Illinois Industrial Carbon Capture & Storage Project

Eliminating CO₂ Emissions from the Production of Bio Fuels - A ‘Green’ Carbon Process

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Acknowledgements

- The Industrial Carbon Capture and Storage (ICCS) project is administered by the U.S. Department of Energy's Office of Fossil Energy and managed by the National Energy Technology Laboratory (award number DE-FE-0001547) and by a cost share agreement with the ADM, U of I (ISGS), SLB, & RCC.
- The Intelligent Monitoring System (IMS) Project is administered by the U.S. Department of Energy's Office of Fossil Energy and managed by the National Energy Technology Laboratory (award number DE-FE-0026517) and by a cost share agreement with the ADM, LBNL, Silixa, SLB, U of I (ISGS), & RCC.
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- The MGSC is a collaboration led by the geological surveys of Illinois, Indiana, and Kentucky.
Illinois Basin Decatur Project (IBDP)

Program Objective
Large scale geologic test to inject 1.0 million tons of CO₂ over a three year period (1,000 MT/day).

Project Team Members

Knowledge Base
- Site Geological Characterization
- Risk Assessment & Reservoir Modeling
- Engineering Design & MVA

Nov 2014-Completed goal of injecting and storing 1,000,000 tons of CO₂.
Program Objectives
- Target & Demonstrate Advanced CCS Technologies at Industrial Scale Facilities
- Inject and Store One Million Tons of CO₂ Annually (3,000 tons/day)

Project Team Members

Knowledge Base
- Site Geological Characterization
- Risk Assessment & Reservoir Modeling
- Engineering Design & MVA
- Education and Public Outreach

Study the interaction between the CO₂ plumes from two injection wells within the same formation.
Intelligent Monitoring System (IMS)

Program Objectives

- Develop and validate software tools that advance CCS-specific IMS by enabling access, integration and analysis of real-time surface and subsurface data for decision-making and automation of process
- Demonstrate integration of system components to validate feasibility of real-world application to CCS.

Project Team Members
Project Process Flow Diagram

Wet CO₂ from Corn-to-Ethanol Fermentation

Centrifugal Blower (3000 HP)

CO₂ Inlet Separator

Reciprocating Compressors (3250 HP)
4 Stages with Intercoolers

Centrifugal Booster Pump (400 HP)

CO₂ P=35

CO₂ P=590

4th Stage Discharge CO₂ P=1425

Dehydrated CO₂ to 4th Stage

Tri-ethylene Glycol Dehydration Unit

CO₂ Contactor

Glycol Regenerator

Return Dry Glycol

CO₂ Sequestration ~7,000 ft. depth in Mt. Simon Sandstone

Supercritical CO₂
8-in, 1-mile Pipeline
2500-3000 MTPD
M<0.005

Injection Well P set by permit (estimate ≤ 2300)

Primary Source of Drinking Water (D=140)

New Albany Shale (D=2000, T=120): Tertiary Seal

Maquoketa Shale (D=2600, T=200): Secondary Seal

St. Peter Sandstone Lower Most USDW (D=4000)

Eau Claire Shale (D=5000, T=500): Primary Seal

Mt. Simon Sandstone (D=5500, T=1600): Saline Reservoir

Pre-Cambrian Granite (D=7200)
Site Selection
Regional Geologic Characterization

- Cratonic basin
- 60,000 square mile area
- Structurally complex to the south with faulting and seismicity

- ADM Decatur facility is located near the center of this geologic formation
- Estimated CO₂ storage capacity between 27 to 109 billion metric tons
Site Characterization
Seismic Acquisition
Test Well Construction

Deep Monitoring & Geophysical Wells
Coring and Well Logging

Core Samples and Well Logging
Geophysical Model Development
Geophysical Modeling

**CO₂ Plume Position - 2012**

- Cross Section Orientation
- Eau Claire
- Upper Mt Simon
- Lower Mt Simon
Geophysical Modeling

