CAB-CS: Central Appalachian Basin CarbonSAFE Integrated Pre-Feasibility Project

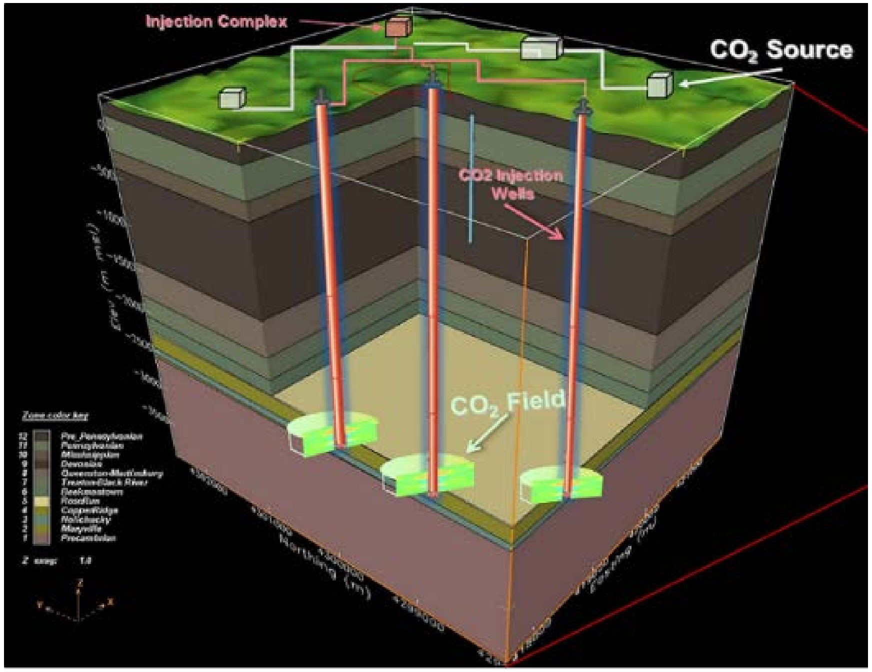
DE-FE0029466

Lydia Cumming, PI/PM
Battelle

U.S. Department of Energy
National Energy Technology Laboratory
Mastering the Subsurface Through Technology Innovation, Partnerships and Collaboration: Carbon Storage and Oil and Natural Gas Technologies Review Meeting
August 1-3, 2017

Presentation outline

- Project Overview
- Technical Status
- Accomplishments To-Date
- Lessons Learned
- Synergy Opportunities
- Project Summary



Central Appalachian Basin CarbonSAFE Integrated Pre-Feasibility (CAB-CS) Project Conceptual Model

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Project goals

Problem: Those wanting to develop carbon capture to meet the demand for environmentally sustainable fossil energy supplies face the risk of not finding a suitable saline storage site.

Solution: Address key gaps in experience and information through the development of commercial scale CO_2 geologic storage sites which provide opportunities to deploy next generation carbon capture technologies.

Central Appalachian Basin CarbonSAFE
An integrated CCS complex constructed and permitted for operation in the 2025 time frame over a series of sequential phases of development.

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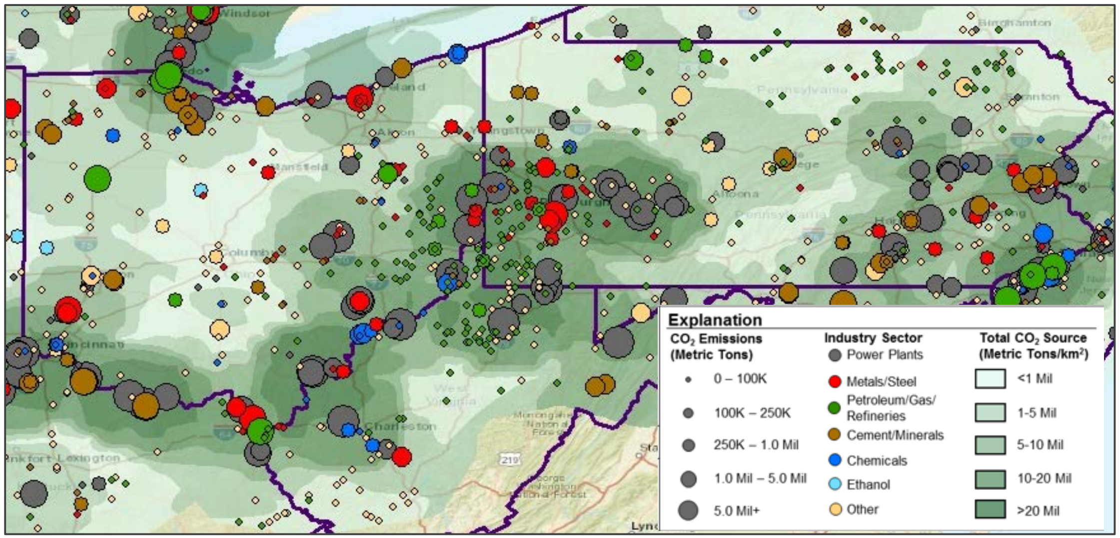
Why CAB-CS?

This area is a good fit because of its existing coal resources, potential EOR opportunities, and potential for capture technology development



Marcellus/Utica Gas Compression/Processing Facilities

PTTGC Ethane Cracker Plant
$5-6 Billion Development

Ethanol Plant

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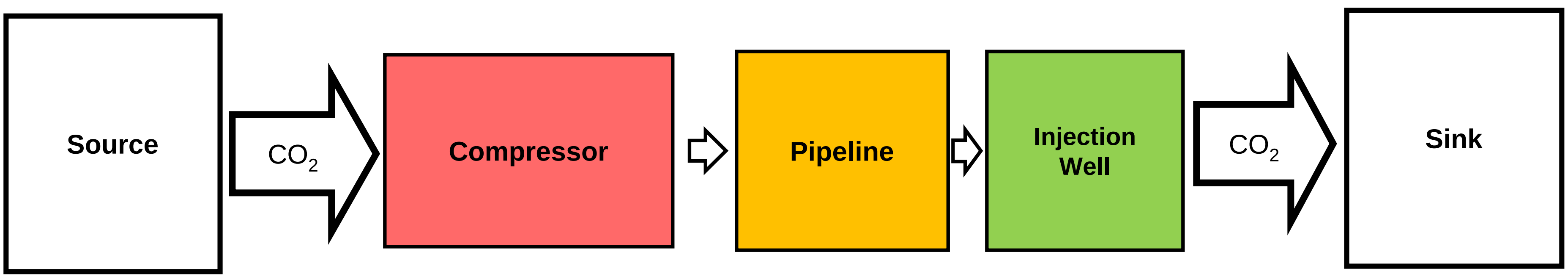
Project objectives

