Integrated Midcontinent Stacked Carbon Storage Hub

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U.S. Department of Energy
National Energy Technology Laboratory
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# Project Team

- ADM
- ARI
- Battelle
- Berexco
- Conservation and Survey Div, SNR, UNL
- DGR&M
- Energy and Environment Research Center
- Great Plains Energy
- Great Plains Institute
- Improved Hydrocarbon Recovery
- Kansas Geologic Survey
- LANL
- Loudon Technical Services
- Nebraska Public Power District
- PNNL
- Schlumberger
Introduction

• The Integrated Midcontinent Stacked Carbon Storage Hub plans to gather CO$_2$ from eastern and central NE and transport it southwest toward Red Willow County, NE along a CO$_2$-source collection corridor. The CO$_2$ will then be piped south into central KS along a stacked storage corridor.

• CarbonSAFE Program Objective: Develop a midwestern carbon storage facility having multiple sites with a 50-Mt or greater capacity to safely, permanently, and economically store CO$_2$ by 2025.
Phase II IMSCS-HUB Objectives

• Objective 1: Demonstrate multiple 50 Mt storage sites for the IMSCS-HUB concept by evaluating a Kansas and Nebraska site, each with the ability to safely, permanently, and economically store anthropogenic CO₂ through stacked-storage.

• Objective 2: Develop 50 Mt+ storage scenarios and provide a basis for UIC permitting.

• Objective 3: Demonstrate long-term seal integrity and minimize induced seismicity.

• Objective 4: Develop strategies to manage and store CO₂ from multiple sources.

• Objective 5: Leverage the data collected to scale the project to develop a regional commercial enterprise (three to ten 50 Mt+ storage sites).

• Objective 6: Identify and mitigate public outreach and regulatory barriers

• Objective 7: Develop a detailed commercial development plan.
Project Area

- Kansas
- Nebraska
- Kansas
Corridors

• Source Corridor (Initially Ethanol Derived CO₂)
  - Run across IA into NE and then southwest across NE
  - Optimize maximize the number of sources/amount of CO₂ to develop market and infrastructure for CCUS
    - Ethanol plants in the corridor with annual emissions of greater than 5 Mt. Capture in the $12/t range
    - Saline storage at many of the ethanol plants in NE
    - Bring in electric utility generated CO₂ as capture comes on line. Existing market from ethanol derived CO₂ will provide certainty that a utilization market and storage is possible
    - 5 other sources (4 electric utility and 1 refinery) with 20 Mt annual emissions. Capture in the $57/t range (NETL 2015)

• Stacked Storage Corridor
  - Run from SW NE southeast into SW KS
    - Saline storage and CO₂ EOR
    - Co-locate infrastructure for Saline and CO₂ EOR.
## Storage: Geology

### STRATIGRAPHY*

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<th>Era</th>
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<td><strong>Precambrian</strong></td>
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<td>crystalline basement</td>
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* formal lithostratigraphic group and stage names used unless otherwise noted; not to scale

### LEGEND:
- **shale + limestone**
- **shale + sandstone + limestone**
- **shale + limestone ± evaporite**
- **shale + sandstone**
- **limestone ± shale**
- **sandstone + limestone ± shale**
- **sandstone**
- **dolomite**
- **igneous and metamorphic rocks**
- **major unconformity**
Geologic Characterization Workflow

Structural and Stratigraphic Framework

Petrophysical Analysis

Dynamic Modeling

Static Earth Modeling
Petrophysics and Static Earth Model

- Structural and stratigraphic framework from formation tops in 205 wells
- Log data from 171 wells (e.g. gamma ray, neutron, density, sonic)
- 267 core data measurements (e.g. porosity, perm, grain density) from 13 wells
Static Earth Model Updates

Effective porosity and permeability histograms for Phase I and Phase II SEMs for the Sleepy Hollow site

Differences due to addition of new core data and updated porosity-permeability transforms
Data Gap Assessment

Data Gaps were examined to address:

1. Regulatory requirements
   - EPA UIC Class VI requirements
     - Fluid Sampling and Coring
     - Well Logging and Testing

2. Reduction in uncertainty of the geologic and reservoir models

Data gaps identified are related to:

- Lithologic data
- Geophysical/Model data
- Geomechanical data
- Geochemical data
Sensitivity Analysis

CO₂ storage is most sensitive to perforation zone, BHP constraints, initial reservoir pressure, and CO₂-brine relative permeability.

