PCOR Partnership Phase III – Commercial-Scale Demonstrations of Geologic CO_2 Storage in the Northern Great Plains

Just like the natural underground accumulations of oil and natural gas, many natural accumulations of carbon dioxide (CO_2) gas have been held in place for millions of years in secure underground geologic reservoirs. Modeled on these natural accumulations, geologic CO_2 sequestration, the permanent underground storage of CO_2 from human activities, is emerging as a promising strategy for managing the large amount of CO_2 gas generated as a by-product of fossil energy use at power plants or other industrial facilities. Geologic CO_2 sequestration, also called carbon capture and storage (CCS), is only one of the many actions that may be taken in the upcoming years to address concerns over climate change by reducing the output of CO_2 and other greenhouse gases that result from human activity.

The 10-year Phase III program of the Plains CO_2 Reduction (PCOR) Partnership, initiated in the fall of 2007, features two commercial-scale demonstrations of geologic sequestration of CO_2 from human activities (Figure 1). These two demonstrations, the Western Canadian Basin Demonstration in northeastern British Columbia and the Williston Basin Demonstration in western North Dakota, are designed to sequester a total of over 15 million tons of CO_2 by 2017 in deep, well-characterized, underground storage reservoirs.[1] These commercial-scale demonstrations are in addition to the four medium-scale field verification tests currently under way through the PCOR Partnership's Phase II program (Figure 1) and the more than 30 other geologic CO_2 sequestration tests and demonstrations under way in the United States and around the world.

Western Canadian Basin Demonstration

Most geologic sequestration projects are designed to emplace CO_2 into an underground geologic structure, referred to as a trap, which may have previously contained oil or natural gas for millions of years. However, another type of geologic setting, known as deep brine reservoirs, are believed to offer even greater potential for CO_2 storage because of their regionally extensive nature. The Western Canadian Basin Demonstration will be one of the first commercial-scale geologic sequestration projects to emplace CO_2 into a North American brine reservoir. To accomplish this, over one million tons of CO_2 from an existing gas-processing facility in northeastern British Columbia, Canada, will be compressed to a supercritical state (CO_2 gas will be put under high pressure so that it behaves like a fluid; the pressure is similar to the conditions in the underground geologic injection zone) before being transported via pipeline approximately 3 miles (5 km) to an injection site. The CO_2 is from an acid gas stream (85% CO_2, 15% H_2S). Once at the injection site, the CO_2 will be sent into the ground to a depth of approximately 6500 ft (2000 meters). There the supercritical CO_2 will be injected into the carbonate rocks (limestone and dolomite) of the Elk Point Group rock formations and dissolve into the highly saline water that fills the pores of the Elk Point Group rocks. Once the CO_2 enters the pores of the carbonate rocks, the naturally high pressure and temperature conditions in the Elk Point Group will maintain the CO_2 in the supercritical state permanently. The injection zone in Elk Point is capped by a substantial shale layer that provides a

Figure 1. Sequestration activities in the PCOR Partnership region (ECBM [enhanced coalbed methane], EOR [enhanced oil recovery]).

very competent seal. Other geologic layers, including the thick shales of the Banff Formation, act as seals in the thousands of feet of rock between the top of the Elk Point Group and the base of the zone of drinkable groundwater. Characterization of the geology of the region has shown that there are many suitable sites for CO_2 storage in the region and that capacities exceed several million tons of CO_2 per square mile. The demonstration is designed to provide improved understanding of the following:

- Cost-effective monitoring, mitigation, and verification (MMV) strategies for large-scale CO_2 sequestration in deep brine reservoirs.
- Testing and refinement of reservoir modeling intended to predict and estimate CO_2 injectivity (the potential for emplacing CO_2 into the reservoir), areal extent and mobility of the supercritical CO_2 plume in the reservoir, and improved methodologies to ensure that site characterization and MMV results better support modeling efforts.
- Testing strategies to predict the effects of CO_2 on the integrity of overlying sealing formations, including the testing and modeling of key geomechanical and geochemical parameters.

Williston Basin Demonstration

The cost-effective separation of CO_2 from flue gases is a major barrier to the widespread implementation of geologic sequestration at conventional power plants and other large-scale stationary sources of CO_2. The Williston Basin Demonstration will be the first large-scale CCS project utilizing CO_2 from a retrofitted conventional coal-fired power plant. A portion of the flue gas output of Basin Electric Power Cooperative's Antelope Valley Station will be processed to capture its CO_2. This CO_2 will then be dehydrated, compressed to supercritical conditions, and combined with additional supercritical CO_2 from the adjacent Great Plains Synfuels Plant before being transported about 150 miles (220 km) via pipeline to the sequestration site. Once at the sequestration site, the CO_2 will be injected at a depth of nearly 2 miles (approximately 10,000 ft or 3000 meters) into the pore space of an oil reservoir. In the pore space, the CO_2 will dissolve into the oil and allow the oil to more easily flow to the production wells. At the end of economical oil production, most of the purchased CO_2 will be left permanently trapped in the underground reservoir. The demonstration will emplace approximately 1 million tons of CO_2 a year. The characterization of the Williston Basin in western North Dakota indicates there are many millions of tons of additional storage capacity in these types of geologic settings.

The primary objective of the PCOR Partnership Phase III Williston Basin Demonstration is to verify and validate the concept of utilizing the region's large number of oil fields for large-scale injection of anthropogenic CO_2 for the purposes of enhanced oil recovery leading to permanent CO_2 storage. Other objectives include:

- Improved understanding of the engineering effects of extreme depth (greater than 2 miles) on EOR and CO_2 sequestration design and operation.
- Opportunities for expansion of commercial anthropogenic carbon management through the initiation of large-scale CO_2 injection operations in oil fields.
- Analysis to determine if deep geologic sinks can provide sufficient storage capacity and commercialization opportunities for large stationary CO_2 sources throughout the region.
- Improved approaches for capacity estimates for the thousands of potential sequestration candidates represented by the oil fields in the region.
- Testing and refinement of reservoir modeling.
- Testing strategies to predict the effects of CO_2 on the integrity of overlying sealing formations, including the testing and modeling of key geomechanical and geochemical parameters.
- Assessment of potential leakage pathways and documentation of any observed leakage (if present).

Proposed Schedule

Phase III activities will last from the fall of 2007 to the fall of 2017. The sites for geologic CO_2 sequestration will be chosen in Year 1, infrastructure including injection wells and monitoring equipment will be emplaced in Years 2 and 3, injection will occur from Years 4 through 10, and assessment will be completed in Year 10.

Notes

[1]The sequestration of approximately 15 million metric tons of CO_2 would equate to the removal of approximately 2.8 million passenger vehicles from the highway for a year, as calculated assuming 5.32 metric tons of CO_2 per passenger vehicle per year with passenger vehicle CO_2 output calculated using the average output for Daimler-Chrysler, Ford, and GM passenger vehicles for 2002 (1.0289 lb per mile) from Figure 7 at http://earthtrends.wri.org/features/view_feature.cfm?theme=3&fid=53 and average annual residential vehicle mileage (11,400 miles) for 1994 from www.eia.doe.gov/emeu/rtecs/Chapter3.html.

The Plains CO_2 Reduction (PCOR) Partnership is a group of public and private sector stakeholders working together to better understand the technical and economic feasibility of sequestering CO_2 emissions from stationary sources in the central interior of North America. The PCOR Partnership is managed by the Energy & Environmental Research Center (EERC) at the University of North Dakota and is one of seven regional partnerships under the U.S. Department of Energy's National Energy Technology Laboratory Regional Carbon Sequestration Partnership Initiative. To learn more, contact:

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