GENERAL PROJECT INFORMATION

Project Type: T - Advance Energy Technology

Project Name: Bakken Cracking the Code 2.0: Broad Infrastructure and Development for CO2-Based EOR

Program Name: Lignite Research Program (LRP)

Grantee Company: University of North Dakota Energy & Environmental Research Center (UND EERC)

Primary Company Contact: Loreal Heebink

State: North Dakota

Project Life Cycle Stage: Award

Project Status: Awarded

Duration of Project (Number of months): 30

Project Description/Abstract: The Energy & Environmental Research Center (EERC) at the University of North Dakota will conduct a comprehensive assessment of the infrastructure needed to capture, transport, and deliver carbon dioxide (CO_2) for enhanced oil recovery (EOR) in North Dakota's Bakken region. The project will evaluate practical pathways to source CO_2 from in-state facilities, including coal-fired power plants and a coal gasification facility, and determine how best to connect these sources to oil fields for EOR use. This effort supports a long-term vision of strengthening North Dakota's energy economy by linking its coal and oil industries. By identifying viable solutions for CO_2 supply and delivery, the project aims to position the state's lignite industry as a key provider of CO_2 while helping extend the life and productivity of Bakken oil fields. Stakeholders across North Dakota's energy sector have expressed strong support for this collaborative approach. The expected outcome is a clear, actionable road map for developing reliable CO_2 infrastructure and markets in North Dakota. This will help support continued energy production, promote job retention and growth, and enhance the state's overall economic stability. The project will run for 30 months, from April 1, 2026, through October 31, 2028, with a total budget of $10 million. Funding includes $5 million requested from the North Dakota Industrial Commission (NDIC) through the Lignite Research, Development and Marketing Program, matched by $5 million from the U.S. Department of Energy (DOE). The project is led by the EERC in partnership with NDIC and DOE, with input from stakeholders across the state. It is also part of the larger Bakken Enhanced Oil Recovery – Cracking the

Code Program, a multipartner initiative working to advance EOR technologies and ensure the long-term success of North Dakota's energy sector.

Project Financial Details

Total Budget: $10,000,000.00

Total Amount Requested: $5,000,000.00

Total Match Share: $5,000,000.00

PROJECT ABSTRACT/OVERVIEW

The Energy & Environmental Research Center (EERC) at the University of North Dakota proposes to conduct a comprehensive engineering assessment of the regional infrastructure needed to source and deliver CO2 and other injectate materials for enhanced oil recovery (EOR) in North Dakota's Bakken petroleum system. The assessment will include modes of capturing and transporting CO2 from multiple stationary sources, including coal-fired power plants and an existing coal gasification facility.

North Dakota's lignite industry is positioned to benefit from CO2-based Bakken EOR by becoming a major regional source of CO2 injectate. Collaboration between North Dakota's coal and petroleum industries is an essential part of this vision to both grow the coal industry and sustain Bakken production as stated in the included letters of support from NACCO Natural Resources, the North Dakota Petroleum Council, Basin Electric Power Cooperative, Minnkota Power Cooperative, and Rainbow Energy Center. This project will ultimately contribute to a cohesive pathway to develop long-term CO2 markets that serve the coal industry, sustain Bakken production, and generally support North Dakota's energy industries and workforce.

The project team consists of the EERC, NDIC, and DOE. The EERC will engage lignite industry companies for collaboration and feedback regarding CO2 sourcing from facilities in North Dakota. The project is also part of the Bakken Enhanced Oil Recovery – Cracking the Code Program, an approximately $142,000,000 multisector effort involving DOE, NDIC, and at least five North Dakota Bakken producers to accelerate the broad deployment of Bakken EOR. Findings from the Cracking the Code Program will be leveraged by the project team to conduct the regional infrastructure assessment.

DETAILED PROJECT DESCRIPTION

Objectives of the proposed project are to develop feasibility-level and pre-FEED-level techno-economic assessments and optimization studies of regional infrastructure needed to commercially scale up and broadly deploy CO2-based EOR across the Bakken. Studied infrastructure will include trunk pipelines from CO2 sources to the Bakken, gathering and distribution lines within the Bakken, and recycling and conditioning facilities that separate and/or purify CO2 for use and reuse in Bakken EOR. An additional objective is to develop an expected EOR CO2 demand timeline based on results from the broader Cracking the Code Program along with a regional assessment of CO2 supply from multiple stationary sources, including coal-fired power plants, an existing coal gasification facility, and other industrial facilities that meet industry specifications for use in Bakken EOR. Broadly speaking, this project will bridge long-standing knowledge gaps between development of CO2 capture from the coal industry and utilization by the oil and gas industry, providing for a more integrated approach to carbon capture, utilization, and storage across the two industries.

