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

January 27, 2021

Ms. Karlene Fine
Executive Director
North Dakota Industrial Commission
State Capitol, 14th Floor
600 East Boulevard Avenue, Department 405
Bismarck, ND 58505-0840

Dear Ms. Fine:

Subject: Revised Quarterly Project Status Report Entitled "Improving EOR Performance Through Data Analytics and Next-Generation Controllable Completions"
Agreement No. G-050-97; EERC Fund 24377

Attached is a copy of the subject project status report for the period of October 1 through December 31, 2020.

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

Sincerely,

Nicholas A. Azzolina

Nicholas A. Azzolina
Principal Hydrogeologist & Statistician

NAA/kal

Attachment

c/att: Brent Brannan, North Dakota Industrial Commission

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

Revised Quarterly Project Status Report

*(for the period of October 1, 2020, through December 31, 2020)*

*Prepared for:*

Karlene Fine

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

Agreement No. G-050-97

*Prepared by:*

Nicholas A. Azzolina
Nicholas W. Bosshart
Lonny L. Jacobson
John A. Hamling
Nicholas S. Kalenze

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

January 2021

## EERC DISCLAIMER

LEGAL NOTICE This research report was prepared by the Energy & Environmental Research Center (EERC), an agency of the University of North Dakota, as an account of work sponsored by the U.S. Department of Energy (DOE) National Energy Technology Laboratory. Because of the research nature of the work performed, neither the EERC nor any of its employees makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement or recommendation by the EERC.

## DOE DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government, nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

## NDIC DISCLAIMER

This report was prepared by the Energy & Environmental Research Center (EERC) pursuant to an agreement partially funded by the Industrial Commission of North Dakota, and neither the EERC nor any of its subcontractors nor the North Dakota Industrial Commission nor any person acting on behalf of either:

(A) Makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

(B) Assumes any liabilities with respect to the use of, or for damages resulting from the use of, any information, apparatus, method, or process disclosed in this report.

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the North Dakota Industrial Commission. The views and opinions of authors expressed herein do not necessarily state or reflect those of the North Dakota Industrial Commission.

## TABLE OF CONTENTS

## LIST OF FIGURES



## LIST OF TABLES

**IMPROVING EOR PERFORMANCE THROUGH DATA ANALYTICS AND NEXT-GENERATION CONTROLLABLE COMPLETIONS**
**Quarterly Progress Report**
**October 1 – December 31, 2020**

## 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 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 goals will be accomplished over 5 years, which includes three budget periods (BPs): BP1: October 1, 2019 – June 30, 2021; BP2: July 1, 2021 – January 31, 2023; and BP3: February 1, 2023 – September 30, 2024. A go/no-go decision point will follow BP1, contingent upon the successful deployment and testing of the controllable completion technology. The project is organized into five tasks: Task 1: Project Management and Planning, Task 2: ICV Pilot Systems Design, Task 3: Operation and Monitoring, Task 4: Active Control System Development, and Task 5: Business Case Development. This quarterly summary describes accomplishments achieved within each task over the preceding calendar quarter and reports the status of project milestones or deliverables in accordance with the Project Management Plan.

The following accomplishments were achieved during the preceding calendar quarter: 1) three-dimensional (3D) seismic data were acquired from the test pattern and are currently being processed; 2) the project team started simulating the pilot test pattern performance to generate initial estimates of reservoir behavior with the ICV system; and 3) initial planning began for the active control system (Task 4) and business case development (Task 5).

Progress on project milestones and deliverables will continue to be tracked and reported in accordance with the Project Management Plan.

The EERC holds an unwavering commitment to the health and well-being of its employees, partners and clients, and our global community. As such, precautionary measures have been implemented in response to COVID-19. Staff continue to carry out project-related activities remotely, and personnel supporting essential on-site laboratory and testing activities are proceeding under firm safety guidelines. Travel has been minimized, and protective measures are being undertaken for those who are required to travel. At this time, work conducted by EERC employees is anticipated to progress with minimal disruption. Challenges posed by

economic variability will be met with open discussion between the EERC, the U.S. Department of Energy Project Manager, and other partners to identify solutions. The EERC is monitoring developments across the nation and abroad to minimize risks, achieve project goals, and ensure the success of our partners and clients.

