

Southern Company's Carbon Management R&D Technology Portfolio

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Southeast Regional Carbon Sequestration Partnership 12th Annual Stakeholders' Briefing

R&EA RESEARCH AND ENVIRONMENTAL AFFAIRS

**SOUTHERN
COMPANY**

Southern Company - 2014



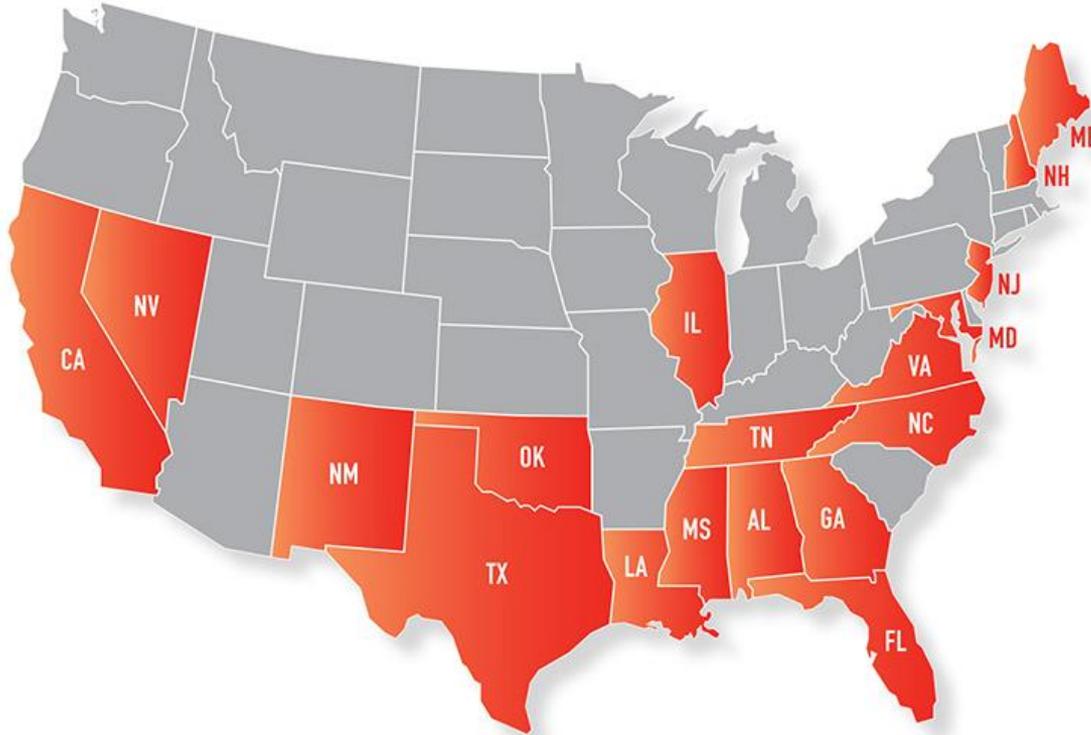
Who is Southern Company in 2017?

APPROXIMATELY
44,000 MW
OF GENERATING
CAPACITY

NEARLY
200,000
MILES OF
POWER LINES

MORE THAN
80,000
MILES OF NATURAL
GAS PIPELINES

190 Bcf
OF NATURAL GAS
STORAGE CAPACITY



OPERATIONS IN
18 STATES

11
ELECTRIC & NATURAL
GAS UTILITIES

32,500
TOTAL EMPLOYEES

9 MILLION
UTILITY CUSTOMERS

MORE THAN
1 MILLION
RETAIL CUSTOMERS

Southern Power Portfolio



July 2016

Who is Southern Power?