1. **Form a CCS coordination team** capable of addressing regulatory, legislative, technical, public acceptance, and financial challenges specific to commercial-scale deployment of the CO_2 storage project
2. Perform a **high-level technical sub-basinal evaluation** and **identify and evaluate potential CO_2 sources**
3. Develop a general **plan for the storage complex and storage site(s)** that would enable an integrated carbon capture and storage (CCS) project to be economically feasible and publicly acceptable



Project organization and team members

Sponsors

U.S. Department of Energy
National Energy Technology Laboratory
Ohio Development Services Agency

Project Lead

Battelle

Technical Advisory Committee

AEP, Buckeye Brine, GE Oil & Gas, The Energy Cooperative, Three Rivers Energy

Technical Advisors

Project Management (Task1)

Strategy Advisors

Task 2
Carbon Source Review & Assessment

Task 3
Sub-Basinal Geologic Storage Assessment

Task 4
CAB-CS Project Definition

Task 5
CCS Project Integration & Planning

Task 6
Team Building Activities

PKM Energy

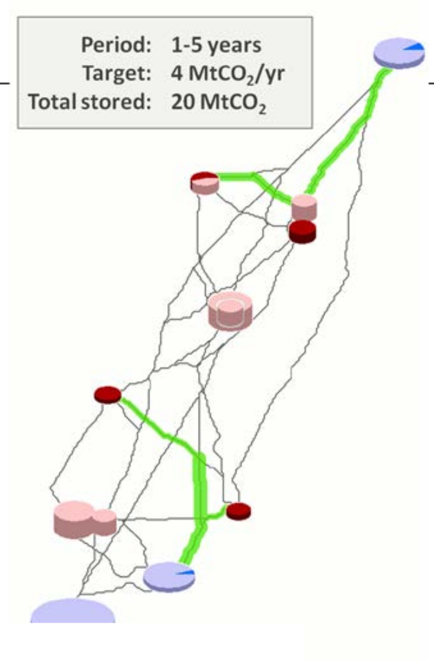
PNNL

Los Alamos National Laboratory EST. 1943

WADE

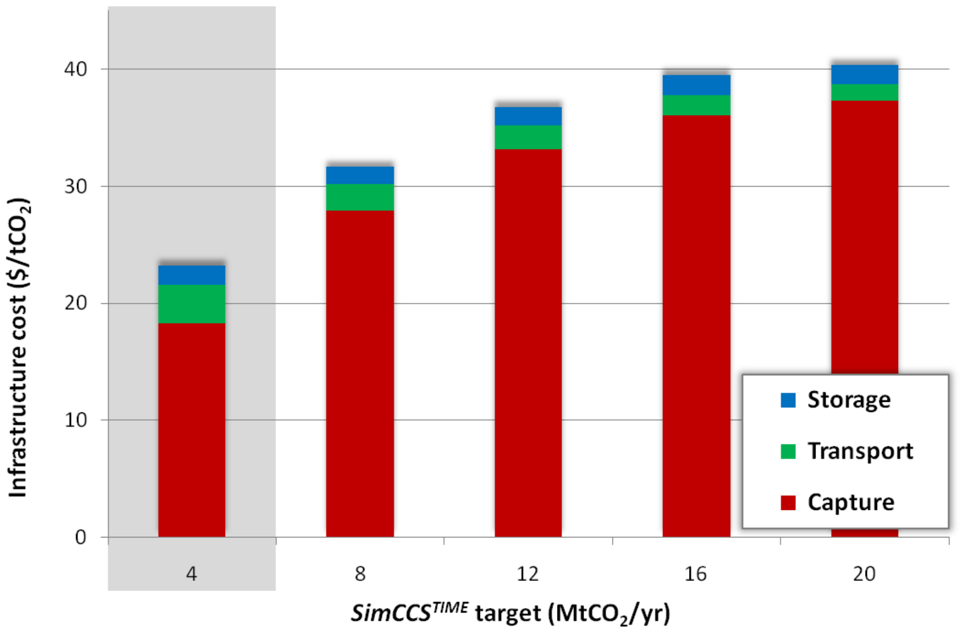
VORYS

Technical status - Task 2. Carbon Source Review & Assessment



Objective: To analyze large point sources, pipeline routing from source to sink, carbon capture technologies, and CCS integration

Pipeline route optimization exercise to be run in the SimCCS software code (LANL) – example for illustrative purposes on right



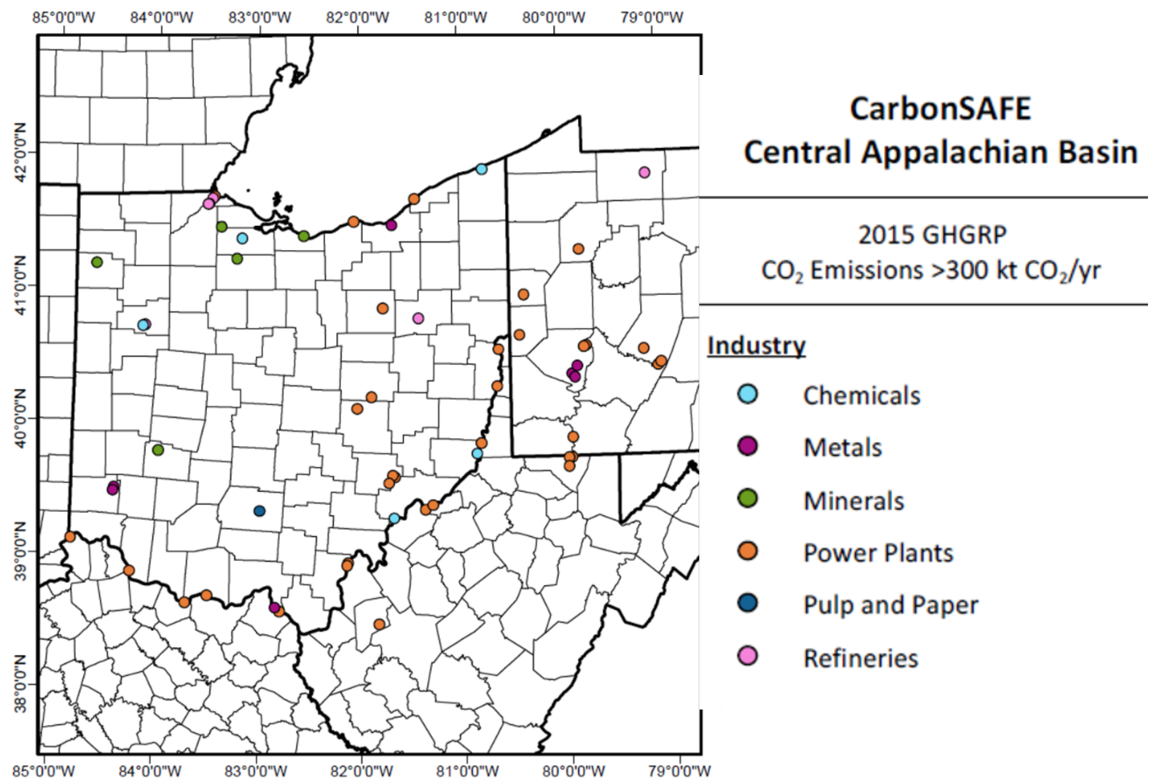
Technical status - Task 2. Carbon Source Review & Assessment