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

## 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 (CCA) 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 will be accomplished over 5 years, which includes three budget periods (BPs): BP1: October 1, 2019 – June 30, 2021; BP2: July 1, 2021 – January 31, 2023; and BP3: February 1, 2023 – September 30, 2024. A go/no-go decision point (DP) will follow BP1, contingent upon the successful deployment and testing of the controllable completion technology. The project is organized into five tasks:

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

This quarterly summary describes accomplishments achieved within each task 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 – Project Management, Planning, and Reporting

The objectives of Task 1 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 during the reporting period include the following:

- Throughout the reporting period, the EERC participated in several project update meetings with Denbury and NCS Multistage, LLC (NCS Multistage). EERC, Denbury, and NCS Multistage comprise the core design team for the project.

- In accordance with the contractual requirements, the EERC submitted a continuation application (CA) to the U.S. Department of Energy (DOE) Project Manager (PM) and DOE contracts specialist on November 2, 2020. The CA submission and DOE acceptance are necessary for project activities to advance from BP1 to BP2. However, based on discussions with DOE PM, the CA was not formally accepted because of not achieving a Go/No-Go DP 1 before the end of the previous BP1 timeline. A revised CA will be submitted 90 days before the end of a revised ending BP1 date (June 30, 2021).

- On December 2, 2020, the EERC notified the DOE PM that due to field delays in response to the COVID-19 pandemic, macroeconomic conditions, and decline in oil prices in 2020, the project would not achieve Milestone 2 (M2 – Field Characterization Activities Complete) or the Go/No-Go DP 1 by the end of the calendar year (December 31, 2020). On December 8, 2020, the DOE PM notified the EERC that the National Energy Technology Laboratory (NETL) Integrated Project Team discussed the situation and recommended a No-Cost Time Extension (NCTE). On December 11, 2020, the EERC submitted a formal request for a no-cost extension to the end of BP1 from January 31, 2021, to June 30, 2021. A revised PMP is forthcoming in January 2021.

- The EERC continued to submit paperwork to Kiteworks for additional EERC foreign nationals (FN)s on the project, to concur with FN requirements established in Modification No. 0002 of the DOE agreement.

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 Systems 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. Significant accomplishments for each subtask within Task 2.0 during the reporting period include the following:

***Subtask 2.1 – Screening and Selection of Test Pattern***

As described in the April 2020 quarterly summary, the project team identified wells that met a set of screening criteria and a final selection was made for the pilot test. The candidate injection well was selected: CHSU-43-18NH-15 (API 3301101001). The selection of a candidate injection well satisfies Milestone 1 (M1) – Screening and Selection of Pilot Test Pattern Complete, and Subtask 2.1 is complete.

**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 | 06/30/21 | | E-mail verification to DOE PM | Revised date per NCTE |
| M3 | Laboratory Characterization Activities Complete | 10/31/20 | 10/20/20 | Reported in subsequent quarterly report | |
| M4 | ICV Installation and Initial Testing Complete | 03/31/22 | | Reported in subsequent interim report | |
| M5 | Tracer Study Initiated | 08/01/22 | | E-mail verification to DOE PM | |
| M6 | Initial Active Control System Design Complete | 01/31/22 | | Reported in subsequent quarterly report | |
| M7 | Active Control System Design Complete | 01/31/23 | | Reported in subsequent interim report | |
| M8 | Geologic Model Complete | 01/31/23 | | Reported in subsequent quarterly report | |
| M9 | Transfer of Operational Ownership of ICV Pilot to Field Operator Initiated | 11/01/23 | | E-mail verification to DOE PM | |
| M10 | Numerical Simulation Complete | 01/31/24 | | Reported in subsequent quarterly report | |

**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 | 01/31/23 | | Summary report submitted | |
| D5 | Business Cases for Commercial Deployment of ICV Systems for Managing | 09/30/23 | | Final technical report submitted | |
| D6 | Development Strategy Plan | 07/31/24 | | Plan submitted | |
| D7 | Data Submitted to NETL EDX | 09/30/24 | | Data uploaded to EDX* | |

* Energy Data eXhange.