- Leading U.S. wholesale energy provider
- Nationally recognized renewable energy portfolio
- Provides electricity for municipalities, electric cooperatives and investor-owned utilities
- More than 10,800 megawatts of generating capacity
 - Including 2,200 megawatts of renewable capacity
- 39 facilities in 10 states operating or under construction
- Operating or under development in Alabama, California, Florida, Georgia, Maine, Nevada, North Carolina, Oklahoma, Texas and New Mexico

Southern Power Portfolio



July 2016

Renewables

Southern Company supports the development and use of renewable energy sources and has added more than 4,000 megawatts since 2012

- **Solar**

- Southern Power and partners operate or are constructing 26 solar plants in six states
- Georgia Power has a growing solar power portfolio expected to be the largest of any investor-owned utility operating without a renewable standard
- Developing projects with the U.S. military in Alabama, Florida, Georgia and Mississippi

Renewables

- **Wind**
 - Alabama Power is purchasing 404 megawatts of wind energy
 - Georgia Power contracted to purchase 250 megawatts of wind energy
 - Gulf Power contracted to purchase 180 megawatts of wind energy
 - Southern Power “owns” three wind energy facilities in Oklahoma and Maine
- **Biomass**
 - Southern Power operates one of the nation’s largest biomass power plants in Texas
- **Hydro**
 - 33 hydro facilities in Alabama and Georgia provide clean, renewable energy
 - Ranked No. 7 among U.S. utilities in hydro capacity

Direct Carbon R&D with Technology

- DOE National Carbon Capture Center (Alabama Power) - SCS
- Kemper County energy facility - 70% CO₂ CCUS (Mississippi Power)
 - TRIG Gasification Technology via Southern Generation Technology
- DOE CarbonSAFE (Mississippi Power) - SSEB
- DOE Brine Extraction Storage Test (Gulf Power) - EPRI
- DOE Biomineralization Wellbore Integrity (Alabama Power) - MSU
- Post-Combustion Carbon Capture (Alabama Power) – MHIA
 - SECARB Phase III Integrated CCS Demonsration

