Overview of iCKan: Integrated Carbon Capture and Storage in Kansas

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Carbon Capture for EOR in Kansas Meeting
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Outline

- Dept. of Energy – CarbonSAFE Program
- Integrated CCS for Kansas (ICKan)
  - Scope
  - Team & participants
  - Technical & nontechnical evaluations
- Next phase of research
- Summary

CarbonSAFE

- **Carbon S**torage **A**ssurance **F**acility **E**nterprise
  - DOE's Office of Fossil Energy
- Recognizes need for CCS to operate on massive scale in order achieve U.S. clean energy goals, but commerciality hindered by:
  - Lack of economic incentives for private sector
  - Identify and certify geologic 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 CO_2

4 Phases of CarbonSAFE

I. Integrated CCS Pre-Feasibility (1.5 years) - $1.2M
II. Storage Complex Feasibility (2 years) - $8-10M
III. Site Characterization (2 years) - TBA
IV. Permitting and Construction (3.5 years) - TBA

Phase I: Integrated CCS Pre-Feasibility

Goals & Objectives:

1. Form a team to identify and address technical and non-technical challenges of implementing commercial-scale CCS in Kansas
2. Perform high-level technical evaluations of the sub-basin and potential CO_2 source(s)
3. Develop a plan (strategy) to address the challenges and opportunities for commercial-scale CCS in Kansas

