PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Carbon Sequestration

04/2008

MIDWEST GEOLOGICAL SEQUESTRATION CONSORTIUM — VALIDATION PHASE

Background

The U.S. Department of Energy (DOE) has selected seven Partnerships, through its Regional Carbon Sequestration Partnership (RCSP) Program, 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, and nonprofit organizations that form the core of a nationwide network helping to establish the most suitable technologies, regulation, and infrastructure needs for carbon sequestration. The Partnerships include more than 350 organizations, spanning 41 states, three Indian nations, and four Canadian provinces. The RCSPs are developing the framework needed to validate and deploy carbon sequestration technologies. They will evaluate and determine which of the numerous sequestration approaches are best suited for their specific regions of the country and are studying possible regulatory and infrastructure requirements that will be needed should policy and economics indicate that sequestration be deployed on a wide scale. The Validation Phase (2005–2009) of the Partnership Program is focused on validating promising CO_2 sequestration opportunities through a series of field tests in the seven Partnership regions.

Description

The Midwest Geological Sequestration Consortium (MGSC) is led by the Illinois State Geological Survey and covers Illinois, southwest Indiana, and western Kentucky. This Partnership was established to assess the safety and capacity of geologic carbon sequestration options in the Illinois Basin, including unmineable coal seams, mature oil fields, and deep saline reservoir formations. The MGSC will focus on testing the ability of these types of reservoirs to serve as sinks for some of the more than 276 million metric tonnes (304 million tons) of annual CO_2 emissions from fixed sources in the Illinois Basin. A series of six small-scale pilot field tests will be conducted during the current Validation Phase. These pilot projects include the testing of unmineable coal seams to adsorb gaseous CO_2, the ability to enhance oil production or recovery from old fields by CO_2 flooding, and the injection of CO_2 into deep saline formations at a depth of 6,000 to 10,000 feet below the surface. Injection into deep coals is expected to produce additional methane to augment natural gas supplies. Injection into mature oil fields is expected to recover some of the approximately 10 billion barrels of oil remaining in Illinois Basin reservoirs.

Primary Project Goal

The MGSC's Validation Phase is a targeted, coherent validation of geologic sequestration that will meet regional needs as well as contribute to a broader generic understanding of carbon sequestration in saline formations, depleted oil reservoirs, and unmineable coal seams.

CONTACTS

Sean Plasynski
Sequestration Technology Manager
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236
412-386-4867
sean.plasynski@netl.doe.gov

John Litynski
Project Manager
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507
304-285-1339
john.litynski@netl.doe.gov

Robert J. Finley
Principal Investigator
Illinois State Geological Survey
615 E. Peabody Dr.
Champaign, IL 61820
217-244-8389
finley@isgs.uiuc.edu

PARTNERS

American Air Liquide

Ameren

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BP

Drummond Company

Duke Energy (Cinergy)

Electric Power Research Institute (EPRI)

Environmental Defense

Illinois Corn Growers Association

Illinois Department of Commerce & Economic Opportunity, Office of Coal Development

Illinois Department of Natural Resources, Office of Scientific Research and Analysis

Illinois Oil and Gas Association

Illinois State Geological Survey

Indiana Geological Survey, Indiana University

Indiana Oil & Gas Association

Interstate Oil and Gas Compact Commission (IOGCC)