### *Subtask 2.2 – Characterization*

*Laboratory Characterization*

As described in the October 2020 quarterly summary, laboratory analyses of core plug samples of the Red River "B" main pay zone interval are complete (M3 – Laboratory Characterization Activities Complete), and there are no additional laboratory activities planned for the project.

*Field Characterization*

**Well logging:** The project team finalized the logging plan for the injection well, and the planned logging tools currently include Schlumberger's quad-combo suite (gamma ray, induction, neutron porosity, density, and sonic), Fullbore Formation Microimager (FMI), and sonic dipole. The revised field schedule anticipates conducting well logging in late Quarter (Q)1 2021. The field work will include a well cleanout with a larger workover rig than the October 2020 field event immediately followed by ThruBit logging.

**Baseline 3D seismic:** A baseline three-component, three-dimensional (3C3D) seismic survey was acquired from the test pattern area on November 1–14, 2020 (Figure 1). Processing of the acquired 3C3D seismic data is expected to occur over a 2-month period, including PP PSTM (prestack time migration) workflow followed by PS processing and registration (Figure 2). The processed P-wave (PP) product is expected in January 2021. Based on the interpretation of the PP product, the converted-wave (PS) product will be registered in preparation for continued processing and characterization steps. The initial interpretation shows a reasonable gamma value resulting from the PP and PS data. Gamma is relative representation of P-wave velocity (Vp) and S-wave velocity (Vs) response (Vp/Vs) calculated from the two-way time in the registration processing workflow. The PS data volumes will be delivered in February 2021. The processed PP and PS products and interpreted derivatives will be integrated by the EERC and Denbury into the baseline geologic model.

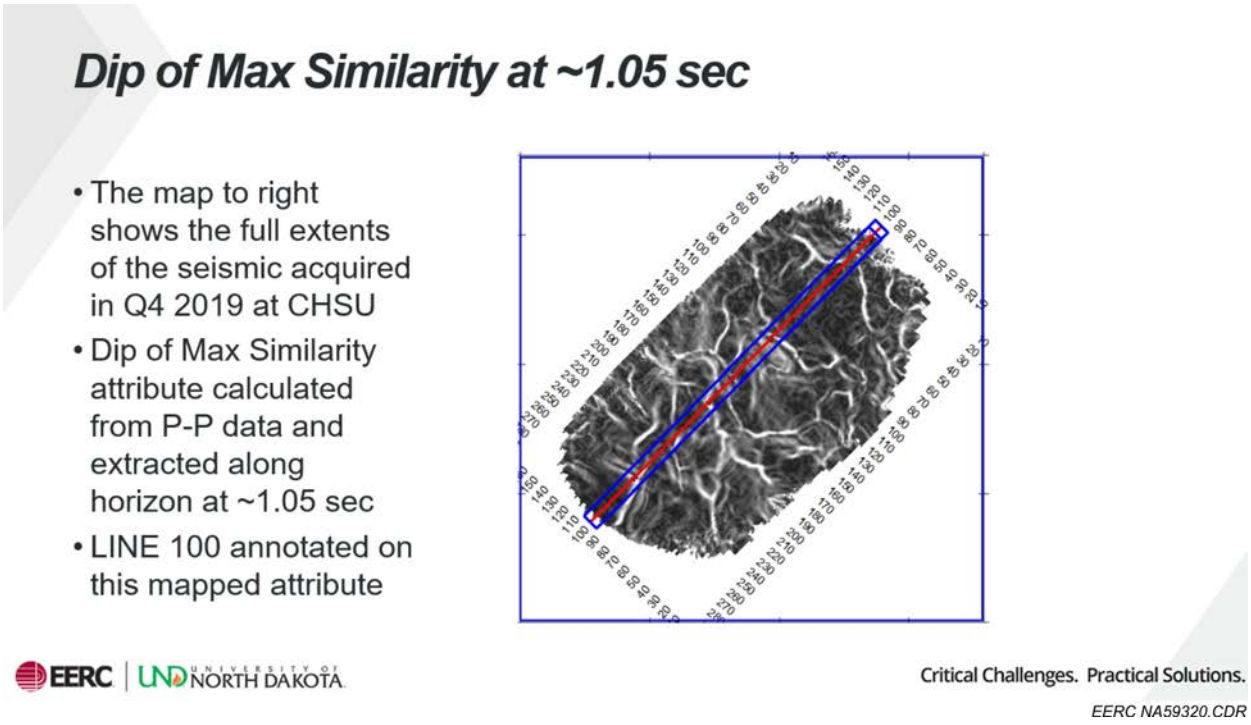


Figure 1. Map of the test pattern area showing dip of max similarity is an extraction along an interpreted horizon showing good data quality across the ~4-mi$^2$ survey.

