Establishing an Early Carbon Dioxide Storage Complex in Kemper County, Mississippi: Project ECO_2S

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Carbon Capture Front End Engineering Design Studies and CarbonSafe

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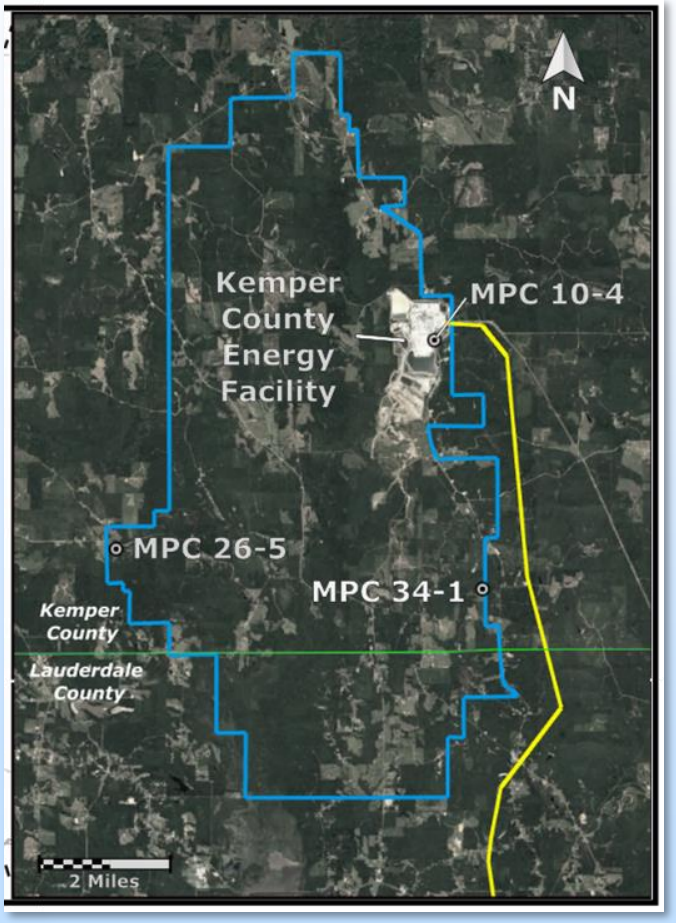
Phase II Accomplishments

- Overall objective was to demonstrate that the subsurface at Kemper can safely and permanently store commercial volumes of CO_2
- Established a 30,000 acre area of interest which contains gigatonne CO_2 storage potential
- Drilled 3 characterization wells (MPC 10-4, MPC 26-5, MPC 34-1)
- Identification and characterization of three storage reservoirs (Massive Sand/Dantzler, Washita-Fredericksburg, and Paluxy)
- Model of CO_2 plume and stabilization
- Regional storage complex commercialization plan