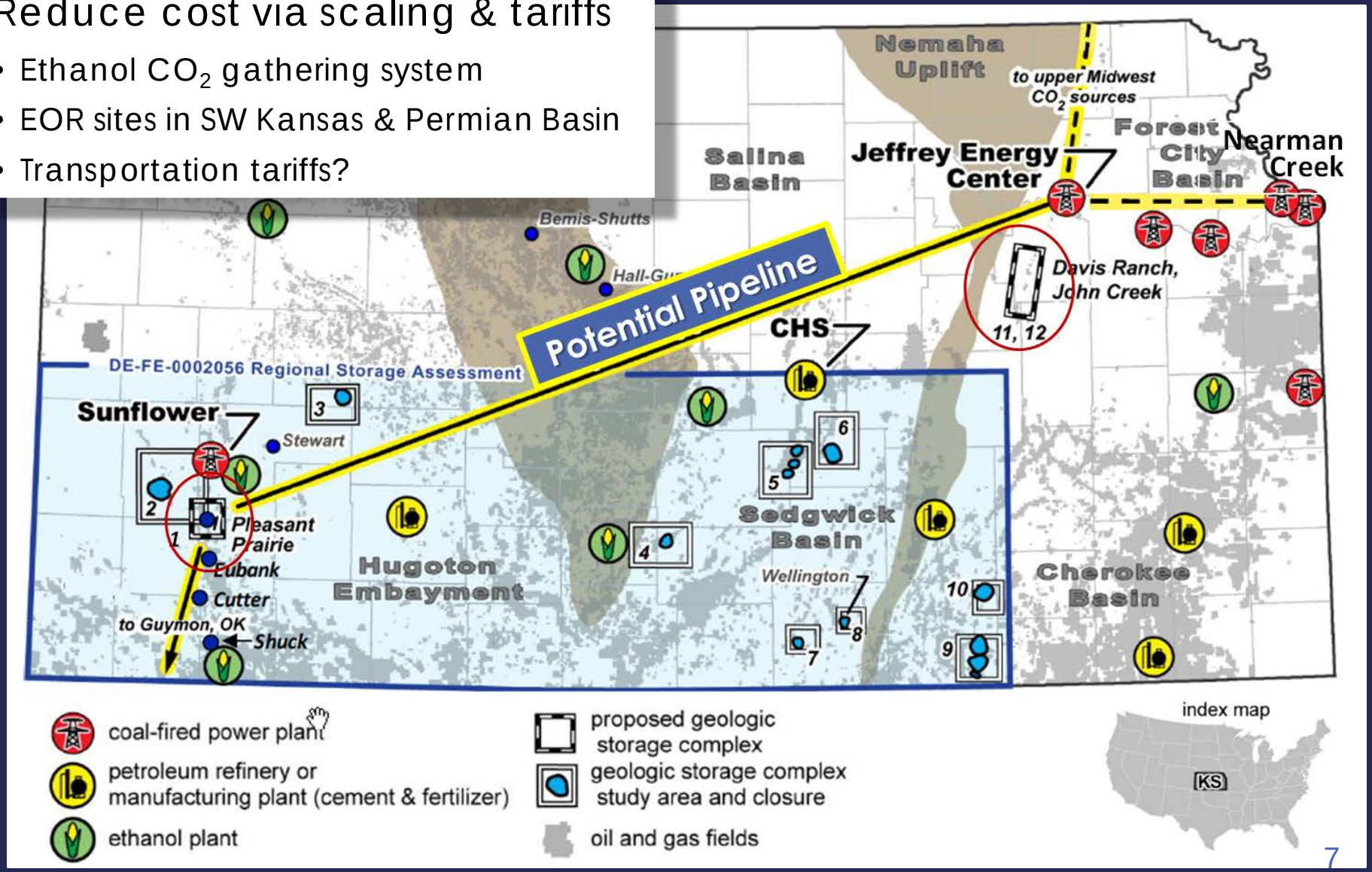
Project Overview: Base Case Scenario

- 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 & transport 300 miles to Patterson 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 Osage & Viola Formations and Arbuckle Group

Jeffrey to SW Kansas

Reduce cost via scaling & tariffs

- Ethanol CO_2 gathering system
- EOR sites in SW Kansas & Permian Basin
- Transportation tariffs?



Technical Evaluations

Sub-Basinal Evaluations

Patterson and others

- 60+ Mt storage
- Osage, 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

- 2.16 GW &13.8 million tons of CO_2

Sunflower's Holcomb Plant

CHS McPherson Refinery

KC Board of Public Utilities

CO_2 Transportation

Pipeline

- 300 km
- Oklahoma and upper Midwest connections
- Branch connections to regional ethanol producers

Non-Technical Evaluations

Implementation Plan

Economics

- Capture & transportation economic feasibility
- Financial backing
- Financial assurance under Class Vi
- State incentives
- Federal tax policy

Legal & Regulatory

- Property rights
- CO_2 ownership & liability
- MVA requirements under UIC Class VI
- Varying stakeholder interests
- Right-of-ways

Public Policy (Public Acceptance))

- Identifying stakeholders
- Fostering relationships
- Public perception
- Political challenges
- Injection-induced seismicity

ICKan Project Team

Project Management & Coordination, Geological Characterization

Kansas Geological Survey
University of Kansas
Lawrence, KS
Tandis Bidgoli, PI, Assistant Scientist
Lynn Watney, Senior Scientific Fellow
Eugene Holubnyak, Research Scientist
K. David Newell, Associate Scientist
John Doveton, Senior Scientific Fellow
Susan Stover, Outreach Manager
Mina FazelAlavi, Engineering Research Asst.
John Victorine, Research Asst., Programming
Jennifer Hollenbah - CO2 Programs Manager

Improved Hydrocarbon Recovery, LLC
Lawrence, KS
Martin Dubois, Joint-PI, Project Manager

CO2 Source Assessments, Capture & Transportation, Economic Feasibility

Linde Group (Americas Division)
Houston, TX
Krish Krishnamurthy, Head of Group R&D
Kevin Watts, Dir. O&G Business Development

Policy Analysis, Public Outreach & Acceptance

Great Plains Institute
Minneapolis, MN
Brendan Jordan, Vice President
Brad Crabtree, V.P. Fossil Energy
Jennifer Christensen, Senior Associate
Dane McFarlane, Senior Research Analysist

Energy, Environmental, Regulatory, & Business Law & Contracts

Depew Gillen Rathbun & McInteer, LC
Wichita, KS
Christopher Steincamp, Attorney at Law
Joseph Schremmer - Attorney at Law

Project Partners & Representatives

CO2 Sources

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

Regulatory

Kansas Department of Health & Environment

Division of Environment

John W. Mitchell, Director

Bureau of Air

Rick Brunetti, Director

Kansas Oil & Gas Operators

Blake Production Company, Inc.