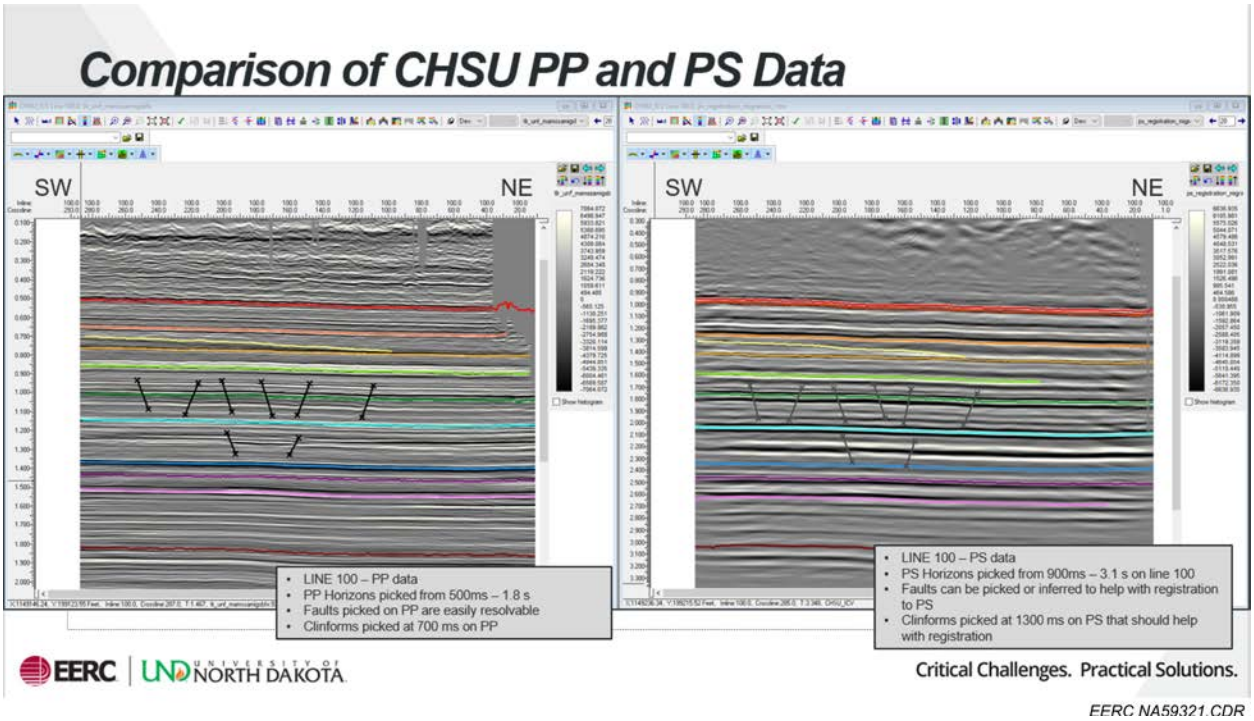


Figure 2. Comparison showing preliminary interpretations of the PP (left) and PS (right) data feeding the registration and continued refinement of the PS data.

**Next steps:** The well logging and baseline 3D seismic survey will constitute Milestone 2 (M2 – Field Characterization Activities Complete) and will be reported to DOE in accordance with Table 1. Outputs from the well logging and baseline 3D seismic survey will be integrated into the baseline geologic modeling under Subtask 2.3.

### *Subtask 2.3 – Baseline Modeling*

*Baseline Geomodel*

The full-field geologic model (geomodel) described in the July 2020 quarterly summary was clipped to the test pattern area to create a sector model for the reservoir simulations. The reservoir matrix and fracture properties of the current sector model reflect the broader full-field geomodel (Baseline Geomodel Version 1). These properties will be updated in the future after completion of the field characterization (Baseline Geomodel Version 2).