$CO_2$ Plume Position - 2013
Geophysical Modeling

$CO_2$ Plume Position - 2014

Cross Section Orientation →

- S-SW
- N-NE

- Eau Claire
- Upper Mt Simon
- Lower Mt Simon
Geophysical Modeling

$CO_2$ Plume Position - 2015

Cross Section Orientation →

S-SW

Eau Claire

Upper Mt Simon

Lower Mt Simon

N-NE
Geophysical Modeling

$CO_2$ Plume Position - 2016

Cross Section Orientation

Eau Claire

Upper Mt Simon

Lower Mt Simon
Geophysical Modeling

$CO_2$ Plume Position - 2017

Cross Section Orientation
Geophysical Modeling

$CO_2$ Plume Position - 2018

Cross Section Orientation →

- Eau Claire
- Upper Mt Simon
- Lower Mt Simon
Geophysical Modeling

$CO_2$ Plume Position - 2019

Cross Section Orientation →

- Eau Claire
- Upper Mt Simon
- Lower Mt Simon
Geophysical Modeling

$CO_2$ Plume Position - 2020

Cross Section Orientation

- Eau Claire
- Upper Mt Simon
- Lower Mt Simon
Environmental Monitoring (MVA) Conceptual Framework

Near Surface
- Soil and Vadose Zone
  - Aerial Imagery
  - Soil CO₂ Flux
- Ground Water
  - Geochemical Sampling
  - P/T Monitoring

Deep Subsurface
- Above Seal
  - Geophysical Surveys
  - Seismic Monitoring
  - P Monitoring
- Injection Zone
  - Geophysical Surveys
  - Geochemical sampling
  - P/T Monitoring
Environmental Monitoring
Near Surface Monitoring

- Near infrared aerial imagery will be used to evaluate plant stress
- Soil resistivity characterized shallow depths for identification of optimum GWM locations
- GWM for baseline conditions and operational surveillance
- Surface soil CO₂ flux monitoring
Environmental Monitoring
Deep Subsurface Monitoring

- Deep P/T monitoring
- Distributed Temp Sensor
- Distributed Vibration Sensor
- Multi-level fluid sampling ports
- P/T monitoring above the seal formation
- Deep geophones arrays allowing vertical seismic profiling (VSP)
- Pulse neutron well logging
Seismic Monitoring

USGS Site Monitoring
Deep Seismic Monitoring

- 3 Geophone Arrays in CCS1
- 24 Active Geophones in GM1
- 5 Level Geophone Array in GM2
- 7 Borehole Stations (500 ft)
- 14 Surface Stations
Distributed Acoustic Sensing (DAS)

Example from PTRC Aquistore

DAS Baseline 3D-VSP

DAS VSP is becoming accepted technology.
IMS Equipment Layout

Intelligent Monitoring System
Fiber Optic and CASS Layout

Plume Overlay

NOTE 1: DISTANCES ARE MEASURED FROM CCS#2
Technologies Developed under DOE Core R&D are incorporated into the IMS

Rotary Orbital Source

Broadside Sensitive Cable
IMS Data Acquisition Architecture
Seismic Monitoring Data

Microseismic Locations
- Blue: Jan 18, 2012 – Jan 31, 2013

Microseismic cluster reference numbers in order of appearance.
CO\textsubscript{2} Based Chemicals

- Carbonates
  - Glycerol Carbonate
  - Propylene Carbonate
  - Dimethyl Carbonate
- Fertilizers
- Alcohols
- Fuels
- Acids
- Others

Transformation of Carbon Dioxide, Sakakura, Choi, & Yasuda, 2007
Enhanced Oil Production

http://www.youtube.com/watch?v=azLVjYij5U4
Illinois Basin Potential

- Illinois Basin - Oil Producing Region
- Est. Recoverable Oil = 700 million bbls\(^{(1)}\)
- Est. CO\(_2\) Requirements = 150 million tons

\(^{(1)}\) BASIN ORIENTED STRATEGIES FOR CO\(_2\) ENHANCED OIL RECOVERY: ILLINOIS AND MICHIGAN BASIN OF ILLINOIS, INDIANA, KENTUCKY AND MICHIGAN; Advanced Resources International, February 2006
Thank You!

Industrial Carbon Capture and Storage Project:

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• Administered by the DOE’s Office of Fossil Energy
• Managed by the National Energy Technology Laboratory

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• Archer Daniels Midland Company
• University of Illinois through the Illinois State Geological Survey
• Schlumberger Carbon Services
• Richland Community College

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