



October 26, 2023

Mr. Reice Haase
Deputy Director
North Dakota Industrial Commission
State Capitol, 14th Floor
600 East Boulevard Avenue, Department 405
Bismarck, ND 58505-0840

Dear Mr. Haase:

Subject: Quarterly Project Status Report Entitled “Improving EOR Performance Through Data Analytics and Next-Generation Controllable Completions”; Agreement No. G-050-97 EERC Fund 23906

Attached is a copy of the subject project status report for the period of July 1 – September 30, 2023.

If you have any questions, please contact me by phone at (701) 777-5120 or by email at nazzolina@undeerc.org.

Sincerely,

DocuSigned by:
Nicholas Azzolina
BD0E6230D802442...
Nicholas A. Azzolina
Assistant Director of Applied Data Analytics

NAA/rlo

Attachment

c/att: Brent Brannan, North Dakota Industrial Commission
Karen Tyler, North Dakota Industrial Commission



IMPROVING EOR PERFORMANCE THROUGH DATA ANALYTICS AND NEXT-GENERATION CONTROLLABLE COMPLETIONS

Quarterly Project Status Report

(for the period of July 1, 2023 – September 30, 2023)

Prepared for:

Reice Haase

North Dakota Industrial Commission
State Capitol, 14th Floor
600 East Boulevard Avenue, Department 405
Bismarck, ND 58505-0840

Agreement No. is G-050-97

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IMPROVING EOR PERFORMANCE THROUGH DATA ANALYTICS AND NEXT-GENERATION CONTROLLABLE COMPLETIONS

Quarterly Progress Report

July 1 – September 30, 2023

EXECUTIVE SUMMARY

The Energy & Environmental Research Center (EERC) and project partners are conducting a project to field-test an advanced machine learning approach integrating controllable completions (interval control valves [ICVs]) to enable active well control during carbon dioxide (CO₂) enhanced oil recovery (EOR). The CO₂ EOR pilot test will be conducted in Denbury Onshore, LLC's (Denbury's) Cedar Hills South Unit Field, which is part of the Cedar Creek Anticline located in southwestern North Dakota. The project goals are to 1) implement controllable completions through a rigorously monitored field test in a reservoir that has undergone primary and secondary recovery but has yet to pursue tertiary recovery, 2) apply advanced data analytics and machine learning to evaluate the test performance and develop a semiautonomous active control system, and 3) assess various business case scenarios to accelerate the development and application of this system for commercial EOR.

The project is scheduled to be accomplished over three budget periods (BPs). The project comprises five tasks: Task 1: Project Management, Planning, and Reporting; Task 2: ICV Pilot Systems Design; Task 3: Operation and Monitoring; Task 4: Active Control System Development; and Task 5: Business Case Development. Task 4 and 5 activities do not start until BP2; therefore, this quarterly summary describes accomplishments achieved within Tasks 1, 2, and 3 over the preceding calendar quarter and reports the status of project milestones or deliverables in accordance with the project management plan (PMP).

Over the reporting period, the EERC worked with Denbury to i) revise the field schedule; ii) budget and plan a sidetrack for the candidate injector well; and iii) engage PetroQuip, Entech, and Head Energy to discuss the design, fabrication, and installation of a mechanical ICV system in the candidate injection well: CHSU-43-18NH-15 (API 3301101001).

IMPROVING EOR PERFORMANCE THROUGH DATA ANALYTICS AND NEXT-GENERATION CONTROLLABLE COMPLETIONS

Quarterly Progress Report July 1 – September 30, 2023

INTRODUCTION

The Energy & Environmental Research Center (EERC) and project partners are conducting a project to field-test an advanced machine learning approach integrating controllable completions (interval control valves [ICVs]) to enable active well control during carbon dioxide (CO₂) enhanced oil recovery (EOR). The CO₂ EOR pilot test will be conducted in Denbury Onshore, LLC's (Denbury's) Cedar Hills South Unit Field (CHSU), which is part of the Cedar Creek Anticline located in southwestern North Dakota. The project goals are to 1) implement controllable completions through a rigorously monitored field test in a reservoir that has undergone primary and secondary recovery but has yet to pursue tertiary recovery, 2) apply advanced data analytics and machine learning to evaluate the test performance and develop a semiautonomous active control system, and 3) assess various business case scenarios to accelerate the development and application of this system for commercial EOR.