*Baseline Reservoir Simulations*

Equation-of-State Parameter Tuning

The reservoir simulation team conducted initial equation-of-state (EOS) parameter tuning based on available data for the CHSU. The EOS parameter tuning used a 10-component model and the Computer Modelling Group (CMG) WinProp Fluid Property Characterization Tool, with match points for i) saturation pressure, ii) liquid density and volume, iii) formation volume factor (FVF), iv) gas:oil ratio (GOR), v) oil/gas gravities, and vi) oil/gas viscosity. The fitted EOS model was then used to predict separator and minimum miscibility pressure (MMP) data to compare the predictions against the experimental data. The initial 10-component model was used in preliminary pattern-level reservoir simulations and will undergo further quality assurance/quality control (QA/QC) prior to finalizing the EOS tuning.

Following previous discussions of EOS parameter tuning with project partner Denbury and collecting feedback, changes were made to the 10-component model including:

- Higher weightage to the saturation pressure values at low $CO_2$ mole % mixing.
- Improved viscosity match.
- Retuned constant composition expansion.

**Next steps:** The EERC will present the new EOS model to internal project members and to Denbury for review and feedback.

Preliminary Pattern-Level Reservoir Simulations

Using the Baseline Geomodel Version 1, an initial pattern-level STARS model was developed to study flow behavior in the pilot test pattern (STARS Version 1). The model includes one water/$CO_2$ injector (Well CHSU 43-18NH 15) and two offset producers (CHSU 13D-17NH 15 and CHSU 33B-18NH 15). The production and injection data of the three wells was processed and integrated into the simulation model. Different boundary conditions, including aquifer support and constant fluid influx, are being tested to match the production and injection history.

The reservoir simulations are using the CMG module, FlexWell, within STARS to segment the injection well into zones using flow control devices (FCDs). The FCD zones will mirror the ICV system that will be deployed into the injection well.

An embedded discrete fracture modeling (EDFM) technique is being used to model natural fractures in the reservoir. The preliminary pattern-level reservoir simulations using Baseline Geomodel Version 1 assume a stochastic fracture network. The stochastic fracture network was converted into fractured grids using SimTech LLC's EDFM software and integrated into the STARS simulation model (STARS Version 2).

Baseline reservoir simulations were conducted using the STARS Version 2 model and FlexWell to emulate the ICV system. The simulations started with production and injection

history matching of primary and secondary (waterflood) production performance and then generated forecasts of EOR performance in response to $CO_2$ injection at the injection well. Figure 3 shows a synthetic scenario where $CO_2$ was injected to the reservoir via Well CHSU 43-18NH 15 and the gas preferentially flowed through the areas of the reservoir with high-permeability fractures. Figure 4 illustrates the increased $CO_2$ mole fraction over time in Well CHSU 33B-18NH 15. The peaks indicate where the wellbore connects to high-permeability fractures. These figures indicate that it is necessary to control the distribution of $CO_2$ injection in the injector using ICVs to prevent quick breakthrough to the offset production wells.

