Southern Company

CCUS Optimism: Legislative Developments, DOE Program Initiatives, and Southern Company R&D

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Southern Company

Approximately
46,000 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
19 States

11
Electric & Natural Gas Utilities

32,500
Total Employees

9 Million
Utility Customers

More than
1 Million
Retail Customers

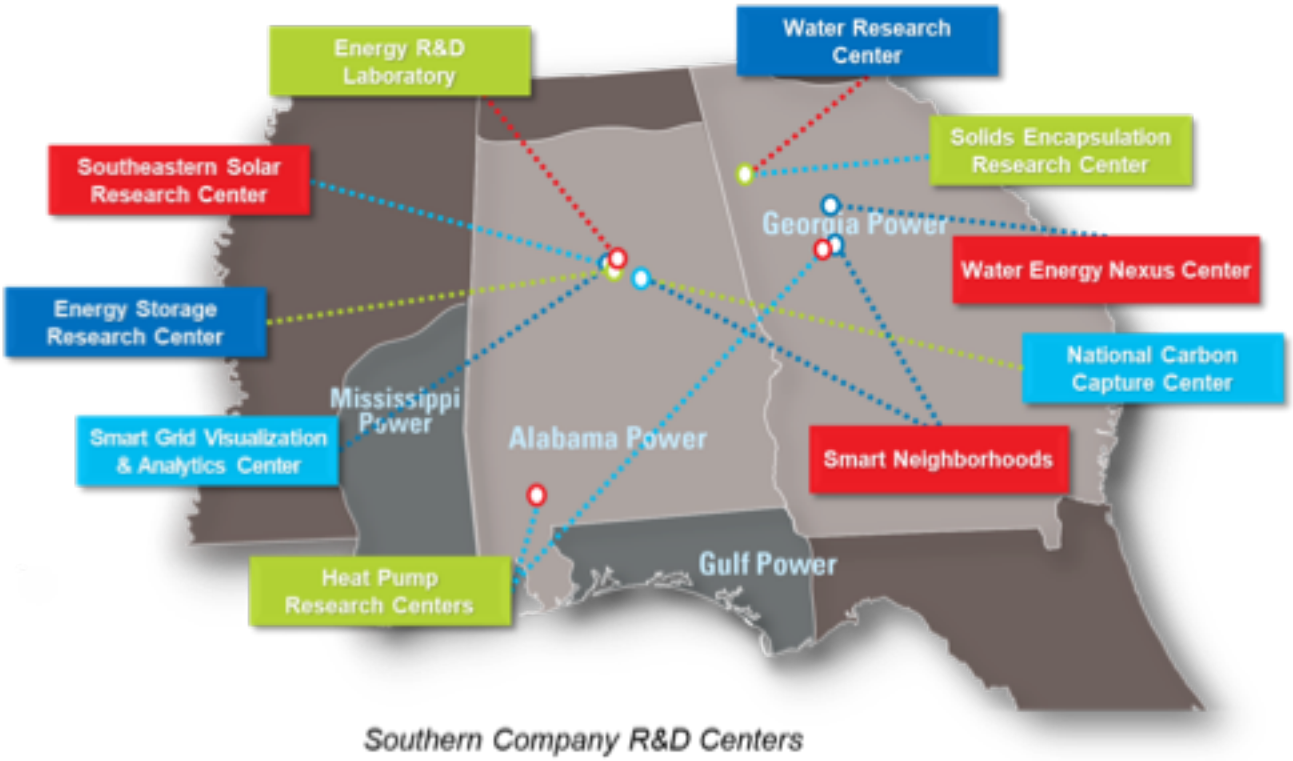
Future Technical and Business Outcomes

Through R&D, enable the following results in a low- to no-carbon future

Next-Generation Nuclear	Carbon Capture, Use & Storage	Hydrogen Economy	Efficient Electrification	Distributed Energy Economy	Resilient & Fully Integrated Grid
Advanced nuclear (non-LWR) power generation developed & operating at NGCC costs with superior safety benefits & polygeneration business opportunities	Cost-effective carbon capture, use & storage technologies developed & operating in an efficient, reliable fossil-fueled fleet	New utility business models created from hydrogen production, delivery & end-use technologies	"Electrify everything" with newly developed and broadly deployed technologies including those for transportation, buildings, industrial processes & food production	Dispatchable solar, wind, storage & other R&D-enabled energy resources developed & operating in microgrid & centralized configurations as the lowest-cost energy sources	Resilient, fully integrated energy delivery grids allowing unrestricted creation & use of low- to no-GHG emissions energy

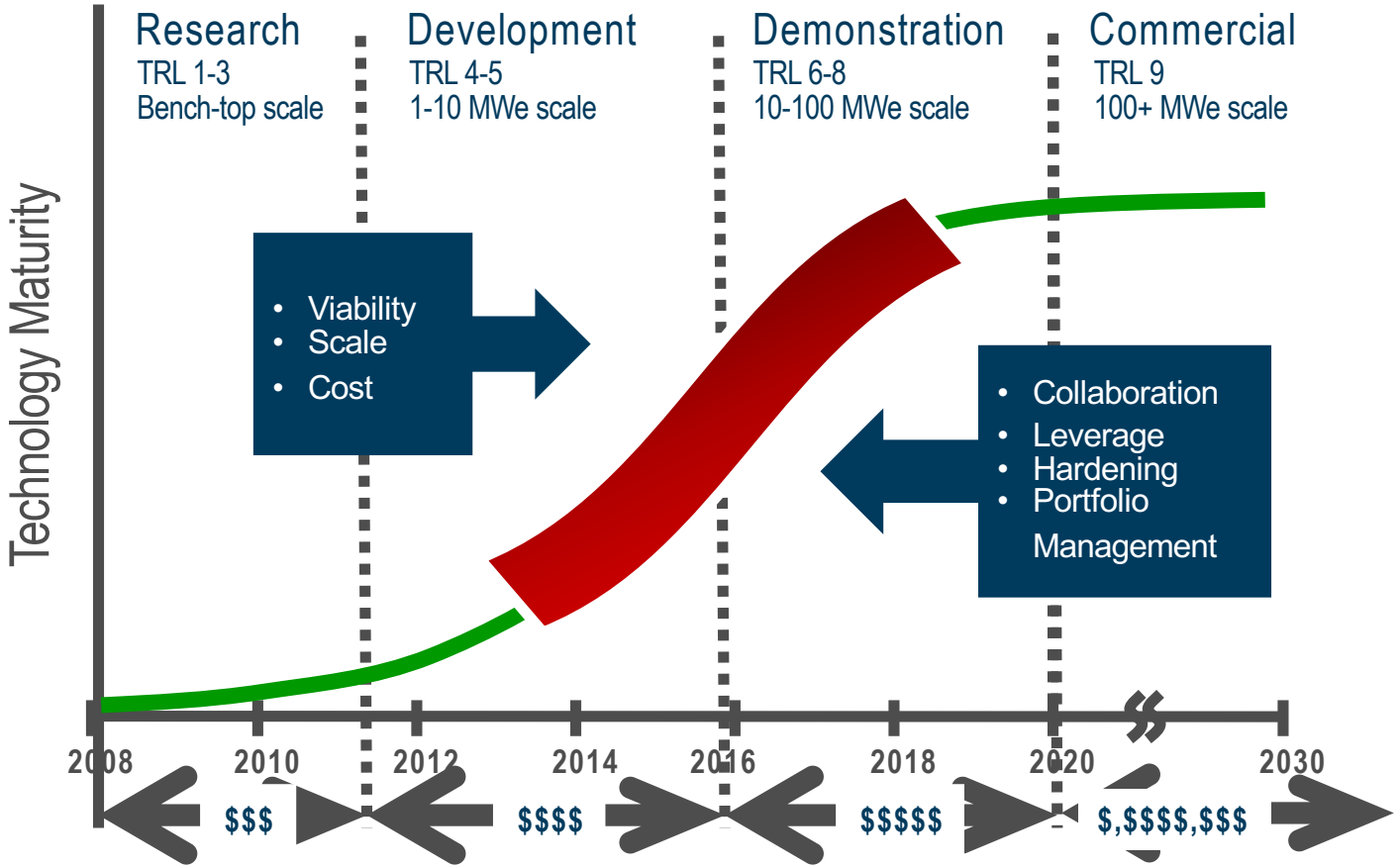
Southern Company R&D Overview

- 10+ **R&D "centers"** in strategic areas
  - ✓ Host national and international technology developers
  - ✓ Neutral environment to **invent**, **break** and **reinvent** energy technologies
  - ✓ Directly address **technology gaps** for Southern Company and others