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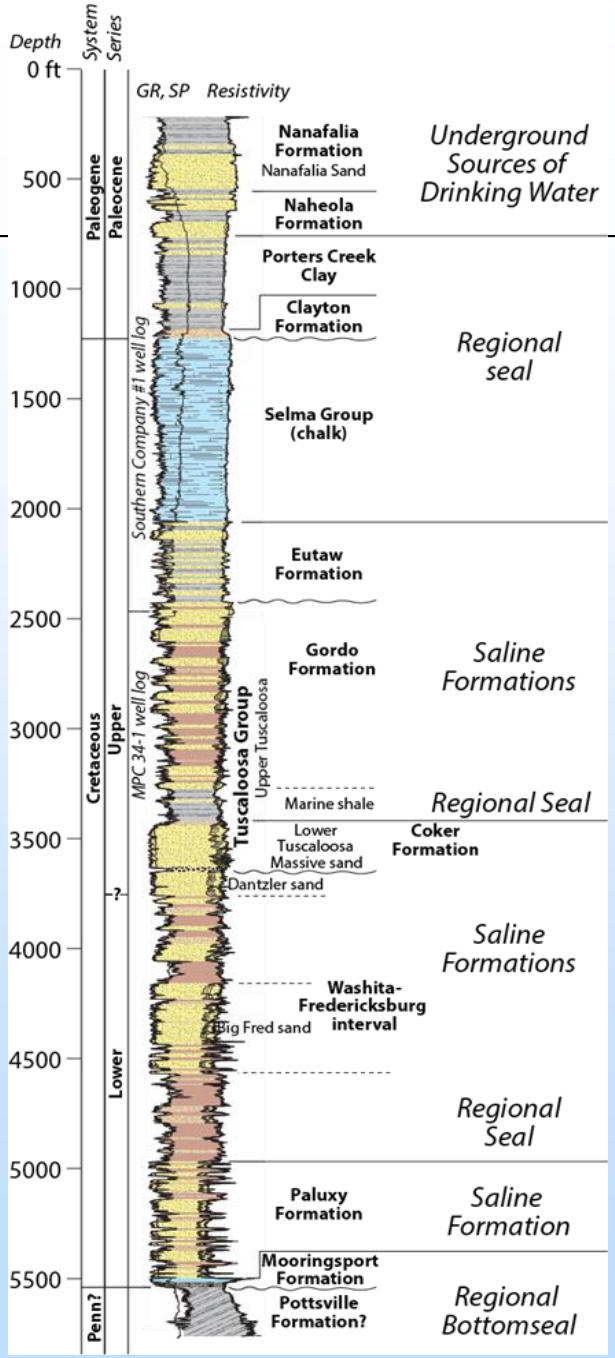
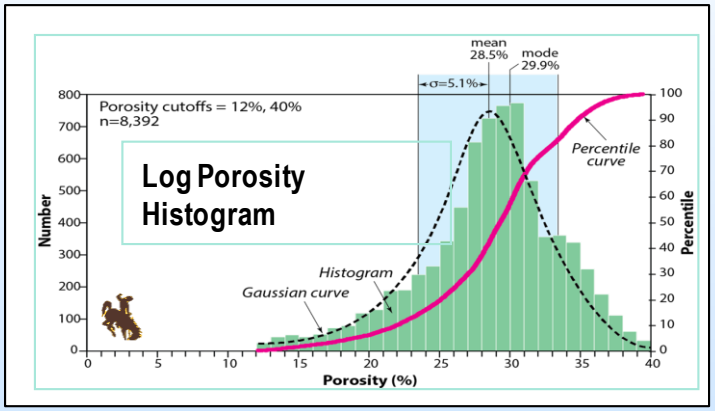
ECO_2S Data Collection

- Three characterization/monitoring wells were drilled in 2017 to test and characterize geologic properties
- 200 ft of hole core was taken from the Paluxy and Washita-Fredericksburg reservoirs and the Marine Tuscaloosa shale confining unit
- Reservoir fluid sampling and injection tests