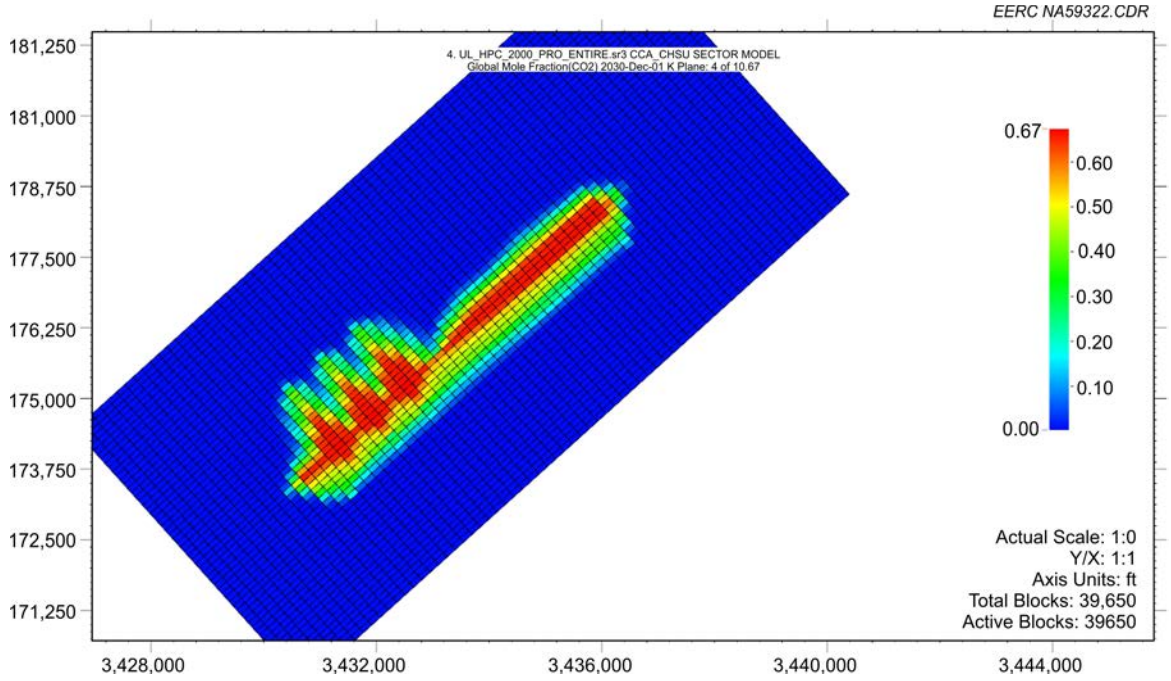


Figure 3. Results of a synthetic injection scenario at Well CHSU 43-18NH 15. Warmer colors (red/yellow) represent higher amounts of $CO_2$ within the reservoir pore space, illustrating the effective sweeping of $CO_2$ within the wellbore and near-wellbore environment. In this example, greater $CO_2$ is shown in the high-permeability fractures perpendicular to the wellbore.

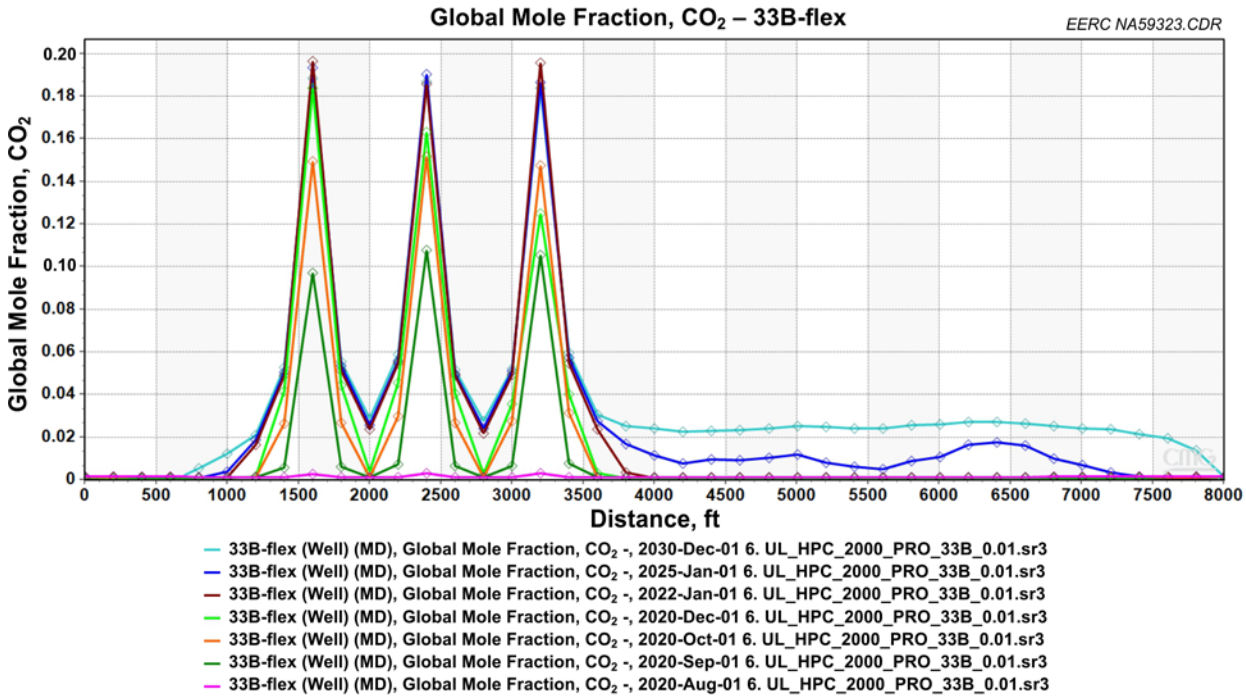


Figure 4. Increase of $CO_2$ mole fraction over time in Well CHSU 33B-18NH 15. The peaks indicate where the wellbore connects to high-permeability fractures in the reservoir.