Kentucky Geological Survey, University of Kentucky

Kentucky Oil & Gas Association

Lincolnland Agri-Energy, LLC

Peabody Energy

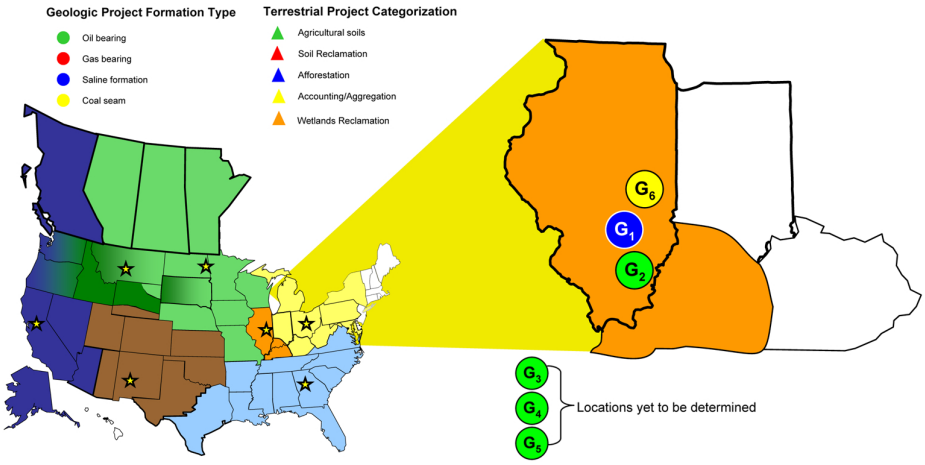
Power Holdings

Schlumberger

Objectives

- Assess and validate aspects of geological CO_2 storage in the Illinois Basin
- Continue investigations into the methods and economics of CO_2 capture at facilities, such as coal-fired power plants
- Examine the costs of transporting large quantities of CO_2 via pipeline
- Develop monitoring, mitigation, and verification (MMV) protocols to ensure safe and effective sequestration operations
- Carbon storage assessment for each of the three geological sinks: coals, oil reservoirs, and saline reservoirs
- Link options for capture, transportation, and geological storage within the environmental and regulatory framework

Field Projects



Midwest Geological Sequestration Consortium Validation Phase Field Tests

Accomplishments

Data gathered during the Characterization Phase (2003-2005) indicates that the geology of the Illinois Basin is favorable for CO_2 sequestration. MGSC's research estimated 440 million metric tonnes (484 million tons) of potential storage capacity in existing depleted oil and gas reservoirs, 3.3 billion metric tonnes (3.63 billion tons) of potential unmineable coal bed storage, and 115 billion metric tonnes (126.5 billion tons) of storage potential in saline formations. In some locations, two or more potential CO_2 sinks are stacked vertically. A particular focus is on formation properties that control CO_2 injectability, total storage capacity near major CO_2 sources, the safety of injection and storage processes, and the integrity of the overlying strata that acts as a seal. The integrity of these seals is critical for safe and effective isolation of CO_2. MGSC is engaged in six geologic field tests during the Validation Phase to assess geologic sequestration opportunities in the Illinois Basin. Each test will have an extensive monitoring program for air, shallow ground water, oil and water produced from oil reservoirs, and for saline water produced from deep reservoirs to provide data to enhance understanding of the fate of injected CO_2 at the test sites. The entire process will be scrutinized to determine what contribution Illinois Basin geological sinks can make to national and international carbon sequestration goals in achieving carbon emissions reductions and how technology developed by the MGSC can be exported to other regions. MGSC's geologic tests are summarized as follows.

Saline Formation Tests (G1)

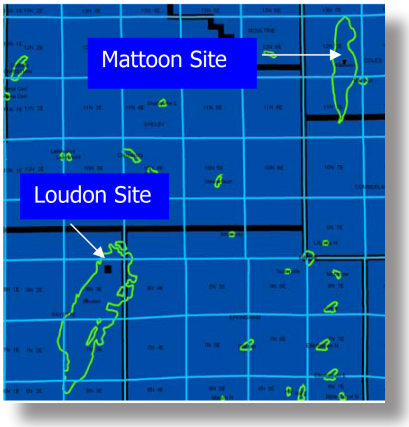
The Mt. Simon Sandstone saline formation has been selected for this project, which involves the injection of approximately 10,000 tons of CO_2 into the formation during a four-month cycle at a depth of 7,000 - 8,600 feet. The Mt. Simon is one of the most significant potential carbon storage resources in the United States. This project will employ groundwater and geochemical modeling along with MMV protocols. The Mattoon oil field, located in Coles County, Illinois and the Louden oil field, located in Fayette County, Illinois, were selected as the best candidates for a saline reservoir sequestration well at a depth of up to 8,300 feet. Mt. Simon is overlain by the Eau Claire Formation, a regional, non-permeable shale, which has proven to be an effective seal for natural gas storage and is expected to perform in a similar manner for CO_2 storage.

Enhanced Oil Recovery Test (G2)

This mature oil field enhanced oil recovery (EOR) test, also known as a "Huff 'n Puff," will evaluate the potential for geological sequestration of CO_2 in mature Illinois Basin oil reservoirs as part of an enhanced oil recovery program. During the process, CO_2 is injected (normally as a gas) into a producing well (the "Huff" phase), the well is shut and CO_2 is allowed to penetrate the formation, and then the well is placed back on production (the "Puff" phase). Site evaluation, evaluation of well data, CO_2 injection, modeling, and MMV efforts will be completed during a thirteen month test schedule. The primary location is in the Louden Field in Fayette County, Illinois. A total of 43 tons of CO_2 were injected over a five-day period into the Mississippian Weiler Sandstone formation at a depth of approximately 1,550 feet.

Accomplishment Highlights:

- Forty-three tons of CO_2 were injected over a five day period.
- Oil production during the first two months following the soak period was 93 barrels.
- Results indicate that the Illinois Basin oilfield may have an added-value benefit as a pre-cursor to build and invest in the infrastructure to establish a sequestration industry within the Basin.



