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Energy & Environmental Research Center (EERC)

CO_2 ENHANCED OIL RECOVERY IMPROVEMENT IN CONVENTIONAL FIELDS USING RICH GAS

DE-FE0031789

U.S. Department of Energy National Energy Technology Laboratory

Oil and Gas Virtual Project Review Meeting

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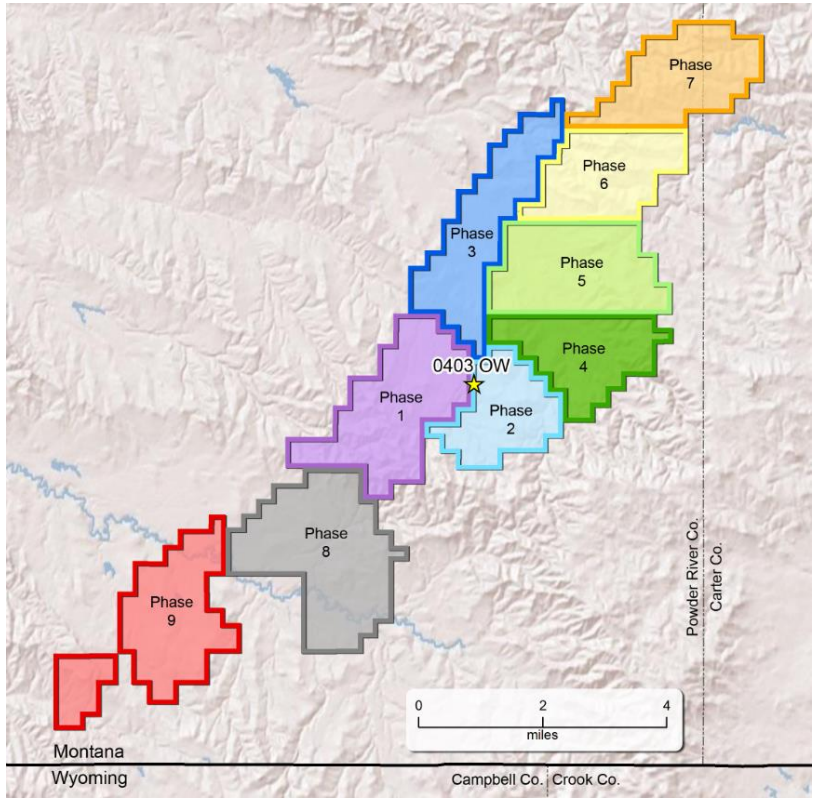
CO_2 BLENDED WITH RICH GAS

Research Hypothesis: *The injection of a blend of rich hydrocarbon gas and CO_2 into an oil reservoir will reduce molecular weight selectivity, lower minimum miscibility pressure and viscosity of the oil, and improve gas solubility, resulting in an overall improvement in EOR performance.*

PROJECT GOAL AND OBJECTIVES

Project Goal: *Determine the effect of injecting blended CO_2 and rich gas into an active CO_2 EOR field to improve production performance.*



Project Objectives: The goal will be accomplished by completing several specific research objectives:

