



the **ENERGY** lab

PROJECT FACTS

Carbon Sequestration

Midwest Regional Carbon Sequestration Partnership—Development Phase

Background

As part of a comprehensive effort to assess options for sustainable energy systems, the U.S. Department of Energy has selected seven regional partnerships, through its Regional Carbon Sequestration Partnership (RCSP) initiative, to determine the best approaches for capturing and permanently storing carbon dioxide (CO₂), a greenhouse gas (GHG) which can contribute to global climate change. The partnerships are made up of state agencies, universities, private companies, national laboratories, and nonprofit organizations that form the core of a nationwide network helping to establish the most suitable technologies, regulations, and infrastructure needs for carbon sequestration. Altogether, the RCSPs include more than 350 organizations, spanning 43 states and four Canadian provinces.

The RCSP initiative is being implemented in three phases. The Characterization Phase began in September 2003 with the seven partnerships working to develop the necessary framework to validate and potentially deploy carbon sequestration technologies. In June 2005, work transitioned to the Validation Phase, a four-year effort focused on validating promising CO₂ sequestration opportunities through a series of field tests in the seven regions. Presently, activities in the Development Phase (2008–2017) are proceeding as an extension of the work completed to date and will demonstrate that CO₂ capture, transportation, injection, and storage can be achieved safely, permanently, and economically at a large scale. These tests will promote understanding of injectivity, capacity, and storability of CO₂ in the various geologic formations identified by the partnerships. Results and assessments from these efforts will help in the commercialization efforts for future sequestration projects in North America.

The Midwest Regional Carbon Sequestration Partnership (MRCSP), led by Battelle Memorial Institute, includes nine contiguous states: Indiana, Kentucky, Maryland, Michigan, New Jersey, New York, Ohio, Pennsylvania, and West Virginia. The MRCSP includes more than 30 organizations. The states in MRCSP region account for over 23 percent of U.S. CO₂ emissions from stationary sources. The region offers significant potential for sequestration in deep saline formations, unmineable coal seams, and depleted oil and gas reservoirs.

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Ohio Consumers' Counsel
Ohio Corn Marketing Program
Ohio Division of Geological Survey
Ohio Environmental Council

Project Description

Project Summary

The MRCSP's primary proposed site for its large-scale, saline injection test is at an ethanol production facility located near Greenville, Ohio. The facility is owned and operated by a joint venture called The Andersons Marathon Ethanol LLC (TAME). By virtue of the fermentation process used to make ethanol, the TAME Greenville plant produces slightly more than 250,000 tons (227,000 metric tons) of nearly pure, wet CO₂, which will be compressed to approximately 1,500 pounds per square inch (psi) and dried prior to injection. During the test, a total of one million tons of CO₂ will be injected into the Mt. Simon Sandstone over a four-year period.

An optional CO₂ source and site for the MRCSP Development Phase test is an integrated gasification combined cycle (IGCC) power plant being developed by Duke Energy, near Edwardsport, Indiana. As part of its regional mapping efforts in the first two years of the Development Phase, MRCSP is characterizing the area around the Edwardsport site for potential future sequestration opportunities. The primary target injection is also the Mt. Simon Sandstone.

Injection Site Description

The TAME site is located near Greenville, Ohio, and the terrain consists of flat farmland. The ethanol plant property is part of an industrial park under development by the city of Greenville. The site is about 80 acres in area. The ethanol plant became operational in February 2008.



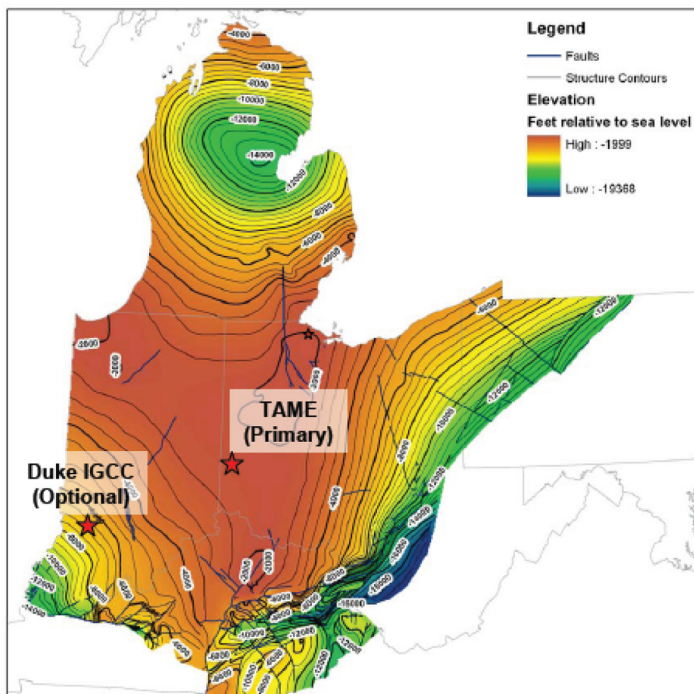
TAME Ethanol Plant Under Construction (Spring 2007), Greenville, Ohio



TAME Ethanol Plant about Two Months Prior to Startup (late 2007)

