7th IEA CCS Network Regulatory Meeting
April 23, 2015
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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 Archer Daniels Midland Company, University of Illinois through the Illinois State Geological Survey, Schlumberger Carbon Services, and Richland Community College. This ICCS project received DOE funding from the American Recovery and Reinvestment Act of 2009 ($141.4 million).

• The Midwest Geological Sequestration Consortium is funded by the U.S. Department of Energy through the National Energy Technology Laboratory via the Regional Carbon Sequestration Partnership Program (contract number DE-FC26-05NT42588) and by a cost share agreement with the Illinois Department of Commerce and Economic Opportunity, Office of Coal Development through the Illinois Clean Coal Institute.

• The Midwest Geological Sequestration Consortium (MGSC) is a collaboration led by the geological surveys of Illinois, Indiana, and Kentucky
Objectives of Today’s Presentation

- Overview of the ADM Decatur IL CCS Projects
- Review of the Project Permitting Process
  - Site Characterization
  - Monitoring, Verification and Accounting
  - Alternative Time Frame: Post Injection Site Closure (PISC)
  - Non Endangerment Demonstration & Site Closure
- Public Outreach & Education
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

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

Began injection in Nov 2011 under IEPA Class 1 Permit.

Reached 1.0 million tons in Nov 2014.

Currently in Post injection monitoring
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.
Project Process Flow Diagram

Wet CO₂ from Corn-to-Ethanol Fermentation

Centrifugal Blower (3000 HP)
4 Stages with Intercoolers

Reciprocating Compressors (3250 HP)

CO₂ Inlet Separator

CO₂ P=35

24-in line 1500-ft

3rd Stage Discharge CO₂ P=590

4th Stage Discharge CO₂ P=1425

Dehydrated CO₂ to 4th Stage

Centrifugal Booster Pump (400 HP)

CO₂ Contactor

Tri-ethylene Glycol Dehydration Unit

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

Water

Regenerator Reboiler

Return Dry Glycol

Tri-ethylene Glycol

Dehydration Unit

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)
UIC Class VI Program

• Protection of Underground Sources of Drinking Water under Safe Drinking Water Act.

• **UIC Permit Elements**
  • Site Characterization
  • Well Construction & Mechanical Integrity
  • Operational Site Monitoring
  • Post Injection Site Monitoring & Closure
  • Alternative PISC Timeframe
  • Demonstration of Non Endangerment
  • Quality Assurance
  • Financial Responsibility
• UIC Class VI permit application submitted in Jul & Sep 2011 (ICCS & IBDP).

• US EPA Region V issued a draft permit on Apr 2014.

• Public hearing conducted on May 21, 2014.

• Public Comment Period concluded May 31, 2014.

• ICCS Final permit issued Dec 2014.

• IBDP Issued Feb 2015.
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 Specific Characterization
Seismic Acquisition
Test Well Construction

Deep Monitoring & Geophysical Wells
Coring and Well Logging

Core Samples and Well Logging
Final Site Evaluation

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>The ADM site has excellent features for CO₂ storage</td>
<td></td>
</tr>
<tr>
<td>High purity source of CO₂</td>
<td></td>
</tr>
<tr>
<td>Thick permeable formation for storage</td>
<td>Porosity &lt;20% and permeability 26 mD</td>
</tr>
<tr>
<td>Formation depth</td>
<td></td>
</tr>
<tr>
<td>Thick seal with no resolvable faulting</td>
<td></td>
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<tr>
<td>Additional seal formations</td>
<td></td>
</tr>
<tr>
<td>No local penetrations of the primary seal formation</td>
<td></td>
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<tr>
<td>Low population density</td>
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</table>
USEPA AoR Delineation Flowchart

1. Site Characterization
2. Proposed Operating Data
   - Pressures
   - Temperature
   - Seismic, Other
3. Computational Modeling/AoR Delineation
   - Geologic Model
   - Reservoir Simulation
4. Monitoring System Design
   - From various wells/sources
     - Pressures
     - Temperatures
     - Monitor logs
     - Seismic
     (See Table 5-1)
5. Monitoring Data Collection and Interpretation
6. Model Calibration