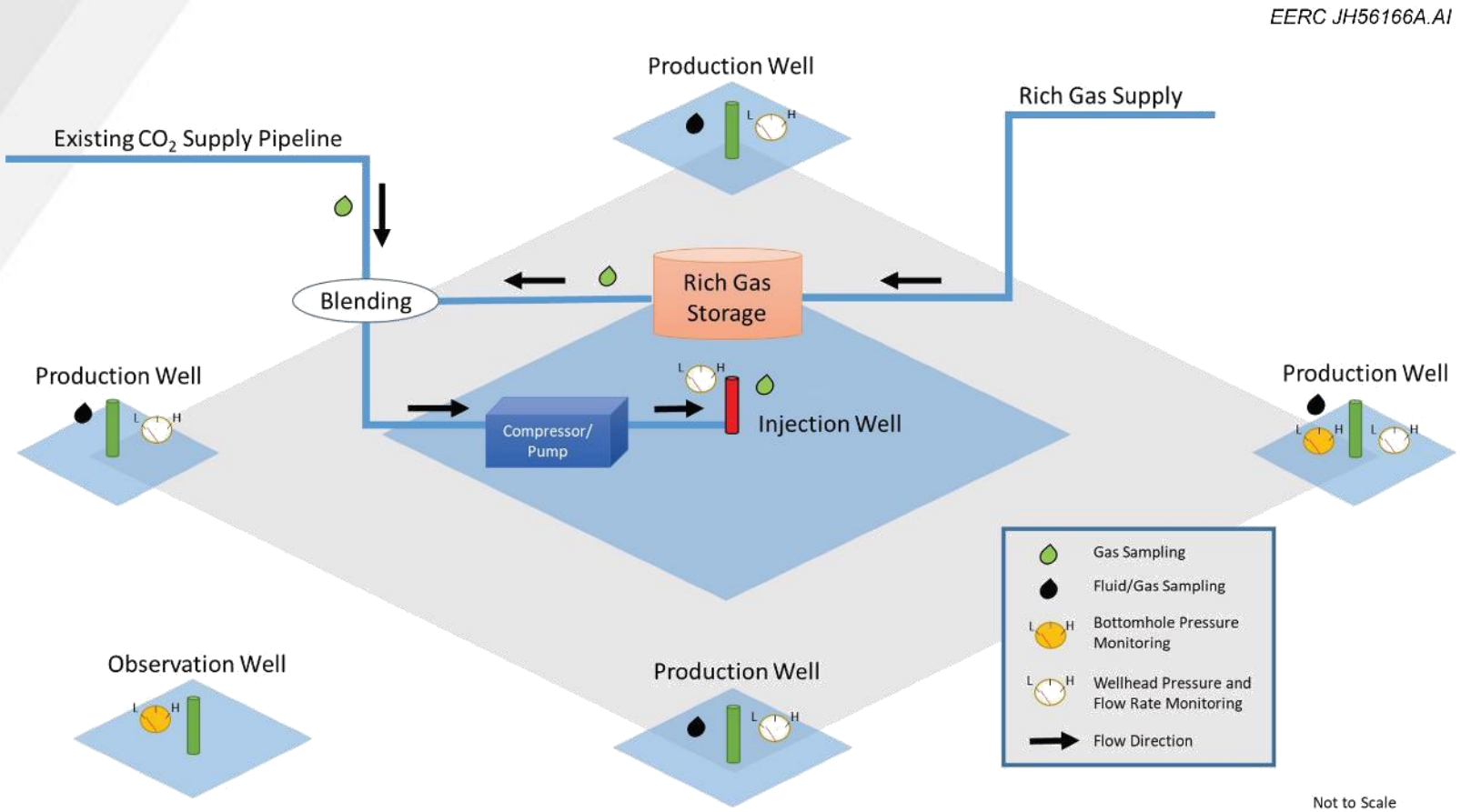
- Determine the quantity, transportation, compression, and injection needs for a field-based injection test.
- Inject blended CO_2 and rich gas in the Bell Creek Field for incremental recovery and associated CO_2 storage.
- Develop field-based data to determine the effects of rich gas additives in CO_2 on oil production.
- Use laboratory experiments to determine the potential for varying compositions of rich gas blended with CO_2 to improve oil recovery in other conventional reservoirs currently undergoing CO_2 EOR.
- Develop business case scenarios to assess the potential for using rich gas added to CO_2 at other EOR locations in the United States.

FUNDING AND PROJECT PERFORMANCE DATES

	BP1 ($) 10/1/2019–3/31/2021		BP2 ($) 4/1/2021–9/30/2024		Total	
	Federal	Nonfederal	Federal	Nonfederal	Federal	Nonfederal
DOE	$2,184,364	–	$5,789,517	–	$7,973,881	–
Schlumberger	–	$334,400	–	$501,600	–	$836,000
CMG	–	$212,993	–	$951,007	–	$1,164,000
Total	$2,184,364	$547,393	$5,789,517	$1,452,607	$7,973,881	$2,000,000
Total Cost Share %	80%	20%	80%	20%	80%	20%

*Note: **Denbury** – Additional collaboration in the form of field support, infrastructure development, design and implementation, gas supply, and injection/production operations.*
***Oneok** – Committed to working with Denbury and EERC to source rich gas for EOR test.*

TECHNOLOGY BACKGROUND: CO_2 BLENDED WITH RICH GAS



- Previous laboratory and modeling work showed ethane can solvate a wider MW range of hydrocarbons than CO_2 alone, which could lead to more oil from the reservoir with better efficiency.
- Blending rich gas components with CO_2 may provide means of improving oil recovery in fields either undergoing or planned for tertiary recovery.
- Use of rich gas or rich gas–CO_2 blends for flooding operations can greatly reduce the quantity of CO_2 needed for EOR injection.