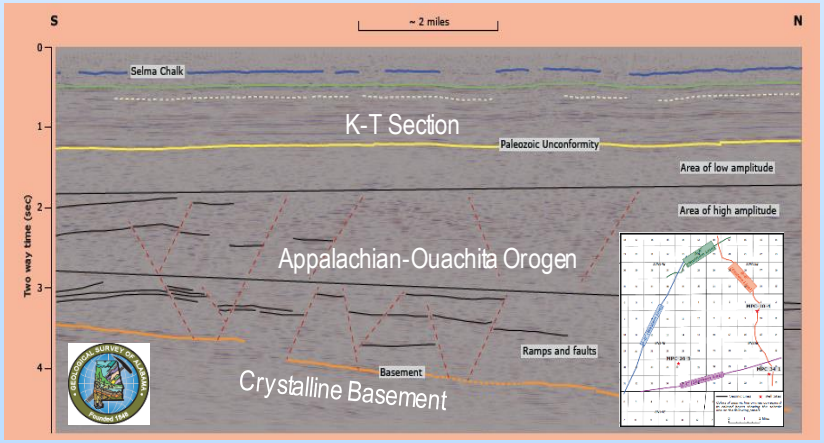
ECO_2S Geologic Characterization



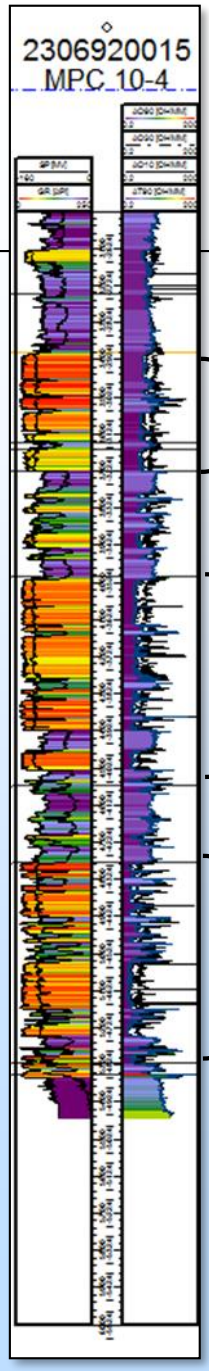
- Major stacked storage potential with >1,300 net feet of sandstone
- Logs and core show sandstone mean porosity of 29%
- Mean permeability of 3.6 Darcies



- No faults in or above the storage interval
- Moderate formation dip (less than one degree)
- Seals include mudrock and chalk with nanoDarcy permeability



ECO_2S Storage Complex Capacity



- Each of the three potential storage zones have commercial capacity
- Together the three storage zones result in a gigatonne capacity storage complex that has the potential to act as a regional hub

CO_2 Storage Reservoir	P_{10} Capacity (MMmt)	P_{50} Capacity (MMmt)	P_{90} Capacity (MMmt)
Massive/Dantzler	85	160	280
Wash.-Fred.	350	660	1,130
Paluxy	200	380	650
TOTAL	**635**	**1,200**	**2,060**

DOE methodology for site-specific saline storage efficiency calculation based on fluid displacement factors for clastic reservoirs where net pay, net thickness and net porosity are known of 7.4% (P_{10}), 14% (P_{50}) and 24% (P_{90}) (Goodman et al., 2011)

