



the **ENERGY** lab

PROJECT FACTS  
Carbon Sequestration

## Midwest Geological Sequestration Consortium—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 (CO<sub>2</sub>), 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 CO<sub>2</sub> 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 CO<sub>2</sub> 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 CO<sub>2</sub> 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 Geological Sequestration Consortium (MGSC) is led by the Illinois, Indiana, and Kentucky State Geological Surveys and covers the entire state of Illinois, southwest Indiana, and western Kentucky. This partnership was established to assess carbon capture, transportation, and geologic carbon sequestration options in unminable coal seams, mature oil fields, and deep saline formations in the Illinois Basin. Regional point source emissions in the MGSC area account for more than 335 million tons (330 million metric tons) of CO<sub>2</sub> per year (Li, et al., 1997), or about 11 percent of the total point source CO<sub>2</sub> emissions in the United States. MGSC's regional geology offers an optimal environment to safely and permanently store these emissions.

### CONTACTS

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U.S. DEPARTMENT OF  
**ENERGY**

## PARTNERS

Ameren Corporation  
American Air Liquide  
American Water Works Association  
Archer Daniels Midland Company  
Aventine Renewable Energy, Inc.  
Baker Hughes, Inc.  
Biorecro  
Blue Source  
British Petroleum  
Carbon Storage Partners  
Conoco Phillips Company  
Continental Carbonic Products, Inc.  
Drummond Coal Company  
Duke Energy Corporation, Inc.  
Edison Mission Energy  
Electric Power Research Institute, Inc.  
Environmental Defense  
GE Energy  
Illinois Corn Growers Association  
Illinois Department of Commerce and Economic Opportunity, Office of Coal Development  
Illinois Department of Natural Resources, Office of Scientific Research and Analysis  
Illinois Department of Transportation  
Illinois Oil and Gas Association  
Indiana Gasification, LLC  
Indiana Geological Survey, Indiana University  
Indiana Oil and Gas Association  
Interstate Oil and Gas Compact Commission  
Kentucky Geological Survey, University of Kentucky  
Kentucky Oil and Gas Association  
Lincolnland Agri-Energy, LLC  
Louisville Gas and Electric Company, LLC  
Natural Resources Defense Council  
Peabody Energy  
Power Holdings, LLC  
Praxair, Inc.