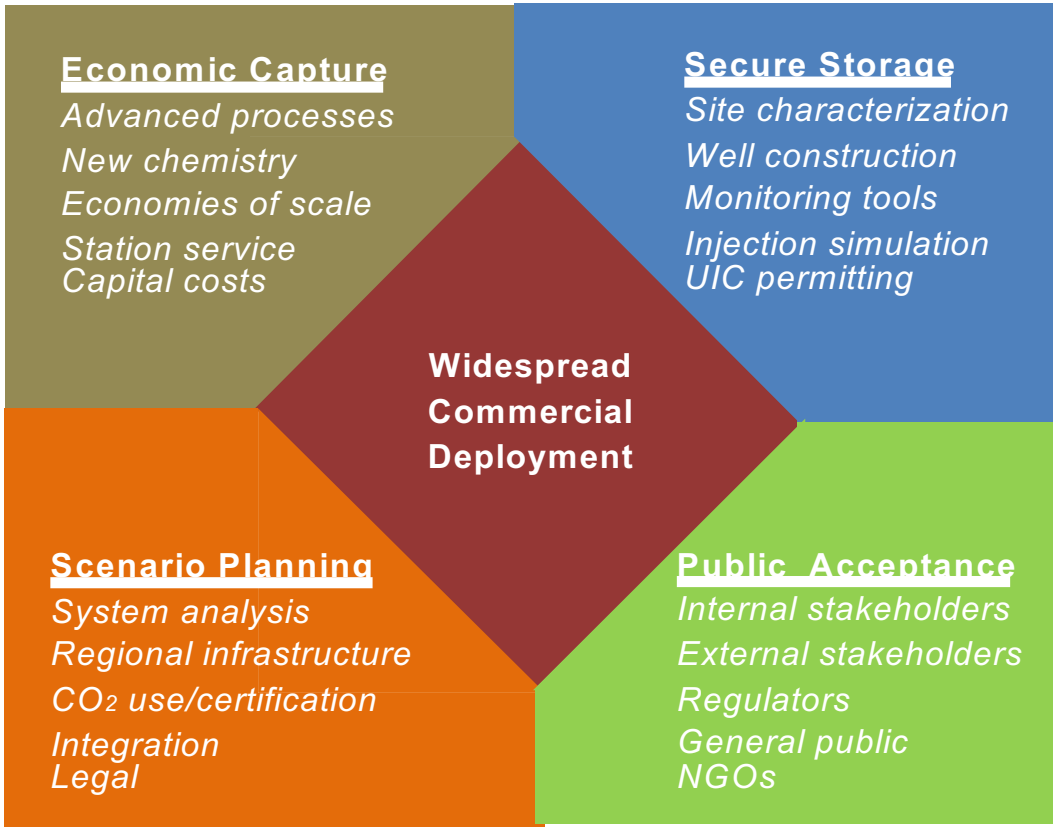


Southern Company R&D Centers

Research and Development Focus (RDDC)



The CCUS Commercialization Puzzle



CCUS Technology - R&D Drivers

Do these drivers stand the test of time?

- GHG environmental regulations (Clean Power Plan)
- Voluntary carbon footprint reductions
- Abundant domestic fossil-fuel resources, transportation infrastructure, all coupled with stable fuel pricing
- Depreciated fossil-fuel generation assets with state-of-the-art environmental controls
- Maintain a balanced fuels portfolio
- Challenging regional renewable portfolio in the Southeast
- World class storage geology with demand for CO_2-EOR
- Energy security and economic development

Reasons for Future Optimism

- Economic incentives for CCS such as the tax credit (45Q) for secure CO_2 storage in geologic formations
- State Primacy for Class VI - Underground Injection Control wells used for the geologic sequestration of CO_2
- Fiscal Year 2018 Omnibus Appropriations for the U.S. Department of Energy with Fossil Energy R&D
- Strategic R&D Programs within DOE with strong partnerships with industry such as the Regional Carbon Sequestration Partnerships (RCSP), Brine Extraction Storage Tests (BEST), the Southeast Storage Offshore Resources Assessment (SOSRA), and CarbonSAFE.

Status of Class VI State Primacy

- **State of North Dakota Primacy Application**
  - Revised state regulations to conform with EPA Class VI regulations
  - Filed with EPA June 21, 2013
  - April 10, 2018 EPA issued a final rule approving North Dakota's application for primary enforcement responsibility

- **State of Wyoming**
  - Revised state regulations to conform with EPA Class VI regulations
  - Filed for Class VI State primacy on January 28, 2018.

- *No other states have taken formal actions to seek primacy but I believe others would be interested now that North Dakota's application is final and Wyoming is in line.*

2018 DOE Coal, CCS & Power Systems Budgets

Coal, CCS & Power Systems (All figures in $ Thousands)	FY 17 Omnibus	FY18 Request	FY18 House	FY18 Senate	FY18 Omibus
Carbon Capture	**101,000**	16,000	95,000	93,930	**100,671**
Carbon Storage	**95,300**	15,000	89,073	88,269	**98,096**
Advanced Energy Systems	**105,000**	46,000	103,000	97,650	**112,000**
Cross-Cutting Research	**45,500**	37,800	51,550	42,315	**58,350**
Supercritical CO2 Technology (STEP) Program	**24,000**	0	24,000	19,530	**24,000**
Transformational Pilot Plant Solicitation			25,000	0	**35,000**
Subtotal Before NETL R&D	**370,800**	114,800	387,623	341,694	**430,117**
NETL R&D	**53,000**	68,100	53,000	72,663	**53,000**
CCS & Power Systems R&D Subtotal	**423,800**	114,800	440,623	341,694	**481,117**
Total for FE R&D Programs	**473,800**	182,900	440,623	414,357	**533,117**

Legislative Initiatives - Regulatory Improvements

- Defining "Secure Geological Storage": IRS guidance defining "secure geological storage" for eligibility for the Section 45Q tax credit is unclear. Congress redirected Treasury this year in the Bipartisan Budget Act to define the term. Bills by Rep. Cramer (R-ND) and Sen. Hoeven (R-ND) would give further direction and set a deadline to define it.

- USE IT Act: Sen. Barrasso's (R-WY) bill amends the FAST ACT to make CCUS projects eligible for streamlined environmental review and requires the CEQ to implement guidelines to establish streamlining. *Passed Senate Environment and Public Works Committee and now waiting floor action.*

- The *Carbon Utilization Act*: Sen. Bennet's (D-CO) bill directs the Secretary of Agriculture to provide and provide loans or loan guarantees under the Rural Electrification Assistance Program to fund CCUS projects connected to biomass and biogas. *Just introduced last week into the Senate and Public Works Committee*.

Legislative Initiatives - CCUS R&D

- The Fossil Energy Utilization, Enhancement, and Leadership Act: Introduced by Sen. Heitkamp (D-ND) and Sen. Manchin (D-WV), directs DOE to establish an updated coal technology program that includes funding for large scale pilot programs and demonstration projects. *Is generally supported by the Senate Energy Committee but no hearings or mark-ups.*

- The Fossil Energy Research and Development Act: Introduced by Rep. Veasey (D-TX) and Rep. McKinley (R-WV), amends the Energy Policy Act of 2005 to promote R&D investment through the establishment of at least three Carbon Capture Test Centers and grants to fund research projects. *Introduced into the Senate Energy Committee but no hearing or mark-ups.*

Legislative Initiatives - CCUS Incentives

- Master and Limited Partnerships: Sen. Coons (D-DE) introduced a bill to amend the Internal Revenue Code to allow income from alternative generation projects, including those with CCS, to be counted as "qualifying income" eligible for the purpose of MLPs with favorable tax structure. *Introduced to senate finance committee but not currently moving forward.*

- Private Activity Bonds: Sen. Portman (R-OH) and Michael Bennet (D-CO) introduced legislation to allow carbon capture projects to be financed by tax exempt private activity bonds issued by local or state governments (private investments with public benefits). *Introduced to Senate Finance Committee but not currently moving forward.*

- Section 41119 of H.R. 1892 the Bipartisan Budget Act (BBA) of 2018, amended the Section 45Q tax credit with expanded provisions for CCUS.

45Q Tax Credit for CO_2 Storage in Geological Formations

Pre-Act 45Q Projects v. Post-Act 45Q Projects

	Pre-Act Projects	Post-Act Projects
Non-EOR	• $20/T + inflation ($22.66/T) • 75 million ton limit for EOR and non-EOR combined • Power, Industrial	• $22.66/T → $50/T over 10 years + inflation after 10 year period • 12-year credit • Power, Industrial, Direct air capture
EOR	• $10/T + inflation ($12.83/T) • 75 million ton limit for EOR and non-EOR combined	• $12.83/T → $35/T over 10 years + inflation after 10 year period • 12-year credit • Applies to: EOR, EGR, photosynthesis, chemosynthesis, chemical conversion, & other commercial use

Overview of Post-Act 45Q Tax Credit

- **Driver -** The initial tax credit was not accomplishing what policy makers envisioned, resulting in a bipartisan effort to increase the credits for private investment in CCS

- **Limitations -** New Credit includes the following limitations:
  - Small facilities - If emitting ≤ 500,000 tpy COx, must capture ≥ 25,000 tpy.
  - Electric generating units - Must capture ≥ 500,000 tpy.
  - Direct air capture facilities - Must capture ≥ 100,000 tpy.

