The Path to a 1-Million Tonne Demonstration of Carbon Sequestration from a Biofuel Source: The Illinois Basin - Decatur Project

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Illinois State Geological Survey
University of Illinois
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Acknowledgments

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• The **Midwest Geological Sequestration Consortium (MGSC)** is a collaboration led by the geological surveys of Illinois, Indiana, and Kentucky

• Landmark Graphics software via University Donation Program and Petrel software via Schlumberger Carbon Services
A collaboration of the Midwest Geological Sequestration Consortium, the Archer Daniels Midland Company (ADM), Schlumberger Carbon Services, and other subcontractors to inject 1 million metric tons of anthropogenic carbon dioxide at a depth of 7,000 +/- ft (2,000 +/- m) to test geological carbon sequestration in a saline reservoir at a site in Decatur, Illinois.
Key Points to Remember about the IBDP

• IBDP is the first demonstration-scale (1 million tonne) US project to use carbon dioxide (CO₂) from a man-made source within the DOE Regional Carbon Sequestration Partnership (RCSP) program.

• IBDP is a fully integrated demonstration, from a compression-dehydration facility and a pipeline to delivery of supercritical CO₂ to a three-well injection and observation system on an intensely monitored site.

• IBDP is the product of four years of effort, from date of funding to CO₂ in the reservoir, including site characterization, permitting, 17,900 ft of drilling, reservoir geology, engineering, and geophysics, risk assessment, outreach, and baseline monitoring.
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<tr>
<th>System</th>
<th>Series</th>
<th>Lithology</th>
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<td>Carboniferous</td>
<td>Pennsylvanian</td>
<td>St. Peter Sandstone</td>
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<td>Eau Claire Shale</td>
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<td>Mt. Simon Sandstone</td>
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<td>Maquoketa Shale</td>
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<td>New Albany Shale</td>
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<td>back-up seals</td>
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- **Pennsylvanian coal seams**
- **Mississippian sandstone and carbonate oil reservoirs**
- **Seal**
- **Reservoir**
Illinois Basin - Decatur Project

Major Project Elements

• UIC permitting: January 2008-ongoing
  • Application, hearing, minor modification, major modification
• Injection well drilled: February-May 2009
• Geophone well drilled: September-November 2009
• Baseline 3D seismic survey completed: January 2010
• Compression/dehy/pipeline facility: design, procure, construct, test: February 2009-October 2011
• Monitoring well drilled, completed: September-November 2010, March-June 2011
• Authorization to inject: November 2, 2011
• Initiated operational testing: November 4, 2011
Illinois Basin-Decatur Project Organization

Schlumberger Carbon Services

Archer Daniels Midland Company

Trimeric Corporation

10 Other Subcontractors and Cooperators

Subcontractors for oilfield services, geophysics, and reservoir simulation

UIC permit holder, CO2 source, site, injection operations and control

Compression & dehydration facility and pipeline (with ADM)

Core analysis, basin structure, well test analysis, geophysics, etc.
MGSC Injection and geophone wells

MGSC monitoring well

MGSC Injection and geophone wells

0.5 mile

photo by Illinois Dept. of Transportation, 8 November 2010
Illinois Basin-Decatur Project Site
(on ADM Industrial site)

- A Dehydration/compression facility location
- B Pipeline route
- C Injection well site
- D Verification/monitoring well site
- E Geophone well
Injection Well Drilled to 7,230 ft (2,190 m)

Completed May 4, 2009
10% Porosity Cutoff

7,000 ft

6,500 ft

Mt. Simon Core 6,751 – 6,780 feet

Perforations: 6,985 -7,015; 7,025 - 7,050
55 ft (16.7 m) open interval

Packer @ 6,365 ft (1,929 m)

Granite Wash

Granite

Mt. Simon Core 6,404 – 6,433 feet

Base of Mount Simon

Injection Well Completion

Mt. Simon Core 6,751 – 6,780 feet

Perforations: 6,985 -7,015; 7,025 - 7,050
55 ft (16.7 m) open interval
Geophone in special carrier strapped to 3.5 inch (8.9 cm) tubing

