Energy & Environmental Research Center
15 North 23rd Street, Stop 9018 • Grand Forks, ND 58202-9018 • P. 701.777.5000 • F. 701.777.5181
www.undeerc.org

July 26, 2023

Mr. Reice Haase
Deputy Executive 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 April 1 – June 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 April 1, 2023, through June 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

Prepared by:

Nicholas A. Azzolina
Trevor L. Richards
Neil W. Dotzenrod
Lonny L. Jacobson
Beth A. Kurz
Charlotte D. Riter

Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

July 2023

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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 (CO_2) enhanced oil recovery (EOR). The CO_2 EOR pilot test will be conducted in Denbury Onshore, LLC's (Denbury) 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
April 1 – June 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 (CO_2) enhanced oil recovery (EOR). The CO_2 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 February 7, 2023, the U.S. Department of Energy (DOE) approved the December 30, 2022, no-cost time extension (NCTE) request, revised the statement of project

objectives (SOPO), and revised the PMP. Modification-008 was finalized on February 27, 2023 (the effective date was February 1, 2023).

- Further conversations between DOE and the EERC since February 27, 2023, discussed additional revisions to the SOPO about go/no-go decision points related to the planned sidetrack and the installation and testing of the ICV system. These revisions will likely be addressed through a subsequent SOPO modification (Modification-009) in the next calendar quarter.

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

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

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 worked 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.

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

* Project manager.

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 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 CO_2 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 CO_2 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 shows the total budget of $9,997,024 for this project and expenses through June 30, 2023.

Table 3. Project-to-Date Financial Report as of June 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	$1,870,604
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**	**$3,207,188**