- **Definition -** Secretary of Treasury required to define **"secure geological storage"** in consultation with EPA, DOE, and DOI.
  - For direct air capture life cycle analyses required to determine secure storage
  - For geologic storage, already in the current law, but provides a new impetus for Treasury to act. It implicates Subpart UU v. Subpart RR GHG reporting issue.
  - EPA Class VI wells report as RR and can receive the tax credit.
  - What is exactly required for Class II EOR wells needs to be clarified beyond existing OGB requirements, Subpart UU, Subpart W, and Subpart C already required of operators.

Overview of Post-act 45Q Tax Credit

- Gradually increases the tax credit value, removes the cap for total available credits, and allows for the transfer of the credit to the person who *disposes* (saline injection), *uses* (CO_2-EOR), or *utilizes* (chemical conversion) the CO_2.

- **Incremental capacity increases -** New higher credit applies to CO_2 captured beyond pre-Act capacity. For non-EOR credit ramps up over time from **$22.66 (2018)** and caps at **$50 (2026)** with rate of inflation added each year after that. If starting in 2017, it would average at around **$37** over the 12 years. The longer you wait the higher the value but **must start construction by 2024.**

- **Otherwise released -** Applies to CO_2 that "would otherwise be released into the atmosphere as industrial emission."

- **Deadline -** Facility **must be under construction before January 1, 2024** and either
  - (1) the carbon capture equipment must also be under construction; or
  - (2) the original planning and design of facility must include carbon capture equipment.

- **Qualifying Facilities -** Includes industrial facilities and direct air capture facilities.

Does the tax credit change the economics of CCS?

- By Federal law, tax credits can only offset tax liability by 75%. With the tax rate recently decrease to 21% from 35%, there is a potential “reduced value” of 45Q going forward.
- Interest deduction is now limited to 30% of earnings before interest, taxes and amortization (EBITA). However, there is a “Carve-out” for the regulated business. Many questions yet to be answered by the IRS regarding what gets “Carved-out” as part of the regulated business.
- Stimulates private investment, with proven business models, based on experiences in the renewables energy sector. Encourages looking closely at new innovative business models.
- Encourages focused R&D investment and innovation
- Models are being built to evaluate the various impacts of tax reform and if high capital investment projects, like carbon capture on fossil fuel assets, can compete moving forward.

EACO_2
Energy Advance Center

- The Energy Advance Center (EAC) is a voluntary association of energy and energy-related organizations dedicated to advancing the development and deployment of carbon capture, utilization and storage (CCUS) to achieve a cleaner energy profile and improve U.S. economic and energy security.

- Specific targeted issues of the EAC include:
  - Reforming Class VI Underground Injection Control requirements to streamline permitting
  - Addressing potential barriers to reporting requirements for the 45Q tax credit
  - Supporting a variety of CCUS incentives to broadly encourage deployment
  - Assuring availability of offshore lands for CO_2 storage
  - Promoting CCUS pipeline & infrastructure development
  - Supporting strong CCUS RD&D funding

National Carbon Capture Center

- **Sponsors:** U.S. Department of Energy and its National Energy Technology Laboratory
- **Partners:** Electric Power Research Institute, power and energy industry leaders
- **Managed and operated by:** Southern Company
- **Location:** Wilsonville, Alabama

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NATIONAL ENERGY TECHNOLOGY LABORATORY

Southern Company

EPRI ELECTRIC POWER RESEARCH INSTITUTE

AMERICAN ELECTRIC POWER BOUNDLESS ENERGY

CLOUD PEAK ENERGY

DUKE ENERGY

CLEARPATH

Mission and Values

A **world-class neutral** test facility and highly specialized staff to **accelerate the commercialization** of advanced technologies and enable fossil fuel-based power plants to achieve **near-zero emissions (low-cost CO_2)**

Safety First
Unquestionable Trust
Superior Performance
Total Commitment

Turn-key Technology Development Process

Evaluate and Screen Technology

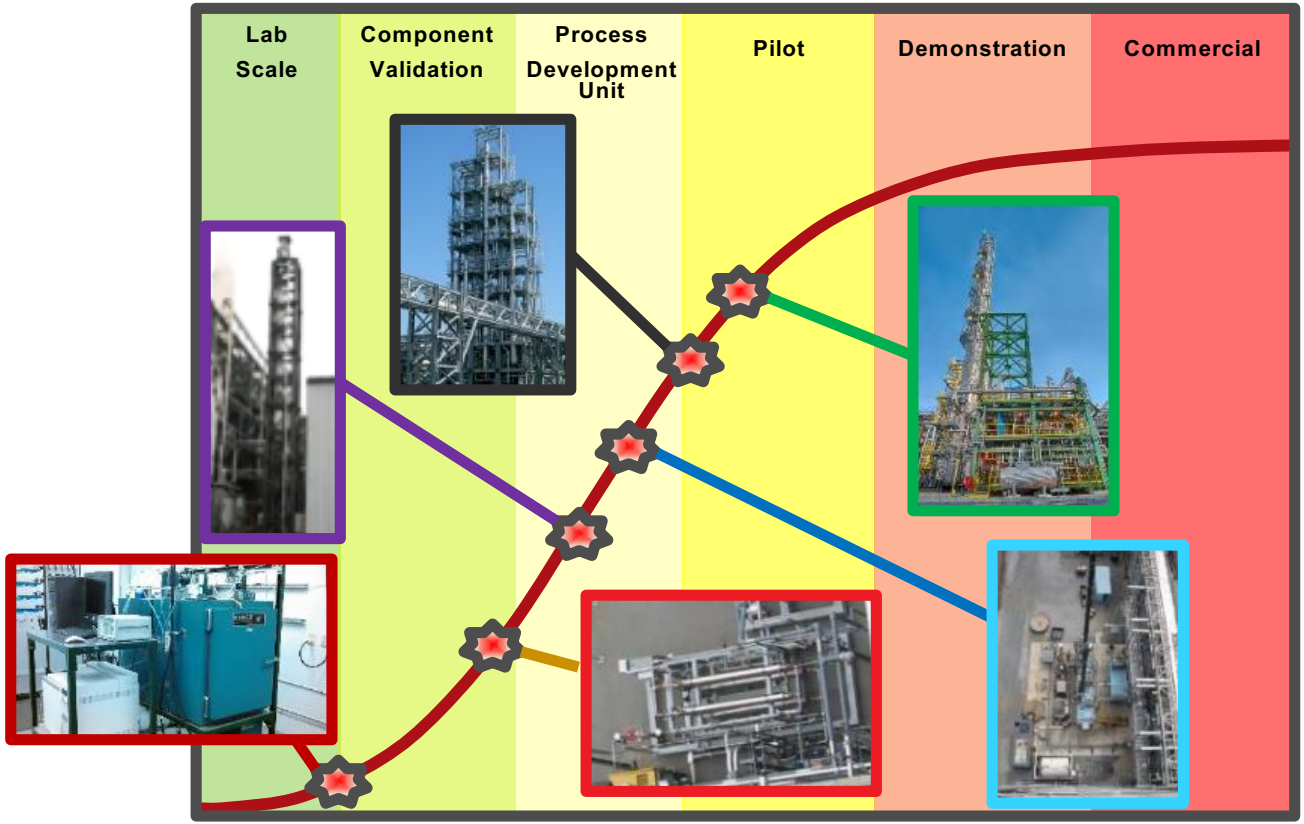
Define Scope of Work with Developer

Design and Construct

Operate According to Test Matrix

Analyze Data and Report

Successful Testing and Partnerships



Major Accomplishments

- More than 100,000 test hours for post- and pre-combustion carbon capture and gasification projects
- Post-combustion operation about 50,000 hours and over 6,000 hours under natural gas conditions
- 30+ post-combustion projects: enzymes, membranes, sorbents, solvents and associated systems
- Supported commercial developers to scale-up and DOE's Carbon Capture Simulation Initiative
- Technology developers from the U.S. and six countries

Carbon Storage Initiatives

Site Certification for Commercial Storage

Geologic resource assessment in saline reservoirs

- Plant Gorgas stratigraphic test well
- Plant Daniel CO_2 pilot injection study
- Plant Barry CO_2 injection demonstration
- Kemper County CarbonSAFE
- Plant Bowen stratigraphic test well

CO_2 Capture, Transportation and Storage Demonstration

Integrated CCS at 25-MW scale

- 12-mile pipeline to injection site
- 250,000+ metric tons captured
- 115,000+ metric tons transported and injected into 9,400-foot deep formation
- Site characterization, permitting, injection, monitoring and closure