The project goals are scheduled to be accomplished over three budget periods (BPs). The project is organized into five tasks:

- Task 1 – Project Management, Planning, and Reporting
- Task 2 – ICV Pilot System Design
- Task 3 – Operation and Monitoring
- Task 4 – Active Control System Development
- Task 5 – Business Case Development

Task 4 and 5 activities do not start until BP2; therefore, this quarterly summary describes accomplishments achieved within Tasks 1, 2, and 3 over the preceding calendar quarter and reports the status of project milestones or deliverables in accordance with the project management Plan (PMP).

ACCOMPLISHMENTS

Task 1.0 – Project Management, Planning, and Reporting

The objectives of Task 1.0 are for the EERC to manage and direct the project in accordance with the PMP to meet all technical, schedule, and budget objectives and requirements. Significant accomplishments for Task 1.0 during the reporting period include the following:

- On July 24, 2023, the EERC submitted a revised statement of project objectives (SOPO) and revised PMP based on discussions between the U.S. Department of Energy

(DOE) and EERC project managers (PMs). Minor revisions to the PMP were requested by DOE, and on July 26, 2023, the EERC submitted an updated version of the PMP. The revised SOPO and PMP will be incorporated into Modication-009, which will likely be finalized by DOE after September 30, 2023.

- EERC staff, including members of the project team, participated in a multiday event during the week of August 7–11. This in-person-only event occurred at the EERC facility in Grand Forks, North Dakota, and comprised training on EERC functions related to research management and execution, team meetings, and team building.

Next steps to accomplish the goals under Task 1.0 include the following:

- Progress on project milestones and deliverables will continue to be tracked (refer to Tables 1 and 2).

Table 1. Milestone Status Report

Milestone (M) Number	Milestone Description	Planned Completion Date	Actual Completion Date	Verification Method	Comments
M1	Screening and Selection of Pilot Test Pattern Complete	01/31/20	11/30/19	Reported in subsequent quarterly report	Completed
M2	Field Characterization Activities Complete	06/30/23		Email verification to DOE PM	Revised date based on NCTE*
M3	Laboratory Characterization Activities Complete	10/31/20	10/20/20	Reported in subsequent quarterly report	Revised date based on NCTE
M4	ICV Installation and Initial Testing Complete	06/30/24		Reported in subsequent interim report	Revised date based on NCTE
M5	Tracer Study Initiated	07/31/25		Email verification to DOE PM	Revised date based on NCTE
M6	Initial Active Control System Design Complete	10/01/25		Reported in subsequent quarterly report	Revised date based on NCTE
M7	Active Control System Design Complete	09/30/26		Reported in subsequent interim report	Revised date based on NCTE
M8	Geologic Model Complete	09/30/26		Reported in subsequent quarterly report	Revised date per NCTE
M9	Transfer of Operational Ownership of ICV Pilot to Field Operator Initiated	06/30/27		Email verification to DOE PM	Revised date based on NCTE
M10	Numerical Simulation Complete	06/30/27		Reported in subsequent quarterly report	Revised date based on NCTE

*No-cost time extension.

Table 2. Project Deliverables

Deliverable (D) Number	Deliverable Description	Planned Completion Date	Actual Completion Date	Verification Method	Comments
D1	Updated PMP	02/26/20	02/25/20	PMP file submitted	Completed
D2	Workforce Readiness Plan	11/01/20	09/28/20	Plan submitted	Completed
D3	Data Management Plan	01/27/20	12/18/19	Plan submitted	Completed
D4	Interim Field Performance Summary Report	04/30/26		Summary report submitted	Revised date based on NCTE
D5	Business Cases for Commercial Deployment of ICV Systems for Managing EOR Performance	05/01/27		Final technical report submitted	Revised date based on NCTE
D6	Development Strategy Plan	07/31/27		Plan submitted	Revised date based on NCTE
D7	Data Submitted to NETL* EDX**	09/30/27		Data uploaded to EDX	Revised date based on NCTE

* National Energy Technology Laboratory.