Identified and assessed point sources

- Looked at aggregated total emissions (EPA GHGRP) and generating units (EPA eGRID)
- Reviewed trade journals, news reports and the State of Ohio Public Siting Board to identify future sources

- **Existing**: 31 coal-fired generating units, 5 NGCC generating units, and 6 other large sources capable of emissons >300K tCO_2/yr.
- **Pending:** 11 large sources capable of emissions >300K tCO_2/yr

Assessing point sources based on size, gas stream, process type, impurities and location



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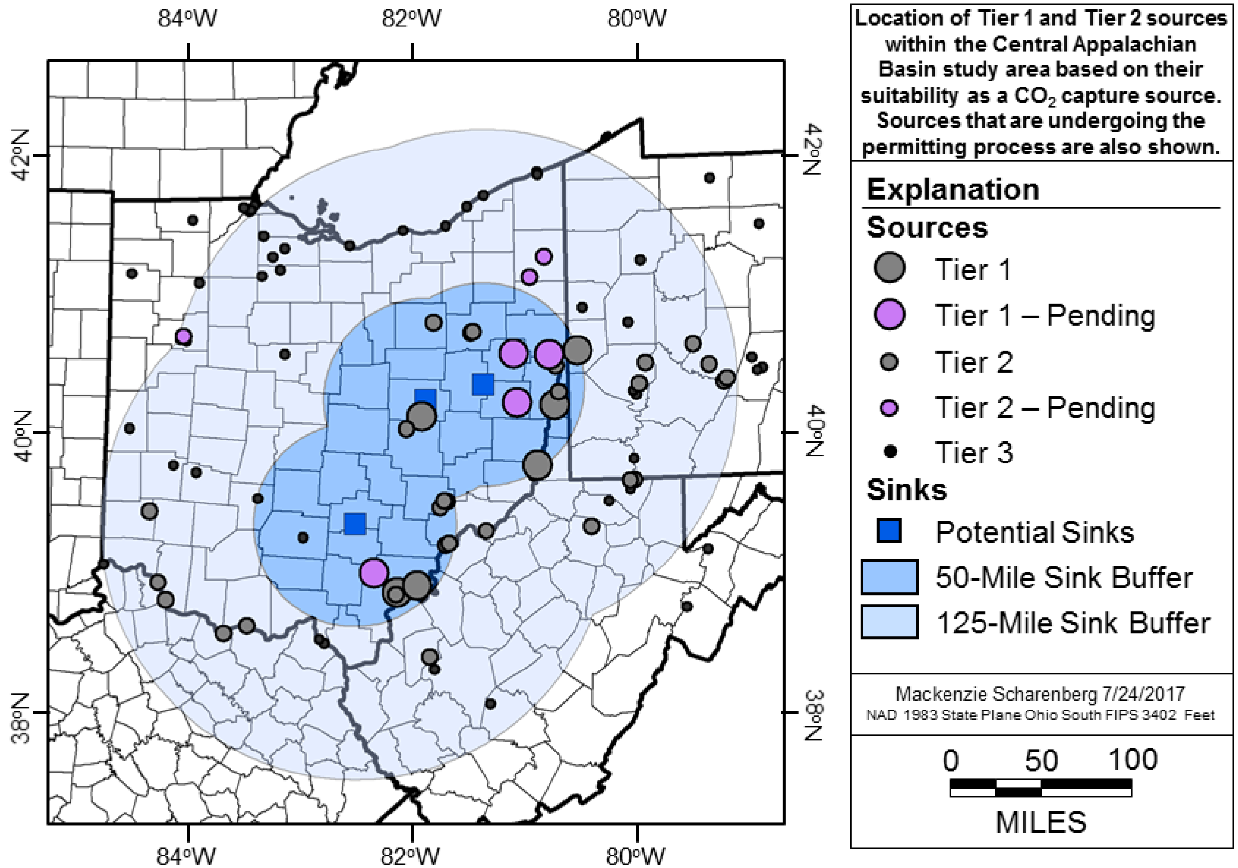
Technical status - Task 2. Carbon Source Review & Assessment

Ranked sources based on location and size

- Tier 1: Located within 50 miles and capable of emitting >1.7 $MtCO_2$ per year
- Tier 2: Located within 125 miles and capable of emitting >1.7 $MtCO_2$ per year; <u>or</u> within 50 miles and capable of at least 300 $KtCO_2$ per year; or project partner
- Tier 3: All other sources



Facilities ranked based on their suitability as a CO_2 capture source (Tier 1, Tier 2, or Tier 3)

Technical status - Task 2. Carbon Source Review & Assessment

Assessed preliminary costs for capture of different source types

- **Cost estimates for CO_2 separation and compression (DOE/NETL, 2015)**
  - Sub-critical Coal-fired - $57/tonne CO_2 captured
  - Natural Gas Combined Cycle - $72/tonne CO_2 captured

- **Cost of CO_2 capture from industrial sources (DOE/NETL, 2014)**
  - High purity sources- $18 to $30/tonne CO_2
  - Low purity sources – $72 to $127/tonne CO_2