TECHNICAL APPROACH/PROJECT SCOPE

- Task 1.0 – Project Management and Planning

- Task 2.0 – Engineering Design
  - 2.1 – Rich Gas Source, Compression, and Transportation Evaluation

    DP: Go/no-go decision based on whether rich gas source is secured 12/31/2020
  - 2.2 – Core and Fluid Laboratory Evaluations
  - 2.3 – Blended CO_2-Rich Gas Injection Modeling and Simulation
  - 2.4 – Injection/Monitoring Program Design

TECHNICAL APPROACH/PROJECT SCOPE (CONT.)

- Task 3.0 – Field Operations and Monitoring (BP2)
  - 3.1 – Field Preparation
  - 3.2 – Field Validation and Monitoring
  - 3.3 – Rich Gas Supply Monitoring
  - 3.4 – Sample Analysis
  - 3.5 – Field Validation Decommissioning Activities

- Task 4.0 – Business Case for Blended CO_2-Rich Gas Utilization
  - 4.1 – Laboratory Studies
  - 4.2 – Data Management and Machine Learning Studies
  - 4.3 – Modeling and Simulation
  - 4.4 – Business Case Analysis

PROJECT SCHEDULE WITH KEY MILESTONES

Budget Period 1	Budget Period 2

Project Year 1	Project Year 2	Project Year 3	Project Year 4	Project Year 5

2019	2020	2021	2022	2023	2024

O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S