National Carbon Capture Center



U.S. DEPARTMENT OF
ENERGY



10/08 to 9/14

Project Value \$251M

6/14 to 5/19

Project Value \$188M



Industry Partners



ELECTRIC POWER
RESEARCH INSTITUTE



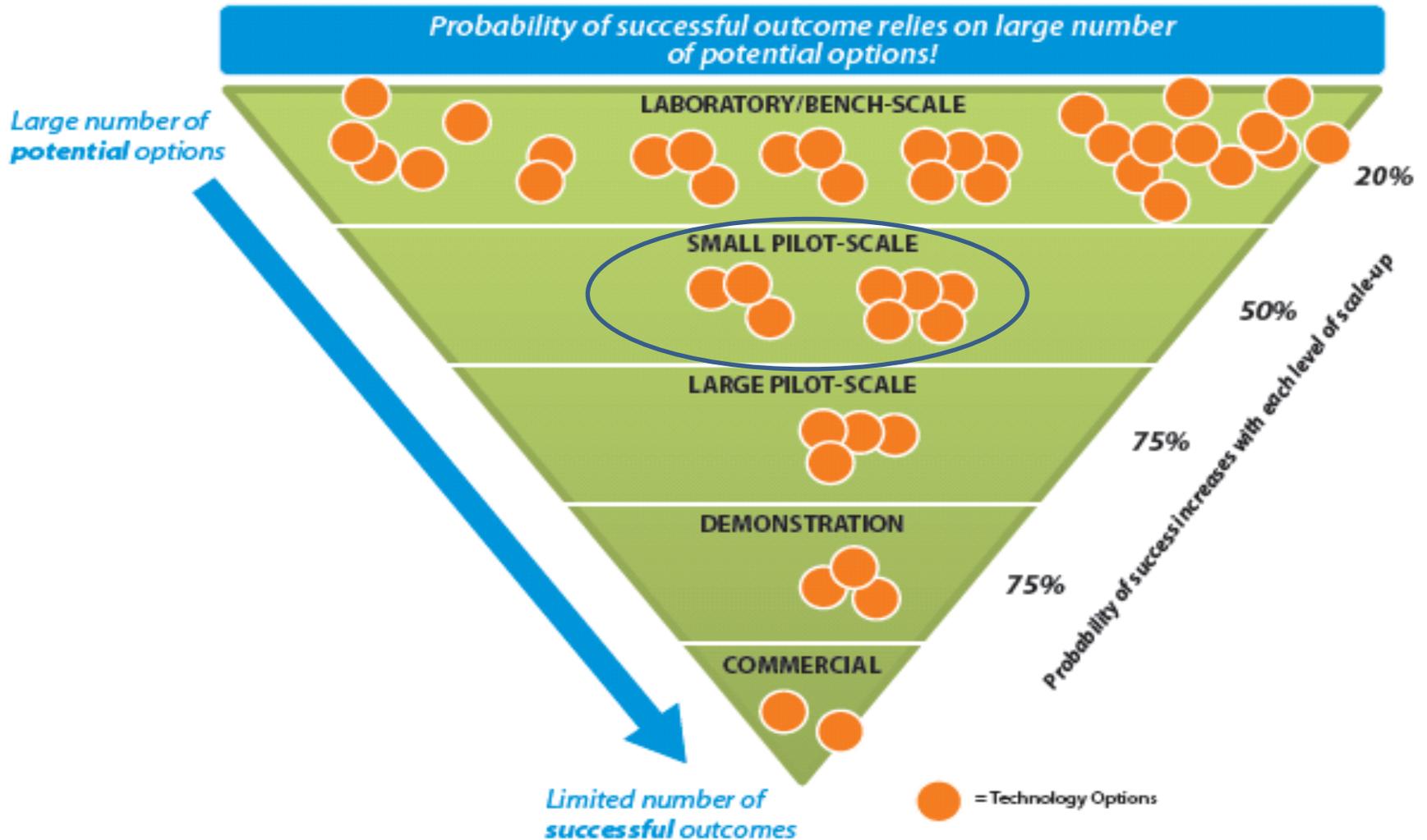
CLOUD PEAK
ENERGY®



Luminant



Offering a world-class neutral test facility and a highly specialized staff, to accelerate the commercialization of advanced technologies and enable coal based power plants to achieve near-zero emissions (low cost CO₂).

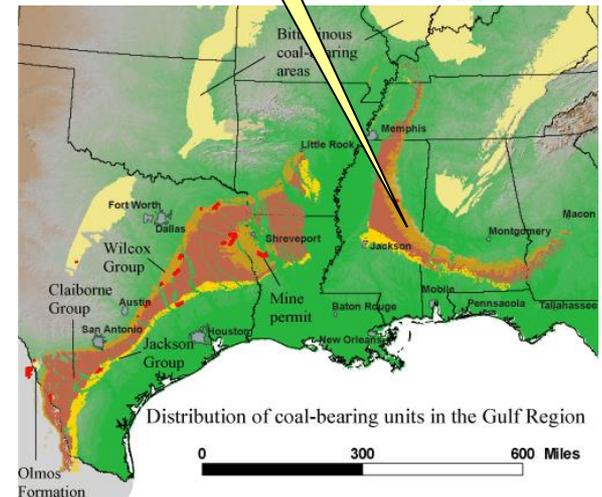
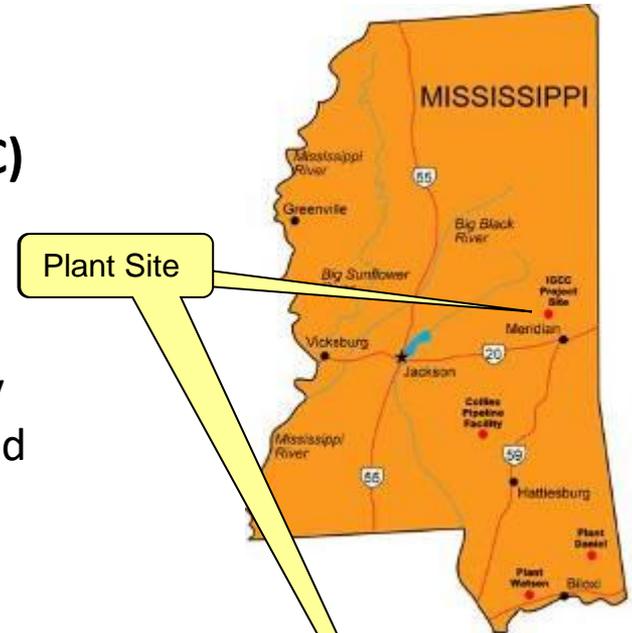