Loudon and Mattoon Area

Enhanced Oil Recovery Test (G3)

The well conversion EOR field test does not require the drilling of any new wells because available well(s) will be converted to handle CO_2 injection and the pattern and spacing of existing wells is adequate to test EOR processes in the reservoir. This pilot will convert an existing water injection well to CO_2 injection, measure volumes of CO_2 injected, volumes of CO_2 recovered with oil, degree to which CO_2 renders the incremental oil producible, and volume of sequestered CO_2 in the reservoir. Well conversion represents a potential near-term, low-cost opportunity to implement EOR. The selected site is an area where fluid flows are well understood and part of the reservoir into which CO_2 will be injected is either geologically constrained or constrained by an existing water injection pattern. A total of 2,500 tons of CO_2 will be injected into the Mississippian Weiler Sandstone formation. A comprehensive monitoring, mitigation, and verification plan will be implemented in all phases of the pilot.

Accomplishment highlights:

- Completion of site-screening-process in order to determine a site with the highest probability of CO_2 response during operations
- Equipment has been ordered to convert the water injector to a CO_2 injector; as well as for data acquisition of the gas casing rates

Enhanced Oil Recovery Test (G4)

This pilot will drill one new well as a CO_2 injector through operational collaboration with the lease operator. Depending on reservoir properties, management scheme of

COST

Total Project Value
$17,384,302

DOE/Non-DOE Share
$13,069,974 / $4,314,328

ADDRESS

National Energy Technology Laboratory
1450 Queen Avenue SW
Albany, OR 97321-2198
541-967-5892

2175 University Avenue South
Suite 201
Fairbanks, AK 99709
907-452-2559

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4764

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-4687

One West Third Street,
Suite 1400
Tulsa, OK 74103-3519
918-699-2000

CUSTOMER SERVICE

1-800-553-7681

WEBSITE

www.netl.doe.gov

the existing waterflood, reservoir geology, and assessment of where in the reservoir unrecovered oil resides, a new well would likely be required to create an optimum field test. Installation of this new well will optimize the test pattern and provide an opportunity to collect additional data, such as core and advanced well logs, which are needed to assess the reservoir and understand sequestration potential. Additional data will be particularly useful to characterize and understand flow in carbonate reservoirs that are often more diagenetically complex compared to sandstones. A comprehensive MMV plan will be implemented in all phases of the pilot.

Accomplishment Highlights:

- Site selection and project design in progress

Enhanced Oil Recovery Test (G5)

A second EOR pattern flood test is planned after Pattern Flood I completion, should funding and operational considerations allow. The second pattern flood test allows for a complementary test to be carried out for a different class of reservoirs among miscible or immiscible conditions and sandstone or carbonate reservoirs. Many reservoirs in the Illinois Basin represent immiscible or near-miscible conditions, so this test will contrast with miscible conditions if the latter are selected for Pattern Flood I. Reservoirs of interest for immiscible flooding will also be under waterflood and, as in the miscible case, will be judged for testing suitability based on the material balance of water injected compared to water produced. Even if the reservoir pressure is below the thermodynamic minimum miscibility pressure, CO_2 is known to somewhat reduce the residual oil saturation through increased vaporization. This pilot will also focus on the drilling of one new well as a CO_2 injector. A comprehensive MMV plan will be implemented in all phases of the pilot.

Accomplishment Highlights:

- Site selection and project design in progress

Enhanced Coalbed Methane Tests (G6)

The purpose of this project is to determine the CO_2 injection and storage capability and the enhanced coalbed methane recovery potential of Illinois Basin coal seams. The target formation is the Pennsylvanian Carbondale formation with injection of approximately 750 tons of CO_2 at a drilling depth of 890 feet (in 7-foot thick Springfield Coal). Injectivity will first be tested with water in a pressure transient test followed by a short nitrogen injection test. Finally, a CO_2 micro pilot to assess coal swelling and permeability reduction will be done. The test location is yet to be determined, but is expected to be in or near an existing oil field.

Accomplishment Highlights:

- Completed drilling of two wells in the summer of 2007. Two additional wells will be drilled in the winter of 2008
- Site monitoring for MMV began in February of 2007
- CO_2 injection scheduled to commence in May of 2008

Benefits

Injection of CO_2 into depleted oil fields will help recover some of the approximately 10 billion barrels of oil remaining in Illinois Basin reservoirs, and injection into unmineable coal seams will help produce trapped methane to augment natural gas supplies. These activities will validate CO_2 sequestration while also helping to meet the nation's need for fossil fuels. Value added benefits include a potential of 200 to 1,000 million stock tank barrels (MSTB) of oil and 3,000 to 11,000 billion cubic feet (Bcf) of natural gas. If storage in unconfined geologic structures proves feasible, an additional 83,000 million tons of CO_2 storage is potentially available.