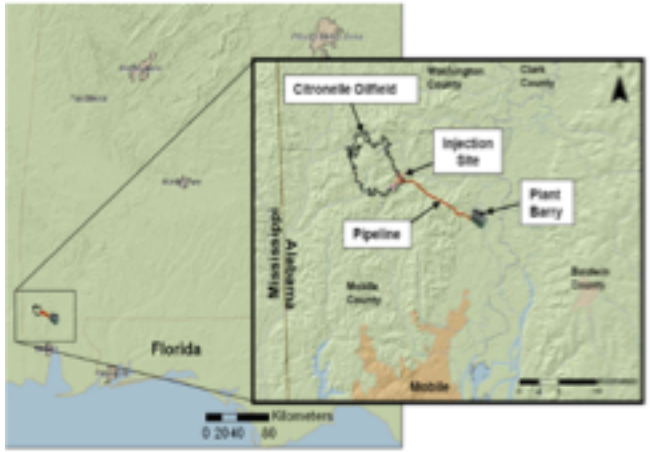
Brine Extraction and Storage Test (BEST)

Test wells at Plant Smith in Florida Panhandle

- Focused on managing CO_2 subsurface injection pressures to facilitate commercial storage
- Includes beneficial reuse of extracted brine associated with commercial-scale CO_2 injection operations

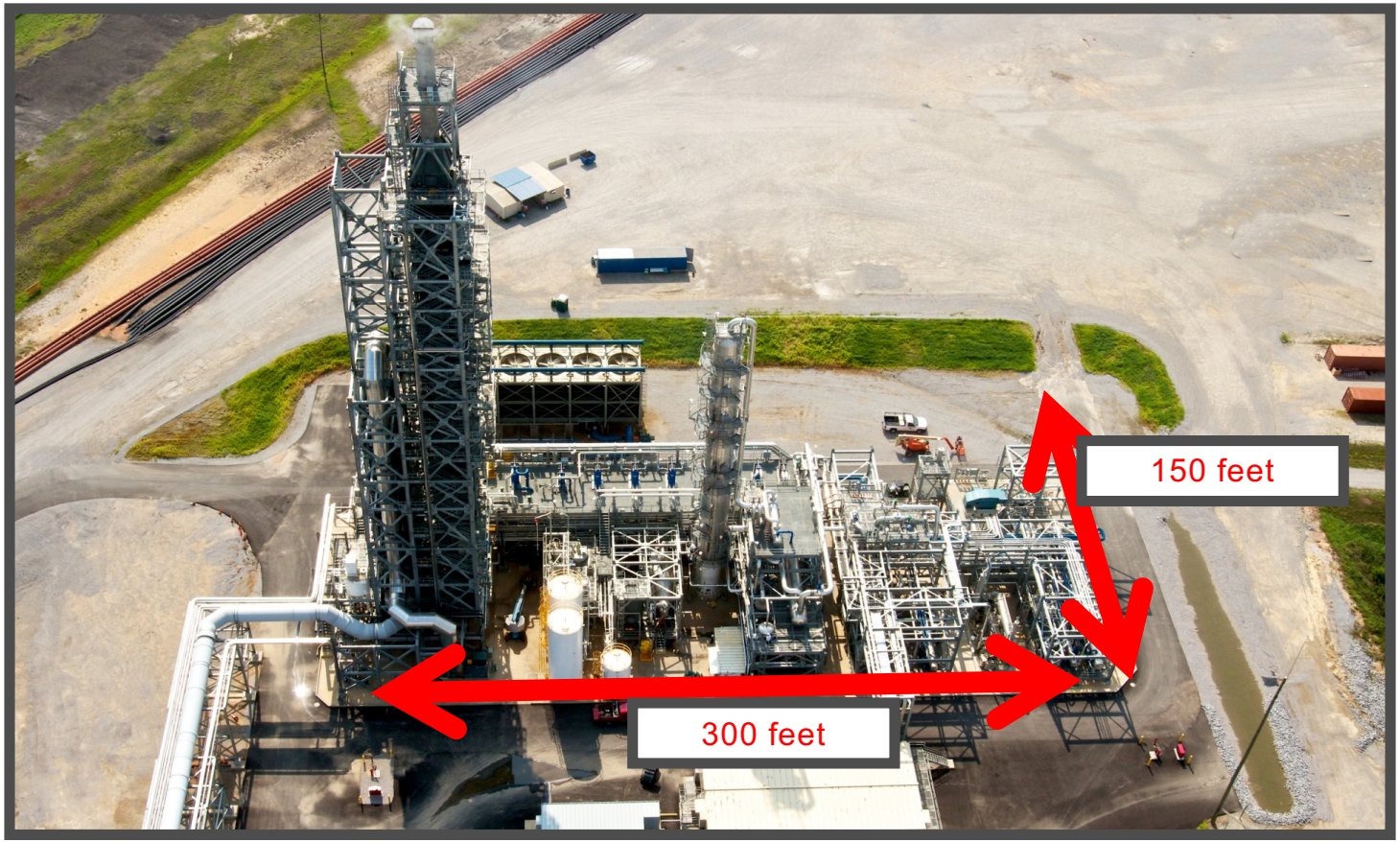
CCS Demonstration at Alabama Power's Plant Barry

Integrated capture, transportation and storage at a fossil-fueled power plant



- CO_2 capture equivalent to 25-megawatts
- 12-mile pipeline linking captured CO_2 with injection site in Citronelle Dome
- 211,000 metric tons CO_2 captured with115,000 metric tons injected into ~9,400-foot deep saline formation
- Site characterization, UIC permitting, injection and monitoring of CO_2 for geologic storage, and closure

25-MW Carbon Capture Demonstration




11/04/2010

DOT 29 CFR 195 4-inch carbon steel, liquid pipeline; buried 5 feet with surface vegetation maintenance.

Directional drilled 18 sections of the pipeline under roads, utilities, railroad tracks, tortoise colonies, and wetlands (some up to 3,000 ft long and 60 ft deep).

CO_2 Pipeline and Injection Infrastructure

Mainline valve station along pipeline

Meter station & building @ Plant Barry

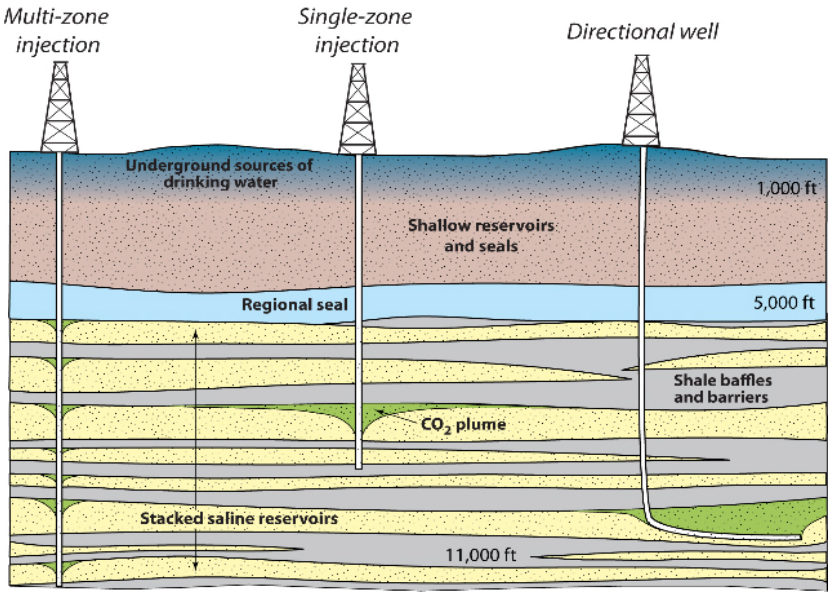
Horizontal CO_2 Booster Pump @ D-9-7 #2 Wellsite

D-9-7 #2 Injection Wellhead

System	Series	Stratigraphic Unit	Major Sub Units	Potential Reservoirs and Confining Zones
Tertiary	Plio-Pliocene		Citronelle Formation	Freshwater Aquifer
	Miocene	Undifferentiated		Freshwater Aquifer
	Oligocene		Chicasawhay Fm.	Base of USDW
		Vicksburg Group	Bucatunna Clay	Local Confining Unit
	Eocene	Jackson Group		Minor Saline Reservoir
		Claiborne Group	Talahatta Fm.	Saline Reservoir
		Wilcox Group	Hatchetigbee Sand	Saline Reservoir
	Paleocene		Bashi Marl	
			Salt Mountain LS	
		Midway Group	Porters Creek Clay	Confining Unit
Cretaceous	Upper	Selma Group		Confining Unit
		Eutaw Formation		Minor Saline Reservoir
		Tuscaloosa Group	Upper Tusc.	Minor Saline Reservoir
			Mid. Tusc. — Marine Shale	Confining Unit
			Lower Tusc. — Pilot Sand / Massive sand	Saline Reservoir
Cretaceous	Lower	Washita-Fredericksburg	Dantzler sand	Saline Reservoir
			Basal Shale	Primary Confining Unit
		Paluxy Formation	'Upper' 'Middle' 'Lower'	Proposed Injection Zone
		Mooringsport Formation		Confining Unit
		Ferry Lake Anhydrite		Confining Unit
		Donovan Sand	Rodessa Fm.	Oil Reservoir
			'Upper'	Minor Saline Reservoir
			'Middle'	
			'Lower'	Oil Reservoir

