



Project ECO₂S Phase 2 CarbonSAFE Field Project

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**U.S. – Norway Collaboration on CCS/CCUS
2017 Bilateral Meeting**

Storage Breakout

Session: 4. Potential New Cooperative Projects

Sponsored by:

**U.S. Department of Energy
Norwegian Ministry of Petroleum and Energy**

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Washington DC



The CarbonSAFE Project: Background

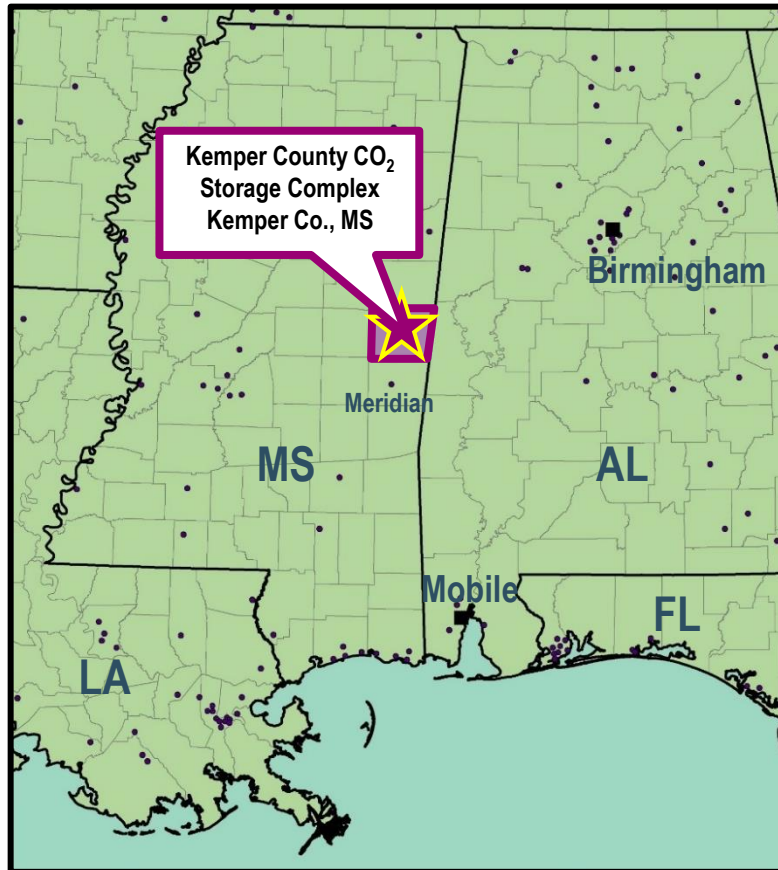
In mid-2016, the U.S. Department of Energy/National Energy Technology Laboratory (DOE/NETL) issued a Funding Opportunity Announcement to develop an integrated CCS storage program ready for commercial operation by 2025.

This program called CarbonSAFE (Carbon Storage Assurance Facility Enterprise) consisted of four distinct phases:

- Phase I. Pre-Feasibility Study
- Phase II. Storage Complex Feasibility Study
- Phase III. Site Characterization and Permitting
- Phase IV. Infrastructure Construction

A consortium of companies, led by Mississippi Power Company (MPC), submitted a proposal and were awarded a Phase II portion of CarbonSAFE. The project called ECO₂S (Early CO₂ Storage) is located in Kemper County, Mississippi.

Kemper County CO₂ Storage Complex



The Kemper County CO₂ Storage Complex is located next to the Kemper Energy Facility in Kemper County, east-central Mississippi.



Source: Mississippi Power Company <https://www.flickr.com/photos/mississippipower/27709115165/>

Background

Prior Pre-Feasibility on the Kemper County CO₂ Storage Complex.

Mississippi Power Company (MPC), in conjunction with Southern Company Services (SCS), Advanced Resources and others had performed considerable pre-feasibility work on the Kemper County CO₂ Storage Complex. This enabled the project to qualify for the Phase II: Storage Complex Feasibility for CarbonSAFE.

