the ENERGY lab

PROJECT FACTS

Industrial Carbon Capture and Storage (ICCS)

Archer Daniels Midland Company: CO_2 Capture from Biofuels Production and Storage into the Mt. Simon Sandstone

Background

Carbon dioxide (CO_2) emissions from industrial processes, among other sources, are linked to global climate change. Advancing development of technologies that capture and store or beneficially reuse CO_2 that would otherwise reside in the atmosphere for extended periods is of great importance. Advanced carbon capture, and storage (CCS) technologies offer significant potential for reducing CO_2 emissions and mitigating global climate change, while minimizing the economic impacts of the solution.

Under the Industrial Carbon Capture and Storage (ICCS) Program, the U.S. Department of Energy (DOE) is collaborating with industry in cost sharing arrangements to demonstrate the next generation of technologies that will capture CO_2 emissions from industrial sources and either sequester those emissions or beneficially re-use them. The technologies included in the ICCS program have progressed beyond the research and development stage to a scale that can be readily replicated and deployed into commercial practice within the industry.

Project Description

Partnership between DOE and Industry

In October 2009, DOE selected the Archer Daniels Midland Company (ADM) team to conduct one of 12 projects in Phase 1 of its ICCS program to test large-scale industrial CCS technologies. DOE again selected the project in June 2010 as one of three projects to receive continued (Phase 2) funding. The Office of Fossil Energy's National Energy Technology Laboratory (NETL) manages the CO_2 Capture from Biofuels Production and Storage into the Mount (Mt.) Simon Sandstone project [Illinois Industrial Carbon Capture and Storage (Illinois ICCS) project], which receives $141.4 million in American Recovery and Reinvestment Act (ARRA) of 2009 funding and another $66.5 million in private sector cost-sharing. The project is scheduled for completion on September 30, 2015. The project team members are ADM, U.S. DOE, Schlumberger Carbon Services, Illinois State Geological Survey (ISGS), and Richland Community College (RCC). The Illinois ICCS project presents a unique opportunity to gather crucial scientific and engineering data in advance of carbon capture requirements to add to the understanding of large-scale CO_2 storage in saline formations. Successful implementation of this project could facilitate exploration of long-term CO_2 utilization options, such as enhanced oil recovery, in the Southern Illinois Basin.

Goals/Objectives

The overall project objective is to develop and demonstrate an integrated system of CO_2 processing and transport from an ethanol plant to the Mt. Simon Sandstone Formation (saline reservoir) for geologic sequestration.

CONTACTS

Michael Knaggs
Director
Office of Major Demonstrations
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4926
michael.knaggs@netl.doe.gov

Sai Gollakota
Project Manager
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4151
sai.gollakota@netl.doe.gov

Scott McDonald
Biofuels Development Director
Archer Daniels Midland Company
1001 N. Brush College Rd.
Decatur, IL 62521
217-451-5142
scott.mcdonald@adm.com

PARTNERS

Illinois State Geological Survey
Schlumberger Carbon Services
Richland Community College

PROJECT DURATION

Start Date	End Date
11/16/2009	09/30/2017

COST

Total Project Value
$207,942,199

DOE/Non-DOE Share
$141,405,945 /$66,536,254

PROJECT NUMBER

ARRA1547

Project Scope

The Illinois ICCS project will demonstrate an integrated system for collecting CO_2 from an ethanol production plant and geologically sequestering it (deep underground storage) in a sandstone reservoir. The CO_2 produced is a byproduct from processing corn into fuel-grade ethanol at the ADM ethanol plant in Decatur, Illinois. Because all of the collected CO_2 is produced from biologic fermentation, a significant feature of the Illinois ICCS project is its "negative carbon footprint," meaning that the storage results in a net reduction of atmospheric CO_2.

The CO_2 will be sequestered in the Mt. Simon Sandstone, a prolific saline reservoir in the Illinois Basin with the capacity to store billions of tons of CO_2. Saline reservoirs are layers of porous rock that are saturated with brine (a concentrated salt solution). Mt. Simon Sandstone is a clean sedimentary rock dominated by silicate minerals and lacking significant amounts of clay minerals (which typically clog pores and reduce porosity), resulting in highly favorable porosity and permeability features for CO_2 storage. Supercritical CO_2 fluid will be injected into the saline reservoir at a depth of approximately 7,000 feet at a site adjacent to the ADM ethanol plant. Nearly 50 years of successful natural gas storage in the Mt. Simon Sandstone indicates that this saline reservoir and overlying seals should effectively contain sequestered CO_2.