## COST

### Total Project Value

\$83,472,578

### DOE/Non-DOE Share

\$65,928,563 / \$17,544,015

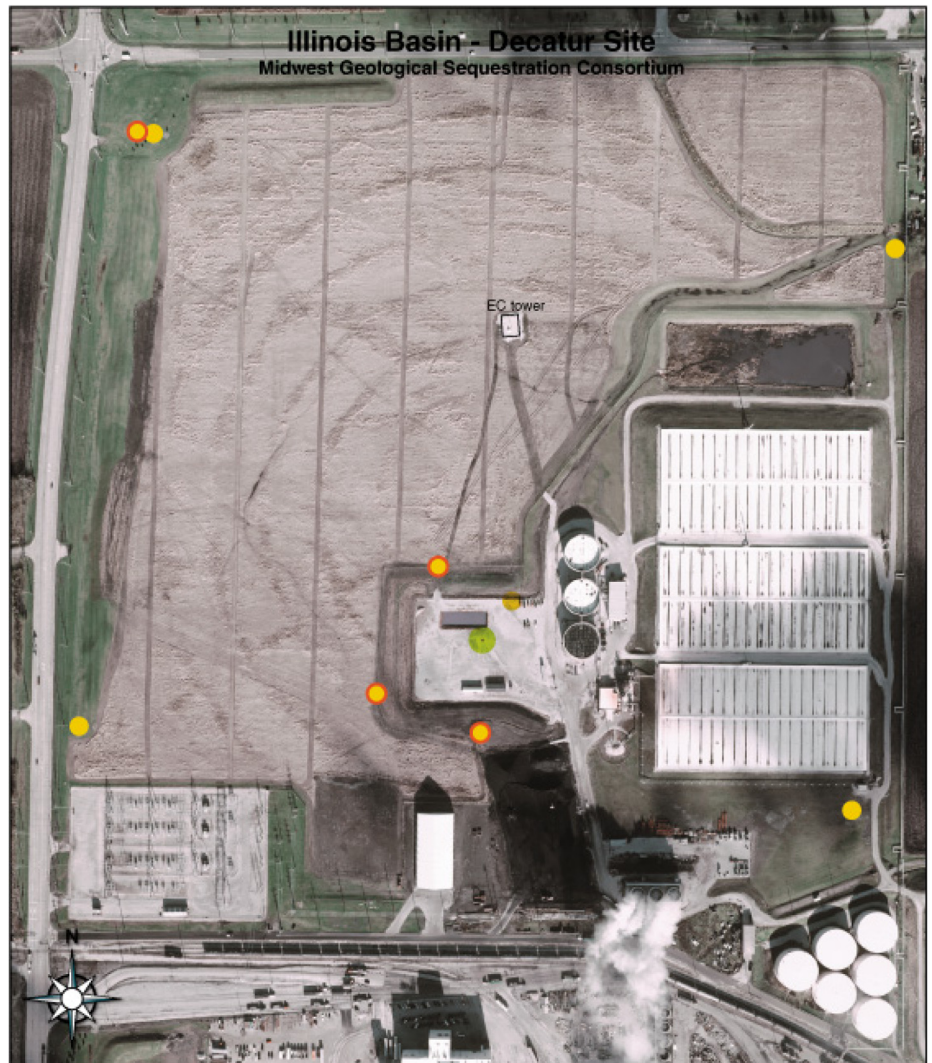
## Project Description

### Project Summary

MGSC has partnered with the Archer Daniels Midland (ADM) Company, an agricultural product processing company, to conduct a large-volume, saline sequestration test at ADM's ethanol by fermentation facility located in Decatur, Illinois. The test will involve the injection of 367,000 tons (333,000 metric tons) of CO<sub>2</sub> per year for three years from the fermentation plant into the Mt. Simon Sandstone, a major regional saline formation in the Illinois Basin.

### Injection Site Description

The site is on the property of ADM's agricultural product processing operations in Decatur, Illinois (Figure 1). The site occupies about 207 acres and is wholly owned by ADM. A CO<sub>2</sub> dehydration/compression facility will be developed near the north boundary of the ADM facility. From there, the CO<sub>2</sub> will be moved approximately 3,200 feet through a four- to six-inch pipe to the injection well location. The site is a pre-existing industrial complex with no significant physical impediments to access.



- CO<sub>2</sub> injection well
- Current groundwater monitoring wells
- Proposed USDW monitoring wells
- Eddy Covariance tower

Figure 1. Aerial Photo of ADM Test Site in Decatur, Illinois

## Description of Geology

The target formation is the Cambrian-age Mt. Simon Sandstone, the thickest and most widespread saline reservoir in the Illinois Basin (Figure 2). It is overlain by the Eau Claire Formation, a regionally extensive, low-permeability shale and underlain by Precambrian granitic basement. The Mt. Simon is used extensively for natural gas storage in the northern half of Illinois. Detailed reservoir data from a few wells at these projects show that the lower Mt. Simon has the necessary porosity and permeability to be a good sequestration target. A regional isopach map of the Mt. Simon suggests that there is probably more than 1,000 feet of Mt. Simon present at the ADM site. The target depth for this project ranges from 6,000 to 7,000 feet deep (1,830 to 2,130 meters). Data from a well drilled 17 miles from the ADM site and a second well drilled 51 miles south of the ADM site indicate that there is good porosity in the Mt. Simon. MGSC estimates that the average porosity of the Mt. Simon at the ADM site will be around 12 percent. The top of the Mt. Simon Sandstone at the ADM site is estimated to lie at a depth of approximately 5,500 feet (1,670 meters).