The storage pre-feasibility work involved:

1. Performing a Geologic Evaluation of the Proposed CO₂ Storage Site
2. Establishing the Presence of Sufficient CO₂ Storage Capacity
3. Performing Reservoir Modeling for the Areal Extent of the CO₂ Plume and a More Rigorous Estimate of CO₂ Storage Capacity
4. Securing Surface and Pore Space Rights
5. Conducting Initial Stakeholders Analysis, and Completing Other Pre-Feasibility Tasks

This presentation will discuss the pre-feasibility work conducted by the study team in preparation for proceeding with the Phase II. Storage Complex Feasibility Study that is now underway.

1. Performing Geologic Evaluation of the Proposed CO₂ Storage Site

The first pre-feasibility effort was a comprehensive, multi-disciplinary geologic evaluation by the Geological Survey of Alabama (GSA), with Dr. Jack Pashin as Principal Investigator, entitled, “Geological Evaluation of the Potential for CO₂ Sequestration in Kemper County, Mississippi.”

This study identified two Lower Cretaceous strata, the Paluxy and the Washita-Fredericksburg sandstone saline formations, and one Upper Cretaceous interval, the Lower Tuscaloosa Massive Sand, as geologically favorable settings for storing CO₂ in Kemper County.

These three formations are overlain by the thick Tuscaloosa Marine Shale, a regionally extensive confining unit (seal).

The study used a 25 well data set, plus information from two previous drilled wells, to establish the geologic foundation for the CO₂ Storage Complex.

Kemper County - Generalized Stratigraphy

Tertiary	Eocene	Lower Wilcox Group	Nanafolia Fm.	USDW
	Paleocene	Midway Group	Naheola Fm	Potential USDW
			Porter's Creek Clay	Regional Seal
Cretaceous	Upper	Selma Group	Predominately Chalk	Regional Seal
		Eutaw Fm.		Potential USDW
		Tuscaloosa Group	Upper	Potential USDW & Water Supply
			Marine Shale	Regional Seal
	Lower & Massive Sand	Potential Saline Fm.		
	Lower	Washita- Fredericksburg	Saline Fm.	
		Paluxy Fm.	Saline Fm.	
Paleozoic Unconformity <i>(Lower Cretaceous Morningsport, Ferry Lake & Rodessa Fms missing @ Kemper Co.)</i>				

■ Tuscaloosa Massive Sand

- Depth: 3,000' to 3,252'
- Porosity: 20%
- Net Sand: 246'

■ Washita-Fredericksburg

- Depth: 3,252' to 4,225'
- Porosity: 18%
- Net Sand: 638'

■ Paluxy

- Depth: 4,225' to 4,808'
- Porosity: 18%
- Net Sand: 444'

Source: Pashin, J.C., D.J. Hills, D. C. Kopaska-Merkel, M.R. McIntyre, Geological Evaluation of the Potential for CO₂ Sequestration in Kemper County, Mississippi, Final Report, prepared for Southern Company Research and Environmental Affairs, June 1, 2008.

2. Establishing the Presence of Sufficient CO₂ Storage Capacity

The GSA study provided a preliminary CO₂ storage capacity estimate (at 10% efficiency) of 4 to 5 MMmt per square mile (640 acres) for the Paluxy Sandstone implying a storage capacity of 200+ MMmt for the proposed CO₂ storage unit.

Subsequently, Advanced Resources performed additional geologic work and constructed a series of geological cross-sections for the CO₂ storage site. These cross-sections confirmed that all three of the saline formations - - the Paluxy, the Washita-Fredericksburg, and the Tuscaloosa Massive Sand - - are regionally extensive with considerable net sand thickness.

Using this additional information, the Project Team calculated a CO₂ storage capacity of 480 MMmt for the proposed CO₂ storage site using the volumetric DOE/NETL CO₂ storage capacity estimation methodology (at 10% efficiency):

- 170 MMmt for the Paluxy,
- 220 MMmt for the Washita-Fredericksburg, and
- 90 MMmt for the Tuscaloosa Massive Sand.