The project scope includes the design, construction, demonstration, and integrated operation of CO_2 compression, dehydration, and injection facilities, and Monitoring, Verification, and Accounting (MVA) of the stored CO_2. More specifically:

- Design, construction, and operation of a new collection, compression, and dehydration facility capable of delivering up to 2,000 metric tons of CO_2 per day to the injection site.
- Integration of the new facility with an existing 1,000 metric tons per day CO_2 compression and dehydration facility to achieve a total injection capacity of up to 3,000 metric tons of CO_2 per day.
- Implementation and validation of deep subsurface and near-surface MVA plans.
- Demonstration of the cost advantages and economic viability of implementing CCS at ethanol production facilities.

Decatur, Illinois is home to two DOE-sponsored CCS projects:

Illinois Basin-Decatur Project (IBDP) led by ISGS under the Midwest Geological Sequestration Consortium (MGSC) Regional Carbon Sequestration Program: This is a large-volume, saline reservoir sequestration test that will inject approximately 333,000 metric tons of CO_2 per year for three years. MGSC, one of the seven DOE Regional Carbon Sequestration Partnerships, was established in 2003 to assess geologic carbon sequestration options in the Illinois Basin. ADM and ISGS have completed construction of the 1,000 metric tons per day CO_2 compression and dehydration facility and drilled and completed the associated injection and deep monitoring wells. The injection well is located adjacent to the ADM ethanol plant in Decatur. Carbon dioxide injection into the Mt. Simon Sandstone began in November 2011 and will continue at a rate of 1,000 metric tons per day over a three-year period. For more details on IBDP and site geology, see: http://www.netl.doe.gov/publications/factsheets/project/Project678_4P.pdf

Illinois ICCS Project led by ADM: This project expands the CO_2 storage capability to that of a commercial-scale operation (i.e., one million tons per year). ADM will integrate the IBDP compression and dehydration facilities with the new facilities constructed under the Illinois ICCS project upon completion of IBDP injection operations in fall 2014. A significant benefit of these two complimentary projects is the unique opportunity to better understand the interaction between the CO_2 plumes and pressure fronts emanating from two injection wells in the same sandstone formation.

Carbon Dioxide Compression, Dehydration, and Transmission

The CO_2 will be collected at atmospheric pressure from ADM's corn-to-ethanol fermentors via a 36-inch pipeline. The fermentor outlet gas stream has high purity CO_2 (greater than 99% purity on a moisture free basis), but also contains some moisture (less than 3% by weight). This gas stream will be compressed and dehydrated to deliver supercritical CO_2 to the injection wellhead for storage. In this process the CO_2 will be compressed to 35 psia using a 3000 hp blower and sent via a 24-inch, 1,500-foot pipeline to a dehydration and compression facility. The CO_2 will be compressed and dehydrated at that facility to approximately 1425 psia and 95°F using a 3250 hp, 4-stage reciprocating compressor and a dehydration system that uses tri-ethylene glycol contactor (absorber)-regenerator columns. The CO_2 gas stream is also processed through various inter-stage coolers and knock-out vessels to decrease temperature and remove moisture, respectively. Finally, the dehydrated CO_2, which has less than 0.005% moisture by weight (>99.9% CO_2 purity), could be further compressed up to 2300 psia using a 400 hp centrifugal booster pump (if additional pressure is required) and transported about one-mile through an 8-inch pipeline to the injection wellhead. The injection operations will be conducted on a 200-acre site adjacent to the ethanol plant, which is also owned by ADM. The injection well head conditions will comply with the permit requirements.

CO_2 Injection

The Illinois ICCS project will initially inject CO_2 into the Mt. Simon Sandstone formation at a rate of 1,500 metric tons per day. The IBDP will also inject CO_2 at a rate of 1,000 metric tons per day during this period. The Illinois ICCS project's injection rate can be increased up to 3,000 metric tons per day once the IBDP project completes injection operations. Each project will have a separate injection well and the distance between the two wells will be approximately 3,700 feet.

At the injection location, the Mt. Simon Sandstone starts at a depth of approximately 5,500 feet below the surface and has a thickness of 1,500 to 1,600 feet. The CO_2 will be injected at a depth of about 7,000 feet where the IBDP project identified a high permeability zone with porosities up to 25%. Carbon dioxide injection will occur at depths far below the Underground Source of Drinking Water (USDW) level thus ensuring the safety of these water sources.

The Mt. Simon Sandstone is overlain by the 500-foot thick Eau Claire formation, of which the bottom 200 feet is primarily shale. The low-porosity Eau Claire Shale acts as the primary cap rock seal preventing upward migration of CO_2 from the Mt. Simon Sandstone. Two other shale formations, the Maquoketa and New Albany Shales, are present at shallower depths and act as secondary and tertiary seals, respectively. The base of the Mt Simon Sandstone is underlain by Precambrian igneous bedrock (granite basement).

