ARCHER DANIELS MIDLAND COMPANY:

CO_2 Capture from Biofuels Production and Storage into the Mt. Simon Sandstone

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

NATIONAL ENERGY TECHNOLOGY LABORATORY

PARTNERS

Illinois State Geological Survey
Schlumberger Carbon Services
Richland Community College

PROJECT DURATION

Start Date - 11/16/2009
End Date - 09/30/2019

COST

Total Project Value
$207,942,199

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

PROJECT NUMBER

FE0001547

BACKGROUND

Advanced carbon capture and storage (CCS) technologies offer significant potential for reducing carbon dioxide (CO_2) emissions, while minimizing the economic impacts of the solution. Under the Industrial Carbon Capture and Storage (ICCS) Program, the U.S. Department of Energy (DOE) has collaborated with industry in cost-sharing arrangements to demonstrate technologies that will capture CO_2 emissions from industrial sources and either store 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 deployed into commercial practice within the industry.

PROJECT DESCRIPTION

Partnership between DOE and Industry

The Archer Daniels Midland Company (ADM) team was selected to conduct one of three projects in the DOE ICCS program to test large-scale industrial CCS technologies. The Office of Fossil Energy's National Energy Technology Laboratory (NETL) manages the CO_2 Capture from Biofuels Production and Storage into the Mt. Simon Sandstone project (Illinois Industrial Carbon Capture and Storage [Illinois ICCS] project). The project team consists of DOE, ADM, 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 to increase 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.

PROJECT SCOPE

The Illinois ICCS project is demonstrating an integrated system for collecting CO_2 from an ethanol production plant and storing it deep underground in a sandstone reservoir. The CO_2 produced is a byproduct of processing corn into fuel-grade ethanol at the ADM ethanol plant in Decatur, Illinois.

The captured CO_2 is being 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. This composition results in highly favorable porosity and permeability features for CO_2 storage. Supercritical CO_2 fluid is being injected into the saline reservoir at a depth of approximately 6,800 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, as well as monitoring, verification, and accounting (MVA) of the stored CO_2. Specific project objectives include the following:

- Design, construct, and operate 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.
- Integrate 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.
- Implement and validate deep subsurface and near-surface MVA plans.
- Demonstrate the economic viability of implementing CCS at ethanol production facilities.

CARBON DIOXIDE COMPRESSION, DEHYDRATION, AND TRANSMISSION

The CO_2 is being collected at atmospheric pressure from ADM's corn-to-ethanol fermenters via a 36-inch pipeline. The fermenter outlet gas stream contains high purity CO_2 (greater than 99 percent purity on a moisture-free basis) but also contains some moisture (less than three-percent by weight). This gas stream is being compressed and dehydrated to deliver supercritical CO_2 to the injection wellhead for storage. In this process, the CO_2 is being 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. There, the CO_2 is being compressed and dehydrated 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 being processed through various inter-stage coolers and knockout vessels to decrease temperature and remove moisture, respectively. Finally, the dehydrated CO_2, which has less than 0.005 percent moisture by weight (greater than 99.9 percent CO_2 purity), could be further compressed up to 2300 psia using a 400 hp centrifugal booster pump (if additional pressure is required) and is being transported about 1 mile through an 8-inch pipeline to the injection wellhead. The injection operation is being conducted on a 200-acre site adjacent to the ethanol plant, which is also owned by ADM. The injection well head conditions comply with the permit requirements.

CO_2 INJECTION

At the injection location, the Mt. Simon Sandstone starts at a depth of approximately 5,500 feet and has a thickness of 1,500 to 1,600 feet. The CO_2 is being injected at a depth of about 6,800 feet, where a high permeability zone with porosities up to 25 percent was detected. Carbon dioxide injection occurs at depths far below underground sources of drinking water (USDW), 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 caprock 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).

MONITORING OF THE STORED CO_2

The Illinois ICCS project is implementing a robust plan to monitor CO_2 migration and protect groundwater sources. The monitoring efforts are employing 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 monitoring plan includes near-surface and deep-subsurface activities. Near-surface monitoring included 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 geo-chemical analysis. Deep-subsurface monitoring includes geophysical (seismic) surveys and passive seismic surveys in the above caprock 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 (3,550 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 caprock 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 percent of the injected CO_2 in the sandstone. ADM received the U.S. Environmental Protection Agency's (EPA) Class VI injection well final permit in September 2014. ADM drilled and completed the injection well (7192 ft. depth) in September 2015. Carbon dioxide sequestration operation, i.e., injecting CO_2 into Mt. Simon Sandstone saline reservoir, was initiated on April 7, 2017.

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. [The Illinois Basin-Decatur Project (IBDP), led by ISGS under the Midwest Geological Sequestration Consortium (MGSC), is a large-volume test that has injected nearly one million metric tons of CO_2 during 2011-14 into the Mt. Simon Sandstone. This project is now undergoing post-injection site care and monitoring. The IBDP injection well is also located adjacent to the ADM ethanol plant in Decatur.]
- 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 the NSEC, an education and training facility housed at nearby RCC in Decatur, which contains classrooms, training, and laboratory facilities. In the fall of 2012, the NSEC initiated an Associate Degree program with a sequestration specialization. Richland shares the NSEC facilities for conducting CCS training and educational programs with project partners and other stakeholders. The project partners have been providing the necessary expertise to develop these programs.