**Next steps:** After completion of the field characterization, the Baseline Geomodel Version 1 will be updated to Baseline Geomodel Version 2. At that time, the STARS Version 2 model will be updated to reflect the updated matrix and fracture properties observed in the test pattern area (STARS Version 3). The STARS Version 3 model will then be used for additional reservoir simulations under Subtask 2.3 and for the Task 5.0 scope of work.

### *Subtask 2.4 – Pilot Design*

The project team has adapted the NCS Qumulus™ Ultimate Recovery System to accommodate a horizontal injection well and site-specific wellbore considerations. The current ICV pilot system design for the injection well includes a 4.5-inch, 12.6-pound tubing (upper section) and 2⅞-inch, 6.4-pound tubing (lower/horizontal section). The project team will reevaluate the ICV design after completion of the field work under Subtask 2.2.

**Next steps:** The project team will continue to evaluate the ICV pilot system design and work toward a final design prior to installing and testing the system in BP2.

### 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 and evaluate performance of virtual ICV applications to the offset

production wells, 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.

**Next steps:** The objectives of Task 3.0 will be completed through two subtasks: Subtask 3.1 – Install and Test Systems and Subtask 3.2 – System Operation and Monitoring. Subtask 3.1 is currently scheduled to begin in Q1 2021, and updates will be reported in the subsequent quarterly summary.

**Task 4.0 – Active Control System Development**

The objective of Task 4.0 is to develop an active control system that integrates downhole measurements with data analytics and machine learning to provide an ICV system that is suitable for semiautonomous operation. The project team developed a Task 4.0 plan and staffing model for BP1 given the revised project timeline and BP1 end date of June 30, 2021.

**Next steps:** For the remainder of BP1, the Task 4.0 work will utilize preliminary synthetic reservoir simulations generated from STARS Version 2 (see Subtask 2.3) to evaluate a "virtual ICV installation." The active control system will be developed through integration of synthetic monitoring and performance data that emulate the pilot design. At a minimum, these synthetic data will include downhole pressure and temperature measurements within each ICV, wellhead temperature and pressure measurements within both the injection and production well, and production data (oil, gas, and water rates/volumes).

**Task 5.0 – Business Case Development**

Task 5.0 includes the calibration and history matching of the final reservoir simulation model developed under Subtask 2.3 and the extension of that model to other scenarios. The objective of Task 5.0 is to evaluate several business case scenarios using simulation models such that the learnings from the pilot test can be extended to the CHSU field and other reservoirs and operating conditions. The project team developed a Task 5.0 plan and staffing model for BP1 given the revised project timeline and BP1 end date of June 30, 2021.

**Next steps:** For the remainder of BP1, the Task 5.0 work will 1) quantify uncertainty in the Baseline Geomodel Version 2 and STARS Version 3 that will be incorporated into the business case development, 2) build a range of scenarios for a simulation case matrix for the CHSU field extent, and 3) compile ranges of properties for lateral well plays for a set of fields that will used in the broader business case evaluations for other reservoirs and operating conditions.

## PRODUCTS

Nothing to report.

## CHANGES/PROBLEMS

The EERC is operational and open for business. Personnel that are not essential for on-site operations have transitioned to working from home. Essential project, laboratory, and field-based activities are proceeding with the incorporation of Centers for Disease Control and Prevention (CDC), state of North Dakota, and University of North Dakota guidelines associated with COVID-19, and mitigation measures have been implemented.

In collaboration with project partners, the EERC is continually assessing potential impacts to project activities resulting from COVID-19 and/or the U.S. economic situation.

If potential impacts to reporting, scope of work, schedule, or cost are identified, then they will be discussed and addressed in cooperation with the DOE PM.

