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Energy & Environmental Research Center (EERC)

Improving Enhanced Oil Recovery Performance Through Data Analytics and Next-Generation Controllable Completions

North Dakota Oil & Gas Research Program
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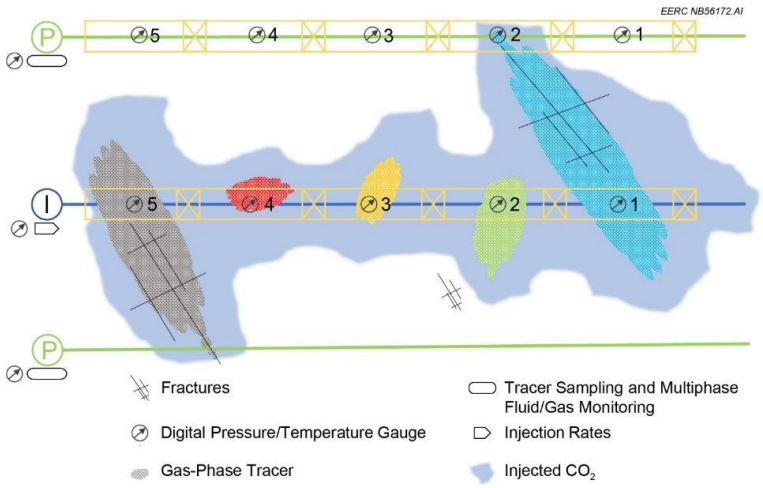
CONCEPTUAL PILOT TEST DESIGN

- Field-test interval control valves (ICVs) for active (smart) well control during CO_2 enhanced oil recovery (EOR)
- One lateral injection well equipped with an ICV system
- Two offset lateral production wells:
  - One with an openhole completion
  - One with an ICV system
- Analogous offset patterns as a reference case, surveillance to assess performance and improve control system for operating ICVs



Red River Fm. Cedar Creek Anticline

EXPECTED RESULTS

- Evaluate perceived risks of deploying ICVs in horizontal wells. Inform ICV system design, installation practices, and operational practices.
- Demonstrate performance and reliability of ICV deployment for CO_2 EOR in horizontal injection and production wells (*first application*).
- Quantify performance:
  - Net CO_2 utilization
  - Oil recovery and sweep efficiency
  - 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).

PARTICIPANTS

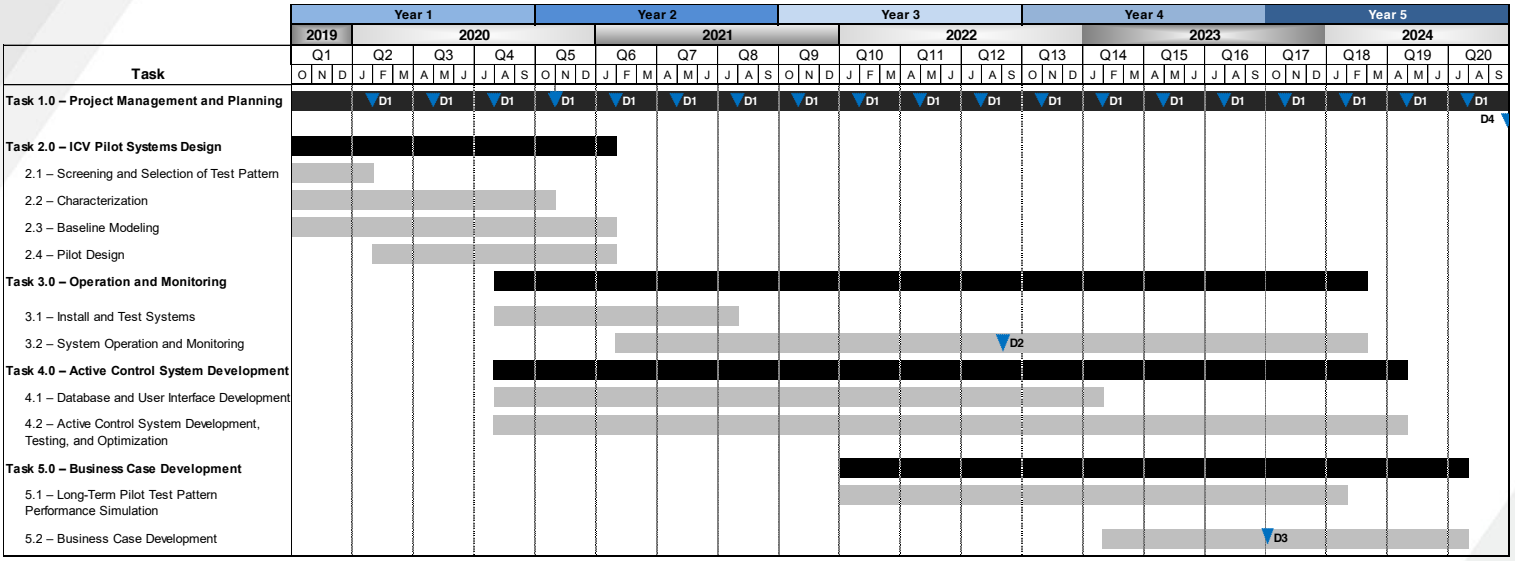
Lead Organization

- Energy & Environmental Research Center

Project Partners

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

PROJECT SCHEDULE



D1 – Quarterly Report

D2 – Interim Field Performance Summary Report

D3 – Business Cases for Commercial Deployment of ICV Systems for Managing EOR Performance