Field Validation

M2
Injection Site
Verified

M3
Rich Gas
Source
Secured

M4
Field
Preparation
Completed

M8
Blended
CO_2-Rich
Gas Injection
Completed

Business Case

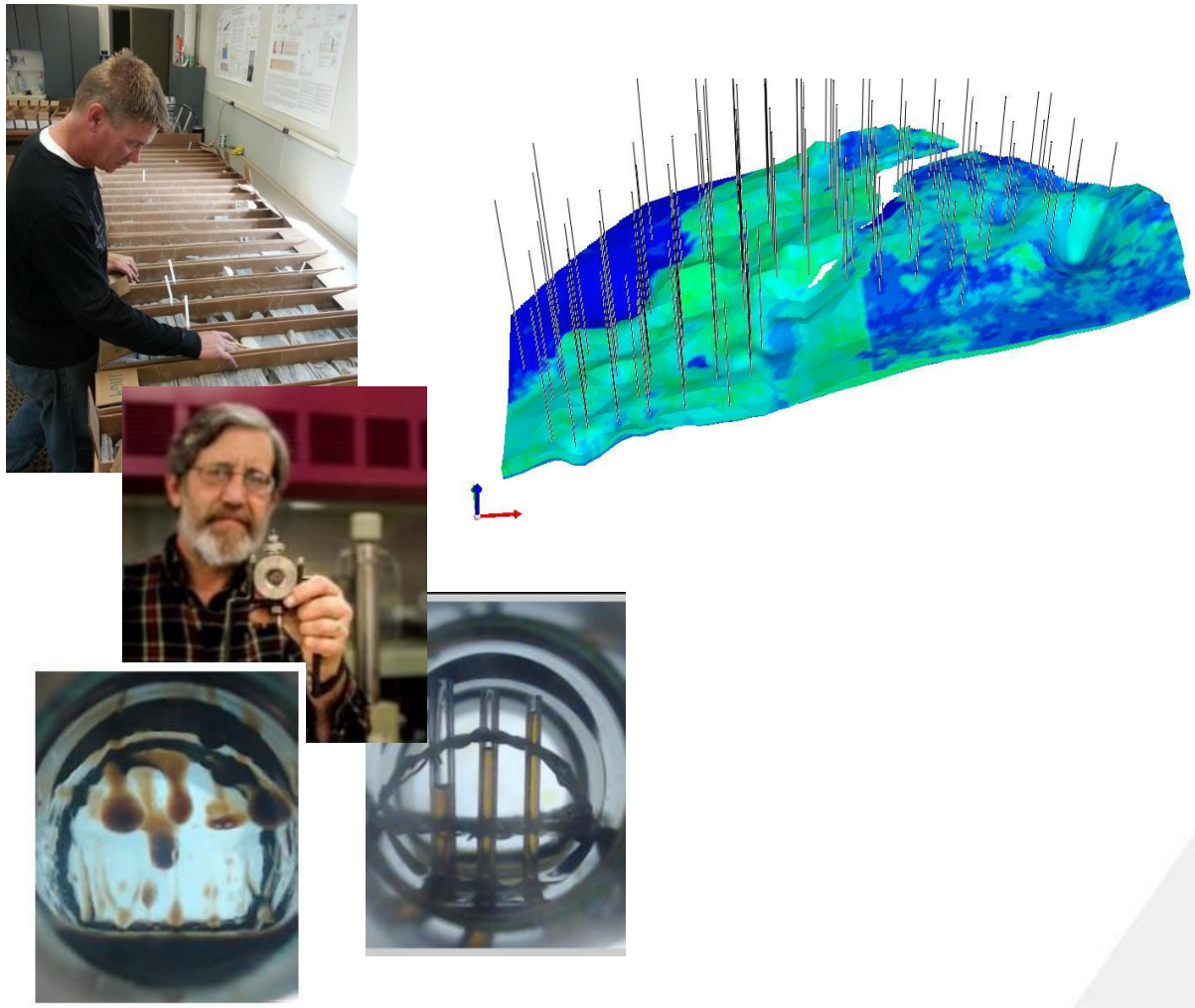
M5
All Core
Samples
Obtained

M9
Validation Test Fluid
Sample Analyses
Completed

PROGRESS AND CURRENT STATUS OF PROJECT

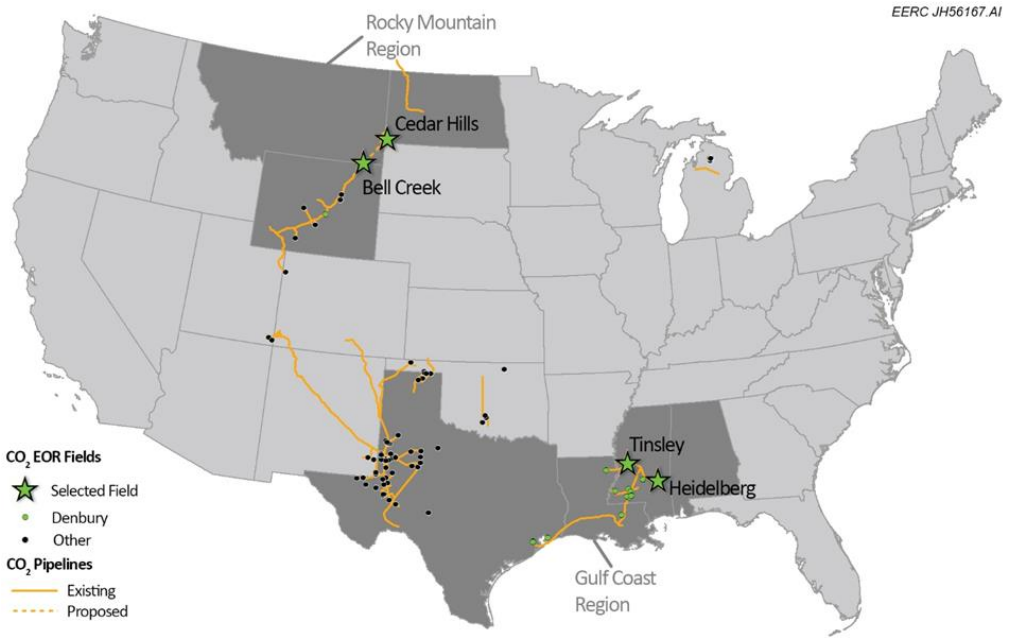
Engineering Design

- EERC and Denbury are working toward a gas delivery plan and contract with a gas supplier.
- Core and fluid laboratory evaluations of Bell Creek samples are progressing.
- The injection pattern and site were selected.
- The geologic model for the pilot pattern has been updated, and EOS modeling based on the injection gas composition is complete.



PROGRESS AND CURRENT STATUS OF PROJECT

- Business case development has been initiated.
  - Rock samples were collected for the Rocky Mountain region.
  - Porosity, permeability, thin sections, and MICP are all complete for this set.
  - Additional samples for the Gulf Coast region are being identified and acquired.
  - Data collection for both regions has been initiated.