Simulation/Storage Capacity

Opportunity to study optimizing stacked storage reservoirs with multiple seals and four-way closure



CO_2 Capture Plant Performance

- Flue gas In for CO_2 Capture Plant: June, 2011
- Commissioning of CO_2 Compressor: August, 2011
- Commissioning of CO_2 Pipeline: March, 2012
- CO_2 Injection: August, 2012

Items		Results*
Total Operation Time	hours	11,200
Total Amount of Captured CO_2	metric tons	211,860
Total Amount of Injected CO_2	metric tons	114,104
CO_2 Capture Rate	metric tons per day	> 500
CO_2 Removal Efficiency	%	> 90
CO_2 Stream Purity	%	99.9+
Steam Consumption	ton-steam/ton-CO_2	0.98

*As of 3/15/2016

DOE Carbon Storage Program Overview

Carbon Storage Assurance Facility Enterprise (CarbonSAFE)

- **Program Goals**: DOE/NETL 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. - Integrate CCS Pre-Feasibility Study (11 projects/2017)
  - Phase 2. - Storage Complex Feasibility (3 projects/2017 + 3 projects/2018)
  - Phase 3. - Site Characterization (TBD)
  - Phase 4. - Permitting & Infrastructure (TBD)

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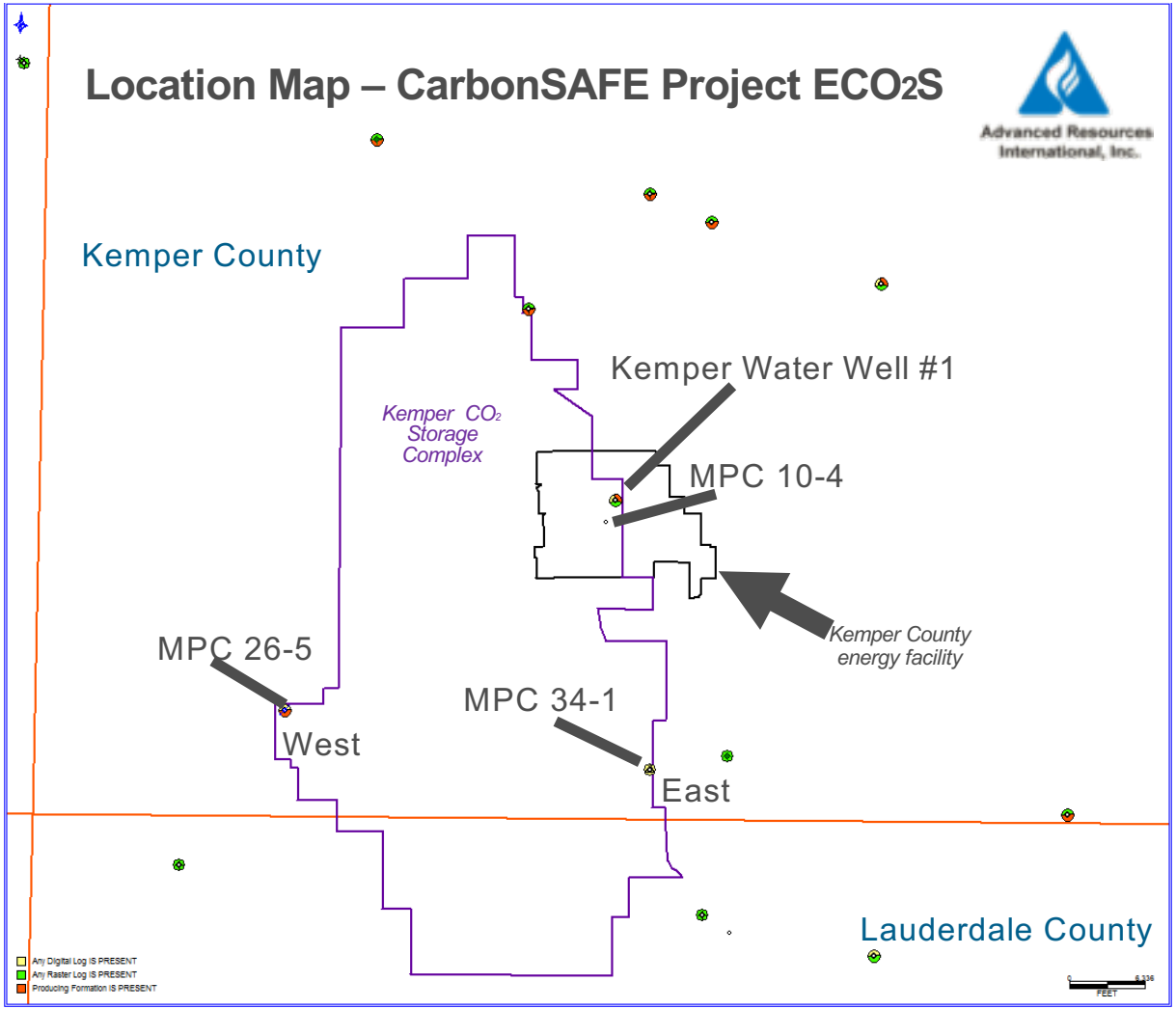
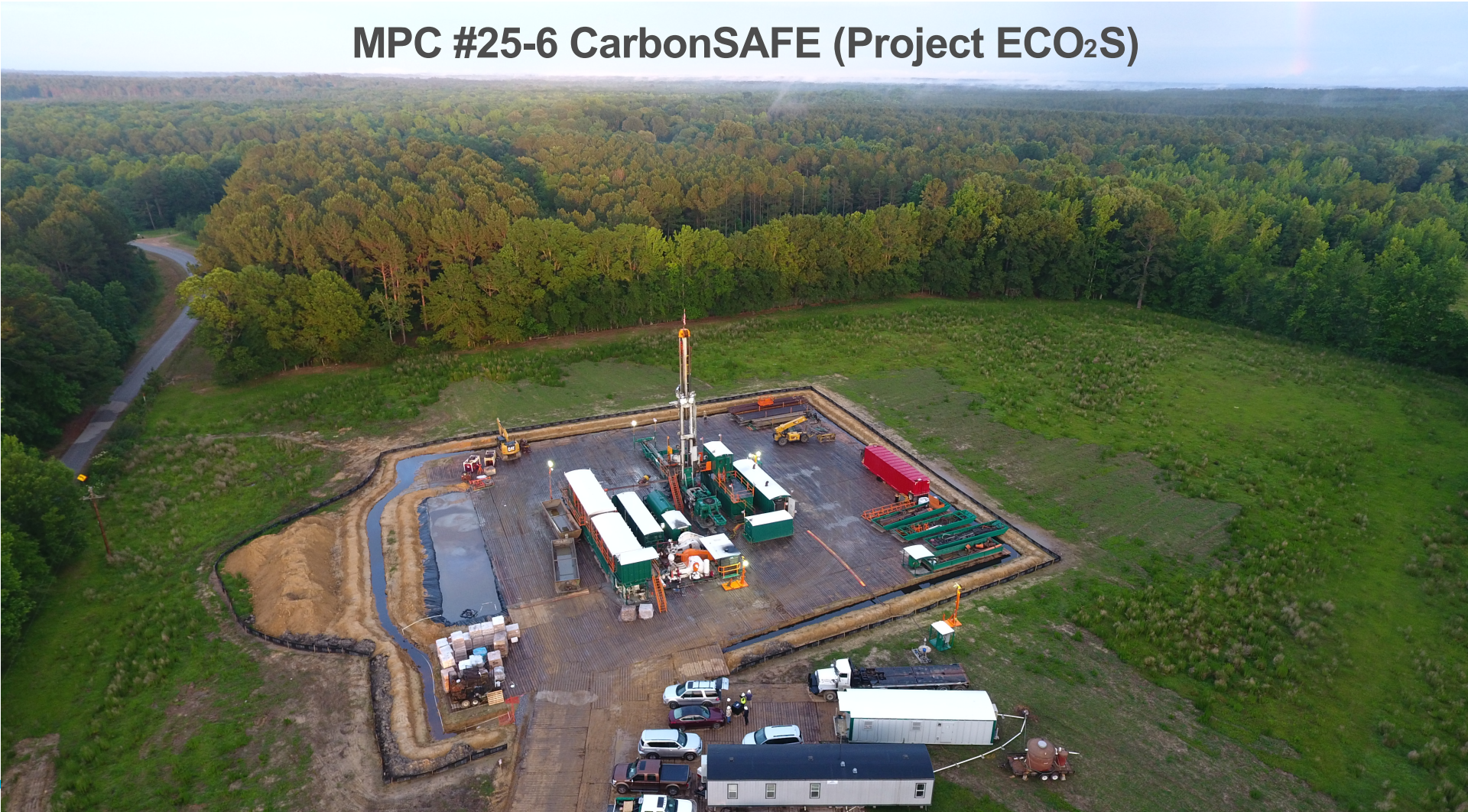
Kemper County Energy Facility

