Integrated CCS for Kansas (ICKan)

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Carbon Capture, Utilization, and Storage in Kansas Forum
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CarbonSAFE

- **Carbon Storage Assurance Facility Enterprise**
  - Department of Energy, Office of Fossil Energy

- Recognizes need for CCS to operate on massive scale in order achieve U.S. and global clean energy goals, but commerciality hindered by:
  - Lack of economic incentives for private sector
  - Need for identification & certification of storage sites

- Major goal is to develop integrated CCS storage complex
  - Constructed and permitted for operation by 2025
  - Storage of 50+ million metric tons of CO₂
4 Phases of CarbonSAFE

I. Integrated CCS Pre-Feasibility (1.5 years)
   - Complete in September 2018

II. Storage Complex Feasibility (2 years)
   - Application due December 2017

III. Site Characterization (2 years)

IV. Permitting and Construction (3.5 years)
Project Overview
Goal & Objectives

- Identify and address major **technical and nontechnical challenges** of implementing CO$_2$ capture and transport and establishing secure geologic storage for CO$_2$ in Kansas

- Evaluate and **develop a plan and strategy** to address the challenges and opportunities for commercial-scale CCS in Kansas
Project Overview
Base Case Scenario

• **Capture 50 million tonnes CO$_2$** from one of three Jeffrey Energy Center’s 800 MWe plants over a 20 year period (2.5Mt/yr)

• **Compress CO$_2$ and transport 300 miles to Pleasant Prairie Field** in SW Kansas.
  – Alternative: 50 miles to Davis Ranch and John Creek Fields.

• **Inject and permanently store 50 million tonnes CO$_2$ in the Viola Formation and Arbuckle Group**
Jeffrey to SW Kansas

Reduce cost via scaling & tariffs
- Ethanol CO₂ gathering system
- EOR sites in SW Kansas & Permian Basin
- Transportation tariffs?
Technical Evaluations

**Sub-Basinal Evaluations**

- **Pleasant Prairie**
  - 170 Mt storage
  - Viola & Arbuckle
  - CO$_2$-EOR reservoirs
  - Adequate data (core)
  - Unitized; single operator

- **Davis Ranch-John Creek**
  - 50 Mt storage
  - Simpson and Arbuckle
  - Proximity to JEC
  - CO$_2$-EOR reservoirs
  - Adequate data
  - Two operators

**CO$_2$ Source Assessments**

- **Westar Jeffrey Energy Center**
  - 2.4 GW & 12.5 million tonnes of CO$_2$

**CO$_2$ Transportation**

- **Pipeline**
  - 300 mile trunk line
  - Connect to Midwest ethanol CO$_2$ gathering system
  - Connect to Permian through Oklahoma Panhandle

- **Sunflower's Holcomb Plant**

- **CHS McPherson Refinery**

- **KC Board of Public Utilities**
Non-Technical Evaluations

Implementation Plan

**Economics**
- Capture & transportation economic feasibility (with or w/o ethanol component)
- Financial backing
- Financial assurance under Class VI
- State incentives
- Federal tax policy

**Legal & Regulatory**
- Pore space property rights including force unitization
- CO₂ ownership & liability
- MVA requirements under UIC Class VI
- Varying stakeholder interests
- Right-of-ways
- Utility rate-payer obligations

**Public Policy (Public Acceptance)**
- Identify stakeholders
- Foster relationships
- Public perception
- Political challenges
- Injection-induced seismicity
# Phase 1 Research Team

18 team members, 4 subcontractors and KGS staff

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<thead>
<tr>
<th>Project Management &amp; Coordination, Geological Characterization</th>
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<tr>
<td><strong>Kansas Geological Survey</strong></td>
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<td>University of Kansas</td>
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<td>Lawrence, KS</td>
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<td>Tandis Bidgoli, PI, Assistant Scientist</td>
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<td>Lynn Watney, Senior Scientific Fellow</td>
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<td>Eugene Holubnyak, Research Scientist</td>
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<td>K. David Newell, Associate Scientist</td>
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<td>John Doveton, Senior Scientific Fellow</td>
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<td>Susan Stover, Outreach Manager</td>
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<td>Mina FazelAlavi, Engineering Research Asst.</td>
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<td>John Victorine, Research Asst., Programming</td>
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<td>Jennifer Hollenbah - CO2 Programs Manager</td>
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<td><strong>Improved Hydrocarbon Recovery, LLC</strong></td>
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<td>Lawrence, KS</td>
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<td>Martin Dubois, Joint-PI, Project Manager</td>
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<tr>
<th>CO2 Source Assessments, Capture &amp; Transportation, Economic Feasibility</th>
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<tr>
<td><strong>Linde Group (Americas Division)</strong></td>
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<tr>
<td>Houston, TX</td>
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<tr>
<td>Krish Krishnamurthy, Head of Group R&amp;D</td>
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<td>Kevin Watts, Dir. O&amp;G Business Development</td>
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<th>Energy, Environmental, Regulatory, &amp; Business Law &amp; Contracts</th>
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<tr>
<td><strong>Depew Gillen Rathbun &amp; McInteer, LC</strong></td>
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<tr>
<td>Wichita, KS</td>
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<tr>
<td>Christopher Steincamp, Attorney at Law</td>
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<td>Joseph Schremmer - Attorney at Law</td>
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<th>Policy Analysis, Public Outreach &amp; Acceptance</th>
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<tr>
<td><strong>Great Plains Institute</strong></td>
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<tr>
<td>Minneapolis, MN</td>
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<tr>
<td>Brendan Jordan, Vice President</td>
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<tr>
<td>Brad Crabtree, V.P. Fossil Energy</td>
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<tr>
<td>Jennifer Christensen, Senior Associate</td>
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<td>Dane McFarlane, Senior Research Analyst</td>
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Industry Partners