MVA of the Stored CO_2

The Illinois ICCS project will implement a robust MVA plan to monitor CO_2 migration and to protect groundwater sources. The MVA efforts will employ methods to provide an accurate accounting of the stored CO_2 and a high level of confidence that it will remain permanently stored deep underground. The MVA plan includes near surface and deep subsurface activities. Near surface monitoring includes aerial infrared imagery to monitor vegetative stress, an electrical resistivity survey of the soil to identify the geophysical nature of the near surface bedrocks, soil CO_2 flux to monitor changes in CO_2 concentrations, and shallow groundwater sampling for geochemical analysis. Deep subsurface monitoring includes geophysical (seismic) surveys and passive seismic surveys in the above cap rock seal locations and geophysical surveys, geochemical sampling, and pressure and temperature monitoring in the injection zone. A monitoring well (7240 ft. depth) and a geophysical well (3555 ft. depth) were drilled in November 2012 for deep subsurface monitoring through direct and indirect measurements of the storage reservoir conditions. A baseline 3-D surface seismic study was conducted in February 2011. A geophysical analysis of the 3-D seismic data did not indicate any geologic faults in the cap rock seal at the proposed ICCS injection site. A lack of geologic faults offers greater certainty that the injected CO_2 will be stratigraphically trapped in the Mt. Simon Sandstone. Other trapping mechanisms such as solubility trapping (dissolution of CO_2 in the brine solution) and residual trapping (CO_2 held in the pores) could also securely retain approximately 50% of the injected CO_2 in the sandstone. ADM received U.S. Environmental Protection Agency's (EPA) Class VI injection well final permit in September 2014.

Project Implementation Roles

- ADM: Overall project implementation, project host site, construction, operation, permits, and ownership.
- Schlumberger Carbon Services: Site characterization, CO_2 injection well installation and operation, and deep subsurface MVA of the stored CO_2.
- ISGS: Site characterization, near-surface and deep subsurface MVA of the stored CO_2, education and outreach.
- RCC: National Sequestration Education Center development, CCS training, community outreach, and development of an associate degree program in sequestration technology.

National Sequestration Education Center (NSEC)

Integral to the Illinois ICCS project was the formation of an education and training facility, the National Sequestration Education Center (NSEC), housed at nearby RCC in Decatur. The center contains classrooms, training and laboratory facilities, and has initiated offering an associate degree with a sequestration specialization in the fall of 2012. Richland shares the NSEC facilities with project partners and other stakeholders for conducting CCS training and educational programs. The project partners have been providing the necessary expertise to develop these programs.

About Project Partners

ADM
ADM's global headquarters is located in Decatur, Illinois. Its more than 265 processing plants and 30,000 employees convert corn, oilseeds, wheat, and cocoa into products for food, animal feed, chemicals and energy uses. The net sales of ADM in fiscal year 2012 were $89 billion. www.adm.com.

Schlumberger Carbon Services
Schlumberger Carbon Services provides technologies and services for the long-term geologic storage of CO_2. Its experience and detailed understanding of the varied challenges posed by CO_2 storage, gained by participation in many carbon capture and storage projects worldwide, is backed up by a corporate history of over 80 years in the oil and gas industry. www.SLB.com/carbonservices

ISGS
The Illinois State Geological Survey (ISGS) leads the MGSC and is part of the Prairie Research Institute at the University of Illinois. The objective of the MGSC is to determine the technical and economic feasibility of using geologic formations for long-term CO_2 storage. www.sequestration.org.

