FACT SHEET FOR PARTNERSHIP FIELD VALIDATION TEST

Partnership Name	Plains CO_2 Reduction (PCOR) Partnership – Phase II	
Contacts:	Name Organization E-Mail	
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Principal Investigator	Edward Steadman	
Field Test Information:		
Field Test Name	Lignite in North Dakota Field Validation Test	
Test Location	Section 36-T159N-R90W in Burke County, North Dakota	
Amount and Source of CO_2	Tons Less than 500 tons for the project	Source Commercial source – Praxair
Field Test Partners (Primary Sponsors)	Flatland Exploration Company, subsidiary of Fischer Oil and Gas	
	North Dakota State Land Department	
	Eagle Operating, Inc.	
	Schlumberger Carbon Services	
	Praxair	

Summary of Field Test Site and Operations:

Lignite coal may have a greater storage capacity than comparable higher-rank coals, and significant acreage of deeply buried unminable coal is present in the Williston Basin. Regional-scale evaluations performed by the PCOR Partnership have indicated that lignite coal contained within the Williston Basin has the potential to store over 100 years of CO_2 emissions from coal-fired power plants within the region. Additionally, several regional coal-fired power plants are located in close proximity to acceptable coal seams for carbon storage. A field validation test was conducted to determine the fate of CO_2 injected into a representative lignite coal in North Dakota and to determine the potential for enhanced coalbed methane (ECBM) production.

The study provides evidence that lignite coal may be a viable target for storing CO_2. Results at this field validation test indicate that CO_2 can be maintained within expected intervals and appears to preferentially adsorb to the lignite coal. Based on a very small-scale injection, it appears that economically viable injection rates may be possible, and injection rates can be sustained at a reasonable level. For a commercial-scale injection, the rate of injection would determine the total number of wells needed to be drilled. Given an injection rate of 1.4 gpm, the overall economic cost to drill and complete lignite storage wells for CO_2 injection can be less than 3% of the delivered cost of CO_2. The delivered cost of CO_2 is expected to be $15–$17 per ton.

Research Objectives:

CO_2 was injected into an unminable lignite seam in northwestern North Dakota. The working hypothesis was that the injected CO_2 will naturally bond to the surfaces of the fractured lignite and be held there by hydrostatic pressure. The injected CO_2 also has the potential to displace methane occupying the coal fractures. This validation test provided valuable information regarding lignite for both CO_2 storage and ECBM production.

The objectives of this demonstration were to 1) determine the accuracy with which CO_2 storage capacity in lignite coal can be predicted, 2) develop a data set regarding the potential for ECBM to be produced from lignite coal as a by-product of CO_2 injection, 3) demonstrate cost-effective monitoring, verification, and accounting (MVA) technologies and protocols for CO_2 storage and ECBM in a lignite coal seam and, 4) provide field validation testing of storage technologies and infrastructure approaches that can lead to wide-scale deployment in coal fields throughout the PCOR Partnership region.

Summary of Results:

Seismic imaging of the pilot lignite coal seam provided the ability to track the fate of the injected CO_2. The extent and direction of underground CO_2 plume migration was determined. The injection of 90 tons of CO_2 provided a plume of approximately 350 ft in diameter, 16 ft thick, as shown in Figure 1.