Four CO₂ Sources

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<th>CO₂ Sources</th>
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| **Westar Energy**                  | Brad Loveless, Exec. Director Environ. Services  
                                  | Dan Wilkus, Director - Air Programs  
                                  | Mark Gettys, Business Manager  
| **Kansas City Board of Public Utilities** | Ingrid Seltzer, Director of Environmental Services  
| **Sunflower Electric Power Corporation** |                       |
| Clare Gustin, V.P. Member Services & Ext. Affairs  
| **CHS, Inc. (McPherson Refinery)** | Richard K. Leicht, Vice President of Refining  
| Rick Johnson, Vice President of Refining  

Five Oil & Gas Companies

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<th>Kansas Oil &amp; Gas Operators</th>
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| **Blake Production Company, Inc.**  | (Davis Ranch and John Creek fields)  
                                  | Austin Vemon, Vice President  
| **Knighton Oil Company, Inc.**      | (John Creek Field)  
                                  | Earl M. Knighton, Jr., President  
| **Casillas Petroleum Corp.**        | (Pleasant Prairie Field)  
                                  | Chris K. Carson, V.P. Geology and Exploration  
| **Berexco, LLC**                    | (Wellington, Cutter, and other O&G fields)  
                                  | Dana Wreath, Vice President  
| **Stroke of Luck Energy & Exploration, LLC** | (Leach & Newberry fields)  
                                  | Ken Walker, Operator  

Regulatory

| Kansas Department of Health & Environment |                       |
| Division of Environment                   |                       |
| John W. Mitchell, Director                |                       |
| **Bureau of Air**                         |                       |
| Rick Brunetti, Director                   |                       |
Storage Site Evaluations
Methodological Approach

**Reservoir seals**
Characterize primary and secondary seals

**3D cellular geologic model**
Utilize existing well and engineering data, 3D seismic, to build cellular static models

**Fault reactivation & induced seismicity***
Map faults, characterize stresses, fault slip and dilation tendency analysis

**Reservoir simulation model**
Use a compositional simulator to analyze capacity, injection rates, and pressure constrained by reservoir seal, fault and seismicity risk, and wellbore risk studies

**Wellbore risk**
Evaluate existing and plugged well construction, plugging records, and estimate risk

*Induced seismicity risks for CO2-EOR sites are significantly lower
Storage Site Evaluations: 
Davis Ranch & John Creek

**Static 3D cellular models:** Porosity & permeability in 3100-3400 ft-deep reservoirs

**Dynamic models:** Analyze injectivity and storage capacity in Simpson and Arbuckle

**Two largest fields in FCB,** located ten miles apart 40-50 miles SW of JEC

**Results:**
- Injected for 25 years
- Combined injection rates: 2350 to 4000 tonnes/day
- Storage: 24.6 million tonnes
- Injection rate satisfactory
- Storage is half the 50 Mt target
Storage Site Evaluations:
Lakin and Pleasant Prairie Complex

- **Target storage zones:**
  - Miss. Osage, 5300-5450’
  - Viola, 5550-5750’
  - Arbuckle, 5800-6400’
- BHP 1650-1750 psi
- BHT 130-135F

Large structures in parts of Kearny, Finney and Haskell counties
- > 100ft of structural closure
- Lakin: 14 mi²
- Pleasant Prairie: 22 mi²
Storage Site Evaluations: Lakin Field

Static 3D cellular model:
- Discovered 1957, 63 well penetrations
- 4.6 MBO from Morrow and Meramec

100 ft closure
VE=20X

3D static model

Post Injection
Plumes

Initial simulation:
- Inject 30.2 Mt in 25 yrs
- Three wells, three zones

Increase storage volume:
- Extend perfs in zones
- Extend injection period beyond 25 yrs
- Evaluate plume extents

Permeability (mD)

Lateral extent of plumes 75 yrs post-injection

CO₂ Concentration

100 ft closure
VE=15X
Storage Site Evaluations:
Pleasant Prairie Field

**Meramec Structure (seismic and well control)**
- 100 ft closure, 22 mi^2
- Discovered 1954

**Status update:**
- Static modeling is underway
- Zones: Osage, Viola, and Arbuckle
- Anticipate having 1.5 to 2X the storage capacity as in Lakin

*EOR potential in Chester incised valley is a bonus*
- 34.9 mmbo
- 2.6 BCF gas
- Miss. Chester and Meramec
Synergy Opportunities

- Link upper Midwest ethanol-based CO$_2$ with Kansas sources and reservoirs
- Complements on-going CarbonSAFE projects
- Collaboration with Battelle underway for Phase II
Questions?