Effects of vertical permeability anisotropy is less sensitive, but non-negligible.

Sensitivity to salinity and thermal gradient appear to be insignificant.
New Geologic Data Collection Plan

- Drilling one new characterization well: Sleepy Hollow field SW Nebraska

- New whole core for specialized core analysis (e.g. rel. perm, geomechanics)

- Advanced wireline log data: e.g. elemental spectroscopy, nuclear magnetic resonance, micro-imagers.

- Well tests – DSTs, mini-frac, to evaluate injectivity, permeability, pressure response.
## Whole Core and Analysis

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<th>Core Samples</th>
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<td>Thin-Section Slide Preparation</td>
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<td>Water and Oil Fluid Saturations (reducible)</td>
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<td>Routine Core Analysis</td>
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<td>Relative Permeability</td>
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<td>reservoir &amp; caprock</td>
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<td>Effective Porosity</td>
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<td>Fluid Typing and Saturations (irreducible)</td>
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<td>Threshold Entry Pressure</td>
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<tr>
<td>PVT Fluid Analysis</td>
<td>reservoir</td>
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</table>

[Diagram showing cross section with labels and core intervals: Admire, Wabaunsee, Topeka, Deer Creek, Cread, Lansing Kansas City (LKC) - A, LKC B, LKC C, LKC D, LKC E, LKC F, Marmon, Base sand, Precambrian.]

New Well

**Option 1**

**Option 2**

**West**

- Depth
- GR
- MD
- PVT
- PWI

**East**

- Depth
- GR
- MD
- PVT
- PWI

### CROSS SECTION LEGEND
- GR<65 gAPI
- GR>65 gAPI
- Anticipated Whole Core Intervals
- Pay Flag
New Data Collection at Sleepy Hollow Field

- Focus on deep saline intervals in the Pennsylvanian Wabaunsee, Shawnee-Douglas, and Pleasanton-Maramaton groups and caprocks of the Council Grove and Sumner groups
- Whole Core: 110 ft
  - Admire, Wabaunsee, Oread, Marmaton
- Sidewall cores: 28
- Logs:
  - Triple Combo
  - Nuclear Magnetic Resonance
  - Dipole Sonic
  - Formation Micro Image
  - Elemental Capture Spectroscopy
New Data Collection at Patterson Heinitz Hartland

Patterson will focus on Mississippian and Ordovician deep saline storage zones within the Osage, Viola, and Arbuckle formations, and confining units such as the Meramec, Morrow and Sumner Group.
Next Steps

Laboratory core sample measurements
- Petrophysical, lithological, geo-mechanical, fluids
- Validate porosity - permeability relationship

3D Static Earth Model (SEM)
- Refine facies model
- Update 3D petrophysical model
- Update storage resource estimate

3D Dynamic Reservoir Model (DRM)
- Updated DRM with new capillary pressure, relative perm, and reservoir data
- Update injection strategy and storage resource estimate
Pipeline Routing

• Ethanol plants in the region use natural gas as a fuel for processing corn.
  - Natural gas pipelines run to every ethanol plant in Nebraska and Kansas.
  - These pipelines occur within 3 miles of each potential site in Nebraska and Kansas.

• Routes generated the weighted-cost surface involves laying a grid overtop of the geographic area and determining the cost to traverse from one cell to a neighboring cell.

• Included Kansas and Nebraska existing pipeline rights of way

• Sources were hardwired into the system
Geographic barriers

- Air Quality
- Surface Water
- Aquifers
- Wetlands
- Vegetation/Land Cover
- Land Ownership
- Protected Lands
- Historic Places
- Wildlife
- Mines
- Contaminated Sites
- Socioeconomic Resources
Updated Pipeline Routes

- Pipeline routes, by source, leading to CO₂-EOR sinks (blue), saline sinks (red), and all sinks (black) for (clockwise from top left) all sources, ethanol plants, CFPPs and ethanol plants, and CFPPs alone.
Risk Assessment

Number of accidents associated with each type of cost for CO₂, gas distribution, gas transmission, and non-CO₂ hazardous liquids pipelines.