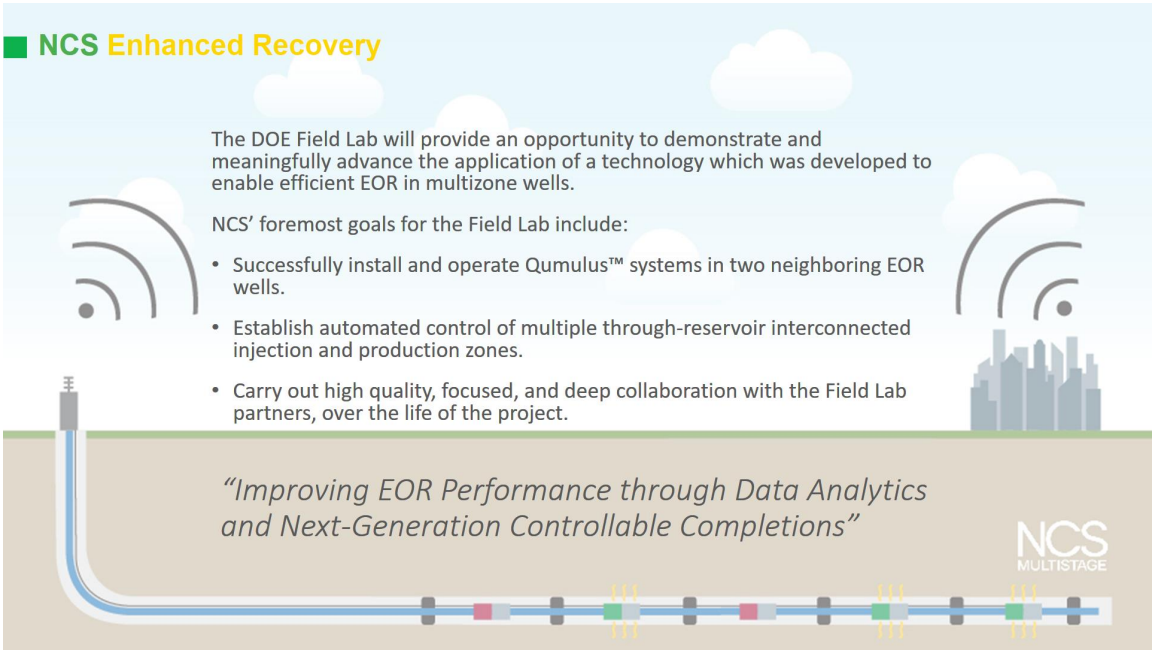
D4 – Final Report

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 CO_2 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.

Denbury

NCS STATEMENT REGARDING BENEFITS



BENEFITS TO NORTH DAKOTA AND NDIC OGRP

- Demonstrate the reliability and performance for 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 Bakken EOR, where conformance is a known challenge.
- Techno-economic assessments indicate horizontal wells are a key to economic EOR in North Dakota's conventional fields.[1]
- 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]"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.

REQUEST

- The estimated cost for the 5-year project is $10,000,000.
- We are requesting $500,000 from NDIC OGRP at $100,000 per year over 5 years.
- Cost share will include $8,000,000 cash from DOE.
- In-kind cost share will be provided by Schlumberger and CMG at a combined $1,500,000 in the form of industry leading software.
- Unenumerated cost-share will also be provided by Denbury and NCS Multistage.

SUMMARY AND CLOSING

- This project offers tremendous potential to greatly increase oil and gas recovery from existing reservoirs in North Dakota, as well as to continue to keep North Dakota at the leading edge of R&D for unconventional oil and gas (i.e., Bakken).
- Deploying ICVs into a horizontal well with active (smart) control is state-of-the-art technology, and the industry partners are all leaders in their respective areas of expertise and equipment design.
- This project offers tremendous value, leveraging a 5% investment by NDIC OGRP in a $10MM project that has strong support and financial commitments from industry partners and DOE.