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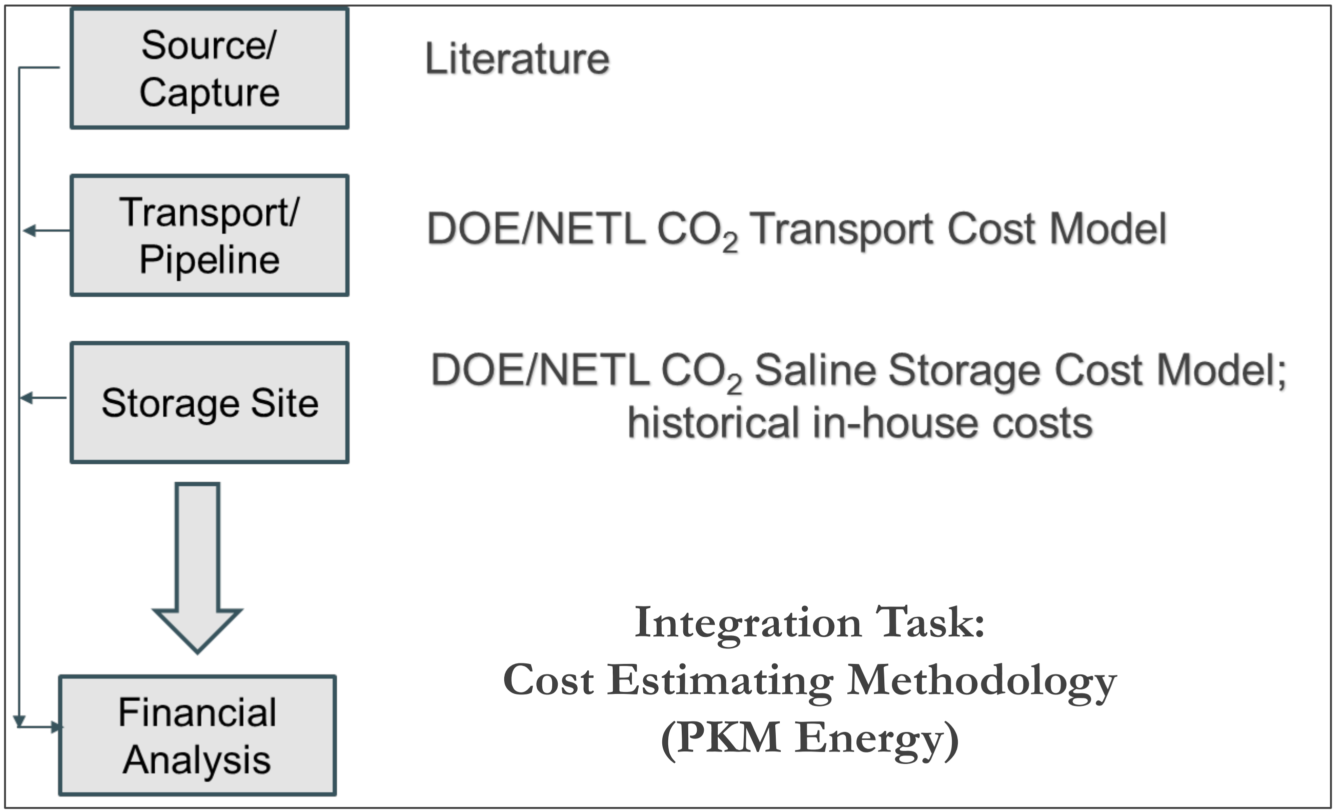
Technical status - Task 2. Carbon Source Review & Assessment

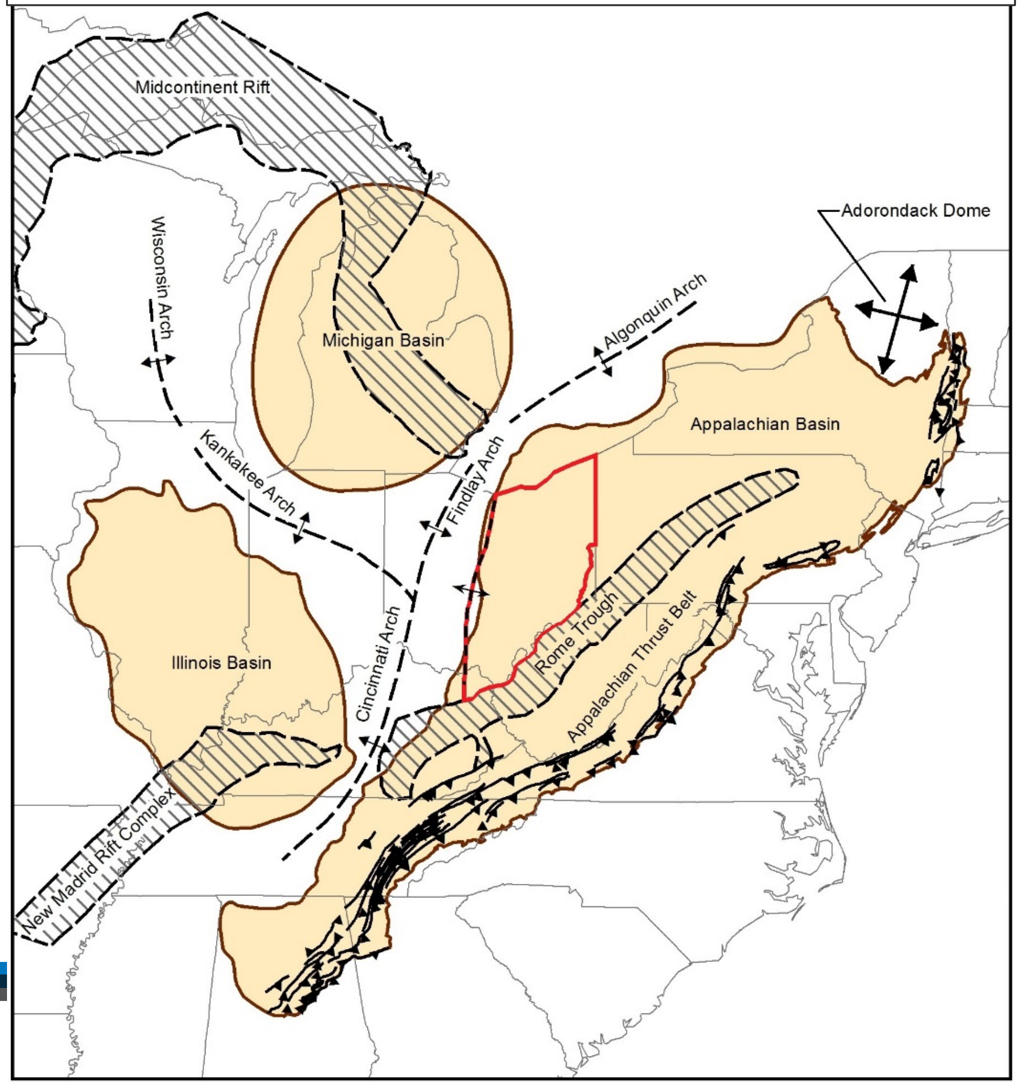
The next steps include using the results as inputs for project definition, integration, and team building tasks