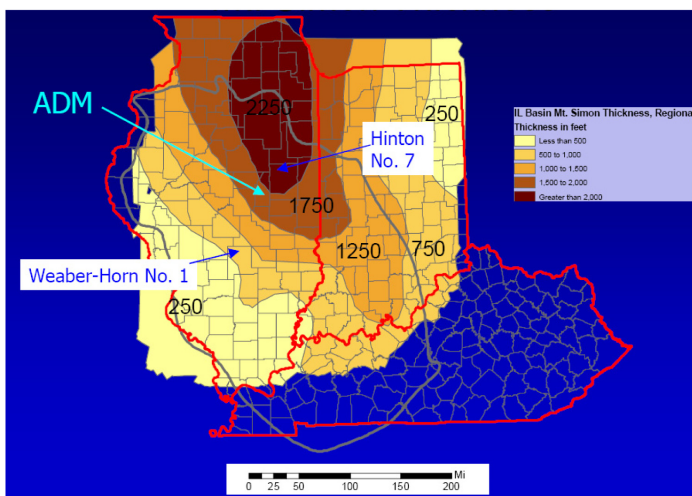


Figure 2. Regional Diagram Showing Thickness of Mt. Simon Sandstone

Within the Illinois Basin, the Devonian-age New Albany Shale, Ordovician-age Maquoketa Formation, and the Cambrian-age Eau Claire Formation thick shale units function as significant regional seals. There are also many minor, thinner Mississippian- and Pennsylvanian-age shale beds that form seals for known hydrocarbon traps within the basin. All three significant seals are laterally extensive and appear, from subsurface wireline correlations, to be continuous within a 100-mile radius of the test site. The Eau Claire is estimated to be 300 to 500 feet (90 to 150 meters) thick and is expected to be the primary seal at the ADM site. The Ordovician Maquoketa Shale and the New Albany Shale are anticipated to act as secondary seals. There are no mapped regional faults and fractures within a 25-mile radius of the ADM site.

## Source of CO<sub>2</sub>

The CO<sub>2</sub> will be obtained from ADM's ethanol production facility. Outlet CO<sub>2</sub> streams from ethanol fermentor vents are typically more than 99 percent pure CO<sub>2</sub>, saturated with water vapor at 80 degrees Fahrenheit, and at atmospheric pressure. Common impurities are ethanol and nitrogen in the range of 600 to 1000 parts per million by volume (ppmv) each. Other impurities in lesser amounts often include oxygen, methanol, acetaldehyde, and hydrogen sulfide (H<sub>2</sub>S). The CO<sub>2</sub> will be purified, dehydrated, compressed to ~1,400 pound per square inch (psi), and delivered to the wellhead as supercritical CO<sub>2</sub>. The dehydration/compression facility is proposed to be located near the north boundary of the ADM facility.

## Injection Operations

MGSC plans to inject approximately 1,100 tons (1,000 metric tons) of supercritical CO<sub>2</sub> per day for a total of 1.1 million tons (1 million metric tons) over three years. It is the intention of MGSC to utilize the ADM site for all injection activities, thus requiring a minimum of transportation activities. The initial data well drilled on the site will serve as the initial injection well. The purified, dehydrated, supercritical CO<sub>2</sub> will be received from a new dehydration/compression facility.

## Simulation and Monitoring of CO<sub>2</sub>

The monitoring, verification, and accounting (MVA) program will have operational, verification, environmental, and mitigation components, with monitoring occurring before, during, and post-injection. The program will rely heavily on 3-D seismic data collected during the first year of injection to monitor the plume's position. The MVA program will be evaluated yearly and modified as needed. A wide range of monitoring techniques may be used, including soil gas sampling, well logging, visible and infrared imaging, CO<sub>2</sub> land surface flux monitoring, and geochemical methods. Groundwater models, such as MODFLOW and GFLOW, will be used to develop a conceptual model for shallow groundwater flow and estimate the time for potential contaminants to travel outside the area of the injection site. This will provide a risk assessment for nearby water supplies in the unlikely occurrence of a CO<sub>2</sub> leak either during or following CO<sub>2</sub> injection. Geochemical models, such as Geochemist's workbench, PHREEQCI, and TOUGHREACT, will be used to conduct thermodynamic modeling of shallow groundwater and injection-formation brine. These models will provide insight on the long-term fate of injected CO<sub>2</sub> and will be used to study the regional impact of multiple injection wells on flow within a saline aquifer across the Illinois Basin.

## Goals and Objectives

MGSC'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:

- Demonstrating the ability of the Mt. Simon Sandstone to accept and retain 1.1 million tons (1 million metric tons) of CO<sub>2</sub> injected over a period of three years.
- Achieving a more thorough understanding of the science, technology, regulatory framework, risk factors, and public opinion issues associated with large-scale injection operations.
- Validating MVA activities, modeling, and equipment operations.
- Refining capacity estimates of the target formation using results of the test.

## Benefits to the Region

The MGSC region currently emits 335 million tons (300 million metric tons) of CO<sub>2</sub> annually (Li, et al., 2007). The target Mt. Simon Sandstone is estimated to have a regional potential CO<sub>2</sub> storage capacity in the Illinois Basin of 30 to 119 billion tons (27 to 120 billion metric tons). Based on the current emissions rate, 50 percent of the regional emissions for the next 100 years amounts to 16.6 billion tons (15.1 billion metric tons), a total which is less than the low end of the basin's estimated storage capacity. Thus, this project is vital to establish the sequestration capabilities of the Mt. Simon Sandstone.

### Reference:

Li, Y., Garner, D., Korose, C., and Rostam-Abadi, M. (2007). Inventory of Industrial Stationary CO<sub>2</sub> Emissions in the Illinois Basin. Summary Report. Illinois State Geological Survey, Champaign, Illinois.

