, 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 and Muskwa shale is approximately 1,800 feet (550 meters), and in some areas the thickness can be in excess of 3,300 feet (1,000 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 not less than 100 feet (31 meters) thick in the Fort Nelson area.

PARTNERS (cont.)

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 Pipeline Authority
North Dakota State University
Otter Tail Power Company
Oxand Risk & Project Management Solutions
Petroleum Technology Research Centre
Petroleum Technology Transfer Council
Prairie Public Broadcasting
Ramgen Power Systems, Inc.
RPS Energy
Saskatchewan Ministry of Energy and Resources
SaskPower
Schlumberger
Shell Canada Energy
Spectra Energy
Strategic West Energy Ltd.
Suncor Energy Inc.
TAQA North Ltd.
TGS Geological Products and Services
U.S. Department of Energy
U.S. Geological Survey Northern Prairie Wildlife Research Center
University of Alberta
University of North Dakota
Weatherford Advanced Geotechnology
Western Governors' Association
Westmoreland Coal Company
Williston Basin Interstate Pipeline Company
Wisconsin Department of Agriculture, Trade, and Consumer Protection
Xcel Energy

COST

Total Project Value

$94,000,0000 approx.

DOE/Non-DOE Share

$69,000,000 approx. / $25,000,000 approx.

Source of CO_2

For the Bell Creek demonstration, CO_2 will be obtained from ConocoPhillips' Lost Cabin Gas Plant, a gas processing facility located in Fremont County, Wyoming. The Lost Cabin Gas Plant currently generates approximately 50 million cubic feet per day of CO_2. The commercial EOR partner and ConocoPhillips have entered into a 15-year CO_2 purchase-and-sale agreement, and plans are under way to build compression facilities adjacent to the Lost Cabin Gas Plant to take the CO_2 from 50 to 2,200 psi, allowing for delivery to the project site at injection-ready pressure.

The Fort Nelson demonstration will utilize sour CO_2 from the Spectra Energy Fort Nelson Natural Gas-Processing Plant in northwestern British Columbia, Canada. The sour CO_2 will be captured using an existing amine-based acid gas removal system, dried, compressed, and transported by pipeline as a supercritical fluid to a nearby injection site. Its composition will be approximately 90 percent CO_2 and 10 percent H_2S.

Injection Operations

For the Bell Creek 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 sour CO_2 to the injection site, including construction of compressors, a dehydration system, a pipeline for the sour CO_2 gas stream, and a pump. The target injection formation is at a depth of >7,200 feet (2,195 meters). Formations in this depth range will be at the temperature and pressure that ensure the injected sour 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 monitoring, verification, and accounting (MVA) plan that will be implemented as part of the Development Phase. Potential MVA techniques 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), vertical seismic profile (VSP) surface CO_2 measurements, ion chemistry and isotopes of sampled fluids, and tracer (e.g., perfluorocarbons) monitoring. Extensive reservoir simulation modeling that includes geochemical and geomechanical processes is also part of the Phase III MVA protocols.

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 the following:

- Conduct a successful Bell Creek 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.
- Verify and validate the technical and economic feasibility of using brine-saturated carbonate formations for large-scale CO_2 injection.
- 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.
- Demonstrate that robust monitoring, verification, and accounting of a brine-saturated CO_2 sequestration project can be conducted cost-effectively.
- Develop methods to provide the technical information needed to monetize carbon credits for CO_2 sequestered in geologic formations.
- Meet or exceed the expectations of the members of the PCOR Partnership by developing project(s) that are commercially successful.

Benefits to the Region

The PCOR Partnership region, which covers over 1.4 million square miles, emits approximately 510 million metric tons (562 million tons) of CO_2 yearly from large stationary sources in the region. 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 22.7 billion metric tons (25 billion tons) and 177 billion metric tons (195 billion tons) of CO_2, respectively, which is approximately four times the anticipated regional emissions over the next 100 years, assuming a static emission profile.