### Pipeline routes

<table>
<thead>
<tr>
<th>Config.</th>
<th>Mileage</th>
<th>CO₂</th>
<th>Gas Distribution</th>
<th>Gas Transmission/Gathering</th>
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<td>Median</td>
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<td>$1,926,171</td>
<td>$512,448</td>
<td>$2,591,747</td>
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Summary

• New Data Collection based on uncertainty and gap assessment is ongoing
   Sleepy Hollow Field: Characterization well drilled and cemented. Core, log, and teste data are under analysis or being added to the geologic model
   Patterson Heinitz Hartland Field: 3D seismic collected for Patterson and Hartland was acquired and is being reprocessed
   New data will be incorporated to site models to update the number and location of planned injection and monitoring wells allowing an update to the storage costs

• Updated pipeline route model nearly complete that will allow for better estimate of pipeline distances and diameters that will allow better estimate of transport costs

• Risk assessment ongoing and providing practical information for commercialization
Thank you!

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Appendix

- These slides will not be discussed during the presentation, but are mandatory.
Benefit to the Program

• The objectives of the IMSCS-HUB program build on the lessons learned from the RCSP’s and extend the framework for geologic storage site characterization and development to the commercial scale. The IMSCS HUB Project will systematically address the technical challenges of commercial-scale CO₂ storage and will aid DOE in meeting their Carbon Storage Research and Development Program goals:
  
  • (1) Develop and validate technologies to ensure 99 percent storage permanence.
  
  • (2) Develop technologies to improve reservoir storage efficiency while ensuring containment effectiveness.
  
  • (3) Support industry’s ability to predict CO₂ storage capacity in geologic formations to within ±30 percent.
  
  • (4) Develop best practice manuals for site characterization, public outreach, risk management and operations for geologic storage
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• Objective 6: Identify and mitigate public outreach and regulatory barriers

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Phase 2 Organization

**Sponsors**
US Department of Energy
National Energy Technology Laboratory

**Steering Committee**
Dr. Andrew Duguid (Battelle)
Mr. Scott McDonald (ADM)
Dr. R.M. Joeckel (CSD)
Mr. Dana Wreath (Berexco)
Dr. Tandis Bidgoli (KGS)
Mr. Neil Wildgust (EERC)

**Task 1: Project Management and Planning**
Leader: Dr. Andrew Duguid (Battelle)
Project Manager: Mr. Michael Heinrichs (Battelle)

**Task 2: Site Access and Permitting**
Leader: Mr. Jarred Hawkins (Battelle)

**Task 3 Feasibility Data Collection Planning**
Co-Leader (Geologic Feasibility): Ms. Isis Fukai (Battelle)
Co-Leader (Reservoir Simulation): Mr. Larry Pekot (EERC)

**Task 4: Storage Complex Feasibility Data Collection**
Leader: Dr. Andrew Duguid (Battelle)

**Task 5 Storage Complex Analysis and Modeling**
Co-Leader (Geologic Characterization): Ms. Isis Fukai (Battelle)
Co-Leader (Reservoir Simulation): Mr. Larry Pekot (EERC)

**Task 6: Outreach**
Task Leader: Brendan Jordan (GPI)

**Task 7: Risk Assessment and Mitigation**
Leader: Dr. Heather McCarren (Battelle)

**Task 8: Regulatory and Contractual Requirements Assessment**
Co-Leader: Mr. Scott McDonald (ADM)
Co-Leader: Dr. Tandis Bidgoli (KGS)

**Task 9: CO₂ Management and Commercial Development Strategy**
Co-Leader: Dr. Andrew Duguid (Battelle)
Co-Leader: Mr. Scott McDonald (ADM)

**Technical Advisor**
Dr. Neeraj Gupta (Battelle)
Gantt Chart

Task Name

- Task 1 Project Management and Planning
- Task 2 Site Access and Permitting
- Task 3 Feasibility Data Collection Planning
- Task 4 Storage Complex Feasibility Data Collection
- Task 5 Storage Complex Analysis and Model Update
- Task 6 Outreach
- Task 7 Risk Assessment and Mitigation
- Task 8 Regulatory and Contractual Assessment
- Task 9 CO2 Management and Commercial Development Strategy

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