Over the 30-month period of performance, the project team will complete a series of feasibility studies, pre-FEED assessments, and a comprehensive regional injectate supply assessment. The team will use process simulation and techno-economic modeling software to evaluate CO2 capture, compression, conditioning, and transportation systems. Geographic information system-based routing and corridor optimization tools will be used to assess regional infrastructure siting and alignment and to support dynamic modeling of injectate movement across the region. The project will comprise the four tasks described in this section.

Task 1.0 – Feasibility Study and Pre-Front-End Engineering Design Studies*:* The project team will establish the scope and initial feasibility level for CO2 transport lines connecting stationary sources, including North Dakota's coal electric generating and gasification plants, to a CO2 distribution and recycling network that connects the individual Bakken EOR wells. High-level design parameters including CO2 delivery pressure and temperature, pipeline sizing, and operating pressure, as well as any additional parameters that are necessary to accomplish subsurface injection, will be determined as part of the assessment. Promising near-term transport scenarios may advance to a pre-FEED study. If a pre-FEED is initiated, the process flow diagram will be generated based on feasibility study results as well as the results from Tasks 2.0 and 3.0. Task 1.0 includes the necessary activities to generate the pipeline route report and maps, design-basis document, key design calculations and drawings, critical safety and risk assessments, construction specifications to meet 49 Code of Federal Regulations Part 195, and environmental

specifications. The sum of these activities and the subsequent documents will constitute a pre-FEED engineering design package.

Task 2.0 – At-Large Recycling and Distribution Facilities Feasibility and Pre-FEED Studies: The project team will conduct feasibility-level and potentially pre-FEED-level assessments for the CO2 distribution and recycling network that will supply and recirculate CO2 to future EOR wells within the Bakken petroleum system. CO2 supplied for EOR may undergo many cycles of injection, production, and recycling before being stored underground. Therefore, a network of recycling and distribution facilities will be needed to gather, recompress, and recondition injectate material and distribute it where it is needed in the Bakken. This task will include feasibility-level and potentially pre-FEED-level assessments to determine the size, possible location, and design of this critical surface infrastructure.

Task 3.0 – Dakota Gasification Plant CO2 Conditioning and Upgrade Feasibility and Pre-FEED Studies: The project team will conduct feasibility-level and potentially pre-FEED-level assessments of CO2 conditioning technology to upgrade CO2 from DGC's GPSP to meet EOR composition requirements. Previous initial assessments by the EERC have identified that sweetened CO2 (i.e., having low sulfur content) from DGC's Rectisol® process as a potential near-term source of CO2 to supply Bakken EOR (Stanislowski and others, 2019). GPSP produces approximately 4 million tonnes of CO2 per year, which could be used for EOR if sweetened to remove sulfur. The project team will build off of past studies and include new technology assessments that include the Rectisol process as well as sorbent-based and oxidative technologies that could be used on or off the DGC site.

Task 4.0 – Regional Injectate Supply Assessment and Development: In this task, a forecast of EOR CO2 demand will be developed that leverages coal-based CO2 infrastructure investments. The forecast will include an assessment of the regional, near-term supply of EOR injectate materials, as well as a longer

The project will deliver a comprehensive set of engineering and techno-economic assessments to support the development of CO2 capture and widespread deployment of CO2-based EOR in the Bakken, where the CO2 is sourced from North Dakota's lignite coal power and gasification plants and other potential sources contributing to the build-out of CO2 infrastructure that supports the lignite industry. Key outcomes include feasibility and pre-FEED studies for the transport lines needed to move CO2 from North Dakota's coal counties to the Bakken and for a CO2 distribution and recycling network within the Bakken to connect potentially thousands of EOR wells. An additional outcome will be an evaluation of options to sweeten CO2 from the GPSP as a substantial, near-term source of CO2 injectate for early EOR.

