An Assessment of Geological Carbon Sequestration in the Illinois Basin

Overview of the Decatur-Illinois Basin Site

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Midwest Geological Sequestration Consortium
www.sequestration.org
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- The Midwest Geological Sequestration Consortium (MGSC) is a collaboration led by the geological surveys of Illinois, Indiana, and Kentucky.
“Most of the observed increase in global average temperatures since the mid-20\textsuperscript{th} century is very likely due to the observed increase in anthropogenic GHG concentrations”

-Intergovernmental Panel on Climate Change
Fourth Assessment Report, 2007
Evidence for Global Climate Change Continues to Develop

- Mitigation responses need to be investigated
- Carbon capture and storage (CCS) repeatedly cited as a necessary technology
“Geological sequestration of CO$_2$ (GCS) in saline aquifers is neither the most expensive nor the most energy intensive part of an integrated CCS process… but it is the aspect currently subject to the highest levels of regulatory and public scrutiny…”

“…and [is] the aspect of CCS most dependent on site-specific characterization of long-term environmental processes.”

The media tells the public climate change is a problem!
But Do the Media and the Public See CCS as a Solution?

- “Strong opposition to a underground carbon dioxide ‘capture chamber’ in the north of Jutland” *(Denmark, Copenhagen Post, 5 Aug 09)*
  - A group of landowners in northern Jutland have collectively dug in their heels to stamp out a power company’s plans to establish a giant underground carbon dioxide storage chamber in Jammerbugten.

- “What the heck is CCS and can it really help fight climate change?” *(U.S., Grist.org, 13 July 09)*
  - But does CCS technology actually exist? Is it practical? Affordable? Who’s working on it? Despite the flurry of chatter about CCS, these basic questions usually go unanswered.
302 million tons per year carbon dioxide emissions in the Illinois Basin from fixed sources
41,370 truckloads of liquid CO$_2$ per day

1,723 truckloads per hour
Illinois Basin Stratigraphic Column

- Mt. Simon Sandstone
- Eau Claire Shale
- Illinois Basin
- Stratigraphic Column
- Maquoketa Shale
- New Albany Shale
- Mississippian sandstone and carbonate oil reservoirs
- Pennsylvanian coal seams

Legend:
- Potential Seal
- Potential Sink
- Coal Bed
- Potential Sink and Seal

(from Leetaru, 2004)
CO$_2$ Storage in Sandstone Reservoir Pore Space
Shale Caprock (Reservoir Seal)

Pin head
No pore space visible
Geological Carbon Sequestration: Reservoir and Caprock System

Shale Seal

Sandstone Reservoir
Illinois Basin-Decatur Project Synopsis

- A collaboration of the Archer Daniels Midland Company (ADM), the Midwest Geological Sequestration Consortium, Schlumberger Carbon Services, and other subcontractors plans to inject 1 million metric tons of carbon dioxide at a depth of 7,000 +/- ft to test geological carbon sequestration in a saline reservoir.
Phase III Project Timeline
Illinois Basin-Decatur Site

- Project funded December 2007
- Baseline environmental activities began late spring 08
- Preliminary UIC permit hearing October 08
- Permit finalized January 27, 2009
- Injection well drilled: February 14-May 4, 2009 (7,230 ft TD)
- Geophone well drilled: October 2009
- 3D seismic survey: November 2009
- Verification well to be drilled: March-April 2010
- Compression/dehydration facility completed: ~ May 2010
- CO₂ injection period: August 2010-August 2013
- Environmental monitoring through January 2015
Illinois Basin-Decatur Test Site

Well Location

~ ¾ mile
Drilling Started
February 14, 2009
Injection Well
Drilled to 7,230 ft

rig released
May 4, 2009
Testing and Sampling at 3 a.m.
One Eau Claire and Two Mt. Simon Cores Collected
Mt. Simon Sandstone
6,414 – 6,415 feet
A Dehydration/compression facility location
B Pipeline route
C Injection well site
D Representative verification well sites
CO$_2$ Process Flow Diagram for Illinois Basin-Decatur Site

**Input**
Wet at 15.5 psia

**Output**
Dry at ~1,400 psia

From Trimeric Corporation, 2009
Westbay System Key Element of Verification Well design

- Packer: independent hydraulic inflation
- Measurement Port: in-situ measurement, low-k testing, and for fluid sampling
- Casing: variable lengths
- Pumping Port: for hydraulic conductivity testing and purging
Environmental Site Monitoring Plan

- Shallow ground water wells
- Instrument the drain tile system
- Electrical resistivity near injection well
- Surface soil flux chambers
- Atmospheric monitoring

Quickbird Satellite Image, September 16, 2008
Groundwater Monitoring Wells Installed
Monitoring of Shallow Groundwater

Electrical resistivity near injection well
Surface use will limit some source (red) and receiver (black) locations.
Fold Coverage

- Shot Lines
- Ideal Migration Aperture
- Receiver Lines
- Image Area
#1: After 3 Years Injection
#2: After 3 Years Injection

ADM, j = 1, 31 Dec 2012
#3: After 3 Years Injection
#3: 100 Years after Injection Starts
Illinois Basin-Decatur Project
Outcomes

- A large-scale injection of 1 million tonnes of CO$_2$ successfully demonstrated and associated safety, efficiency, and effectiveness requirements met
- Volume sufficient to monitor geophysically; overall effort scalable to coal gasification plants
- An “active” geological site model developed and continually updated as new data are acquired
- A process model established for site characterization permitting, equipment, injection, environmental monitoring, and outcome assessment that will support energy facility development with integrated carbon sequestration in the Illinois Basin, nationally, and globally
Illinois Basin-Decatur Project Attracts International Attention

Delegation from China
February 25, 2009
“…world primary energy demand grows by 1.6% per year on average in 2006-2030… an increase of 45%.”

“Fossil fuels account for 80% of the world’s primary energy mix in 2030…”

-International Energy Agency
World Energy Outlook, 2008
Coal production – Coal consumption

World coal consumption grew by 4.5%, well above the 10-year average. Coal was the world's fastest-growing fuel for the fifth consecutive year. Growth was above average in all regions except the Middle East. Chinese consumption growth accounted for more than two-thirds of global growth.