PROGRESS AND CURRENT STATUS OF PROJECT

Characteristics of CO_2 EOR Fields in Proposed Project

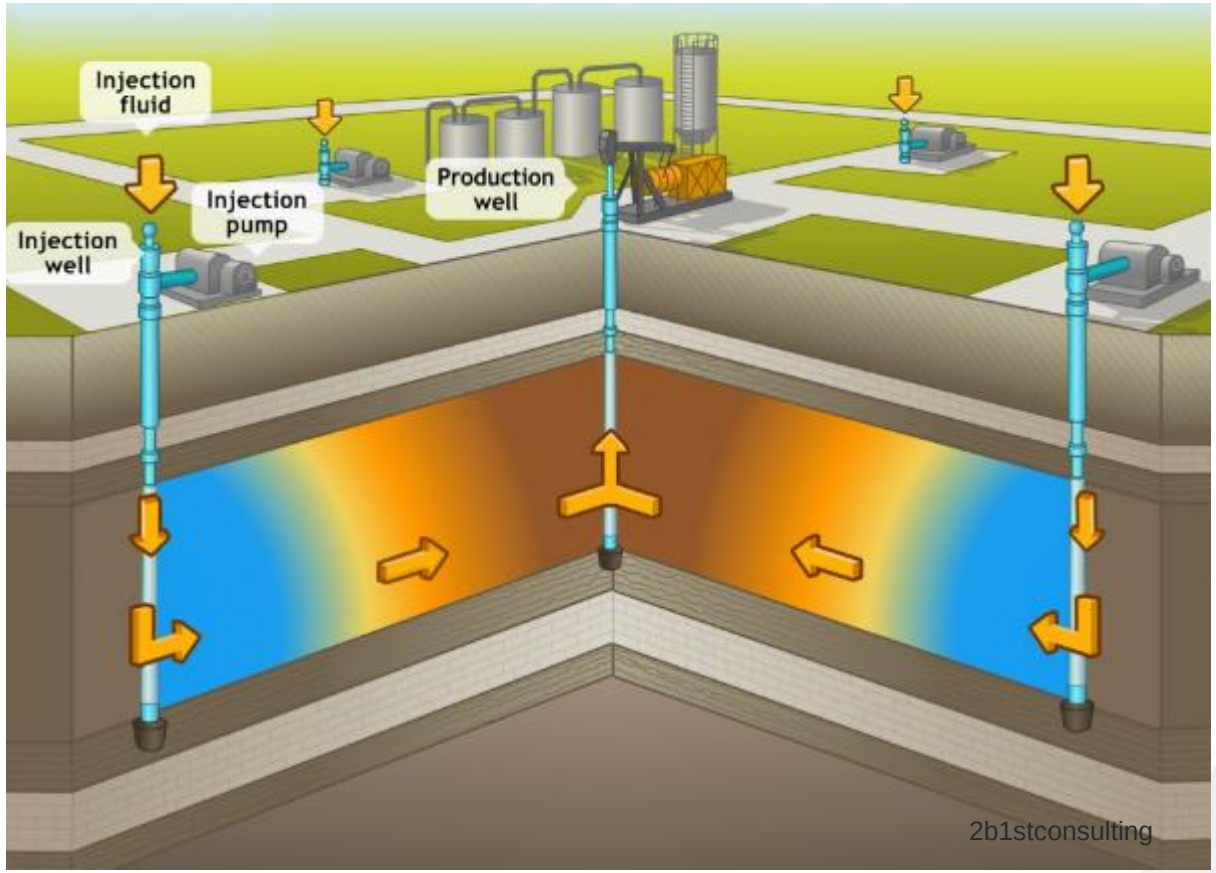
Field	Basin	Zone	Dominant Lithology	Porosity Range, %	Permeability Range, mD	Thickness, ft	API Gravity
Bell Creek	Powder River	Muddy	Marine sandstone	25–35	150–1175	30–45	32–41
Cedar Hills	Williston	Red River	Dolostone	13–23	15	10	30
Tinsley	Mississippi Interior Salt	Woodruff	Shallow marine sandstone	26–28	1040–1300	80–90	32
Heidelberg	Mississippi Salt	Eutaw	Marine sandstone	28	10–3115	550	23

PLANS FOR FUTURE TESTING/DEVELOPMENT/COMMERCIALIZATION

- The pilot test during BP2 will provide a unique U.S. data set on rich gas EOR, paving the way for larger-scale tests and deployment.
- Positive pilot test results would support the development of infrastructure and a market for stranded rich gas.
- Results would be applicable to develop business cases for other potential target fields.
- Because of the ability to leverage existing oilfield infrastructure, commercial implementation of rich gas EOR could occur quickly.