Location Map – CarbonSAFE Project ECO2S



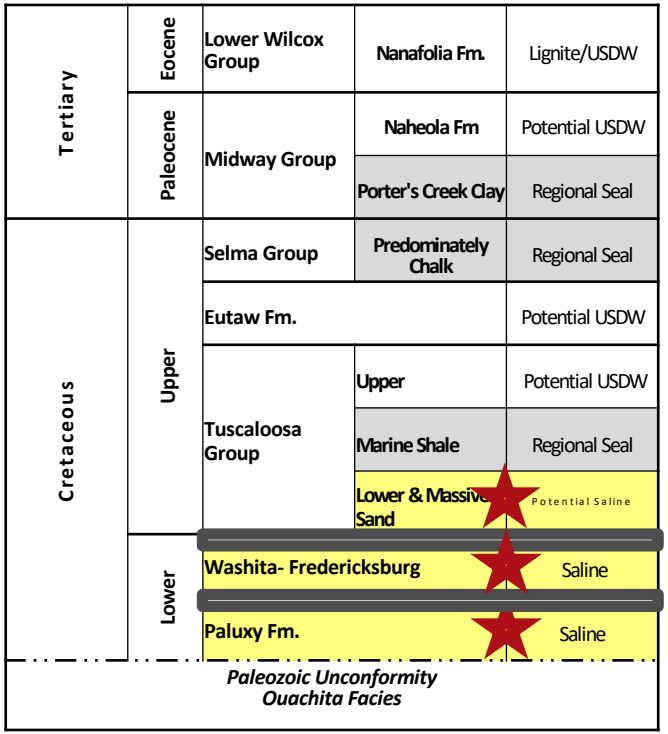
- Project ECO2S is a storage complex "feasibility study" awarded for work at the Kemper County Energy Facility.
- Scope is to perform detailed site-characterization of a storage complex having high potential for commercial storage.
- Three deep wells were drilled in 2017 for site characterization
- World class high-capacity low-cost storage geology, low-cost rapid drilling, large fee-simple acreage ownership, multiple low-permeability reservoir seals.

MPC #25-6 CarbonSAFE (Project ECO$_2$S)




MPC #26-5 drill site

Kemper Storage Complex – Lots of Storage Options



- Three Cretaceous storage units containing formations with high porosity:
  - Lower Tuscaloosa Group (massive sand)
  - Washita-Fredericksburg interval
  - Paluxy Formation
- Three prominent caprocks (reservoir seals):
  - Tuscaloosa marine shale
  - Shale interval at top of the Washita-Fredericksburg
  - Shale interval at base of Washita-Fredericksburg
- Shallow seals in the Selma and Midway Groups

Preliminary Conclusions

The Kemper County Storage Complex appears to be a "world class" CO_2 storage prospect!

- Three separate reservoirs vertically confined resulting in the option for "stacked storage" at depths between 3,000 and 6,000 feet bgs
- No structural "show stoppers" or concerns with induced seismicity
- Low-cost "predictable" drilling equates to low CO_2 storage costs in the $2 to $3 per ton range
- Exceptional permeability (up to 10 Darcy) and porosity (28%) in multiple staked formations provided for high injectivity and large storage capacity
- Multiple low-permeability continuous reservoir seals appear to have very good confining properties for protection of shallow USDWs
- Existing wildcat oil exploration wells and seismic data suggest formations are regional in distribution
- Large fee-simple acre position owned by MPC provides ready access and legal framework for commercial-scale injection operations

Brine Extraction and Storage Test (BEST)

Managing CO_2 Injection Pressures is Important for CO_2 Storage Integrity

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Advanced Resources International, Inc.

Pressure Buildup and Brine Displacement

Caprock Damage

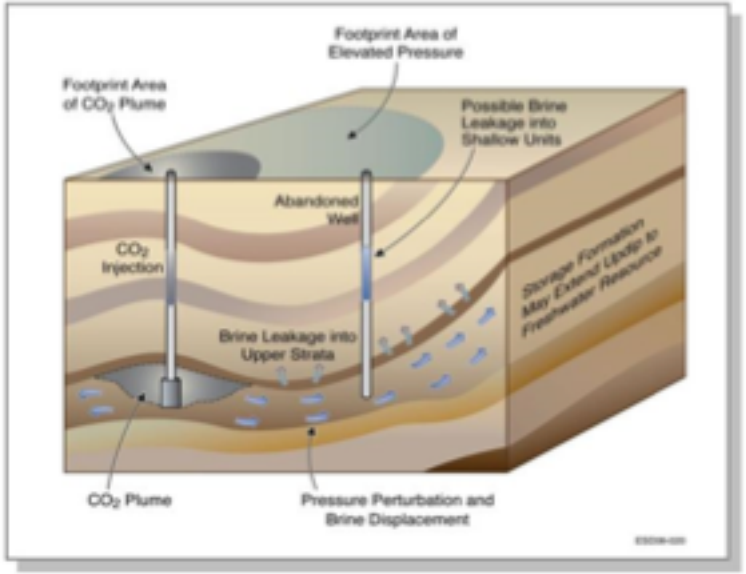
Induced Seismicity

Interference Between Storage Sites

Effect on Other Georesources

Permitting and AoR

Reduced Storage Capacity

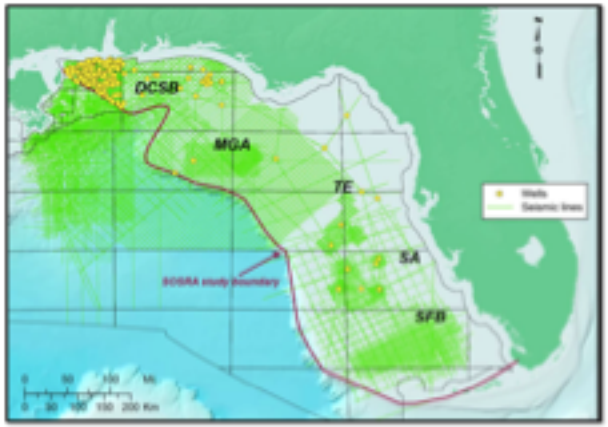


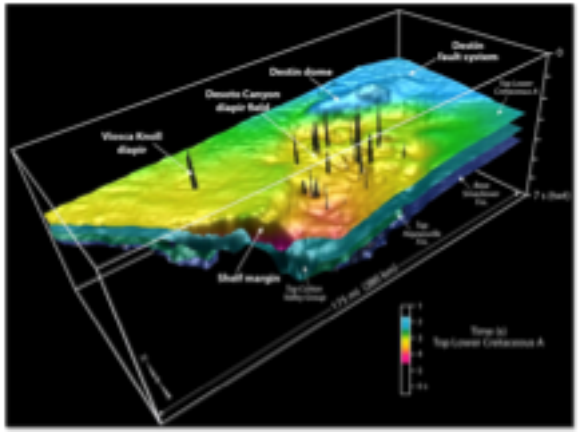
Reservoir Management Via Brine Extraction

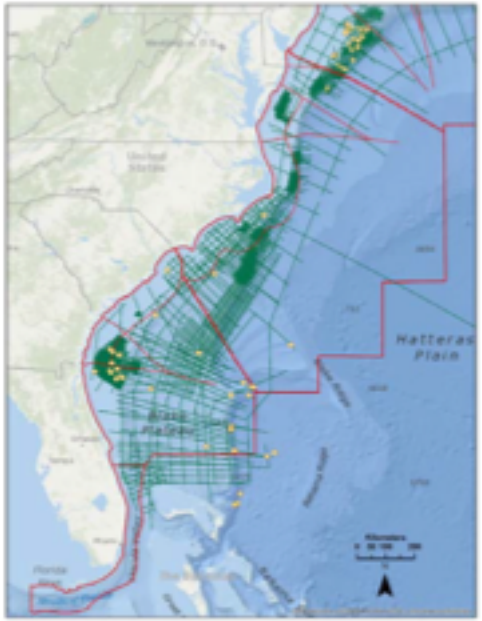
Beneficial Use of Extracted Brine

Southeast Storage Offshore Resources Assessment (SOSRA)

- Managed by the Southern States Energy Board (SSEB)
- SSEB appointed three planning area managers to each offshore region (Eastern GOM, South Atlantic, Mid-Atlantic)
- Geologic characterization of offshore storage opportunities
- Static volumetric assessment of storage capacity using NETL methodology

