the ENERGY lab

PROJECT FACTS

Carbon Sequestration

Plains CO_2 Reduction Partnership—Development Phase

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 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 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 (2008–2017) 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

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Alberta Energy Research Institute
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Minnesota Power
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Missouri Department of Natural Resources
Missouri River Energy Services
Montana – Dakota Utilities Co.
Montana Department of Environmental Quality
Montana Public Service Commission

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 includes more than 80 organizations. The nine states in the PCOR Partnership account for about 16 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). The Williston Basin demonstration will transport one million tons (907,000 metric 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 the CO_2 into an oil reservoir located in western North Dakota or eastern Montana (Figure 2). This large-scale test will demonstrate the simultaneous achievement of two objectives—EOR and sequestration of CO_2.

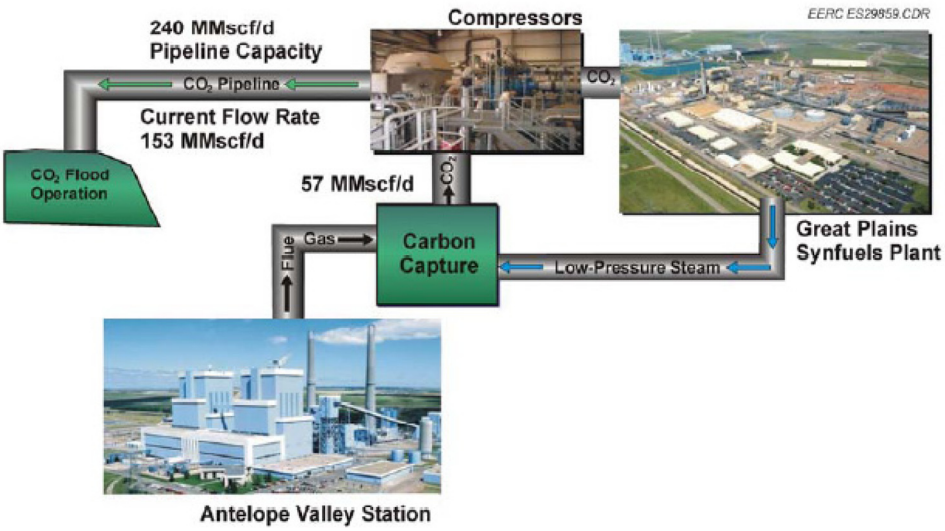

Figure 2. Basin Electric Power Cooperative CO_2 Optimization Project

The Fort Nelson project will utilize more than one million tons (907,000 metric 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. The target zone is the Devonian-age Elk Point carbonate rock formation located in relatively close proximity to the gas plant (three miles) at a depth of >5,000 feet (1,530 meters).

Injection Site Description

The specific host site for the injection wells needed for the Williston Basin demonstration will be determined during the first year of the Development Phase. Discussions with likely partners indicate that there are at least 40 unitized oil fields in western North Dakota and eastern Montana that are likely suitable for CO_2-based EOR operations. The specific host site for the injection wells for the Fort Nelson is located in northeastern British Columbia and approximately three miles from the Fort Nelson gas plant.

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 (4,880 feet). It underlies several hundred thousand square miles of parts of Montana, North Dakota, South Dakota, and the Canadian provinces of Manitoba and Saskatchewan. The Williston Basin is considered to be tectonically stable and 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 hydrodynamic trapping mechanism, the migration of a low-gravity fluid like CO_2 will be expected to occur updip along the stratigraphic trap, toward the flanks of the basin (Figure 3). However, 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.

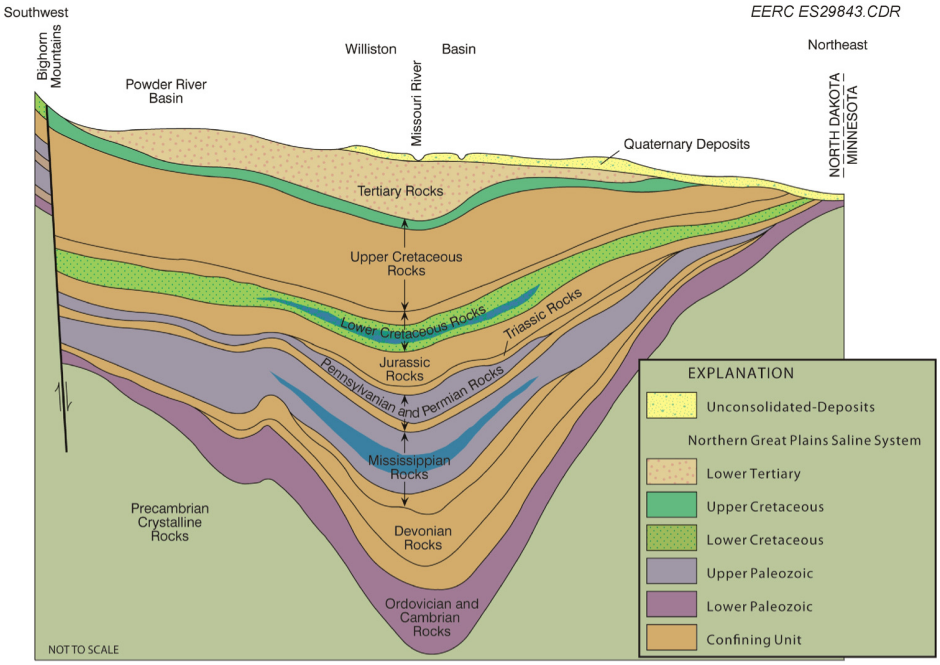

Figure 3. Generalized Cross Section of the Williston Basin

The oil fields that will most likely be considered for the demonstration are located in four areas of the Williston Basin: the Cedar Creek Anticline, the Billings Anticline, the Nesson Anticline, and the Northeast Flank. While general information on the structural geology, lithostratigraphy, hydrostratigraphy, and petroleum geology of the Williston Basin is readily available, additional characterization data for specific candidate sinks will be necessary before their utilization as CO_2 storage sites. The thickest, most comprehensive seal for most of the oil fields under consideration will be provided by the Mississippian-age Charles Formation, which is dominated by thick evaporites (anhydrite and halite) characterized by extremely low permeability and high geomechanical strength. No seismically active faults are present in North Dakota. No historically known earthquakes have occurred in the vicinity of any of the oil fields being considered.

The target zone for the Fort Nelson injection test is a carbonate rock formation, known as the Elk Point group, located three miles from the Fort Nelson Gas Plant at a depth of > 5,000 feet (1,530 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 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

PARTNERS (cont.)

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University of Regina
University of North Dakota Energy & Environmental Research Center
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

$135,699,278

DOE/Non-DOE Share

$67,113,219 / $68,586,059

of the Fort Simpson Formation is approximately 1,640 feet (500 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.

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 central 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 to a selected injection site 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, dried, compressed, and transported by pipeline as a supercritical fluid to a nearby injection site. Its composition will be approximately 85 percent CO_2 and 15 percent hydrogen sulfide (H_2S).

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 target injection formation is at a depth of >5,000 feet (1,530 meters). Formations in this depth range will be at the temperature and pressure that 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 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 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.
- 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 575 million tons (522 million metric 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 3.2 billion tons (2.9 billion metric tons) and 117 billion tons (106 billion metric tons) of CO_2, respectively, which is approximately 50 percent of the anticipated regional emissions over the next 100 years, assuming a static emission profile.