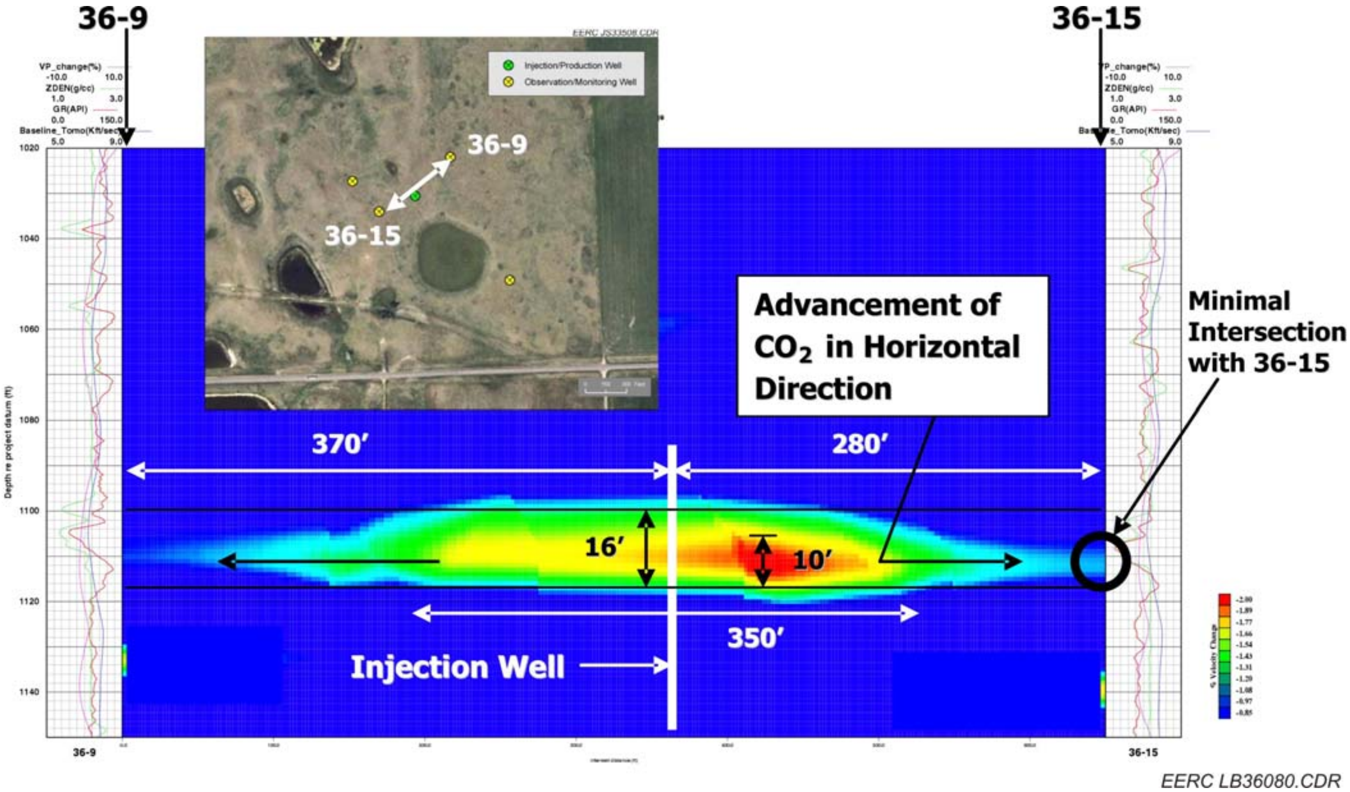


Figure 1. Seismic imaging from injection of CO_2 into lignite coal.

The seismic results indicated that CO_2 remains within the expected interval and that advancement of the CO_2 along the centerline of injection seems to indicate that CO_2 movement is influenced by properties of the coal interval. The seismic results were verified by downhole measurements of pressure, and fluid pH in monitoring wells. Estimation of the injected CO_2 geometry suggests that the injected CO_2 was initially occupying 2%–3% porosity in the coal and adjacent sand and will slowly adsorb to the coal micropore matrix.

A combination of results from reservoir saturation tool logging and seismic imaging indicate that CO_2 preferentially migrates in the horizontal direction and does not compromise low-permeability clays in the vertical direction, ensuring that injected CO_2 will remain in the coal zone. Microseismic monitoring further verified that the injection of CO_2 did not produce fractures that could potentially compromise seals and caps. Geophysical logging identified multiple layers of coal above and below the targeted coal interval, which is typical of areas containing coal-bearing strata. The additional coal layers provide added protection to adsorb any CO_2 in the unlikely event of migration in the vertical direction.

Reservoir modeling was used to determine the characteristics of coal in the injection area. The characteristics include relative slope, overburden, depth, and coal-seam thickness. Regional influences did not appear to affect the movement of injected CO_2. Reservoir modeling was also used to predict movement of CO_2. Predicted CO_2 buoyancy did not prove to be a concern after review of seismic data.

Injection of 90 tons of CO_2 was completed over 16 days. Various injection rates and conditions were tested. Generally the highest flow rates were achieved at the highest injection pressures. Changing conditions to lower density and viscosity downhole were not successful at producing increased injection rates. Heating the CO_2 at the surface and injection at maximum permitted pressures are recommended. Downhole pressure and pH were the most significant indicators for the presence of CO_2.