Structure Cross-Section A-A'; Depth 1300' – 5500'

North

South



<13.67MI>



<5.82MI>



<8.91MI>

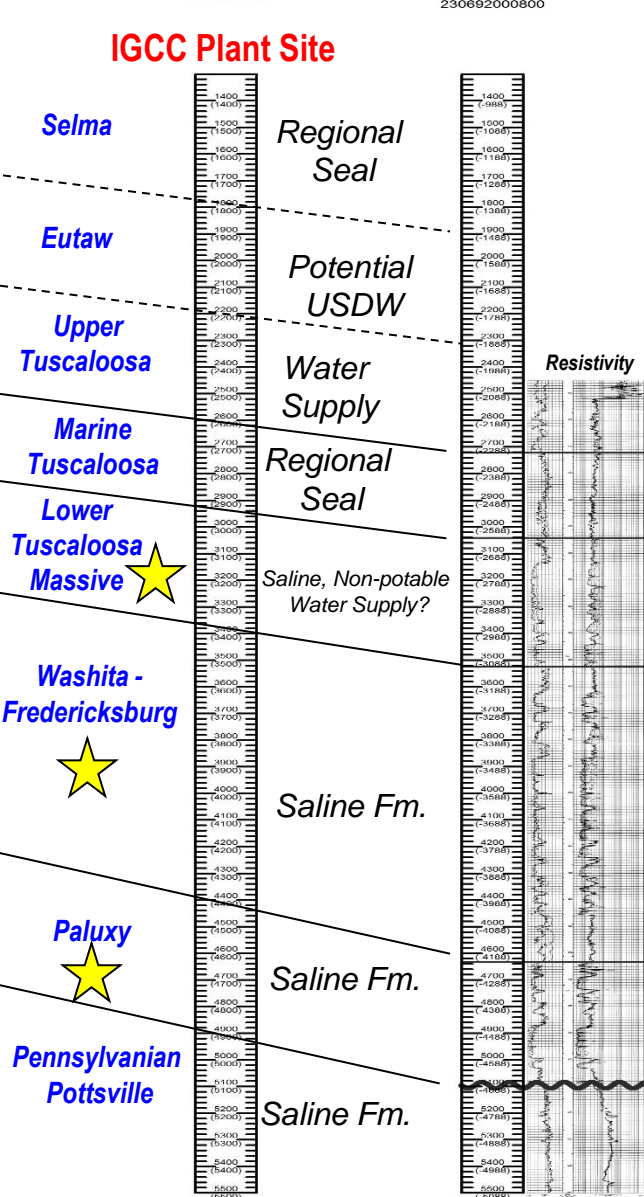
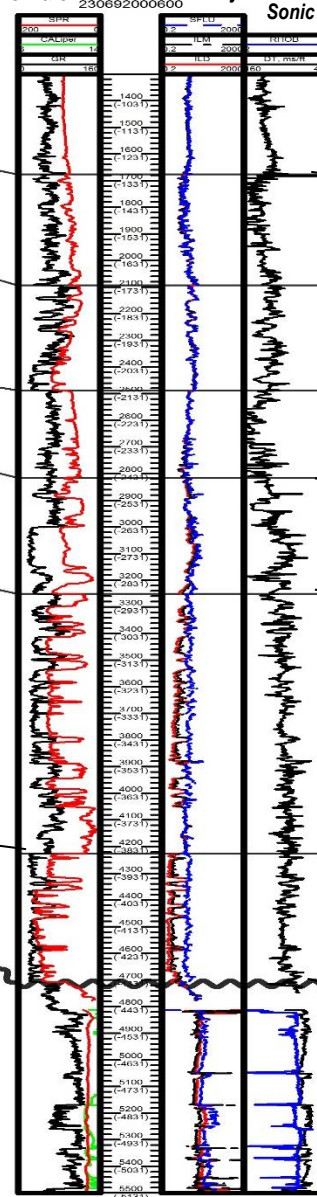
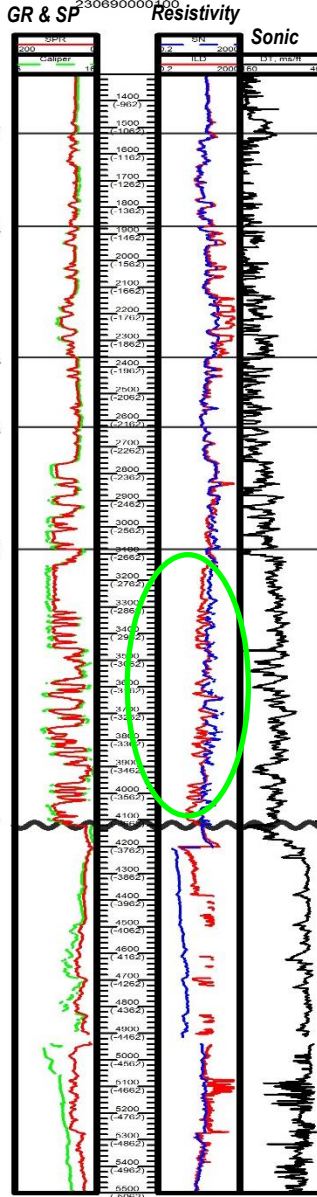