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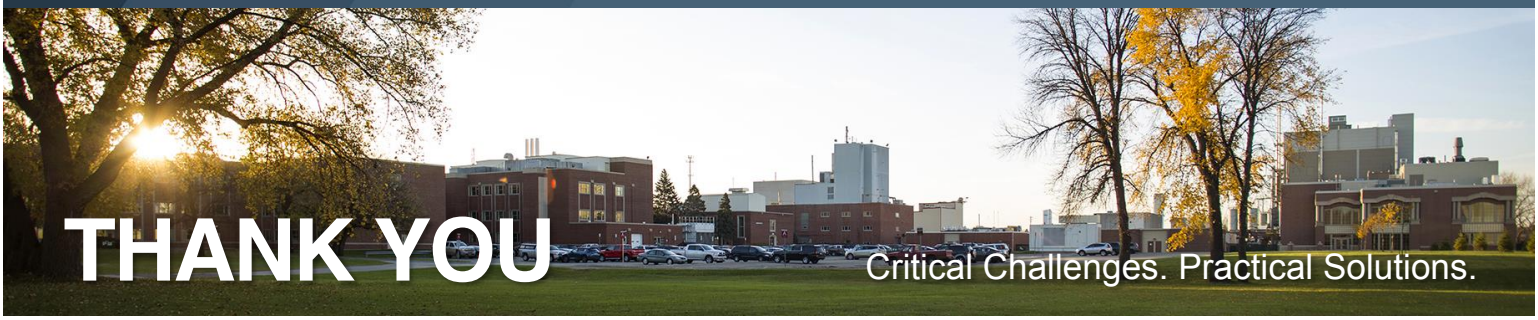

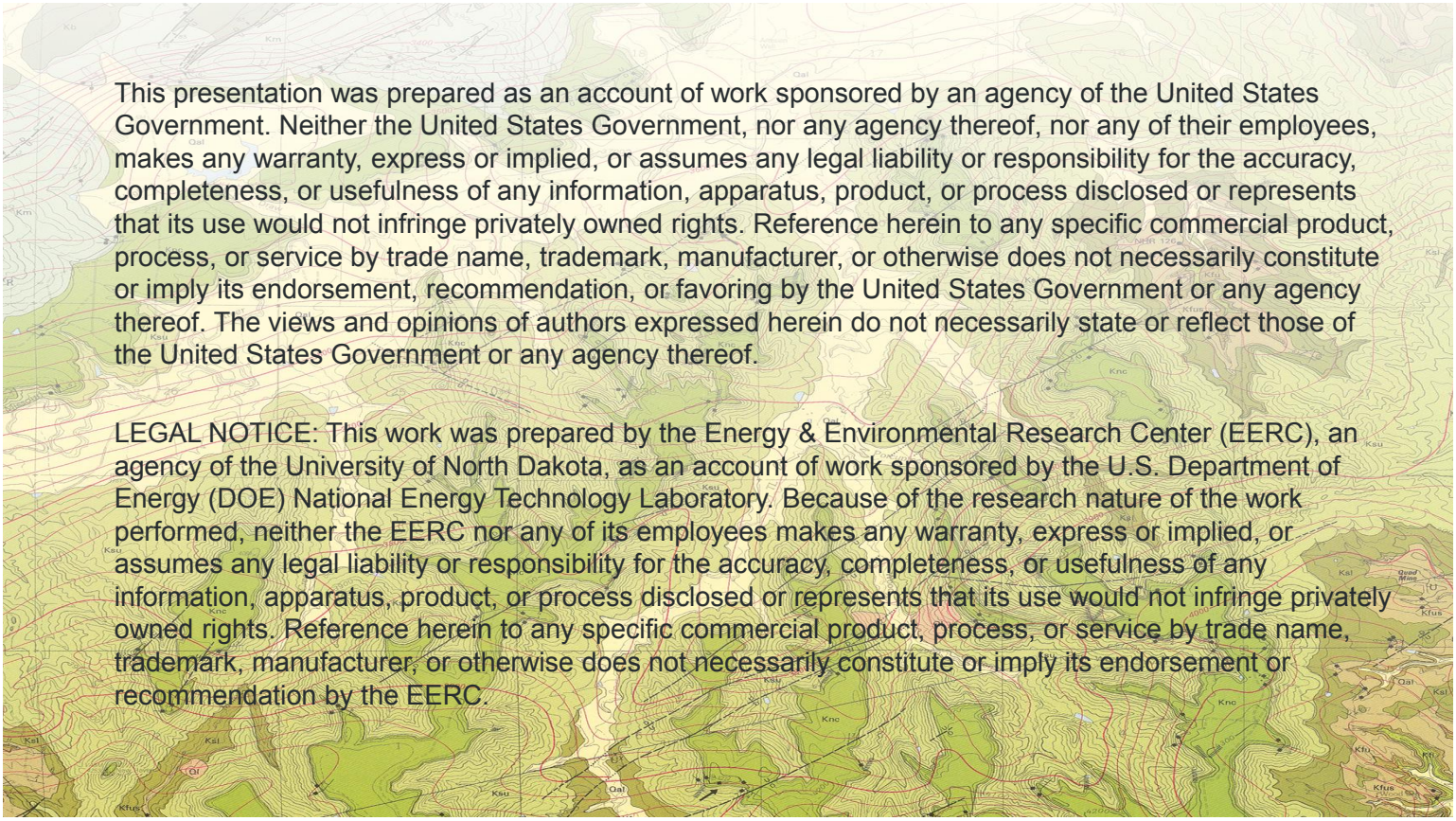

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