Description of Geology

The target formation for the large volume injection of CO₂ at the Greenville ethanol plant is the Mt. Simon Sandstone, the largest potential CO₂ sequestration sink in the MRCSP region. The ethanol plant site is located in the Cincinnati Arch, where rocks dip very gently toward the west. No major faults have been identified at the site. The Mt. Simon does not outcrop within several hundred miles of the site. Thickness of the Mt. Simon is estimated at 300 feet (91 meters) at the TAME site and lies at a depth of approximately 3,300 to 3,600 feet (1,000 to 1,100). It is generally a white, pink, or purple, fine- to coarse-grained, moderately to well-sorted, quartz arenite that can be arkosic. In general, regional Mt. Simon permeability values range from less than one millidarcy to several hundred millidarcies. Permeability varies with depth, location, and analysis method. Regional porosities range from 4 percent to 25 percent in the basal sandstone with an average of 12 percent. In the study areas, porosity maps suggest approximately 10 to 15 percent. Porosity in the basal sandstone appears to be primary intergranular space, which makes the Mt. Simon a favorable formation for injection. The primary containment unit is the Eau Claire shale, which is approximately 500 feet (150 meters) thick near the TAME site. The injected CO₂ is expected to remain in the target formation for geologic time periods at the site due to the presence of the thick, low permeability Eau Claire shale layer. The formation consists of dark gray, red, and green shales; dolomitic, feldspathic, and partly glauconitic siltstone; very fine-grained to fine-grained, well-sorted sandstone; silty to sandy dolostone; and oolitic limestone. Regional hydrologic test data suggest a porosity of less than three percent and permeability of less than 10⁻⁶ millidarcies, indicating a tight, low permeability formation.



Geologic Setting of Proposed MRCSP Development Phase Test Sites

PARTNERS (cont.)

Ohio Soybean Growers
Ohio State University, School
of Natural Resources
Pennsylvania Geological Survey
Praxair
Schlumberger
Stanford University
The Andersons and Marathon
Petroleum (TAME)
The Keystone Center
University of Maryland
West Virginia Geological Survey
West Virginia University
Western Michigan University

COST

Total Project Value

\$93,000,000

DOE/Non-DOE Share

\$61,000,000 / \$32,000,000

Source of CO₂

At the TAME site, CO₂ is available from the ethanol process at greater than 97 percent purity at ambient pressure and a temperature slightly above ambient. By virtue of the fermentation process used to make ethanol, the CO₂ comes directly from the production process without any need for capture. Availability of CO₂ is expected to be just over 275,000 tons (250,000 metric tons) per year. MRCSP plans to construct a compression and dehydration facility and implement the wells needed to support injection and monitoring operations on and adjacent to the TAME property. Carbon dioxide will be transported from the ethanol plant to the compression plant over an estimated distance of about 700 feet (215 meters). The compression plant is expected to consist of a four- to five-stage reciprocating, skid-mounted compressor package that includes compression of the CO₂ to a supercritical pressure of 1,500 psi with dehydration occurring at intermediate stages.

Injection Operations

At the TAME site, supercritical CO₂ (~1,500 psi) from the compression/dehydration facility will be transported a short distance and injected through a 3,300- to 3,600-foot (1,000 to 1,100 meter) well into the Mt. Simon sandstone. The injection rate will be about 275,000 tons (250,000 metric tons) per year for four years.

Simulation and Monitoring of CO₂

An extensive monitoring program will be used to ensure that the injection systems are operated correctly and that CO₂ is permanently stored in the target formation. Monitoring techniques to be used include soil gas composition, surface flux emissions, CO₂ monitoring of existing wells, borehole microtiltmeter array, crosswell seismic, wireline logging, microseismic array, and surface seismic. To conduct a detailed evaluation of CO₂ sequestration, it is useful to employ numerical reservoir simulations. Carbon dioxide storage simulations will be run using the water (H₂O)-CO₂-sodium chloride (NaCl) operational mode of the STOMP CO₂ simulator.

Goals and Objectives

MRCSP's overall goal is to validate the information and technology developed under the Characterization and Validation Phases relative to research and field activities, public outreach efforts, and regional characterization. Specific objectives include:

- Conduct a successful test at the TAME site to verify the concept of sequestering at least one million tons of CO₂ into the Mt. Simon Formation, one of the Midwest's largest potential deep saline storage targets.
- Verify the ability of the Mt. Simon Formation to meet the goal of storing 50 percent of the region's point source CO₂ emissions for the next 100 years.
- Develop a thorough understanding of the science, technology, regulatory framework, risk factors, and public opinion issues associated with large-scale injection operations.
- Corroborate monitoring, verification, and accounting (MVA) activities and modeling and equipment operations.
- Refine capacity estimates of the target formation based on results.
- Collaborate with local stakeholders and solicit input to identify factors that contribute to public acceptance.

Benefits to the Region

The Mt. Simon sandstone is the most promising target for CO₂ sequestration in the Midwest and has the largest sequestration potential of any individual geologic unit within the MRCSP region. Emissions from large point sources in the MRCSP region total more than 825 million tons (750 million metric tons) of CO₂ per year. The Mt. Simon storage capacity estimate is at 95,600 million tons (86,900 million metric tons), which suggests that the Mt. Simon should have the capacity to store at least 50 percent of the regional emissions from point sources for at least 100 years.