Frequency: fit for purpose
- Some Continuous
- Some Annual
- Some only if monitoring or operational conditions warrant
AoR is the greater of the pressure front required to lift reservoir fluid from the injection zone to the lowermost underground source of drinking water or the maximum extent of the plume.
Detailed Modeling Flow Chart

- Seismic Logs Core
  - Structure Porosity Perm
- Static Model
- 3D MEM
  - Structure Elastic Moduli Features
- 1D MEMS Seismic
- Initial Conditions
  - Pressure Saturation Fluid Props Rel Perm
- History Match
- Geomechanical Model (VISAGE)
  - Obs Deformation, microseismic
- Forecast (ECLIPSE 300)
  - Rate schedules, completions
  - Predicted Saturation Pressure
- Evaluate
  - Predicted Deformation, failure
  - Cap rock, wellbore, induced seismicity risk
  - Regulations Operations Economics
  - Targets/Objectives
  - Iterate

VISAGE* reservoir geomechanics modeling software
Detailed Modeling Flow Chart

Required Under UIC Permitting
Permeability and skin factors were the main parameters impacting the injection pressure calibration and were used as fitting parameters.
Geophysical Modeling

Extent of Plume & Saturation Cross Section
January 1, 2012 [DP_{fs} > 86 psi, SCO_{2} > 1.0%]
Geophysical Modeling

Extent of Plume & Saturation Cross Section
January 1, 2013 [DP_{ij} > 86 psi, SCO_2 > 1.0%]
Geophysical Modeling

Extent of Plume & Saturation Cross Section
January 1, 2014 [DP_{sat} > 86 psi, SCO_{2} > 1.0%]
Geophysical Modeling

Extent of Plume & Saturation Cross Section
January 1, 2015  [DP₂ > 86 psi, SCO₂ > 1.0%]
Geophysical Modeling
Geophysical Modeling

Extent of Plume & Saturation Cross Section
January 1, 2017 [DP_{hi} \geq 86 \text{ psi, } SCO_2 \geq 1.0\%]
Geophysical Modeling

Extent of Plume & Saturation Cross Section
January 1, 2018  \[\text{DP}_{\text{ef}} > 86 \text{ psi, SCO}_2 > 1.0\%\]
Geophysical Modeling

Extent of Plume & Saturation Cross Section
January 1, 2019 [DP_{H} > 86 psi, SCO_{2} > 1.0%]
Geophysical Modeling

Extent of Plume & Saturation Cross Section
January 1, 2020 [DPit > 86 psi, SCO2 > 1.0%]
Geophysical Modeling

Extent of Plume & Saturation Cross Section
January 1, 2025 [SCO₂ > 1.0%]

- Eau Claire
- Mt Simon
- Mt Simon A
- Mudstone
- Pre-Mt Simon
Geophysical Modeling

Extent of Plume & Saturation Cross Section
January 1, 2030 [SCO₂ > 1.0%]
Geophysical Modeling
Geophysical Modeling

Extent of Plume & Saturation Cross Section
January 1, 2050 \([\text{SCO}_2 > 1.0\%]\)
Geophysical Modeling

Extent of Plume & Saturation Cross Section
January 1, 2060 [SCO₂ > 1.0%]
Geophysical Modeling

Extent of Plume & Saturation Cross Section
January 1, 2070 [SCO₂ > 1.0%]
Environmental Monitoring (MVA) Conceptual Framework

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

Deep Subsurface
- Above Seal
  - Geophysical Surveys
  - Geochemical Seismic P/T Monitoring
- Injection Zone
  - Geophysical Surveys
  - Geochemical Seismic P/T Monitoring
Environmental Monitoring (MVA)  
Required Under UIC Permit

Near Surface

- Soil and Vadose Zone
  - Aerial Imagery
  - Seismic Monitoring
  - Soil CO₂ Flux
- Ground Water

Deep Subsurface

- Above Seal
  - Geophysical Surveys
  - Geochemical Seismic P/T Monitoring
- Injection Zone
  - Geophysical Surveys
  - Geochemical Seismic 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
- 3 years GWM for baseline conditions and operational surveillance.