(Davis Ranch and John Creek fields)

Austin Vernon, 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

Storage Site Evaluations: Methodological Approach

Reservoir seals
Characterize primary and secondary seals

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

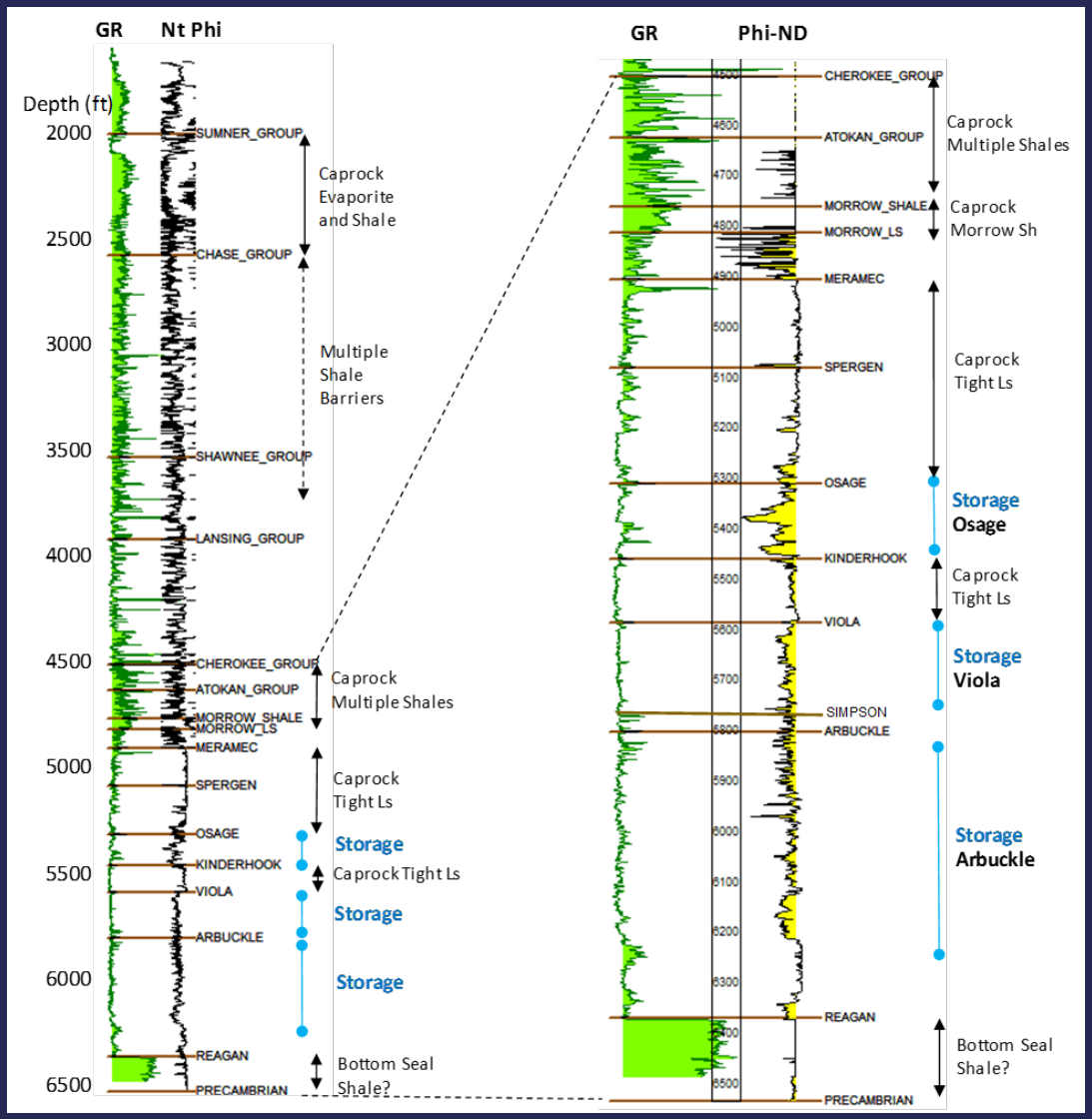
Wellbore risk
Evaluate existing and plugged well construction, plugging records, and estimate risk