North Dakota has suitable land area, overburden depths, and coal thicknesses to accommodate injection and subsequent storage of CO_2 in lignites. The costs to drill and complete wells can be less than 3% of delivered CO_2 costs, assuming $17/ton delivered. Economic development costs to drill and complete can be reduced by greater than 50% if additional work is performed to increase injection rates considering horizontal drilling, fracture treatment, and dewatering. Low permeability, lack of continuity, and the potential for wellbore damage present challenges to CO_2 injection in lignite.

Accomplishments to Date:

Injection and noninvasive monitoring are complete.

Summarize Target Sink Storage Opportunities and Benefits to the Region:

The results of Phase I reconnaissance-level characterization activities indicated that low-rank coal seams (such as lignite) in the region may have the capacity to store 8.36 billion tons of CO_2. Phase I results also suggested that there may be over 17 trillion cubic feet of methane that could be produced from low-rank coal seams. This is the first field study completed to determine the ability of lignite coal seams to store CO_2. Results indicate good potential to store nearly 100 years worth of local power plant emissions in lignite coal seams within the region.

Cost:

Total Field Project Cost: $6,600,179

DOE Share:	$3,973,118	60%
Non-DOE Share:	$2,627,061	40%

Field Project Key Dates:

Baseline Completed: December 2008

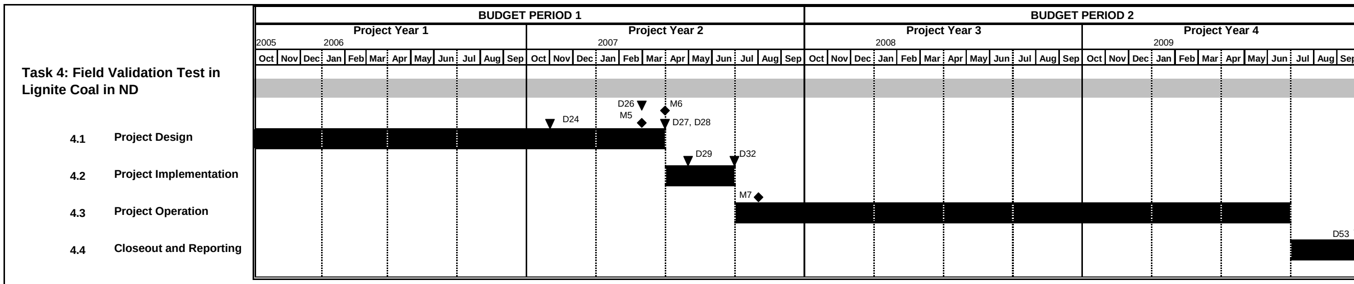
Drilling Operations Begin: August 2007

Injection Operations Begin: March 2009

MVA Events: January 2008 – June 2009

Field Test Schedule and Milestones (Gantt Chart):

- National Environmental Policy Act Compliance document completed October 2006.
- Experimental Design Package completed February 2007.
- Site Health and Safety Plan completed March 2007.
- Regulatory Permitting Action Plan completed March 2007.
- Outreach Action Plan completed April 2007.
- Sampling Protocols completed June 2007.
- Regional Technology Implementation Plan completed September 2009.



Summary Task | Activity Bar | Progress on Activity | Time Now | Deliverable ▼ | Milestone ◆

Key for Deliverables ▼	Key for Milestones ◆
D24 Lignite Field Validation Test Site – NEPA Compliance Document	M5 Identification of Specific Well Location at the Lignite Field Validation Test
D26 Lignite Field Validation Test Site – Experimental Design Package	M6 Finalized Drilling Prognosis for the Five-spot Research Wells for the Lignite Field Validation Test
D27 Lignite Field Validation Test Site – Site Health & Safety Plan	M7 White Paper on CO_2 Flood Design for CO_2 Sequestration and ECBM Recovery Completed
D28 Lignite Field Validation Test Site – Regulatory Permitting Action Plan	
D29 Lignite Field Validation Test Site – Outreach Action Plan	
D32 Lignite Field Validation Test Site – Sampling Protocols	
D53 Lignite Field Validation Test Site – Regional Technology Implementation Plan	

Additional Information