Improving EOR Performance Through Data Analytics and Next-Generation Controllable Completions

(DE-FE0031790)

U.S. Department of Energy National Energy Technology Laboratory
Oil & Natural Gas
2020 Integrated Review Webinar
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Principal Hydrogeologist & Statistician
Conceptual Pilot Test Design

- Field-test controllable completion for active well control during carbon dioxide (CO$_2$) enhanced oil recovery (EOR).
- One lateral injection well with ICV system.
- Two offset lateral production wells with openhole completion.
- Rigorously monitored field test.
- Use offset patterns as a reference case to assess performance.
- Combine field and simulation data to develop business case scenarios.

Red River Fm. Cedar Creek Anticline

Interval Control Valves (ICVs)
Lead Organization
• Energy & Environmental Research Center

Project Partners
• U.S. Department of Energy
• North Dakota Oil & Gas Research Program
• Denbury Onshore LLC
• NCS Multistage LLC
• North Dakota Geological Survey
• Schlumberger
• Computer Modelling Group Ltd.
Funding and Project Performance Dates

Funding Profile by Budget Period (BP) (October 1, 2019 – September 30, 2024)

| Budget Period | Federal     | Nonfederal | Total       | Federal     | Nonfederal | Total       | Federal     | Nonfederal | Total       | Federal     | Nonfederal | Total       | Federal     | Nonfederal | Total       | Federal     | Nonfederal | Total       |
|---------------|-------------|------------|-------------|-------------|------------|-------------|-------------|------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| NDIC OGRP     | –           | 133,000    | 133,000     | –           | 200,000    | 200,000     | –           | 167,000    | 167,000     | –           | 500,000    | 500,000     | –           | 733,304    | 733,304     | –           | 733,304    | 733,304     |
| Total         | 2,671,594   | 1,116,930  | 3,788,524   | 3,297,845   | 466,501    | 3,764,346   | 2,027,638   | 416,516    | 2,444,154   | 7,997,077   | 1,999,947  | 9,997,024   | 79,97,077   | 1,999,947  | 99,97,024   | 79,97,077   | 1,999,947  | 99,97,024   |

Total Cost Share %

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Note: **Denbury** is providing additional contributions in the form of field support, infrastructure development, CO₂ supply, and injection/production operations. **NCS Multistage** is providing additional contributions in the form of field activities: multizone completions and injection well tracer testing.
Technology Background: 
Qumulus™ Ultimate Recovery System

• Packers provide isolation between zones.
• Injection valve control at each zone.
• Pressure and temperature at each zone.
• Single wire for all valves and gauges.
• Operate from anywhere using a cloud-based supervisory control and data acquisition (SCADA) system.
• Slim dimensions, suitable for common onshore wells.
Technical Approach/Project Scope

- Task 1.0 – Project Management and Planning
- Task 2.0 – ICV Pilot Systems Design
  2.1 – Screening and Selection of Test Pattern
  2.2 – Characterization \( \leftarrow DP1: \text{Go/no-go decision for the candidate injection well 12/31/20} \)
  2.3 – Baseline Modeling
  2.4 – Pilot Design
- Task 3.0 – Operation and Monitoring
  3.1 – Install and Test Systems

\( DP2: \text{Go/no-go decision for successful ICV system in the injection well 3/31/22} \)
Technical Approach/Project Scope (cont.)

• Task 3.0 – Operation and Monitoring (cont.)
  3.2 – System Operation and Monitoring

• Task 4.0 – Active Control System Development
  4.1 – Database and User Interface Development
  4.2 – Active Control System Development, Testing, and Optimization

• Task 5.0 – Business Case Development
  5.1 – Long-Term Pilot Test Pattern Performance Simulation
  5.2 – Business Case Development
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**Virtual ICV System**

- Modeling and simulations
- Field Characterization
- M2 Field ICV Installation and Testing
- M4 ICV Installation and Testing
- M6 Initial Active Control System
- M7 Final Active Control System
- Field-Based Learning
- Parameter Tuning
- Finalizing Simulations

**Field ICV System**

- Design, Installation, and Testing

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**Critical Challenges. Practical Solutions.**
Progress and Current Project Status

- Pilot test pattern and candidate injection well have been selected.
- Rock core laboratory analyses complete.
- Full-field geologic model complete.
- Initiated numerical reservoir simulations.
- Wireline logging in early October 2020.
- Baseline three-component, 3D seismic acquisition planned for November 2020.
- Preliminary ICV system design complete and pending field data.
Expected Results

• Demonstrate performance and reliability of ICV deployment for CO\textsubscript{2} EOR in horizontal injection and production wells (*first application*).

• Evaluate perceived risks of deploying ICVs in horizontal wells. Inform ICV system design, installation practices, and operational practices.

• Develop/improve active control systems for ICV operation.

• Quantify performance metrics: 1) net CO\textsubscript{2} utilization, 2) oil recovery and sweep efficiency, and 3) operating costs.