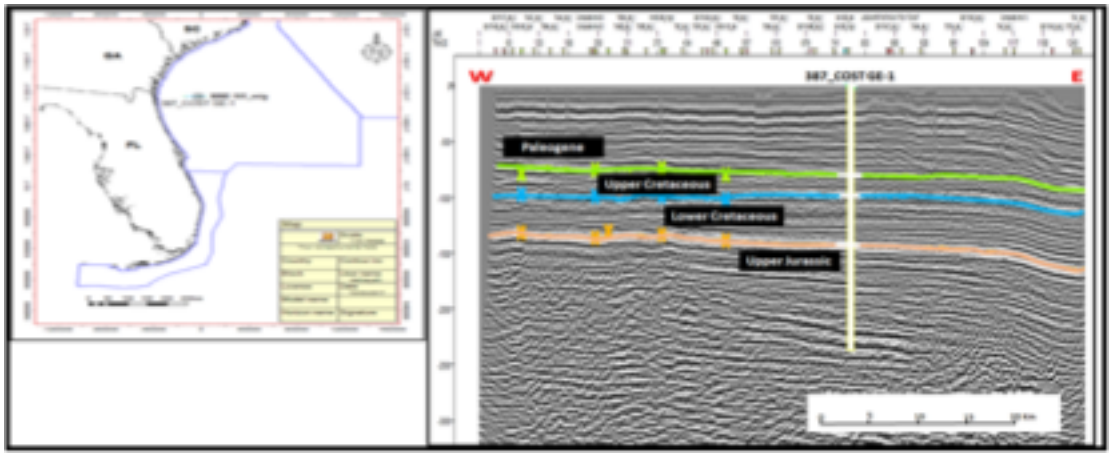


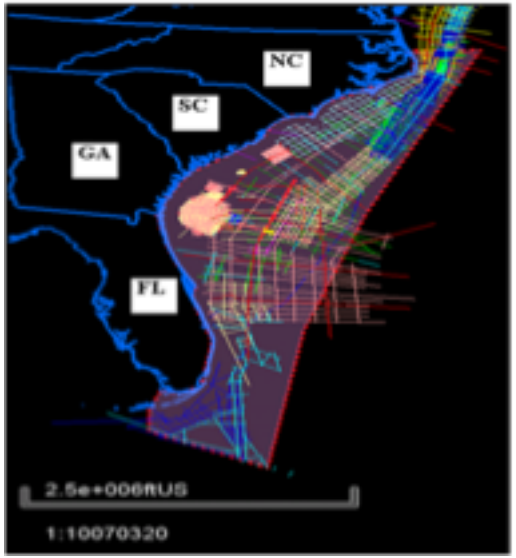




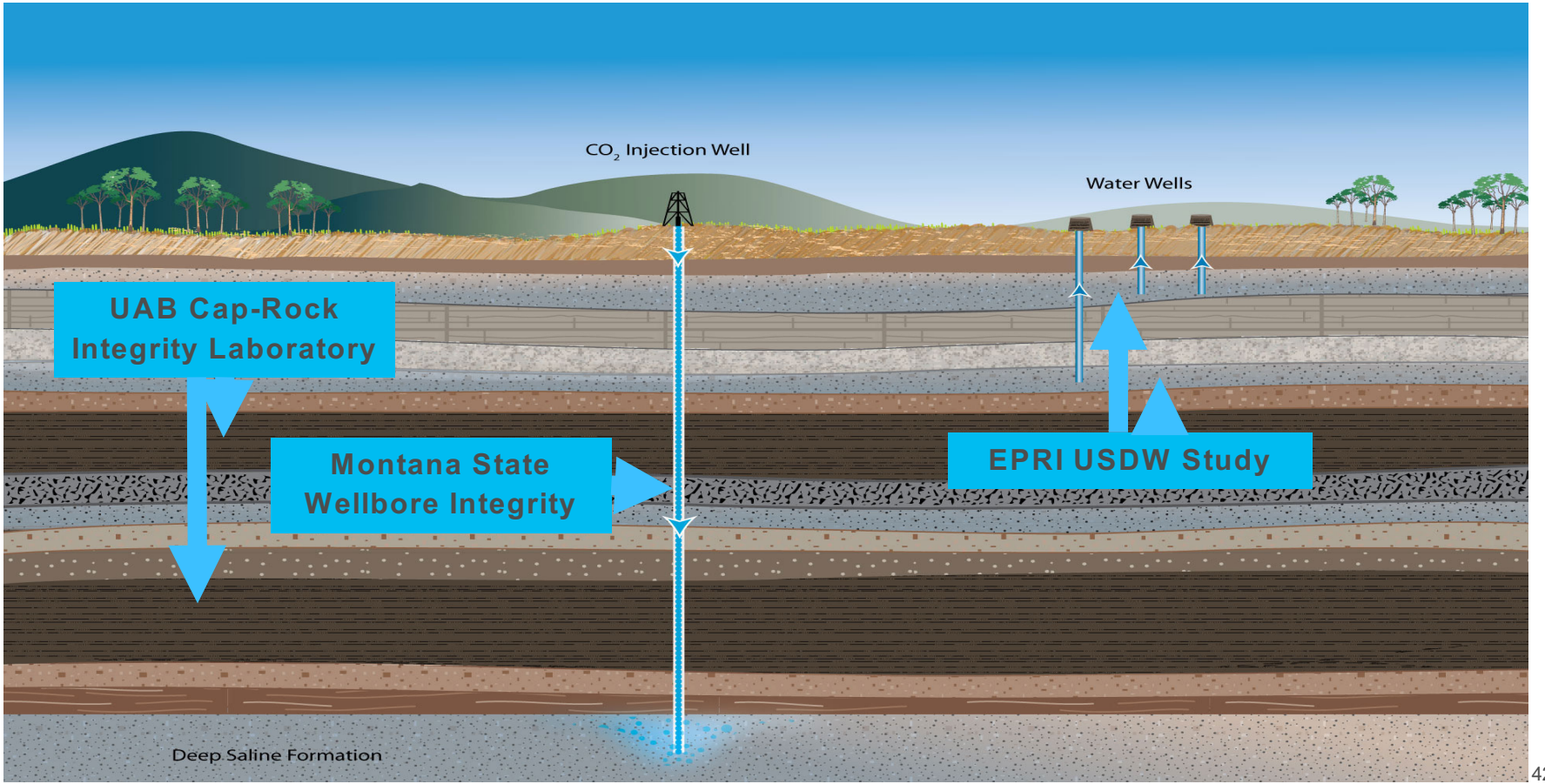
Southeast Storage Offshore Resources Assessment

- Giant potential for offshore CO_2 storage.
- Large portfolio of potential sinks and seals in eastern Gulf and Atlantic regions
- Seismic and well data being interpreted.
- High porosity reservoirs identified in sandstone and carbonate; seals include mudrock, chalk, and evaporites.
- Pristine reservoir potential represented by much of the southeast offshore.





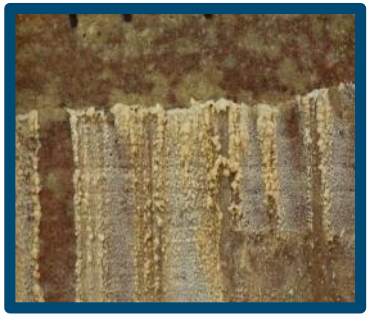
Supplemental CO_2 Storage Risk Studies

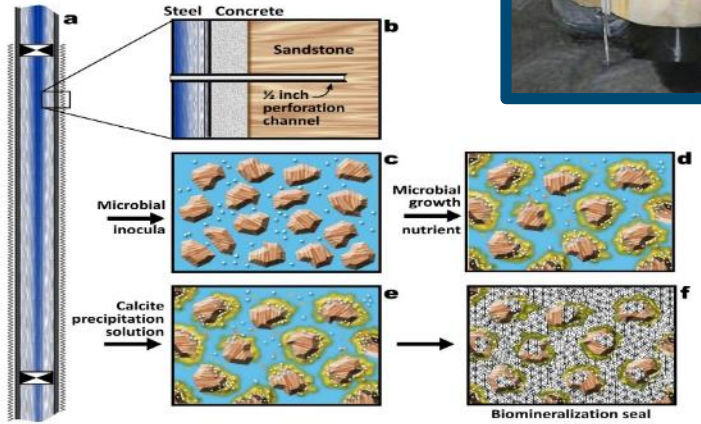


Deep Wellbore Integrity and Leakage Mitigation

DOE Office of FE project awarded to Montana State University to perform wellbore mitigation studies at Alabama Power's Plant Gorgas

- Proof of concept from lab studies to field-scale
- 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
- Currently looking at a new phase of work in 2018