Kemper County Energy Facility

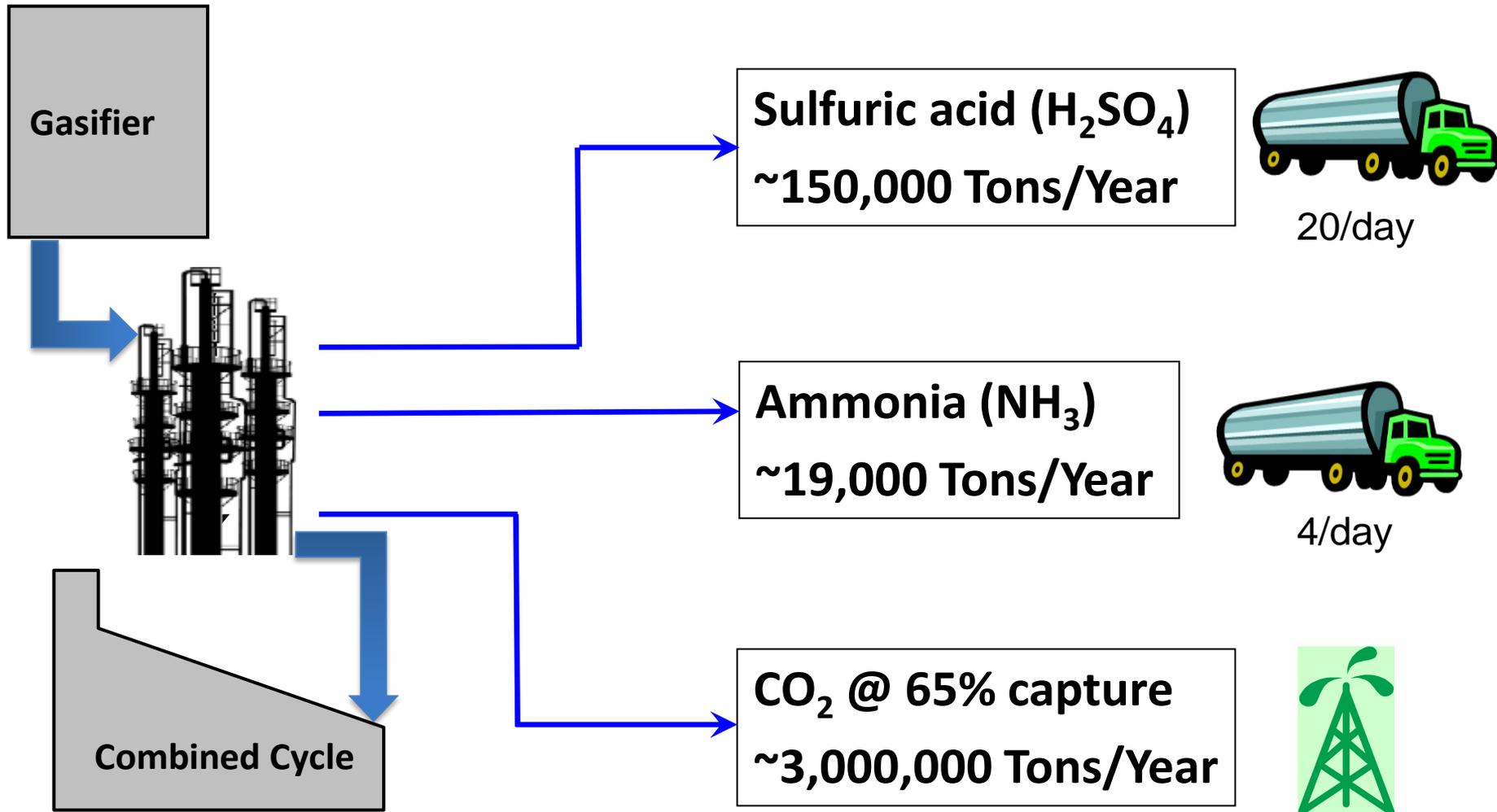


Project Overview

- **2x1 Integrated Gasification Combined Cycle (IGCC)**
 - 2 Transport Gasifiers
 - 2 Siemens SGT6 - 5000F gas turbines
 - 1 Toshiba steam turbine
 - 740 MW gross capacity; 582 MW net peak capacity
 - Chemical products: carbon dioxide, sulfuric acid, and ammonia
- **Project Information**
 - Mine-mouth lignite (brown coal)
 - Zero liquid discharge
 - Uses treated effluent as makeup water
- **Mine Operations**
 - Commercial operation; June 5, 2013
 - Dragline in-service; Fall 2013
 - More than 1 million tons of lignite mined
 - 20 acres of mined property reclaimed already