H.W. Henry 1-15

F.M. Legette et al

IGCC Plant Kemper, MS

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EUTAW
UPPER_TUSCALOOSA
MARINE_TUSCALOOSA
LOWER_TUSCALOOSA
WASHITA-FREDERICKSBURG

Selma
Eutaw
Upper Tuscaloosa
Marine Tuscaloosa
Lower Tuscaloosa
Washita - Fredericksburg
Paluxy
Pennsylvanian Pottsville

Regional Seal
Potential USDW
Water Supply
Regional Seal
Saline, Non-potable Water Supply?
Saline Fm.
Saline Fm.
Saline Fm.

Resistivity declines with depth; possible indicator of increasingly saline formation water

Geologic Survey of Alabama report identifies the Paluxy as main saline formation of interest for CO₂ storage at Kemper Co. IGCC site.

3. Performing Reservoir Modeling to Establish the Areal Extent of the CO₂ Plume and A More Rigorous Estimate of CO₂ Storage Capacity

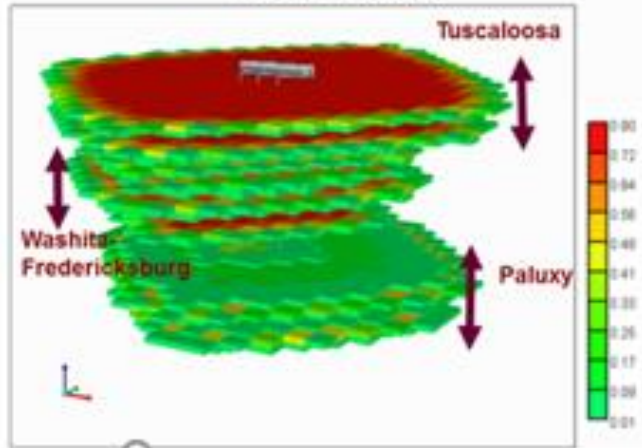
Advanced Resources undertook reservoir modeling to: (1) better understand CO₂ injectivity, (2) calculate the areal extent of the CO₂ plume, and (3) provide a more rigorous estimate of CO₂ storage capacity.

The reservoir model used 43 distinct layers to represent the individual sands and shales of the three proposed CO₂ storage formations - - Tuscaloosa Massive Sand, Washita-Fredericksburg and Paluxy, including their interburdens and seals.

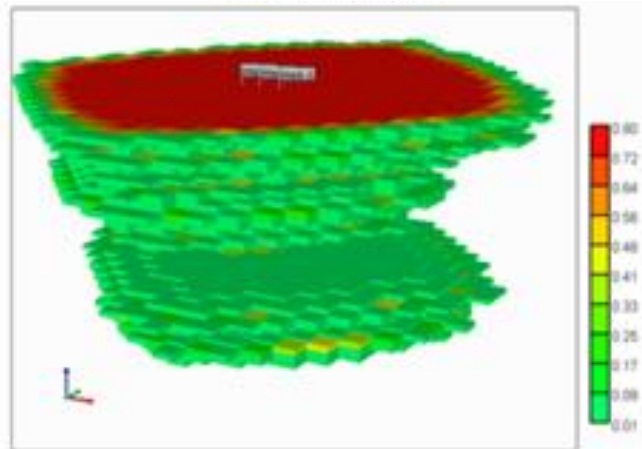
Reservoir modeling showed that the 30,000 acre proposed CO₂ storage site had an overall CO₂ storage capacity of 300 MMmt and could readily accommodate 3 MMmt/yr of CO₂ injection for 30 years.