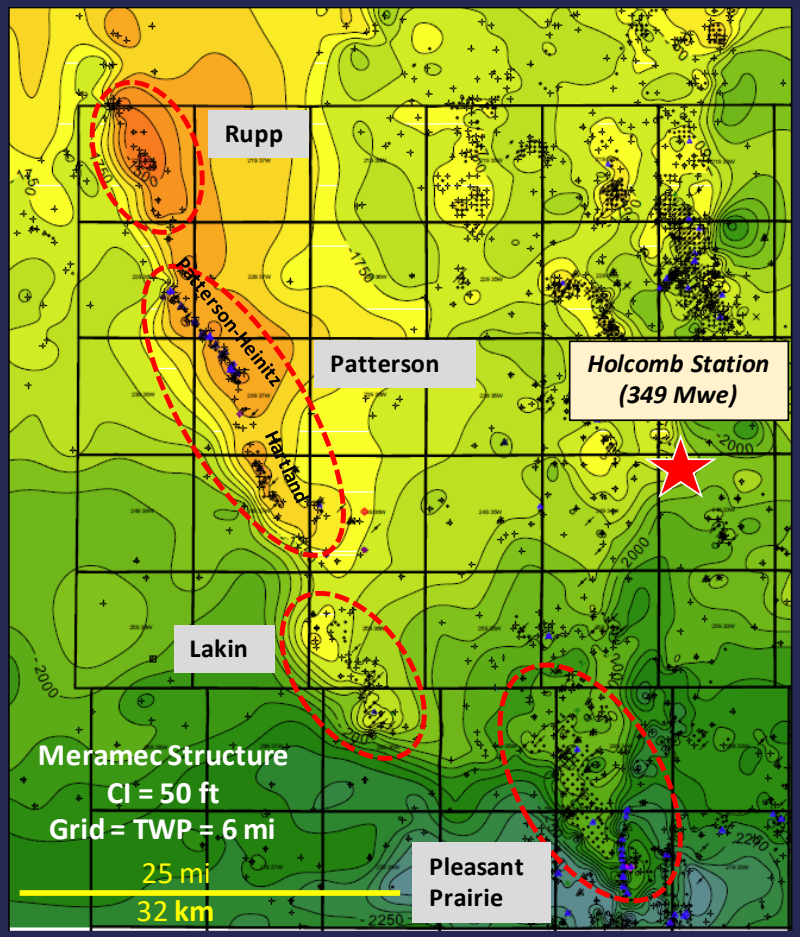
3D cellular geologic model
Utilize existing well and engineering data, 3D seismic, to build cellular static models

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

*Induced seismicity risks for CO_2-EOR sites are significantly lower

Storage Site Evaluations: North Hugoton Storage Complex





- BHP 1650-1750 psi
- BHT 130-135F

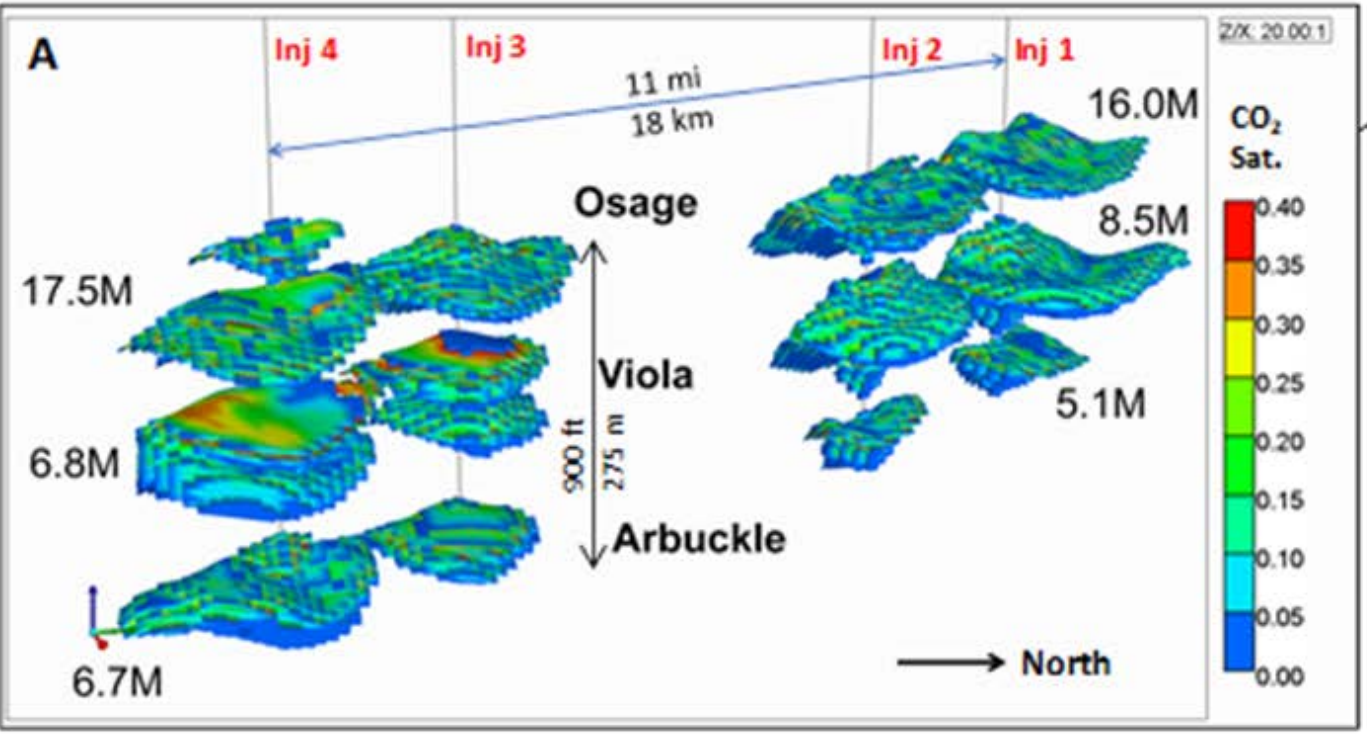
Storage Site Evaluations: Patterson-Heinitz-Hartland Fields