• Evaluate business cases for the implementation of ICVs for improving EOR performance for a range of reservoirs, fields, and operational scenarios (including potential application for conformance control for Bakken EOR).
Benefits

• Demonstrate the reliability and performance to enable broad adoption of controllable completions in horizontal wells.
  – Current state: Limited demonstration of reliability and performance.
  – Path forward: Validate a potential pillar technology for unlocking EOR in unconventional tight oil plays, where conformance is a known challenge.

• Techno-economic assessments indicate horizontal wells are a key to enabling economical EOR in conventional fields.

• Controllable completions may allow horizontal wells to be managed like a series of vertical wells and drive efficiency, reduce CO$_2$ net utilization rates, and increase oil recovery with fewer wells.

1
d"Techno-Economic Assessment of Implementing Lignite Based CO$_2$ EOR in North Dakota" Final Report, submitted to North Dakota Department of Commerce, Grant Agreement No. 1867.
Denbury Statement Regarding Benefits

• Piloting next-generation controllable completions offers an attractive value proposition to Denbury.

• This pilot test will provide new insights on reservoir performance prior to and during CO₂ EOR. Additionally, it will give us operational experience deploying advanced completions in horizontal wells. Furthermore, this pilot will allow us to leverage data analytics to optimize well and reservoir performance.

• The pilot’s well-thought-out design will streamline our ability to interpret results. Our findings will be used to evaluate the business case for applying this technology at Cedar Creek Anticline and in other fields.
This project has adapted to the 2019–2020 operating conditions and is on track to complete the modified scope of work and project timeline.

Field work is under way, which will inform the ICV design and reservoir simulations.

The expected installation date for the ICV system is Q3-2021.
THANK YOU

Critical Challenges. Practical Solutions.
Improving EOR Performance Through Data Analytics and Next-Generation Controllable Completions (DE-FE0031790)

APPENDIX
Project Organizational Chart

Project Partners
- U.S. Department of Energy
- Denbury Onshore LLC
- NCS Multistage LLC
- Schlumberger
- Computer Modelling Group Ltd.
- North Dakota Oil and Gas Research Program
- North Dakota Geological Survey

Lead Organization
- EERC
  - Principal Investigator
    - N. Azzolina

EERC Project Advisors
- J. Hamling
- J. Sorensen

Denbury Field Advisor
- Kate Ryan

Task 1
- Project Management
  - Lead
    - N. Azzolina

Task 2
- ICV Pilot Systems Design
  - Lead
    - N. Dotzenrod

Task 3
- Operation and Monitoring
  - Lead
    - L. Jacobson

Task 4
- Active Control System Development
  - Lead
    - L. Jin

Task 5
- Business Case
  - Lead
    - N. Bosshart
### Project Gantt Chart

#### Task 1.0. Project Management and Planning
- **Start Date**: 10/1/19
- **End Date**: 9/30/24

- **Milestone (M)**
  - M1 – Screening and Selection of Pilot Test Pattern Complete (11/30/20)
  - M2 – Field Characterization Activities Complete (12/31/20)
  - M3 – Laboratory Characterization Activities Complete (10/31/20)
  - M4 – ICV Installation and Initial Testing Complete (3/31/21)
  - M5 – Geologic Model Complete (1/31/23)
  - M6 – Initial Active Control System Design Complete (1/31/22)
  - M7 – Active Control System Design Complete (1/31/23)
  - M8 – Geologic Model Complete (1/31/23)
  - M9 – Transfer of Operational Ownership of ICV Pilot to Field Operator Initiated (11/1/23)

- **Deliverables (D)**
  - D1 – Project Management Plan (2/26/20)
  - D2 – Workforce Readiness Plan (11/1/20)
  - D3 – Data Management Plan (1/27/20): Revised for Definitized Agreement
  - D4 – Interim Field Performance Summary Report (1/31/22)
  - D5 – Business Cases for Commercial Deployment of ICV Systems for Managing EOR Performance (9/30/23)
  - D6 – Development Strategy Plan (7/31/24)
  - D7 – Data Submitted to NETL EDX (9/30/24)

#### Task 2.0. ICV Pilot Systems Design
- **Start Date**: 10/1/19
- **End Date**: 9/30/21

- **Milestone (M)**
  - M1
  - M2

- **Deliverables (D)**
  - M3

#### Task 3.0. Operation and Monitoring
- **Start Date**: 12/1/20
- **End Date**: 6/30/24

- **Milestone (M)**
  - M4

- **Deliverables (D)**
  - M5

#### Task 4.0. Active Control System Development
- **Start Date**: 2/1/21
- **End Date**: 6/30/24

- **Milestone (M)**
  - M6

- **Deliverables (D)**
  - M7

#### Task 5.0. Business Case Development
- **Start Date**: 8/1/20
- **End Date**: 7/31/24

- **Milestone (M)**
  - M8

- **Deliverables (D)**
  - M9

- **Decision Points (DPs)**
  - DP1 – Go/No-Go decision for the candidate injection well (12/31/20)
  - DP2 – Go/No-Go decision for successful ICV system in the injection well (3/31/22)