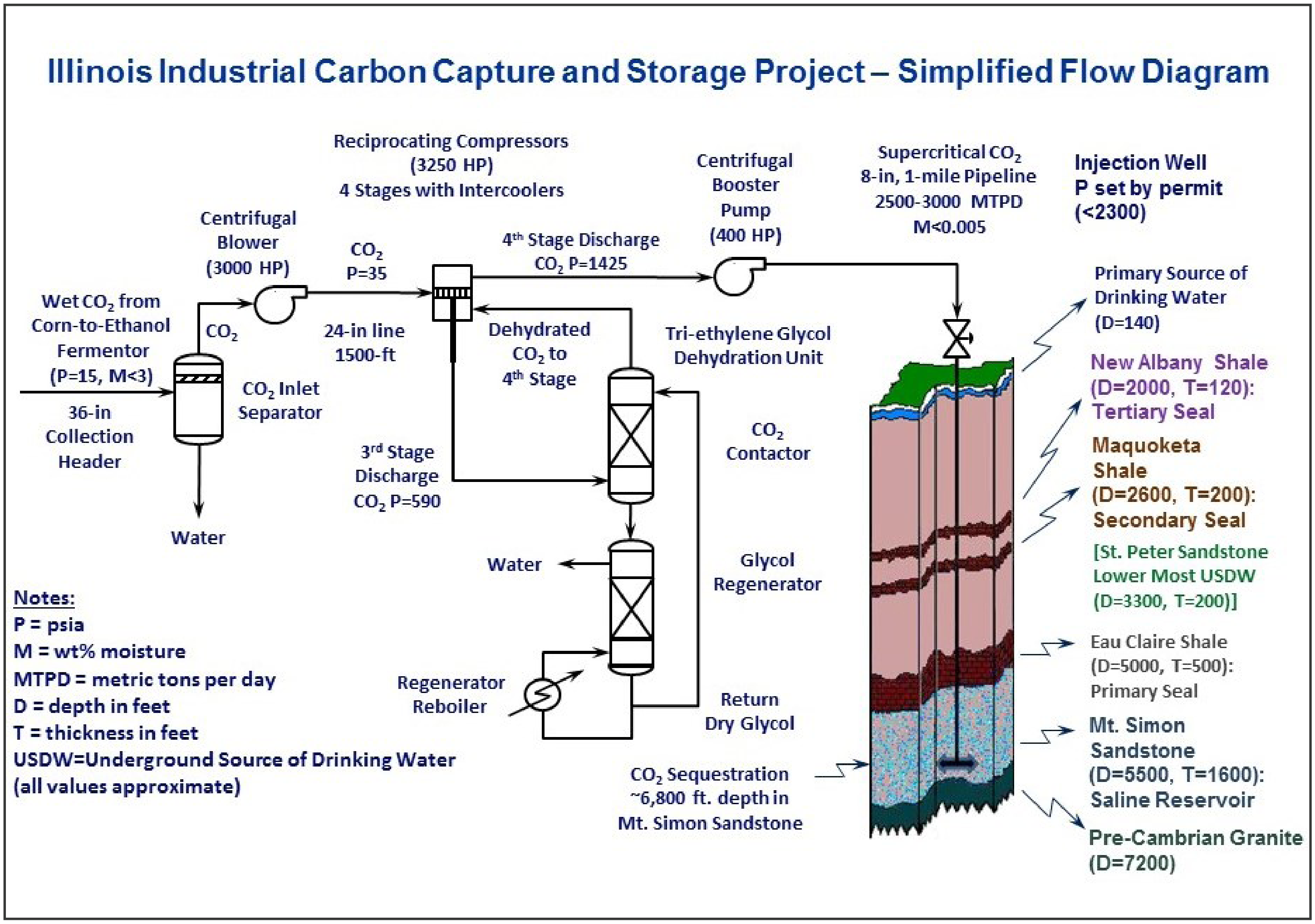
GOALS/OBJECTIVES

The project objective is to develop and demonstrate an integrated system of processing CO_2 and transporting it from an ethanol plant to the Mt. Simon Sandstone formation (saline reservoir) for permanent geologic storage.

BENEFITS

Widespread deployment of large-scale CCS technologies at stationary CO_2 sources offers significant potential for reducing CO_2 emissions to the atmosphere. The Illinois ICCS project is the largest saline storage demonstration project in the United States. The project addresses CO_2 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:

- Storing approximately one million tons of CO_2 annually via a combination of existing and new processing capacity.
- Establishing a potential market for the technology in the United States for some of the approximately 200 fuel-grade ethanol plants that have access to geologic storage.
- Using U.S. geologic saline storage capacity of CO_2, which is estimated to range from 1,700 to 20,000 billion metric tons.
- Enhancing project economics, since CO_2 concentration in the collected stream is already high.
- Avoiding the expense of developing a lengthy pipeline, since the project is located very near the CO_2 injection site.
- Demonstrating CO_2 compression and storage with the first Class VI injection well, which is applicable to geologic sequestration of CO_2 from coal-fired power generation.



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