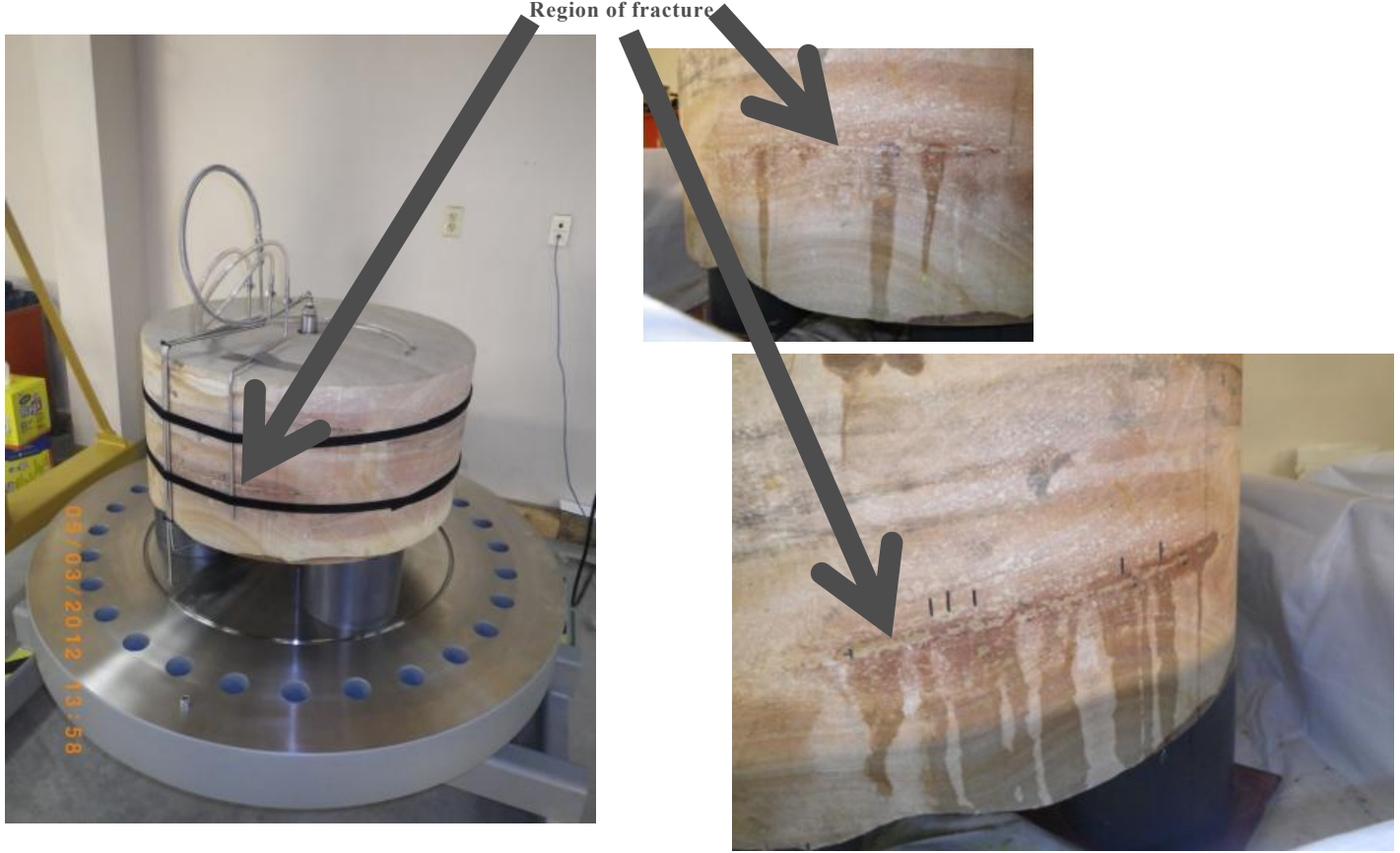
Sample collection in the field

Sample collection for
“field-scale lab study”

U.S. DEPARTMENT OF ENERGY

MONTANA STATE UNIVERSITY

Before images of induced fractures



Ongoing field testing - Sealing Experiment

Valuation of potential CCS Damages

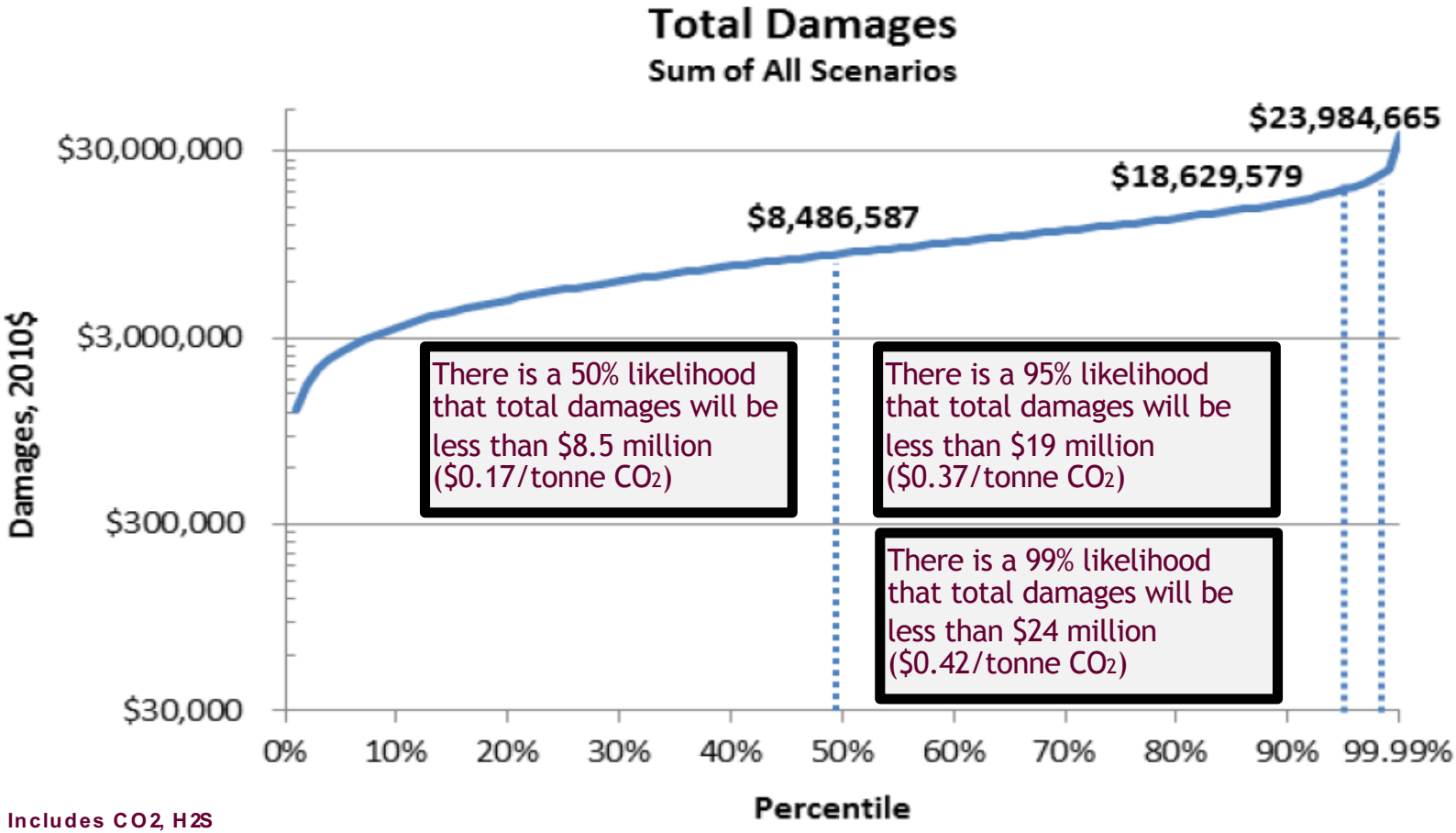
IEc
Industrial Economics, Incorporated (IEc)

What is the study:

- Analytical model for estimating financial damages for environmental and human health from commercial-scale CCS using a Monte Carlo simulation and scenario analysis to develop range of estimates (maximum and expected).

Why we conducted it:

- Provides foundation for communicating risk and risk management strategy to stakeholders and with energy policy.
- Gain understanding of project liabilities and site or reservoir specific sensitivities, including timeframe under which liabilities exists to help understand what risks need to be retained and addressed internally.
- Useful tool in the public debate around policy options for addressing financial assurance and the need and role of captive insurance programs, the public role in long-term stewardship of CCS, project finance, and other public policy issues.



- Includes CO2, H2S
- Per ton values assume 50MMt CO2stored
- 100-year Time Horizon

Summery of the results

- Estimated environmental damages are driven by each project and site-specific characteristics, and can vary by orders of magnitude. But in general are 10’s of millions of dollars and not 100’s of millions of dollars.
- Well-sited, well-operated CCS projects have a relatively small potential for environmental and human health damages.
- The risks of CCS are in line with the risks associated with other activities that the electrical utility industry engages openly.

What is needed to advance CCUS in utility sector

- Recognize that CCUS is a viable option but maybe a niche opportunity
- Stable policies, workable regulations, and markets are needed
- Usable incentives and policy parity with other low-carbon options
- Focused R&D to further reduce costs both with capital and O&M
- Stakeholder acceptance as a low carbon technology

NASEO
National Association of State Energy Officials

Southern Company

Thank you for the opportunity to speak today!