SUMMARY

- Project was successfully initiated in winter 2019.
- Project partners are engaged and involved in discussions pertaining to gas supply and composition.
- Task 2 activity is progressing with core flooding studies conducted for the Bell Creek site. Preliminary posttest fluid analysis supports MW selectivity.
- Task 2 modeling and simulation are ongoing and being updated with new laboratory results.
- Business case development has been initiated through data collection and laboratory analyses.



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THANK YOU

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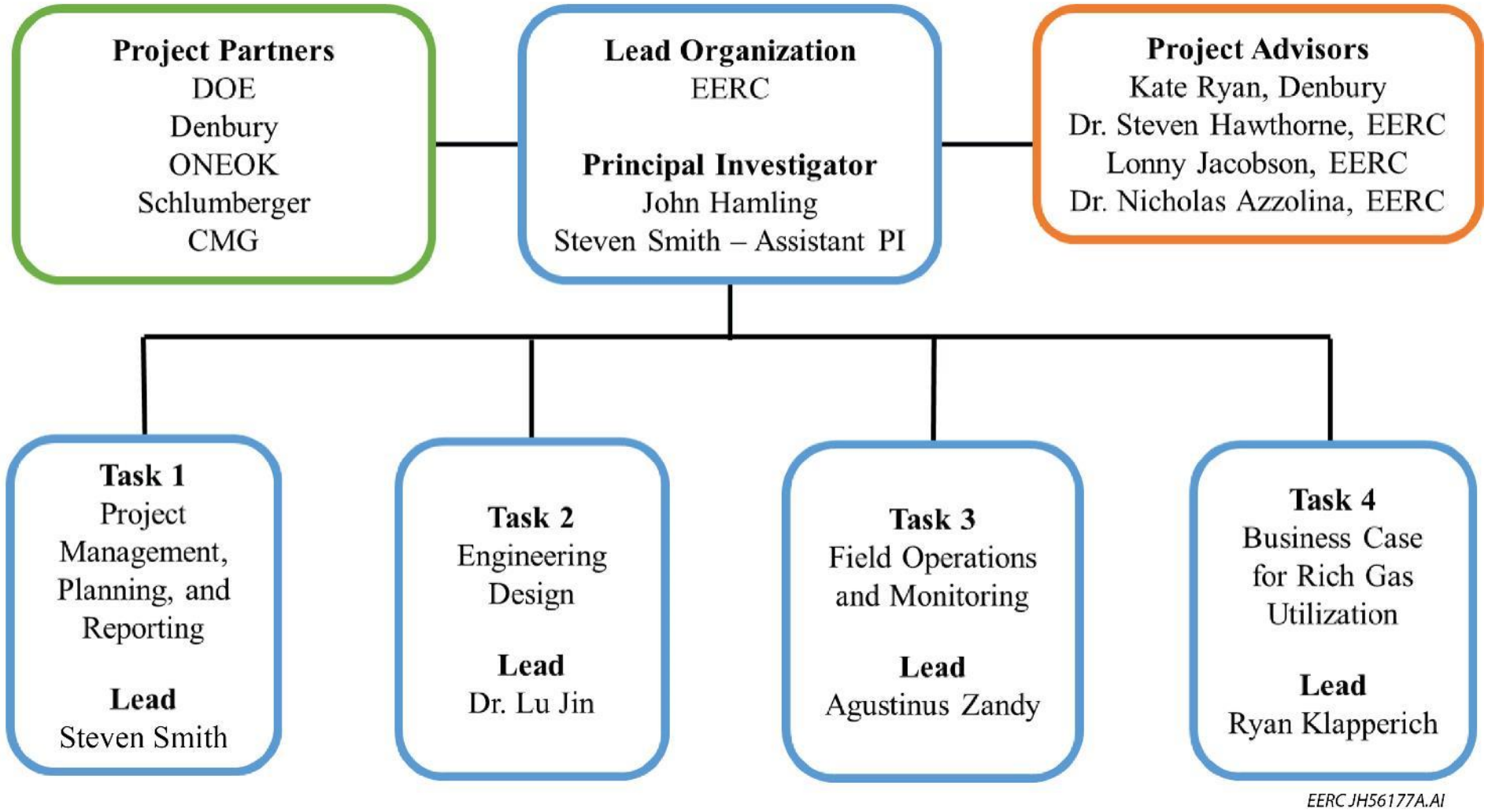
APPENDIX