Technical status - Task 3. Sub-Basinal Geologic Storage Assessment

Objective: To produce information necessary to effectively portray the subsurface impact of a CCS complex and related risks

Regional tectonic setting and focus area. Focus area lies in eastern Ohio



Technical status - Task 3. Sub-Basinal Geologic Storage Assessment

Gathered existing data for reservoir characterization, caprock/trapping assessment and geohazards assessment subtasks

- Capacity maps and structure contours for Cambrian-Ordovician Units
- Distribution of depleted oilfields and production based capacity estimates
- Deepest USDW formations in Ohio (~ 1,100 ft)
- Data from hydrologic tests in brine disposal wells across eastern Ohio (flow zones across the same stratigraphic units can have transmissivity (*kh*) up to ~200,000 mD-ft.)
- Peak Ground Acceleration Map of Area (1 in 50 odds (2% probability) of undergoing ground shaking >0.04 to 0.06 g's in the next 50 years)
- Induced Seismicity and Regional Stress (many UIC wells with no induced seismicity)

Technical status - Task 3. Sub-Basinal Geologic Storage Assessment

Potential storage resources, caprocks and seals were identified

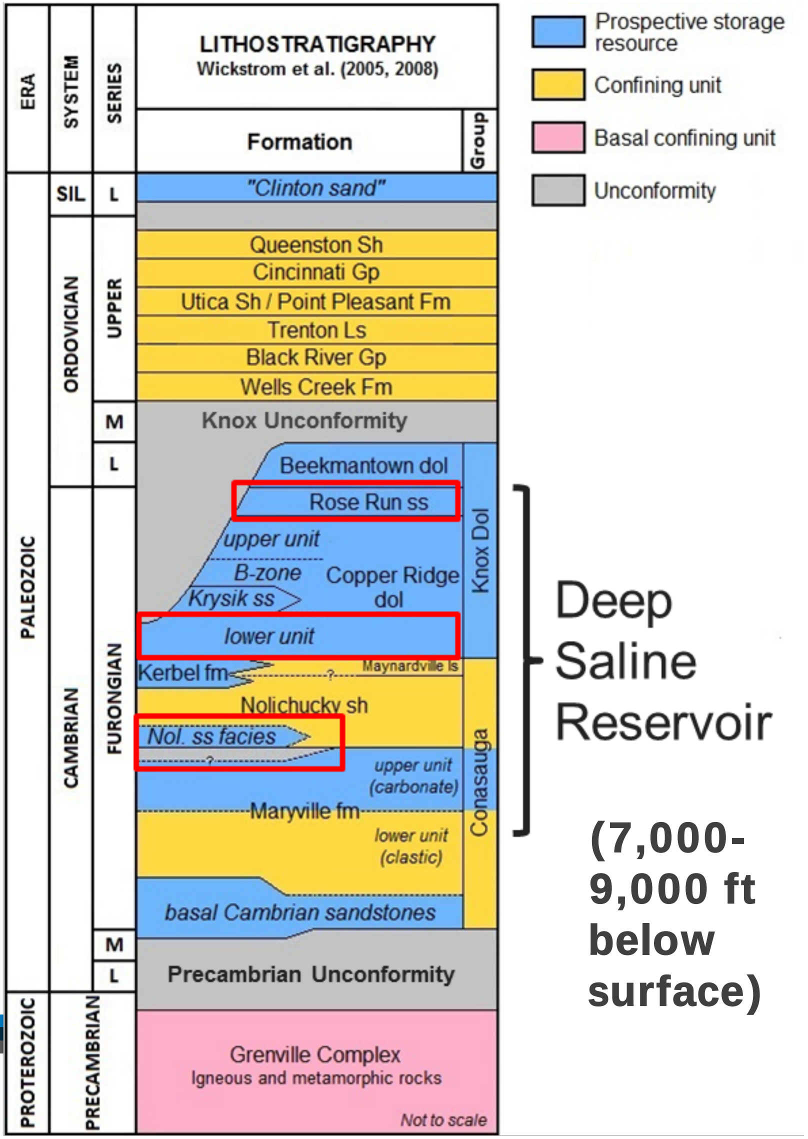
Depleted hydrocarbon field →

Caprock and seal

Rose Run ss →

L. Copper Ridge dol (vugular porosity) →

Nolichucky ss facies over Maryville vuggy/karsted dol →



Deep Saline Reservoir

(7,000-9,000 ft below surface)

Note: *Stratigraphic nomenclature follows the nomenclature adopted by the MRCSP (Wickstrom et al., 2005, 2008)*

Technical status - Task 3. Sub-Basinal Geologic Storage Assessment

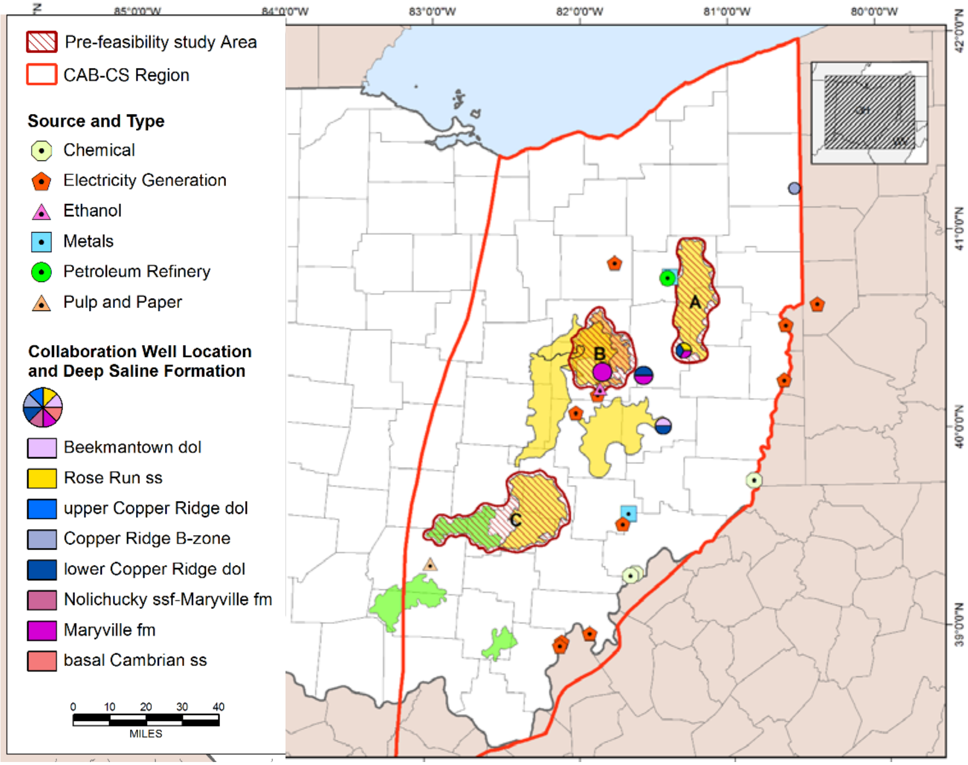
Sub-basinal assessment areas within the larger study area were selected for more detailed studies using a combination of three data sets*:

- Best intersecting deep saline formation volumes using a Petrel model

- Brine disposal wells with high transmissivity values

- Depleted oil fields with sufficient storage capacity

***Obtained primarily from MRCSP and OCDO studies**



Data sets were combined and analyzed to delineate geologic scenarios for assessment

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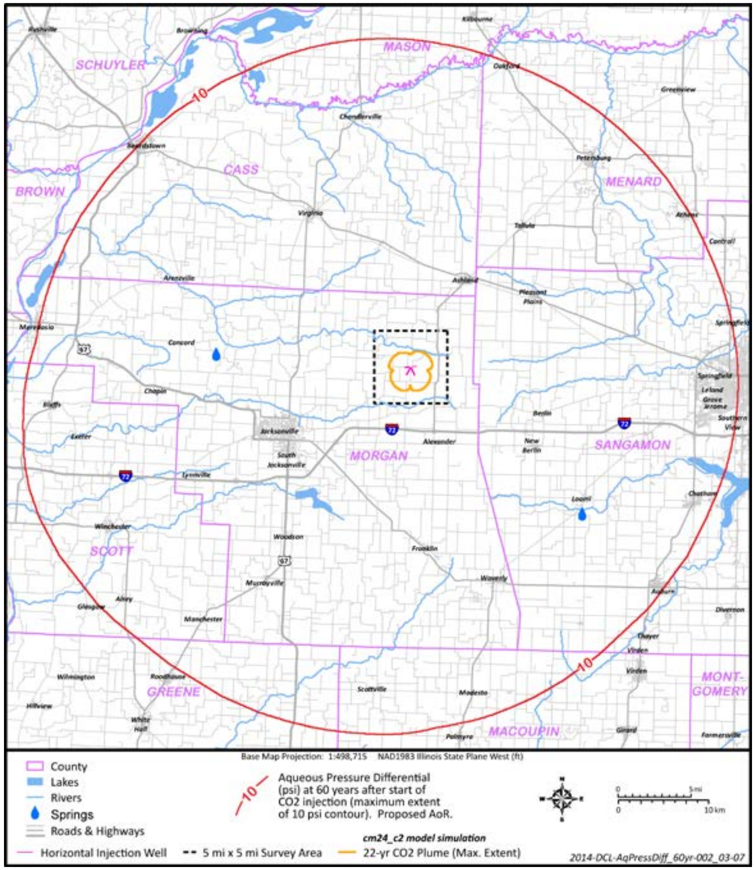
Technical status - Task 3. Sub-Basinal Geologic Storage Assessment

Geologic information from these sub-basinal assessment areas will be used as input values for other subtasks

Example: Risk-based AOR delineation using NRAP-IAM-CS (PNNL)

1. Develop simple reservoir model
2. Use wellbore leakage ROM to simulate hypothetical open wellbore(s) located at varying distances from the injection well
3. Assess drinking water aquifer impact
4. Delineate the AoR based on allowable pressure increase



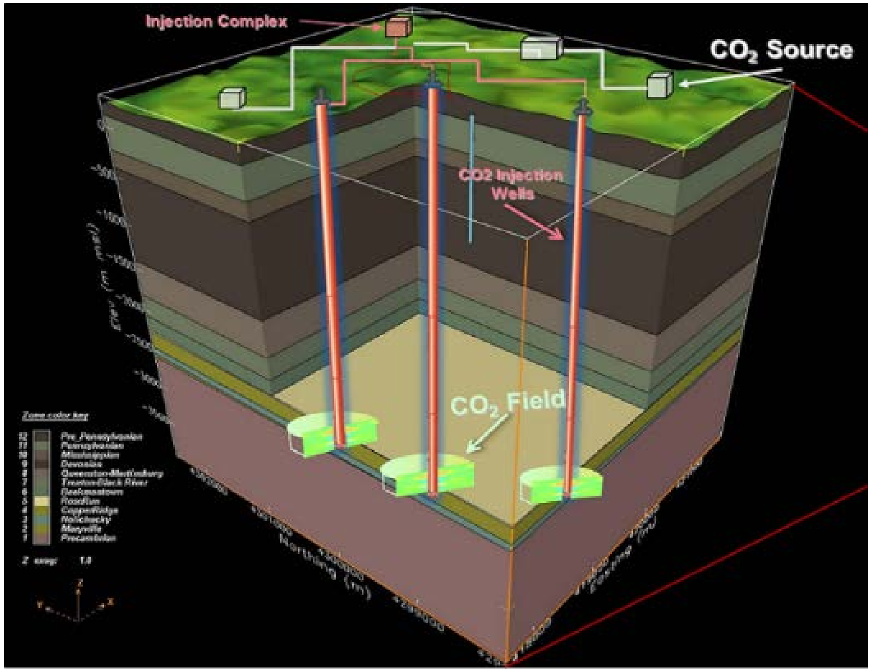
Aqueous Pressure Differential map for Futuregen: Over-pressurized injection formations are challenging for delineating AoR

Technical status - Task 4. CAB-CS Project Definition

Objective: To define the surface and subsurface dimensions, infrastructure, and construction requirements for the CAB-CS complex

Status: Working with Vorys on property rights issues.

Next steps will be to use recent results from Tasks 2 and 3 to develop scenarios.



- About 3-4 injection wells emplaced at 7,000-9,000 ft below surface in a saline storage complex with injection of ≥ 50 million tonnes CO_2 over a CCS project lifetime of 30 yrs
- Potential for stacked storage with depleted oil fields

Technical status - Task 5. CCS Project Integration & Planning

Objective: To integrate various technical and non technical aspects into a plan for development of a CarbonSAFE complex in the Central Appalachian Basin

Status: Planning underway - preliminary social characterization (Wade) and legal analysis (Vorys) completed; risk assessment workflow completed.