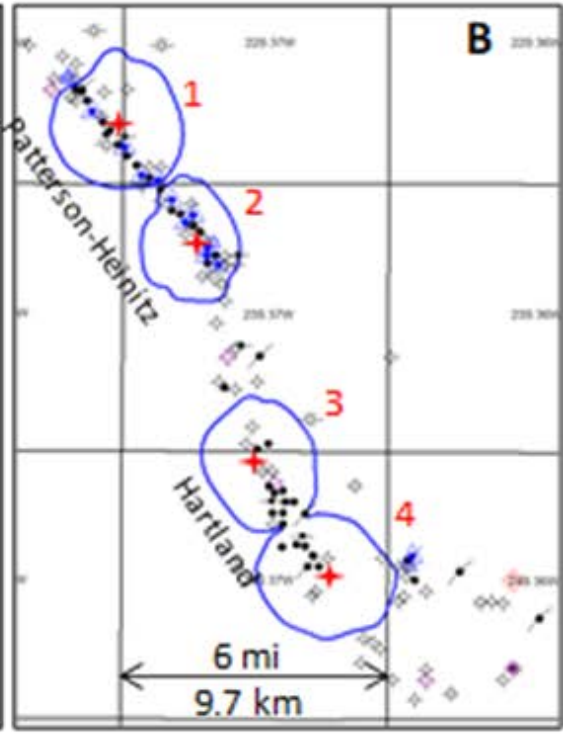
Static 3D cellular model:

- Few wells penetrate saline storage zones (21 wells total)
- Properties established from limited core and injection test

Initial simulation:

- ✓ Inject 5,800 metric tonnes/day
- ✓ 60.6 Mt in 30 yrs
- ✓ Four wells, three zones
- ✓ Additional work to optimize injection