- 3,500 ft (1,060 m) well with 31 geophones cemented into uncased hole on tubing string

Injection Well

Geophone Well
Completed
November 2009
Cored 110 m (360 ft) of Lower Mount Simon
Core Equivalent to Upper Perforated Interval

Porosity = 17%
Perm = 193 md
Core Equivalent to Lower Perforated Interval

Porosity = 22%
Perm = 144 md
Injection Wellhead Installed and Pipeline Constructed

January 2010

February 2011
Schlumberger Westbay* System First-in-the-World Deployment at 7,000 ft+ for Eleven Sampling Levels

Nine Sampling Levels In the Mount Simon Sandstone

Two Sampling Levels Above the Eau Claire Shale

Two Fluid Sample Sets Collected Preinjection

*Mark of Schlumberger
IBDP Model development

Upscaling to Build Model

- Reservoir Model:
  - 20 × 20 mile
  - 143 × 143 × 148
    ~ 3 million Cells
  - 50ft to 1500ft lateral cells
Verification Well at One Month

Verification Well 1: Probability Map at 1 months

Measurement Screening Chart

ΔP > 1 psi
ΔP > 5 psi
ΔP > 10 psi

Depth, ft

ΔPressure, psi

Depth, ft

Probability

Courtesy Schlumberger Carbon Services
Verification Well at 10 Years

Verification Well 1: Probability Map at 10 yrs

Measurement Screening Chart

ΔP > 1 psi
ΔP > 5 psi
ΔP > 10 psi

Depth, ft

ΔPressure, psi

Probability

Courtesy Schlumberger Carbon Services
IBDP - CO₂ Plume & Pressure Pulse Evolution

1 Year

3 Years

lower 900 ft of Mt. Simon

Courtesy Schlumberger Carbon Services
IBDP - CO₂ Plume & Pressure Pulse Evolution

10 Years

50 Years

Courtesy Schlumberger Carbon Services
Baseline 3D Geophysical Survey
Completed January 2010
Data Comparisons: Legacy 2D Line 17

Seconds (s)
Data Comparisons: Q-Land 3D Crossline

Seconds (s)

Courtesy Schlumberger Carbon Services
Inversion Analysis: 3D X-line 2203

Acoustic Impedance

(Interpretation by H. Leetaru)

Courtesy of Schlumberger Carbon Services
Acontic Impedance Model

Top Eau Claire
Top Mt. Simon
Top Mt. Simon Porosity

produced with Petrel
Inversion Analysis: Lithology Distribution

Limestone

>20% sandstone

Shale

10 - 20% sandstone

<10% sandstone

Courtesy of Schlumberger Carbon Services
Enviromental Monitoring

Soil flux

Satellite interferometry

Groundwater
Dual 550 TPD Reciprocating Compressors with Dehydration

- Inlet separator
- Dehy inlet separator
- Dehydration unit contactor
- Shell and tube heat exchangers
- Cooling water
- Supply & return
- Suction scrubber
- Pipeline to wellhead
- Compressor
- Motor
- Blower
- Blower aftercooler
- Discharge separator
Feed Blower, Glycol Regenerator, and High-Pressure Pump
Compressor, Motor, Heat Exchangers

October 2011
Surface & Downhole Pressure at Startup

Pressure at the packer

Wellhead pressure

Oscillation in compression/vent system

Courtesy Schlumberger Carbon Services
Surface & Downhole Temperature at Startup

Temperature at the packer

Cooler brine reaches packer

Heat exchange increased

Wellhead temperature

50 °F

100 °F

Courtesy Schlumberger Carbon Services
Westbay Pressure Data  November 4-6, 2011

Zone 2-3
~15 psi increase at verification well during injection

Courtesy Schlumberger Carbon Services