Project ECO$_2$S Phase III

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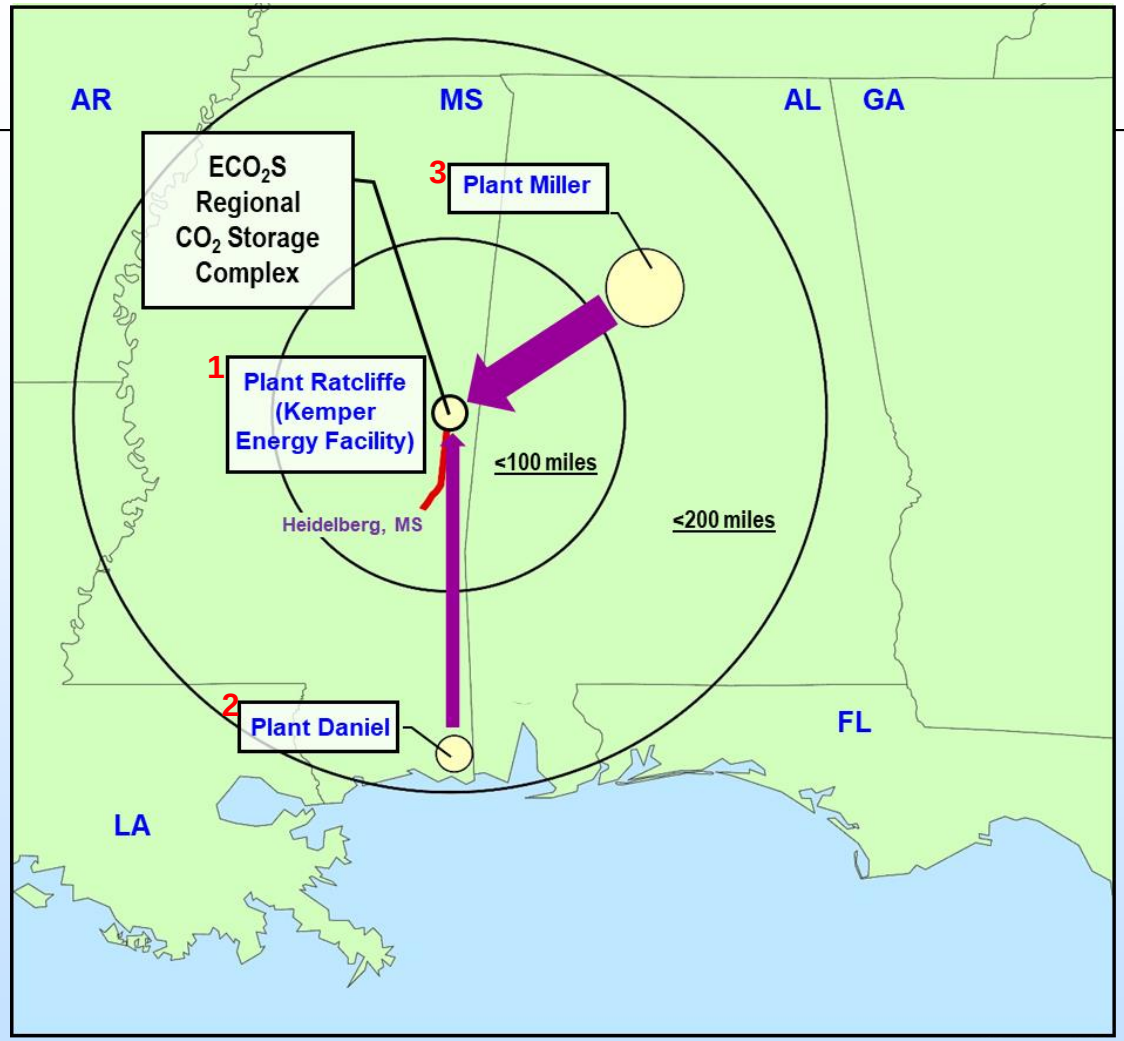
Project ECO$_2$S Phase III Objectives

- Demonstrate that the Subsurface Saline Formations at the Storage Complex Can Store Commercial Volumes of CO_2 Safely and Permanently.
- Conduct Pre-Feasibility Studies to Establish the Technology, Design and Costs of CO_2 Capture at Three Southern Company Power Plants
- Optimize the CO_2 Storage Capacity of the Storage Complex Including Establish the Areal Extent of the CO_2 Plume and Pressure Front.
- Confirm the Viability of Each of the Reservoir Seals to Serve as a Long-Term, Reliable Confining System for the CO_2 Storage Site
- Conduct a Comprehensive Risk Assessment Utilizing Reservoir Modeling and the NETL-Sponsored Integrated Assessment Model

Project ECO$_2$S Phase III Objectives

- Baseline Characterization of USDWs
- Develop a Methodology for Refining/Sharpening the Characterization/Monitoring Protocols Employing Machine Learning/Artificial Intelligence Protocols
- Define a Comprehensive CO_2 MVA System and a Quick-Response Contingency Plan
- Conduct Additional Public Outreach
- Apply and Obtain Approval for An Underground Injection Control (UIC) Class VI Permit to Construct
- Evaluation of Project Commerciality

CO_2 Sources



Pipelines linking sources of CO_2 to the ECO_2S Regional CO_2 Storage Complex

- **Pipeline #1.** A 5-mile main CO_2 pipeline plus short distance CO_2 distribution lines would transport 0.7 MMmt of CO_2 per year from the Kemper County Energy Facility to the ECO_2S Regional CO_2 Storage Complex
- **Pipeline #2**. A 180-mile CO_2 pipeline with five booster stations would connect Plant Daniel and its 3 MMmt per year of captured CO_2 emissions (160 MMcfd) with the Storage Complex
- **Pipeline #3.** A 150-mile, CO_2 pipeline with four booster stations would connect Plant Miller and its 18.8 MMmt per year of captured CO_2 emissions (1 Bcfd) to the Storage Complex