CO_2 Sources

Jeffrey Energy Center, St. Marys, KS

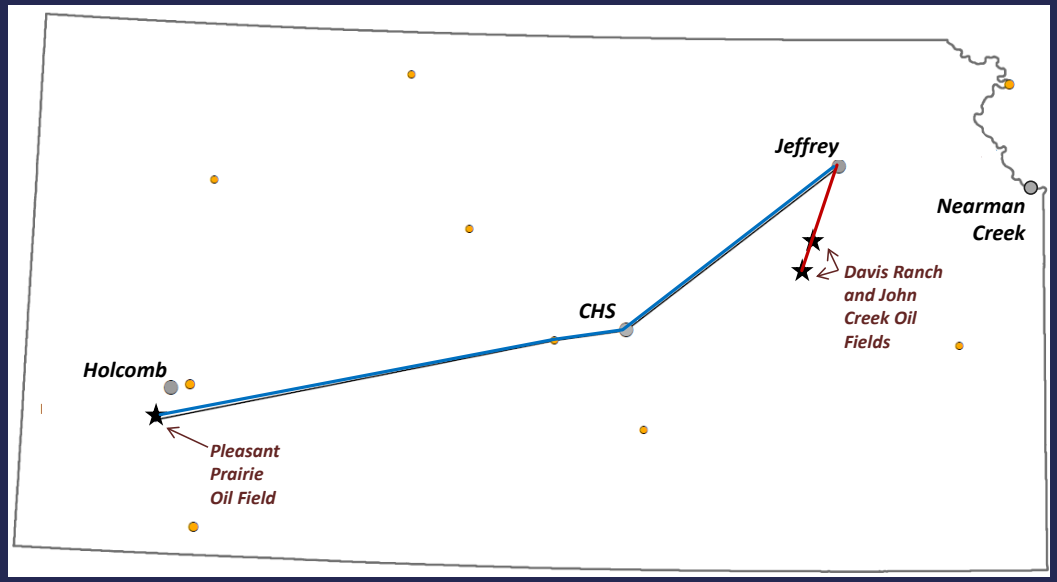
- 3x 800 MWe plants with annual CO_2 emissions of 12.5 million tonnes
- Partial capture of flue gas (~350 Mwe) can meet needs over 20 years
- Optimize: waste heat

CHS Refinery at McPherson, KS

- Flue gas: ~760,000 tonnes/yr (30% of the project needs)
- Solvent-based post-combustion capture process
  - 90% reduction in CO2 emissions
- Optimization via centralized steam generation possible

CO2 Transportation Assessment

- Modified FE/NETL CO_2 Transport Cost Model (Grant & Morgan, 2014)
- 7 inputs (e.g., length, pumps, capacity, pressures, etc.)
- 12 outputs, including CapEx and OpEx



	Scenario	Distance (mi)	Distance (mi) X 1.2	Volume (MT/yr)	Size (inches)	CapEx ($M)	Annual OpEx ($M)
Jeffrey to MidCon Trunk	**part of 1**	151	181	2.5	12"	$164	$3.8
Jeffrey to Davis Ranch and John Creek	**2**	42	51	2.5*	12" & 8"	$47	$1.3
Jeffrey to CHS and Pleasant Prairie	**3**	294	353	3.25**	12"	$323	$8.0
Jeffrey to Pleasant Prairie	**4**	294	353	2.5	12"	$322	$7.2

White paper

- Multi-state group that launched in 2016
- Working to expand carbon capture, utilization, and storage
- Critical to passage of 45Q

http://www.betterenergy.org/blog/capturing-utilizing-co2-ethanol-adding-economic-value-jobs-rural-economies-communities-reducing-emissions/

Capturing and Utilizing CO_2 from Ethanol:
Adding Economic Value and Jobs to Rural Economies and Communities While Reducing Emissions