** Energy Data eXchange.

Task 2.0 – ICV Pilot System Design

Task 2.0 includes four subtasks: 1) screening and selection of a test pattern, 2) field and laboratory characterization of the test pattern, 3) baseline modeling and simulation to support the preliminary pilot design, and 4) pilot design. The four subtasks within Task 2.0 will result in a final pilot design that will be implemented in Task 3.0.

Subtask 2.1 – Screening and Selection of Test Pattern

Subtask 2.1 is complete, and the candidate injection well is CHSU-43-18NH-15 (API 3301101001).

Subtask 2.2 – Characterization

The EERC continued working with Denbury to revise the field schedule for the abandonment of the candidate injection well CHSU 4318NH 15 lateral and for preparations for the sidetrack, which will be conducted under AFE CW2326788CAP. Denbury has planned for a sidetrack of the candidate injection well (CHSU 43-18NH 15 ST) to provide a clean lateral for logging and ICV system installation, which will be conducted under AFE AN38407. Denbury continues to finalize its drilling rig schedule for the Cedar Creek Anticline and is coordinating the abandonment of the candidate injection well CHSU 4318NH 15 lateral and sidetrack of the candidate injection well (CHSU 43-18NH 15 ST) with broader field activities.

Subtask 2.3 – Baseline Modeling

Subtask 2.3 is complete.

Subtask 2.4 – Pilot Design

The EERC worked with Denbury to engage PetroQuip, Entech, and Head Energy to discuss the design, fabrication, and installation of a mechanical ICV system. The ICV system design will be conducted under AFE AN3840. The current schedule estimates having the ICV system key parts delivered to PetroQuip in late September, with the EERC and possibly DOE visiting the PetroQuip facility in Waller, Texas, sometime in the early-to mid-November time frame to see the assembled and functional system.

There is uncertainty in the sidetrack and ICV system installation schedule. Most scenarios have the move in and rig up (MIRU), lateral abandonment, sidetrack drilling, run completion, rig down and move out (RDMO), and final surface work occurring between October 2023 and January 2024. It is unlikely that a drilling rig will come to the CHSU before early November 2023; however, there is still optimism about installing the ICV system before the end of the calendar year.

Task 3.0 – Operation and Monitoring

Task 3.0 entails installation and testing of the pilot design and the operation and monitoring of the ICV system. The objectives of Task 3.0 are to 1) install a set of up to ten ICVs into the CO₂ injection well; 2) execute a tracer study using ICV interval-specific tracers to quantify connectivity within the reservoir and inform the subsequent operational designs; and 3) operate the ICVs and quantitatively show that the deployment of the ICVs can reduce premature breakthrough of injected fluids, increase CO₂ sweep efficiency, and improve incremental production.

No work was conducted under Task 3.0 during the performance period.

PRODUCTS

Nothing to report.

CHANGES/PROBLEMS

Nothing to report.

SPECIAL REPORTING REQUIREMENTS

Nothing to report.

PARTNERS AND FINANCIAL INFORMATION

This project is sponsored by the North Dakota Industrial Commission (NDIC), DOE, Computer Modelling Group (CMG), and SLB. Table 3 presents the total budget of \$9,997,024 for this project and expenses through September 30, 2023.

Table 3. Project-to-Date Financial Report as of September 30, 2023

Funding Source	Cash	In-Kind	Project Total	Expenses to Date
NDIC	\$500,000	\$0	\$500,000	\$94,930
DOE	\$7,997,077	\$0	\$7,997,077	\$1,886,574
CMG	\$0	\$733,304	\$733,304	\$733,304
SLB	\$0	\$766,643	\$766,643	\$508,350
Total	\$8,497,077	\$1,499,947	\$9,997,024	\$3,223,158