Saleable by-products



Plant and Aerial View - 2016



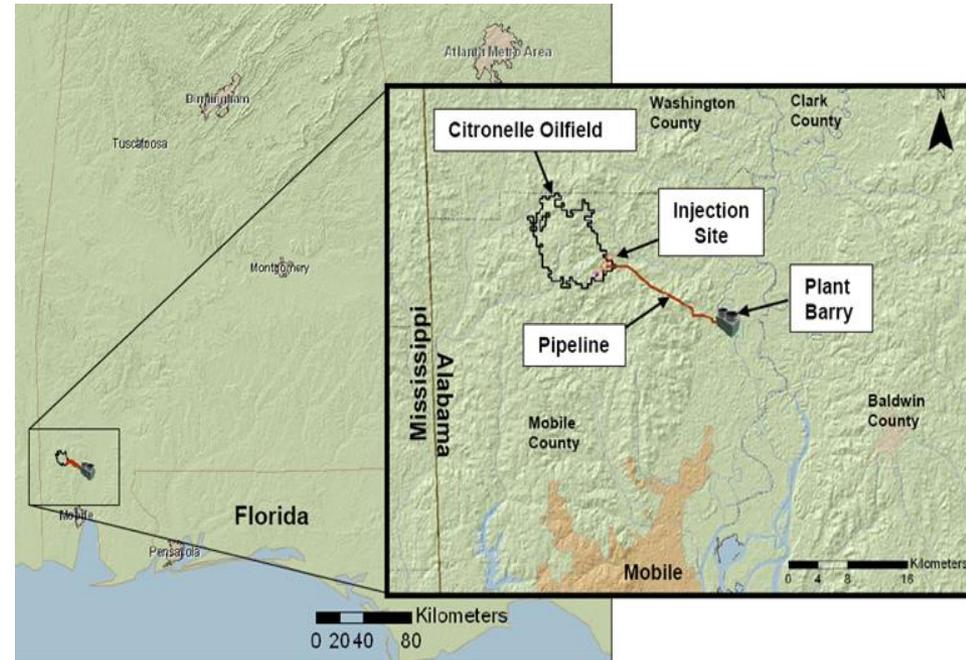
Lignite Handling and Drying



Plant Barry CCS Demonstration

“Largest capture facility on a fossil-fueled power plant in the USA”

- Carbon capture from Plant Barry (equivalent to 25MW of electricity).
- 12 mile CO₂ pipeline linking captured CO₂ with the injection site.
- CO₂ injection of 115,000 metric tons of into ~9,400 ft. deep saline formation.
- Monitoring of CO₂ storage during injection and three years post-injection.



Power Plant



Capture



Transport



Storage

New Testing Proposed Objectives

- Develop and quantify viable cost and energy saving methods for the capture and sequestration of CO₂ produced from pulverized coal (PC) combustion
 - **Built-in Reboiler:** Construct and test built-in-reboiler to confirm technology is suitable for the regenerator
 - **Particulate Matter Management:** Complete Particulate Management Test to determine maximum allowable PM concentration and determine if solvent purification steps can be eliminated
 - **New Solvent:** Demonstrate performance and energy efficiency improvements of New Solvent A over KS-1 and MEA
- Evaluate the technical and economic feasibility of full-scale implementation of this technology

Geologic Characterization

“to advance site certification for commercial storage”

Alabama Power Plant Gorgas Stratigraphic
Test Well (one 5,000 foot well drilled)



Mississippi Power Plant Daniel CO₂ Pilot
Injection Study (two 8,500 foot wells
drilled/3,000t/injected)



Alabama Power Plant Barry CO₂ Injection
Demonstration (three 9,500 foot wells drilled,
115,000 t/injected)



Kemper County Energy Facility
CarbonSAFE (three wells proposed to be drilled in 2017)