White paper prepared by the
State CO_2-EOR Deployment Work Group

December 2017

Remaining work & next steps

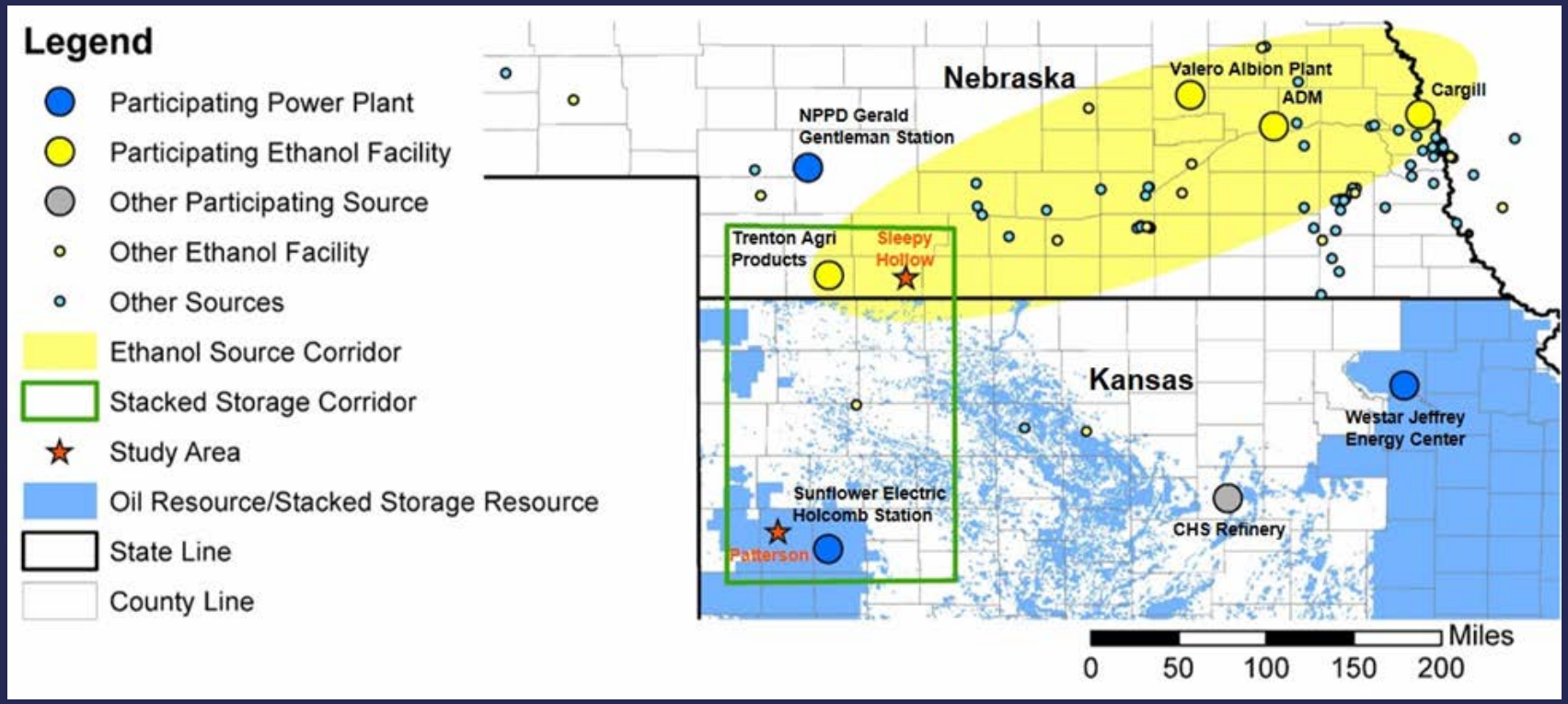
- Economic analysis of integrated project
  - Capture and compression, transportation, and storage site preparation and operations
  - Implications of 45Q tax credit
- Development of an implementation plan
- Phase II
  - Battelle, KGS, and EERC

CO2 price for 6.7% ROR

	Pipeline	Ethanol	Total
CapX ($/T)	$17.92	$7.81	$25.73
OpX ($/T)	$4.77	$8.58	$13.35
Total ($/T)	$22.69	$16.39	$39.08
Total ($/mcf)	$1.19	$0.86	$2.06
	With 45Q		
Total ($/T)	$5.00	$8.68	$13.68
Total ($/mcf)	$0.26	$0.46	$0.72

Current CO2 value = $22.80/tonne ($1.20/mcf)

“Midcontinent Stacked Carbon Storage Hub”



Agency	NGO/Association	Ethanol Producer	Electric Utility	Oil Producer	Other
KS Gov. Colyer	Clean Air Task Force	ADM	NPPD	Berexco	ION Engineering
NE Ethanol Board	Great Plains Institute	Cargill	Westar Energy	Merit Energy	MV Purchasing
NE Dept. of Agriculture	Kansas Independent Oil and Gas Association	Trenton Agri Products	Sunflower Electric Power	Great Plains Energy	The Linde Group
NE Dept. of Environmental Quality	NE Petroleum Producers Association	Valero Renewables	Kansas City Board of Public Utilities	Casillas Petroleum	
NE Corn Board	Renew Kansas	Pacific Eth.		Central Operating	
NE Energy Office					

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Industry and regulatory partners in study

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Graduate students: Andrew Hollenbach and Jeff Jennings

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Disclaimer:

Questions?

ICKan Kick-Off Meeting, Feb. 2017

CCUS in Kansas Forum, Sept. 2017