Next steps will be to use results from Task 2, 3 and 4 for planning

Current focus (steps 1–3)

1. Define Project Information and Values
2. Define Risk Areas (Geologic, public, legal, business) or by Task
3. Set Severity and Likelihood scales
4. Review and Rank Features, Events and Processes (FEP's)
5. On Selected FEP's, Brainstorm Scenarios
6. Rank Scenarios using Severity and Likelihood Scales
7. Based on Rankings, Make Cut Off for Scenarios to Action (Watch for Black Swans)
8. Brainstorm / Assign Treatments for Each Scenario (Remedial Action Plan)
9. Responsible, Accountable, Consult, Inform (RACI) Matrix for Treatments
10. Schedule for Follow up with Responsible Person / Group
11. Reassess after Defined Key Milestones

Risk Assessment workflow

Technical status - Task 6. Team Building Activities

Objective: To establish a CCS coordination team in conjunction with the other tasks

Status: Communication plan has been developed and is being implemented. Data sharing and meetings with technical advisors and national labs

Next meeting of the technical advisors is on August 31

Project Overview Factsheet

CAB-CS: Central Appalachian Basin CarbonSAFE Integrated Pre-Feasibility Project

Performer:	Battelle
Website:	www.battelle.org
Award Number:	DE-FE0029466
Project Duration:	02/01/2017 - 07/31/2018
Total Award Value:	$1,513,718
DOE Share:	$1,194,626
Performer Share:	$319,092
Technology Area:	Storage Infrastructure
Key Technology:	Carbon Capture and Storage
Location:	Columbus, Ohio

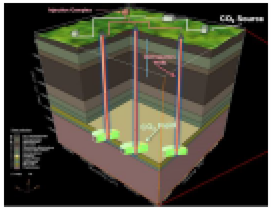


Figure 1: Conceptual Model of CAB-CS Storage Complex (not to scale)

Project Description

The objective of this research project is to complete a pre-feasibility assessment for an integrated commercial carbon dioxide storage site for deep geologic intervals in the Central Appalachian Basin. This region of the country has many, diverse carbon dioxide sources including coal-fired power plants, natural gas processing, refineries, chemical plants, and natural gas power plants. Thus, this is an attractive area for developing a realistic, commercially viable carbon dioxide storage complex that may act as a hub for many different sources of carbon dioxide. In addition, the carbon dioxide injection pilot project at the AEP Mountaineer Plant and several Class II brine disposal operations in deeper Cambrian-Ordovician age rock formations provide examples for the project. This project will focus on an area in east-central Ohio, within the Central Appalachian Basin adjacent to areas of Pennsylvania and West Virginia. A major emphasis of the work will be to develop an effective team capable of addressing the technical, economic, legal, engineering, surface, and public acceptance related to implementation of a CO_2 storage project in the Appalachian Basin.

Project Benefits

This project addresses U.S. DOE Funding Opportunity Announcement-1584 Phase I: Integrated CCS Pre-Feasibility. The proposed work is designed to integrate carbon capture and storage with existing and emerging carbon dioxide sources in this area with a dense concentration of power plants, natural gas processing facilities, and other industry. This core project team has substantial experience with developing carbon dioxide storage projects, which will contribute to establishment of a safe, economic, and effective commercial-scale carbon storage complex. Results of the work will support DOE goals on storage permanence, reservoir efficiency, storage resource predictions, and best practices through the completion of a CarbonSAFE pre-feasibility plan for the Central Appalachian Basin.

Contact Information

Federal Project Manager: Venkat Venkataraman: Venkat.Venkataraman@netl.doe.gov
Technology Manager: Traci Rodosta: traci.rodosta@netl.doe.gov
Principal Investigator: Lydia Cumming: cummingl@battelle.org

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Accomplishments to date

- Initial source assessment completed (Task 2 report submitted)
- Three prefeasibility assessment areas for carbon storage scenarios defined
- Economic modeling workflow set up
- Risk assessment process mapped out
- Preliminary legal assessment of pore space access & liability issues specific to Ohio performed
- Preliminary social characterization of CAB-CS project area performed

Lessons learned

CAB-CS project represents the first steps towards developing a commercial scale project:

- Keeping options open, but prioritizing the ones with the greatest chance of success
- Identifying and assessing sources using a tiered approach and considering future sources
- Identifying areas first based on geology (not considering source location)
- Remaining flexible on location considering transportation costs

Current focus is on:

- Optimizing the scenarios with limited data sets
- Efficiently testing the NRAP tools
- Building the business case in the face of changing oil prices, natural gas prices, electricity generation make-up, industrial landscape, and policies

Changes to consider in future work:

- Collaboration with Next-Generation Capture projects?

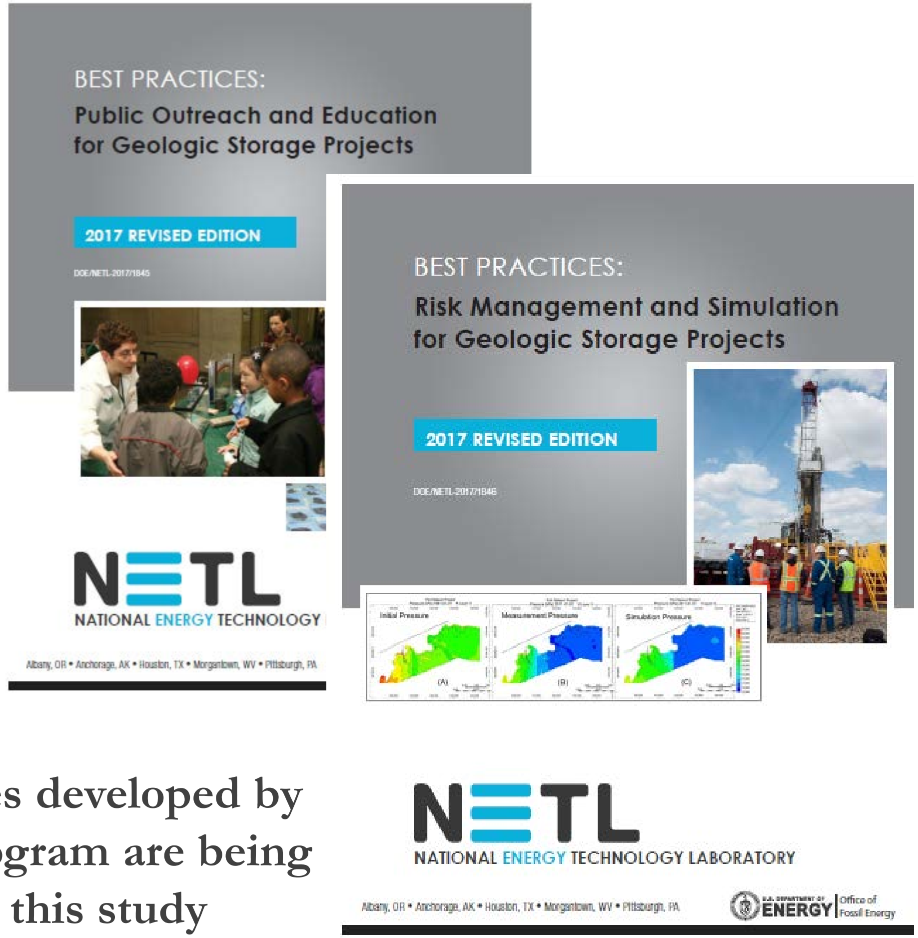
Synergy opportunities

Building on results from the MRCSP Program

Exchanging ideas with other CarbonSAFE projects

Collaborating with national labs

- NRAP-IAM-CS (Integrated Assessment Model)
- Wellbore integrity evaluation
- SimCCS