Carbon Storage Assurance Facility Enterprise

Host Site is Kemper County Energy Facility

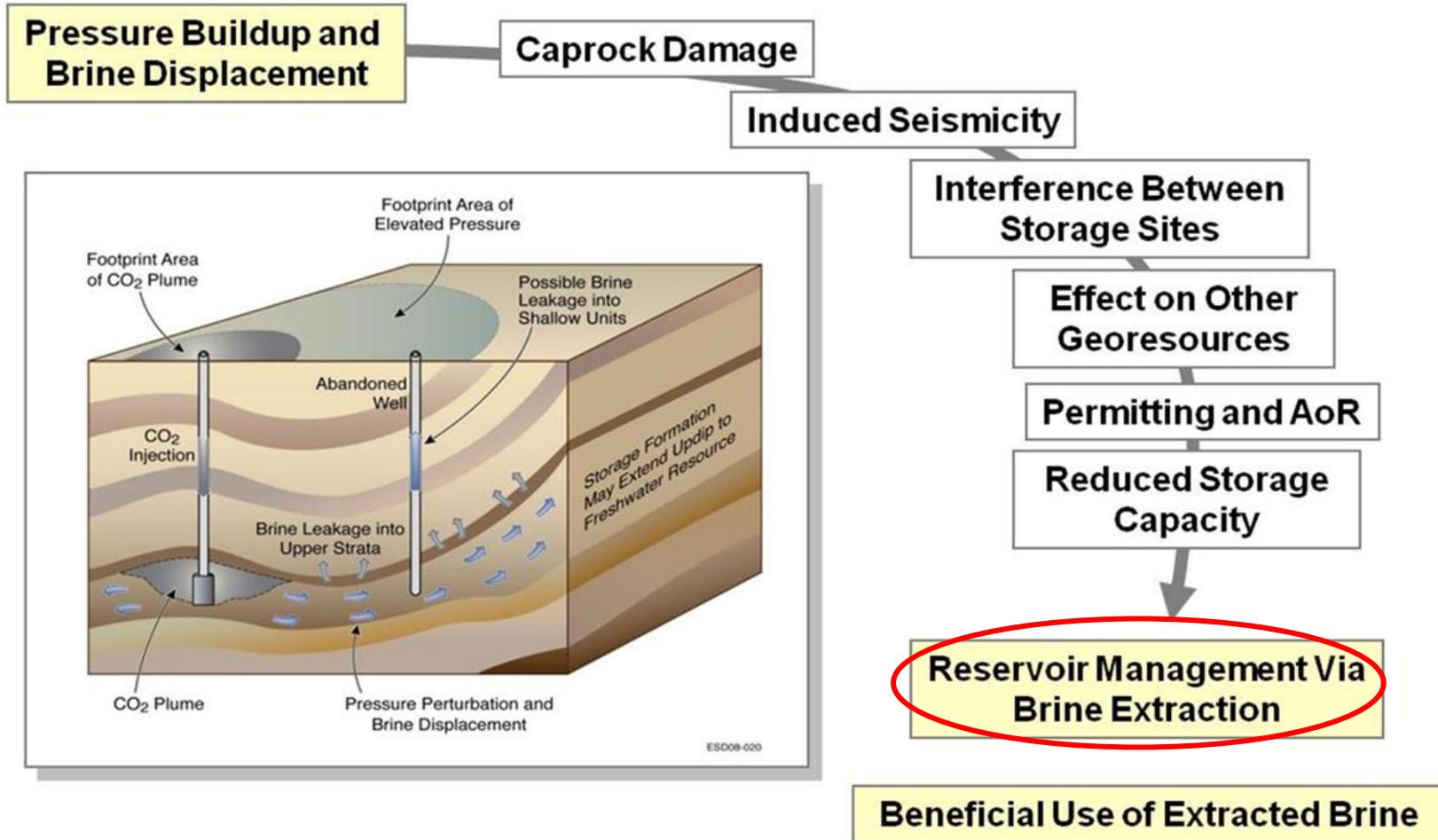
- **Program Goals:** DOE – Office of Fossil Energy effort to develop a commercial-scale integrated CCS storage complex constructed and permitted in the 2025 timeframe over a series of sequential phases of development.
- **Program Phases:**
 - Phase 1. Integrated CCS Pre-Feasibility Study
Develop plans encompassing technical requirements, as well as both economic feasibility & public acceptance of an eventual storage project
 - Phase 2. Storage Complex Feasibility Study
Perform initial site characterization of a storage complex having high potential for commercial storage (50+ million tonnes CO₂)
 - Phase 3. Site Characterization
 - Phase 4. Permitting & Construction