### No-Cost Time Extension

On December 11, 2020, EERC submitted a formal request for a no-cost extension to the end of BP1 from January 31, 2021, to June 30, 2021.

With an expected decision and announcement regarding commencement of $CO_2$ pipeline construction in 2021, the project partners have agreed to defer field characterization of the ICV injection well until after that announcement. Therefore, in addition to a BP1 end date of June 30, 2021, allowing for the completion of Milestone 2 (M2 – Field Characterization Activities Complete) and the Go/No-Go DP 1, the new end date will allow the project team to know the status of the $CO_2$ pipeline construction before DP 1. Deferring the BP1 end date benefits all project partners and improves the ability for project partners to share technical risk with potentially increased financial contributions of incremental costs associated with the cleanout and reattempt to characterize the candidate injection well. There are no negative financial or technical implications expected by the NCTE. Extending BP1 to June 30, 2021, will establish the timeline necessary to satisfy completion of M2 by integrating field data and determining the Go/No-Go DP 1 to progress into BP2.

### Revised SOPO and PMP

As described in the October 2020 quarterly summary, on August 6, 2020, the EERC submitted revised versions of the SOPO (Statement of Project Objectives) and PMP to the DOE PM, based on updates from the July 20, 2020, meeting. The DOE PM confirmed via e-mail on August 21, 2020, that the DOE Technology Manager agreed with the proposed changes to the SOPO and PMP; therefore, the EERC should proceed with the project as presented in the August 6 versions of these documents. A formal contract modification has not been executed but is anticipated to be imminent.

In response to the NCTE, a revised PMP will be submitted in January 2021 that reflects the 1) updated project timeline, 2) new end date for BP1 of June 20, 2021, 3) new start date for BP2 of July 1, 2021, and 3) new planned completion dates for M2 and DP1 of June 30, 2021. The revised PMP will also include an updated organizational structure chart and bios for new task leads.

The revised SOPO and PMP are not anticipated to impact the overall performance period and budgets within the BPs of the project., The total project cost across all three BPs will not change, and there is no net effect to labor budgets within each task. The goals, objectives, and outcomes of the project will not be adversely impacted.

**Baseline Cost Plan Variance**

As shown in the Budgetary Information table and described in the October 2020 quarterly summary, there is currently a variance between the Baseline Cost Plan and the Actual Incurred Cost.

The following items currently impact the project spending plan:

- Field activities were delayed until later in 2020, which was a necessity to adjust budget and reallocate planned contractual field expenses from BP1 to BP2.

- The costs of the originally planned ICV system in the production well were reallocated to a baseline and repeat 3D seismic of the test pattern area.

- A portion of planned field activities (labor only) were deferred from BP1 to BP2.

- The Denbury subcontract was executed later than originally planned, by Q4 2020. With many field activities initiated and ongoing in Q4 2020, invoices have not yet been incurred from Denbury to the EERC. The EERC anticipates invoiced items to occur once 3D seismic activities are at or near completion, along with additional field and laboratory characterization activities closer to the end of BP1. Once actual expenses are invoiced, this will bring the actuals closer to the baseline spending plan.

The revised project timeline in the forthcoming PMP will adapt any variances to the Baseline Cost Plan accordingly. There are no changes to the currently approved scope of work or budget for BP2.

## SPECIAL REPORTING REQUIREMENTS

Nothing to report.

## PARTNERS AND FINANCIAL INFORMATION

This project is sponsored by the North Dakota Industrial Commission (NDIC), DOE, CMG, and Schlumberger. Table 3 shows the total budget of $9,997,024 for this project and expenses through the reporting period.

**Table 3. Project-to-Date Financial Report at December 31, 2020**

| Funding Source | Budget | Current Reporting Period Expenses | Cumulative Expenses as of 12/31/20 | Remaining Balance |
|---|---|---|---|---|
| DOE | $7,997,077 | $176,442 | $1,000,738 | $6,996,339 |
| NDIC | $500,000 | $11,172 | $70,956 | $429,044 |
| CMG – In Kind | $733,304 | $347,004 | $733,304 | $0 |
| Schlumberger – In Kind | $766,643 | $0 | $508,350 | $258,293 |
| **Total** | **$9,997,024** | **$534,618** | **$2,313,348** | **$7,683,676** |