Best practices developed by the RCSP program are being used for this study

Project summary

Key Findings:

- Available data on sources and sinks indicate a suitable location for a storage hub
- Data being used to populate and test models and to assist planning

Next Steps: Using results from Tasks 2 and 3 for project definition, planning & integration, and team building

Takeaway Message: This project is addressing key gaps in experience and information needed to advance CCS technologies.

- CAB-CS has a strategy aimed at the development of a CO_2 storage hub in an area with existing coal resources, potential EOR opportunities, and potential for capture technology development
- The study area is technically challenging. Improvements in the technical evaluation of sources and sinks, integration planning, and network building are enabling progress

Appendix

- These slides will not be discussed during the presentation, but are mandatory.

Benefit to the Program: DOE Program Goals

- Develop and validate technologies to ensure 99% storage permanence
- Develop technologies to improve storage efficiency while ensuring containment effectiveness
- Support industry's ability to predict CO_2 storage capacity in geologic formations to within ±30 percent
- Develop Best Practice Manuals for MVA; site screening, selection, and initial characterization; outreach; well management activities; and risk analysis and simulation.

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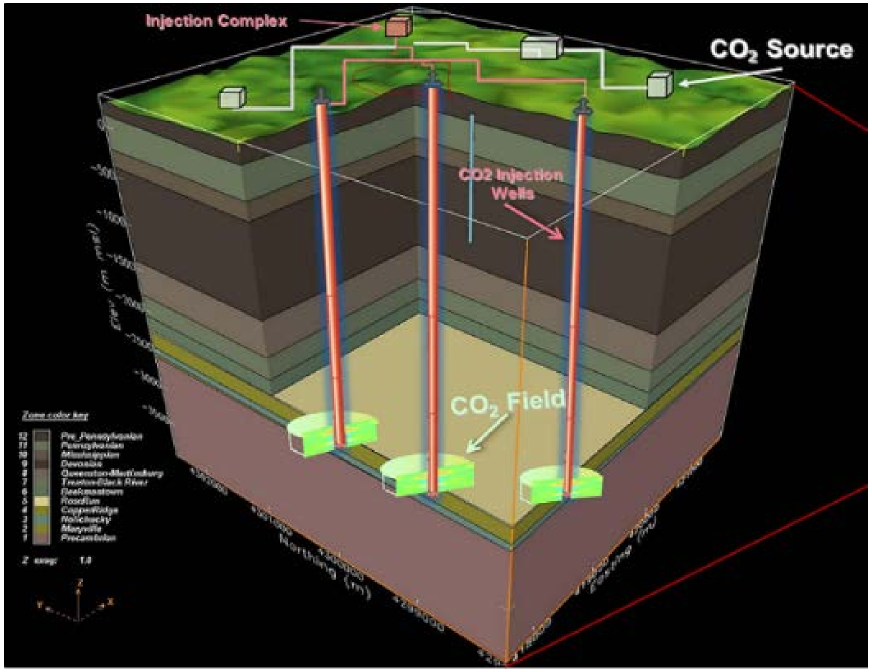
Benefit to the Program: Benefit Statement

- This project is designed to integrate storage with existing and emerging CO_2 sources in an area with a dense concentration of power plants, natural gas processing facilities, and other industry through the completion of a CarbonSAFE pre-feasibility plan for the Central Appalachian Basin.



Central Appalachian Basin CarbonSAFE Integrated Pre-Feasibility (CAB-CS) Project Conceptual Model

Project objectives

Objectives	Tasks
Perform a **high-level technical sub-basinal evaluation** to identify a potential storage complex with storage site(s), including a description of the geology and risks associated with the potential storage site. **Identify and evaluate potential CO_2 sources**	2 – Source Review 3 – Sub-Basin Assessment
Develop a general **plan for the storage complex and storage site(s)** that address the challenges and would enable an integrated capture and storage project to be economically feasible and publicly acceptable	4 – Project Definition 5 – Project Integration
Formation of a CCS coordination team capable of addressing regulatory, legislative, technical, public policy, and financial challenges specific to commercial-scale deployment of the CO_2 storage project	6 – Team Building

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Organization chart

Sponsors

Project Lead

Technical Advisory Committee

AEP, GE Global Research, Buckeye Brine, Energy Cooperative, Three Rivers Energy

Technical Advisor

Dr. Srikanta Mishra

Mr. Mark Kelley

Project Management (Task1)

PI/PM: Lydia Cumming

Strategy Advisor

Dr. Rodney Osborne

Dr. Neeraj Gupta

Task 2

Carbon Source Review & Assessment

Justin Glier

PKM Energy

Task 3

Sub-Basinal Geologic Storage Assessment

Glenn Larsen

Task 4

CAB-CS Project Definition

Joel Sminchak

Task 5

CCS Project Integration & Planning

Jared Walker

Task 6

Team Building Activities

Gantt chart

Task Name	FY2017			FY2018			
	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task 1: Project Management & Planning	━	━	━	━	━	━	━
Project Kickoff Meeting	◆						
Task 2: Carbon Source Review & Assessment	━	━	━				
Complete Review of Carbon Sources, Capture Feasibility			◆				
Task 3: Sub-Basinal Geologic Storage Assessment		━	━	━			
Complete Sub-Basinal Geologic Storage Assessment				◆			
Task 4: CAB CarbonSAFE Project Definition		━	━	━			
Complete Project Definition				◆			
Task 5: CCS Project Integration & Planning	━	━	━	━	━	━	
Develop Plan for Next Phase of CAB-CS Complex Development				◆			
Task 6: Team Building Activities	━	━	━	━	━	━	━
Finalize Commercialization Plan						◆	

*Final deliverable is due 90 days after project end date of 7/31/2018.

Bibliography

- None to date