CO₂ Plume Model for Kemper County CO₂ Storage Complex

CO₂ Plume After 30 Years

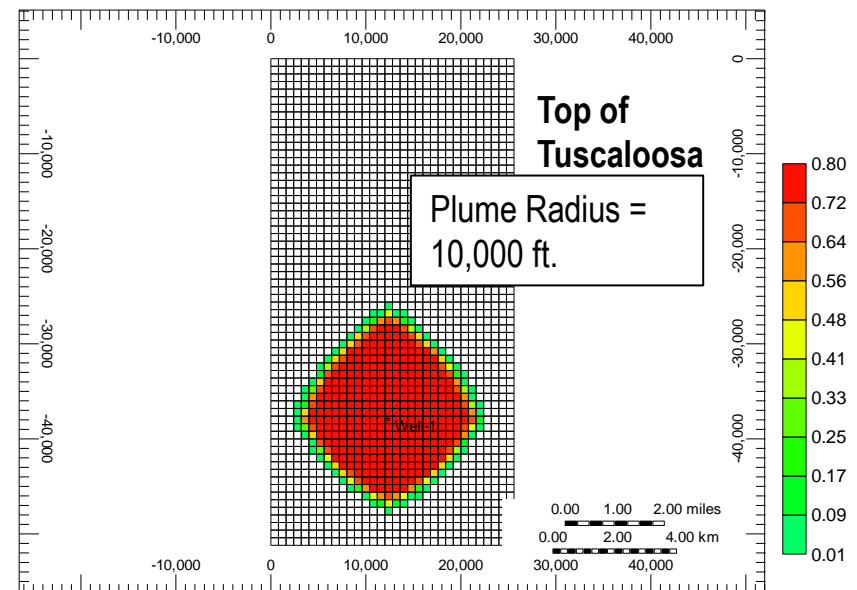


CO₂ Plume After 50 Years



The reservoir model used 30 years of CO₂ injection at 3 MMmt/year and 20 years of shut-in to establish the maximum areal extent of the CO₂ plume.

CO₂ Plume After 50 Years



4. Securing Surface and Pore Space Rights

The proposed CO₂ storage area would encompass a ~30,000 acre area surrounding the Kemper energy facility. As part of defining and securing the proposed CO₂ storage site, MPC had performed the following work:

- Defined the protected and environmentally sensitive areas at and near the proposed well pad to avoid potential conflict.
- Successfully secured surface and pore space rights in the center of the CO₂ storage site.
- Examined and resolved any conflicts with lignite development and mineral rights in the CO₂ storage area.

5. Conducting Initial Stakeholder Analysis and Other Pre-Feasibility Tasks

MPC, as part of siting and constructing the Kemper energy facility, had already conducted extensive stakeholder analysis in the communities near the CO₂ storage site and within the expected areal extent of the CO₂ plume.

MPC, in conjunction with ARI, also prepared preliminary capital and operating costs for commercial-scale CO₂ storage at the Kemper County CO₂ Storage Complex.