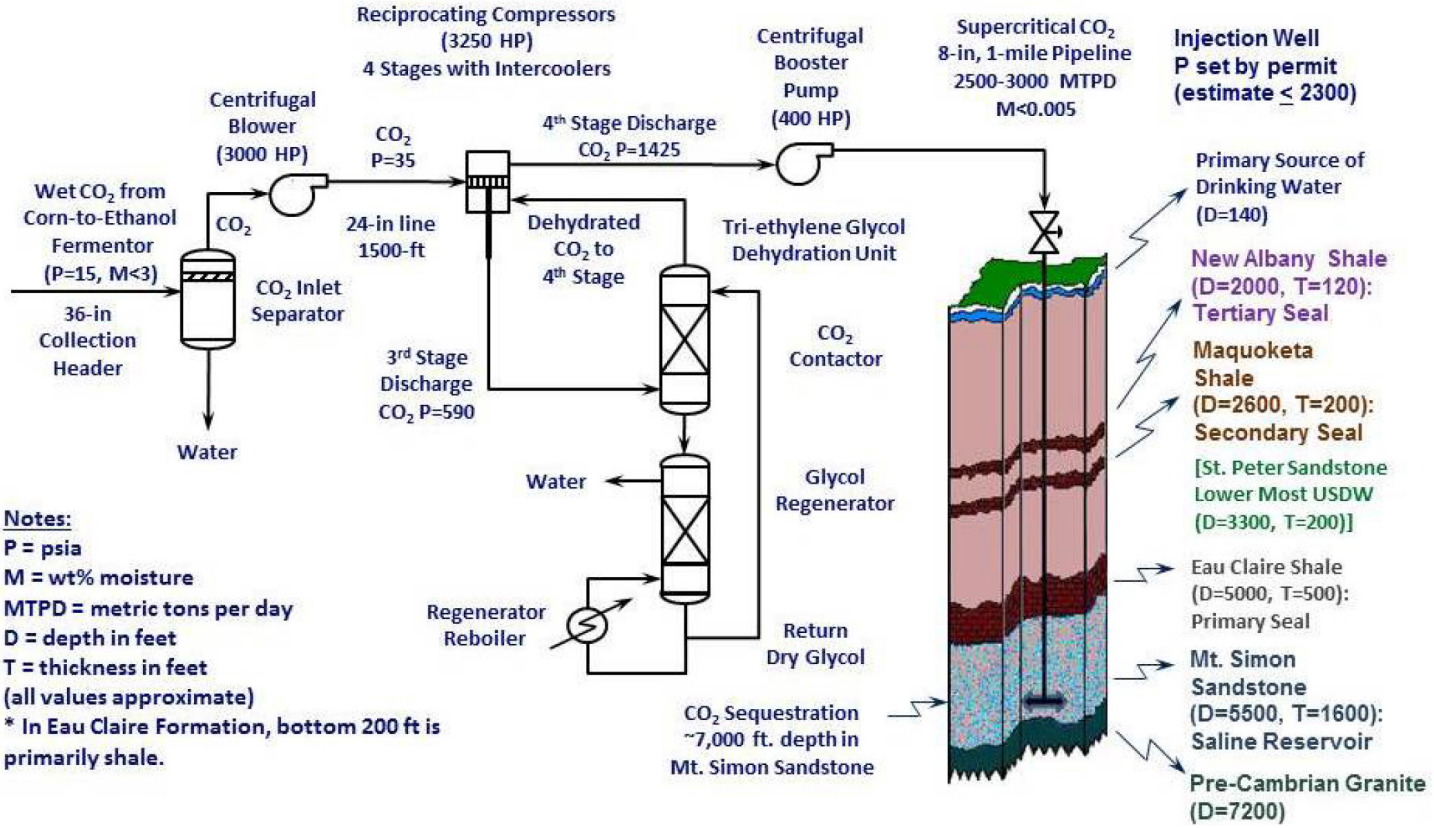
Richland Community College

Richland Community College, located in Decatur, Illinois, features a main campus and four major extension sites and offers over 150 degrees and certificates. The college has established itself as a vital asset to the community during its 40-year presence in Decatur-Macon County region. http://www.richland.edu/

Benefits

Carbon dioxide emissions from industrial processes and fossil-fuel power plants, among other sources, are linked to global climate change. Widespread deployment of large-scale CCS technologies at stationary sources offer significant potential for reducing CO_2 emissions to the atmosphere and mitigating global climate change. The Illinois ICCS project is the largest saline storage demonstration project under construction in the U.S. The project addresses climate change concerns by collecting and compressing CO_2 derived from a large-scale industrial process and storing it in a saline reservoir. Specific advantages of the project include:

ADM's Agricultural Processing and Biofuels Plant, Decatur, IL.

- Sequestration of approximately one million tons of CO_2 annually via a combination of existing and new processing capacity.
- A potential market for the technology in the U.S. for some of the approximately 200 fuel grade ethanol plants that have access to geologic storage.
- Utilization of U.S. geologic saline storage capacity of CO_2 that is estimated to range from 1,700 to 20,000 billion metric tons.
- Carbon dioxide concentration in the collected stream is already high, which enhances project economics.
- Project location is very near the CO_2 injection site, thereby avoiding the expense of developing a lengthy pipeline.
- Demonstration of capture and compression technology, as well as CO_2 storage experience, is applicable to coal-fired power generation.

Illinois Industrial Carbon Capture and Storage Project – Simplified Flow Diagram