ORGANIZATIONAL CHART



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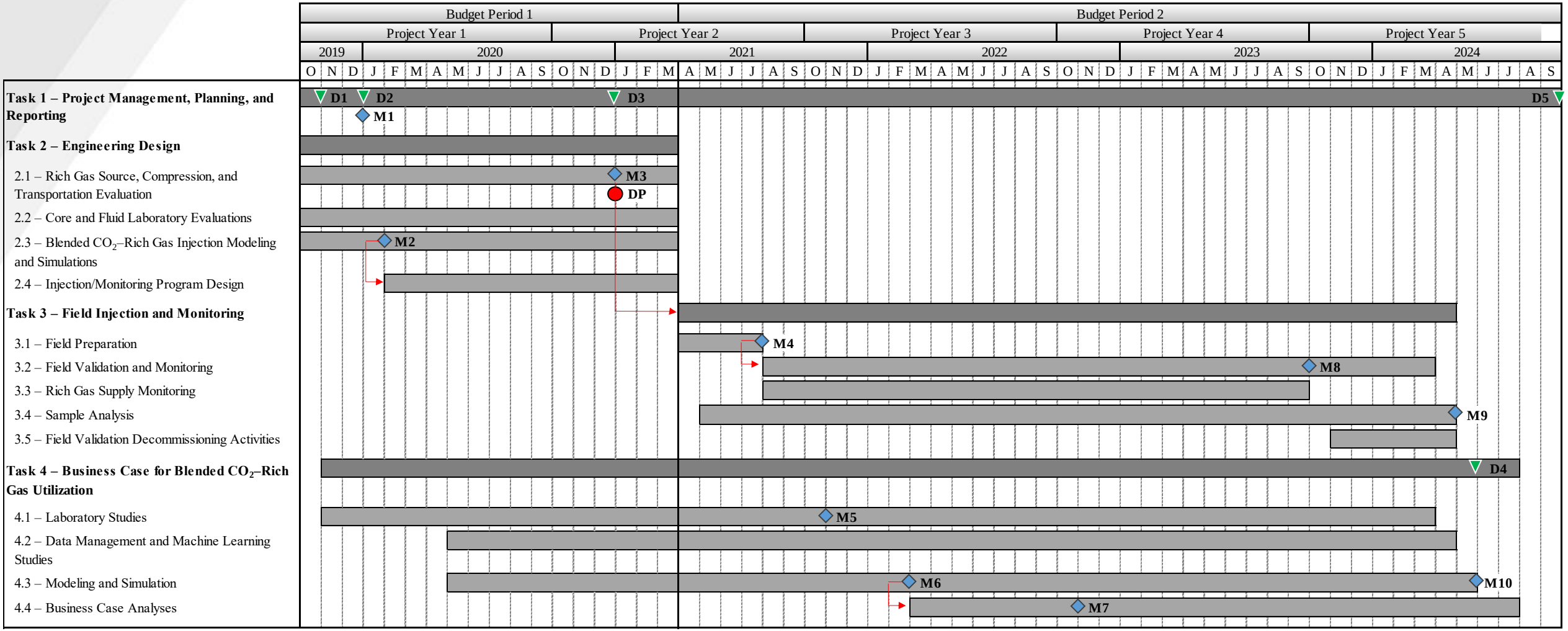
CO_2 BLENDED WITH RICH GAS TIMELINE



Key for Deliverables (D)	Key for Milestones (M)		
D1 – Updated Project Management Plan	M1 – Kickoff Meeting Held	M7 – First Field Business Case Developed	Summary Task
D2 – Data Management Plan	M2 – Injection Site Verified	M8 – Blended CO_2–Rich Gas Injection Completed	Activity Bar
D3 – Workforce Readiness Plan	M3 – Rich Gas Source Secured	M9 – Validation Test Fluid Sample Analyses Completed	Deliverable (D)
D4 – Laboratory Studies of Blended CO_2–Rich Gas EOR	M4 – Field Preparation Completed	M10 – Modeling and Simulation Completed	Milestone (M)
D5 – Data Submitted to NETL EDX	M5 – All Core Samples Obtained		Decision Point (DP)
	M6 – Initial Geostatic Models Completed		Critical Path

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