Geologic Storage of Sour CO_2 from a Natural Gas-Processing Plant – A Commercial Demonstration

Nearly 1600 facilities around the world remove impurities such as carbon dioxide (CO_2) from natural gas, and Spectra Energy's Fort Nelson facility is among the largest. For this reason, Spectra Energy and the Plains CO_2 Reduction (PCOR) Partnership are leading a collaborative venture involving government, industry, technologists, and researchers that will fully demonstrate the concept of *carbon capture and storage* (CCS) to manage the CO_2 emissions of natural gas-processing facilities. In this demonstration, over a million tons a year of sour CO_2 (mixture of CO_2 and hydrogen sulfide [H_2S]) will be injected into a saline formation deep underground. The behavior of the sour CO_2 in the subsurface will be closely monitored to ensure the safe and effective operation of regional geologic storage sites for CO_2. Over the next decade, the demonstration will store over 10 million tons of CO_2 that would have otherwise entered the atmosphere. This demonstration is included in the U.S. Department of Energy National Energy Technology Laboratory's Regional Carbon Sequestration Partnership (RCSP) Initiative. The PCOR Partnership, led by the Energy & Environmental Research Center, is one of seven RCSPs.

Natural Gas, Gas Processing, and Carbon Capture Before natural gas can be transported or used, it must be purified. In many cases, this means removing CO_2, H_2S, nitrogen, and natural gas liquids like butane and propane. These impurities are removed at large facilities called natural gas-processing plants. At many plants, processing results in a gas stream referred to as "sour CO_2," a combination of CO_2 and H_2S. There are more than 1300 natural gas-processing plants in the United States and Canada and nearly 1600 worldwide (1). Because they are among the few sources of relatively pure streams of CO_2, natural gas-processing plants are good candidates for developing CCS projects that feature geologic CO_2 sequestration (2).

Project Description

The sour CO_2 stream from Spectra Energy's Fort Nelson gas-processing facility, located near Fort Nelson, British Columbia, Canada, will be piped to a nearby site where it will be injected over 7200 feet underground for permanent storage in a rock formation containing very salty water ("saline" formation).

The sour CO_2 stream (90% CO_2, 10% H_2S) will first be compressed to a supercritical state. This means that the CO_2-rich gas will be pressurized to meet the conditions it will encounter in the underground injection zone. The supercritical sour CO_2 has a density like a liquid but still behaves like a gas. The supercritical fluid will be transported via pipeline approximately 9 miles (15 km) to an injection site.

The supercritical fluid will be injected into the carbonate rocks (limestone and dolomite) of a rock formation in the Elk Point Group, where some of it will dissolve into the highly saline water that fills the pores of the rock, while some will precipitate as new carbonate minerals. Some of the sour CO_2 will remain in the pores of the carbonate rocks, and the naturally high-pressure and high-temperature conditions will help maintain that sour CO_2 in the supercritical state. The injection zone is capped by 1800-foot (550-meter)-thick Fort Simpson and Muskwa shale, which forms an impermeable seal. Characterization of the geology of the region has shown that there are many suitable sites for CO_2 storage in the region and that CO_2 storage capacities could exceed several million tons of CO_2 per square mile (3).

Spectra Energy's Fort Nelson Gas-Processing Plant, northeastern British Columbia, Canada.

"Carbon capture and storage represent an important opportunity to help achieve the emission cuts that will reduce B.C.'s greenhouse gas emissions by 33% by 2020," Richard Neufeld, British Columbia's Minister of Energy, Mines, and Petroleum Resources, May 2008 (4).

Utilizing Proven Natural Underground Storage

Oil has been commercially produced in the PCOR Partnership region since the early 1900s. Throughout that century, thousands of underground deposits of oil and natural gas were found and characterized. Geologists call these underground deposits "reservoirs" or "traps." Other gases, like CO_2 and helium, can also occur in natural underground deposits, just like oil and natural gas. The fact that these fluids and gases have been held in place underground for millions of years indicates that CO_2 can be securely stored under similar geologic conditions.

Research Objectives

The primary objectives of the PCOR Partnership Phase III Fort Nelson demonstration are to verify and validate the concept of utilizing the region's large number of saline formations for large-scale injection of anthropogenic CO_2 for permanent storage. Specific goals include:

- Cost-effective risk management; simulation; and monitoring, verification, and accounting (MVA) 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 placing 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 MVA results better support risk management objectives and 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.

Schedule

The PCOR Partnership's role in the Fort Nelson CCS project runs from the fall of 2007 to the fall of 2017. The injection site was chosen in 2008, and an exploration well and shallow groundwater-monitoring wells were completed in the spring of 2009. Injection is planned to begin in 2012, and Spectra Energy intends to continue injection of sour CO_2 over the remaining operational lifetime of the Fort Nelson gas-processing plant. An MVA plan will be implemented to monitor the underground movement of CO_2. The MVA data may also be used to modify and improve the injection design, if needed. A comprehensive report will be issued in the fall of 2017.

Notes

1. PennWell, 2008, Worldwide gas-processing database.
2. Gale, J.J., 2003, IEA (International Energy Agency) Greenhouse Gas R&D Programme File Note, Opportunities for Early Application of CO_2 Sequestration Technology: www.cslforum.org/publications/documents/EarlyOppsFile.pdf (accessed May 2009).
3. One million metric tons of CO_2 is equivalent to the average annual CO_2 emissions of approximately 188,000 passenger vehicles, assuming 5.32 metric tons of CO_2 per passenger vehicle per year; passenger vehicle CO_2 output calculated using 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.
4. Ministry of Energy, Mines, and Petroleum Resources, 2008, $12.1 million carbon capture project to cut emissions: www2.news.gov.bc.ca/news_releases_2005-2009/2008EMPR0036-000814.htm (accessed April 2009).

Examples of MVA Techniques

Measurement Technique	Measurement Parameters	Application
Introduced and Natural Tracers	Travel time Partitioning of CO_2 and H_2S into brine Identification of sources of CO_2	Tracing movement of CO_2 in the storage formation Quantifying solubility trapping Verifying that no leakage is occurring
Water Composition	CO_2, bicarbonate, carbonate Major ions Trace elements Salinity	Quantifying solubility and mineral trapping Quantifying CO_2–water–rock interactions Verifying that no leakage is occurring
Subsurface Pressure	Formation pressure Annulus pressure Groundwater aquifer pressure	Controling formation pressure below fracture gradient Monitoring wellbore and injection tubing integrity Verifying that no leakage is occurring
Well Logs	Brine salinity Sonic velocity CO_2 saturation	Tracking CO_2 movement Tracking migration of brine Calibrating seismic velocities for 3-D seismic surveys

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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Visit the PCOR Partnership Web site at www.undeerc.org/PCOR. New members are welcome.

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