Budget Periods/Program Cost-Share

- Approximately 44M available in FY2017 through FY2020.
 - Eleven (11) Phase I awards were selected (average award was 1.0M)
 - Three (3) Phase 2 awards were selected
 - SSEB - \$11,220,537 DOE Funds
 - University of North Dakota - \$8,787,662 DOE Funds
 - University of Illinois - \$8,906,264 DOE Funds
- To expedite being “storage ready” we are accelerating the schedule to be “injection ready” in FY2022 by moving directly into Phase 2 (by-passing Phase 1).
- Phase 2. (Jan, 2017 - Sept, 2018)
- Phase 3. (Oct, 2018 - Sept, 2020)
- Phase 4. (Oct, 2020 - Sept, 2025)

DOE EPRI Brine Extraction Storage Test

Host Site is Gulf Power – Plant Smith



Research Focus - Managing CO₂ Injection Pressures to Facilitate Commercial CO₂ Storage

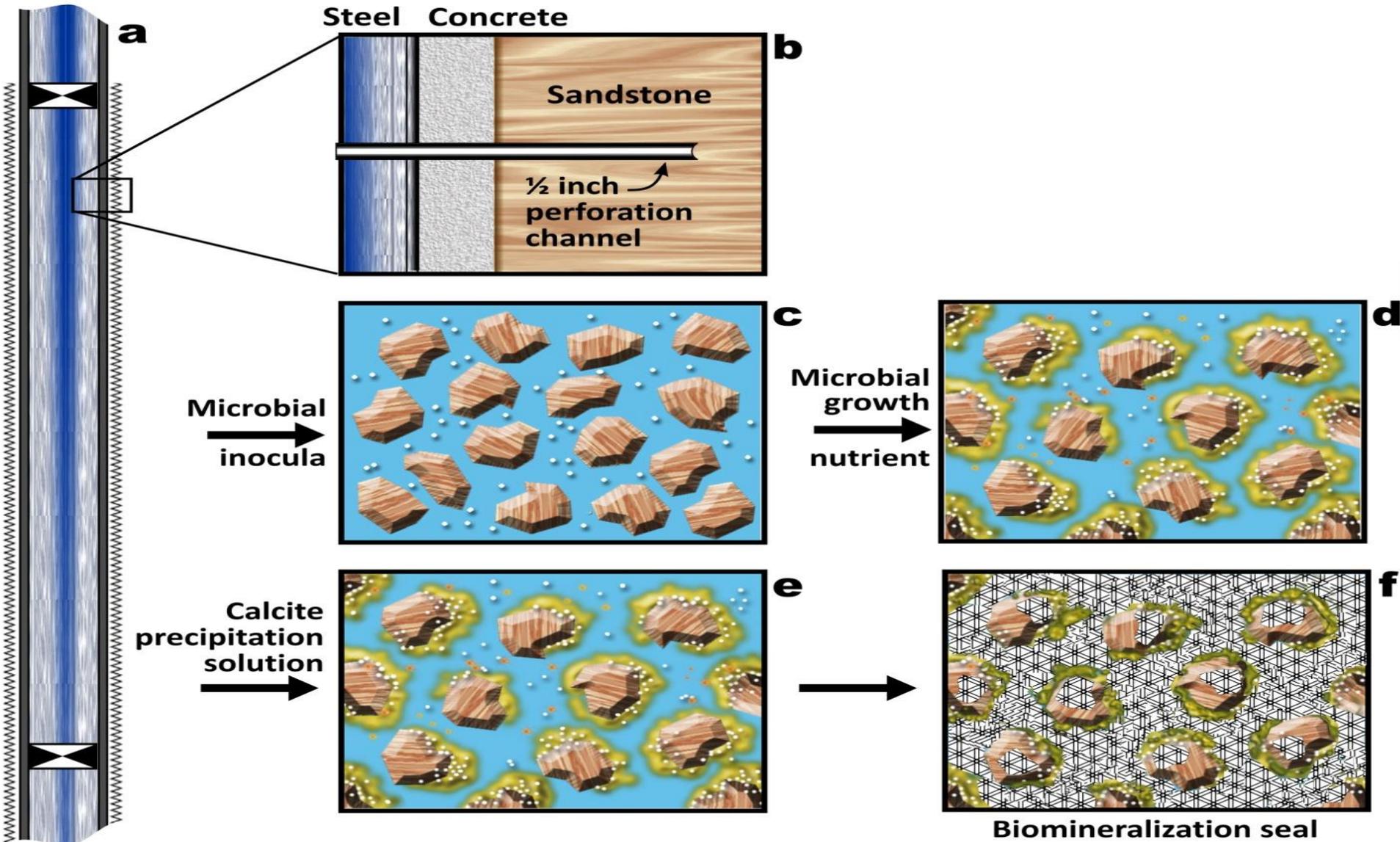
DOE – MSU Well Bore Leakage Mitigation

Host Site is Alabama Plant Gorgas

Motivation behind the leakage mitigation study:

- Wellbores are identified as a leakage pathway risk in many storage systems
- Biological control of permeability and sealing leaking boreholes
- Sealing fractures and cap rocks
- Reassure stakeholders that geologic sequestration is safe and secure

Proof of concept to field demonstration



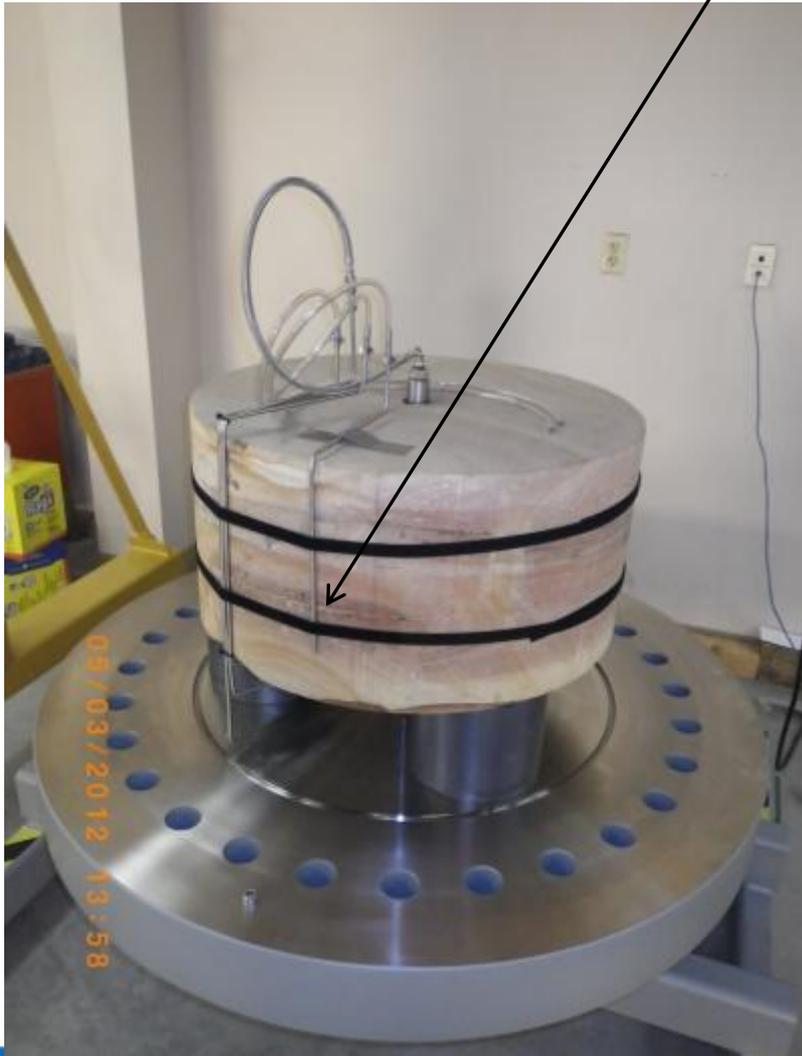
Sample collection in the field

Sample collection for
“field-scale lab study”



Before images of induced fractures

Region of fracture



The core was hydraulically fractured under ambient conditions right before loading into the vessel. Distinct flow channels were formed.



**After images of
sealed fractures**



Path Forward (2017-2018)

- Continued focus on CCS R&D with both basic science, field science, and commercial-demonstration
 - Support CarbonSAFE program at Mississippi Power - Kemper County Energy Facility
 - Support BEST project at Gulf Power - Plant Smith
 - Open to new funding opportunities with R&D due diligence with CCUS including non-EOR utilization