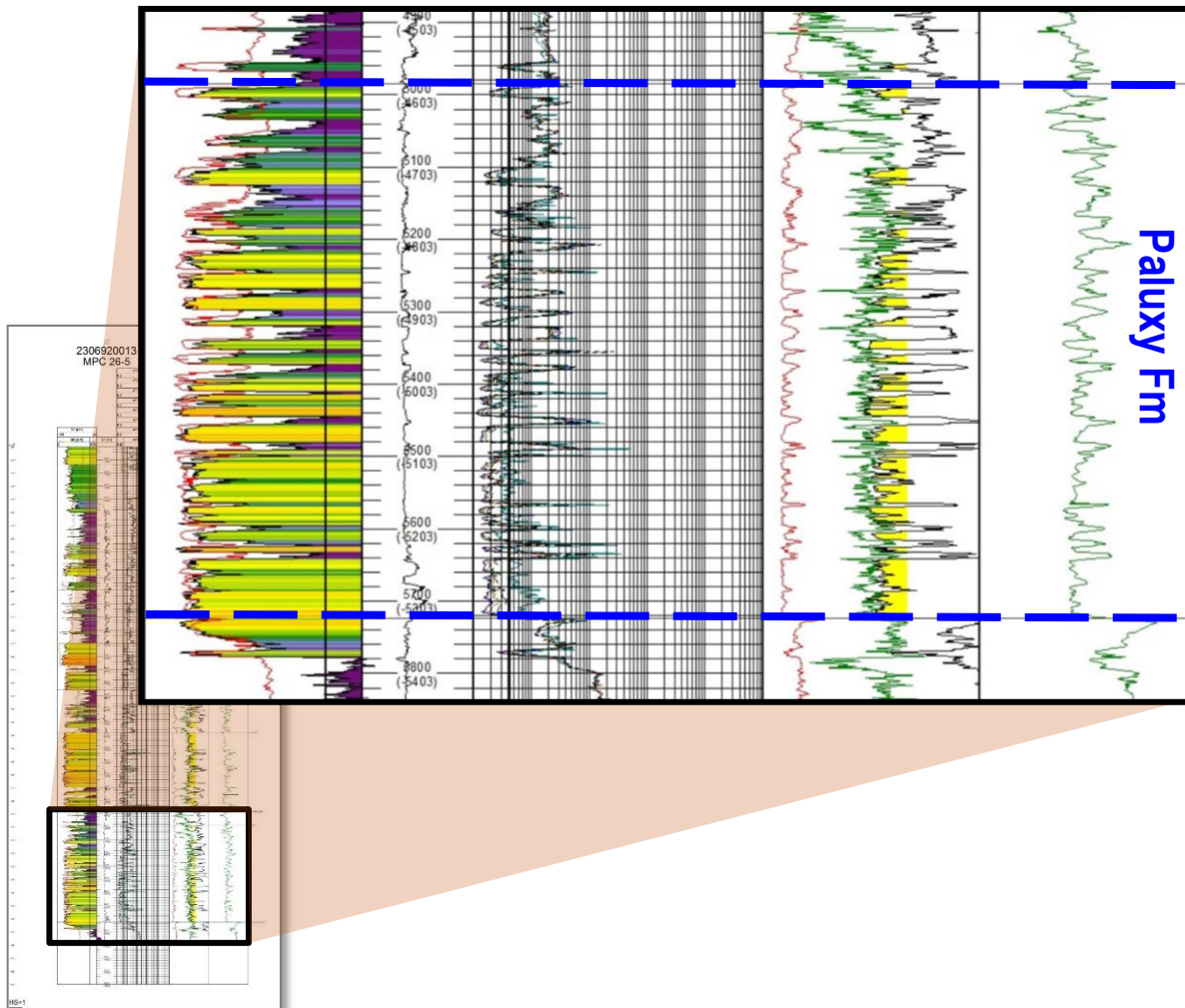
Current Status of ECO₂S

Currently, two deep wells have been drilled, logged and cored to provide more site specific reservoir characterization data. Drilling of the third well is underway.

These wells will subsequently become key CO₂ plume and pressure monitoring wells for the commercial phase of Project ECO₂S.



Collection of Reservoir Characterization Data



A suite of geophysical logs were run across the 3,160 foot reservoir interval, from 2,560' to 5,720'.

Obtaining core samples in the unconsolidated sand portions of the reservoir has been a challenge.



Potential Areas for U.S. and Norwegian R&D Cooperation on Project ECO₂S

Two areas offer the potential for fruitful cooperation between Project ECO₂S and Norwegian R&D institutes:

1. Application of Microseismic for Detection of Seismic Activity:

- Baseline Surveys
- Design and Establish Location for Recording System
- Long-Term Surveillance of CO₂ Injection and Post-Injection Storage Behavior

2. Cooperation on CO₂ Storage Modeling and Monitoring:

- Geologic Model
- Comprehensive Site Monitoring Plan
- Modeling of Plume Dynamics
- Input to ISO Standards

Acknowledgements



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