Surface soil CO₂ flux monitoring
Environmental Monitoring
Deep Subsurface Monitoring

• CCS#1 & CCS#2 T/P monitoring
• Distributed Temp Sensor
• VW#1 Westbay system
• VW#2 IntelliZone System
• Multi-level sampling ports reservoir fluid collection and T/P monitoring
• P/T sensors to monitor above the reservoir seal
• GM#1 has 31 sensor array
• GM#2 5 level 20 sensor array w P/T at 3500’
• Allow offset or walkaway Vertical Seismic Profile (VSP)
• Well logging (RST)
Surface Seismic Monitoring

14 Monitoring Stations
5 - Project Deployment
9 - USGS Deployment
Deep Seismic Monitoring

- 3 Level Geophone Array in CCS#1
- 31 Level Geophone Array in GM#1
- 5 Level Geophone Array in GM#2
- 4 Borehole Monitoring Stations (USGS)
Seismic Monitoring Data

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

- Frequency of Detected Events/Day
  - 800
  - 700
  - 600
  - 500
  - 400
  - 300
  - 200
  - 100
  - 0

- Time:
  - 2/1/12
  - 5/11/12
  - 8/19/12
  - 11/27/12
  - 3/7/13

- Microseismic cluster reference numbers in order of appearance.
Alternative PISC Timeframe

- Default PISC is 50 Years
- Permittee allowed to petition for an alternative timeframe
- ADM Proposed 10 Year PISC
  - Reservoir Pressure Decline
  - Plume Stabilization
  - CO$_2$ Partitioning
Alternative Timeframe
Reservoir Pressure Decline

Aggregate differential pressure contours at the end of the operational period.
Alternative Timeframe

Plume Stabilization

Based on a plume growth of 1.0% per year, it would take over 600 years for the project’s CO2 plume to reach the closest well.
Alternative Timeframe

$CO_2$ Partitioning

Over 50% of the $CO_2$ is trapped within the reservoir after 10 years.
Demonstration of Non Endangerment

Prior to approval of the end of PISC period, the operator will submit a demonstration of non-endangerment of USDWs. The report will contain:

- Comparison of Monitoring Data vs Model Predictions
- Evaluation of Carbon Dioxide Plume
- Evaluation of Mobilized Fluids
- Evaluation of Reservoir Pressure
- Evaluation of Potential Conduits for Fluid Movement
- Evaluation of Passive Seismic Data
Non Endangerment

Reservoir Pressure Decline

VW#2 - Pressure Differentials \([P(t_i) - P(t_0)]\)

- Year
- Pressure Port
  - Mean Depth (ft)
    - 6,800
    - Actual 6,800

![Graph showing pressure differerentials over time, with values for years 2010 to 2030 and pressure港 mean depth of 6,800 ft.](image-url)
Non Endangerment

Time Lapse Geophysical Surveys

Time Lapse RST logs show the development of the vertical extent of $\text{CO}_2$ over time.
Non Endangerment

Time Lapse Geophysical Surveys

Time Lapse VSP surveys show the development of the vertical and lateral extent of CO₂ over time.
Non Endangerment

Time Lapse Geophysical Surveys

Extent of Plume & Saturation Cross Section
January 1, 2012 [DP, ≥ 86 psi, SCO₂ ≥ 1.0%]

Extent of Plume & Saturation Cross Section
January 1, 2017 [DP, ≥ 86 psi, SCO₂ ≥ 1.0%]

Extent of Plume & Saturation Cross Section
January 1, 2010 [SCO₂ ≥ 1.0%]

Extent of Plume & Saturation Cross Section
January 1, 2020 [DP, ≥ 86 psi, SCO₂ ≥ 1.0%]
Non Endangerment

Passive Seismic Data
Outreach and Education
Building on Current CCS Activities

• Trusted Information Source
• Local, Regional, National, and International Events
  - Decatur Public Events
  - AAPG Short Courses
  - IEA GHG Summer School 2011
• Providing Information
  - Invited presentations
  - Technical presentations
  - Model presentations
  - Teacher workshops
  - Coordination with STEM.
• Education Development
  - STELA Learning Environment
  - Undergraduate CCUS course

Working with local programs to leverage funding.
Thank You!

Industrial Carbon Capture and Storage Project:

• U.S. Department of Energy Award No. DE-FE-0001547
• Administered by the DOE’s Office of Fossil Energy
• Managed by the National Energy Technology Laboratory
• DOE cost share from American Recovery and Reinvestment Act of 2009

Cost Share Agreements:

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

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