Funding & Schedule

Project ECO2S Phase III	Phase I								Phase II			
	Budget Period 1								Budget Period 2			
	YEAR 1				YEAR 2				YEAR 3			
TASK DESCRIPTIONS												
TASK 1.0: PROJECT MANAGEMENT AND PLANNING												
TASK 2.0: NATIONAL ENVIROMENTAL POLICY ACT (NEPA)												
TASK 3.0: RISK MANAGEMENT												
TASK 4.0: SITE SELECTION AND WELL DRILLING												
TASK 5.0: COMPLETE GEOLOGIC CHARACTERIZATION												
TASK 6.0: GEOLOGIC DATA ANALYSIS												
TASK 7.0: CO2 CAPTURE ASSESSMENT												
TASK 8.0: PROJECT INTEGRATION												
TASK 9.0: UIC PERMITTING												
TASK 10.0: KNOWLEDGE DISSEMINATION AND TECHNOLOGY TRANSFER												

Funding

- Federal: $ 17,479,430
- Non-Federal: $ 6,113,380
- Cost Share Percentage: 26%

Performance Period: 3 Years

(Official Start Date Pending Award)

- Budget Period 1: 2 Years
- Budget Period 2: 1 Year

Project ECO_2S – Southern Company Host-Site Update

- All site activities in CarbonSAFE Phase II were accomplished with Target Zero corporate safety goals
  - Drilling and well testing are inheritably safe operations if done responsibly
- Corporate support for the CarbonSAFE program is strong with Southern
  - Host-site access (Phase II and Phase III)
  - Cost-share of 4M in cash for Phase II & Phase III combined
  - Commitment to Class VI UIC permit application
- CarbonSAFE program provides synergy with corporate GHG reduction goals and system planning for deployment of CCUS
- Results to date fit well with commercialization strategy to leverage the Section 45Q tax credits
- Strong synergy with FEED study awarded to Southern Company on Plant Daniel NGCC units

Kemper County - Site Attributes

- Significant legal - pore space ownership and site access for drilling
- Staked formations provide for large storage capacity
- Site characterization/monitoring well Infrastructure provides not only site certification and reduces risk, but cost offsets for commercial storage consideration
- Class VI UIC permit (TBD) in-hand presents the site as being storage ready
- Low-cost storage option in SE USA (Esposito et al 2019)

Esposito, R.A., Kuuskraa, V.A., Rossman, C.G., Corser, M.M., 2019, Reconsidering CCS in the US fossil-fuel fired electricity industry under section 45Q tax credits; Greenhouse Gas Science & Technology, 0:1–14 (2019); DOI: 10.1002/ghg.1925

Capital Costs for Establishing Storage Site

	Total Cost (millions)
A. Site Design	
1. Site Characterization and Modeling ▪ Drill Characterization Wells ▪ Purchase and Interpret 2-D Seismic ▪ Build Geologic Model ▪ Conduct Reservoir/Geophysical Modeling	$8.4
2. Class VI Permit Application	$0.6
3. MRV Plan for Subpart RR	$0.1
4. Financial Bonds	$0.2
5. Site Preparation (included in well costs)	-
6. Acquisition of Pore Space Rights (assumed available)	-
Sub-Total	**$9.3**
B. Site Installation	
1. CO2 Injection Wells	$14.3
2. Monitoring Wells	$20.0
3. Seismic/Microseismic	$2.1
4. Transportation	$7.4
5. Other Costs/Contingency	$7.4
Sub-Total	**$51.2**
C. Total	**$60.5**

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- The overall capital costs for the regional CO_2 storage facility for 3 million metric tons/year is $60.6 million.
- With annual storage site transportation and operating costs of $2 million (for 12 years) and annual post-injection operating and closure costs of $1.3 million (for 10 years), the NPV of these costs is about $20 million (at a 7% discount rate).
- This storage complex results in CO_2 storage costs of less then $3 metric ton.
- Approximately 25% of these costs would be covered by the CarbonSAFE Program through Phase III.