Future CO2 demand estimates will be informed by detailed EOR reservoir modeling and actual pilot field tests that will be conducted under the broader Cracking the Code Program. This demand information will be used to model build-out scenarios for the regional injectate supply assessment where CO2 availability predictions will be based on factors such as proximity, quantity, and the relative cost to capture and condition the CO2. It is expected that this analysis will segregate near-term, lower-cost CO2 supply opportunities from those that will become competitive once strong EOR demand and/or foundational transport infrastructure is in place.

For more than 70 years, the EERC has conducted research, testing, and evaluation across fossil and renewable energy systems, emission control technologies, and carbon capture and storage. The EERC employs a multidisciplinary staff of about 260 and has 254,000 square feet of state-of-the-art offices, laboratories, and technology demonstration facilities, which enable staff to address a wide variety of research topics. The EERC's engineering and scientific staff have access to state-of-the-art analytical, modeling, and engineering facilities to support the broad range of infrastructure studies proposed as part of this project.

The key resource for this project will be the EERC's staff of engineering analysts who collectively have the multidisciplinary experience necessary to evaluate all aspects of CO2-based EOR infrastructure, from CO2 capture at power plants and industrial facilities to CO2 transport pipelines and conditioning systems. Many of these staff members have direct technical experience from prior pilot-scale testing of CO2 capture at North Dakota power plants and in the planning and permitting of their associated CO2 storage sites. For pre-FEED studies, the EERC will be supported by third-party engineering firms to be identified once the project is underway. The EERC is committed to supplying the personnel and resources necessary to ensure timely completion of all project activities.

The techniques to be used for data generation include techno-economic assessments, optimization studies, and detailed engineering evaluations of systems for CO2 capture, conditioning, and transport. These studies will use generally accepted good engineering practices and costing techniques appropriate to the targeted level of evaluation, i.e., feasibility or pre-FEED.

The proposed work is a paper-based study of CO2-based EOR infrastructure that will not create significant environmental or economic impacts during the project. No infrastructure development or modification to partner facilities will occur as part of this project.

Regulatory uncertainty and the Section 45Q tax credit have driven significant advances in carbon capture technology for North Dakota's lignite power generation facilities. However,

long-term CO2 market development (post-45Q) remains one of the challenges for commercial deployment of this technology. At the same time, production of the Bakken Formation continues to mature and is anticipated to decline significantly over the next 10 years. As a major revenue source for North Dakota, new methodologies must be developed that enable the continued production of over 1 million barrels per day of oil in the state. CO2-based EOR has significant potential to alter the economic trajectory of North Dakota by maintaining production in the Bakken for decades to come while contributing to regulatory and market certainty for existing and future lignite facilities.

The proposed study will advance technology planning for the infrastructure needed to capture and condition CO2 from North Dakota's coal-based power and gasification plants to be used for Bakken EOR. As such, the ultimate impact of the project is to create a material link between two of North Dakota's largest industries, lignite coal and petroleum, which will create substantial new value for both. CO2-based EOR in the Bakken could produce an estimated 3.2–7 billion barrels of incremental oil compared to primary production alone. This incremental oil will generate billions of dollars of added extraction tax revenue as well as preserve the related workforce. CO2 used for EOR will create an added value stream for lignite plants, and the CO2 stored as part of EOR operations is eligible for 45Q tax credits of up to $85 per tonne for 12 years after being placed in service. Stored CO2 can also reduce the carbon intensity of electric power and products produced from lignite, which might provide a competitive advantage in a decarbonizing marketplace. Finally, the investment into CO2 capture and transport infrastructure that is initiated by EOR will equip North Dakota's coal power plants to respond to future changes in federal policy on CO2 emissions regulation, thereby giving these plants the ability to preserve jobs and continuing contributing to the state's economy in the absence of consistent federal energy policy.

North Dakota's lignite industry is positioned to benefit from CO2-based Bakken EOR by being a major regional source of needed CO2 injectate. However, meeting this need will require a large network of CO2 capture, conditioning, and transport systems that will extend from North Dakota's coal counties to the Bakken. The proposed study is needed to outline the overall techno-economic potential of CO2 capture and transport for EOR and communicate this vision to key stakeholders including those in the lignite industry, Bakken oil production, and state policymakers and regulators.

STANDARDS OF SUCCESS

The measurable results that will determine whether the project is a success may include:

The ultimate success metric for this project will be to catalyze follow-on action by the state and industry to pursue the potential benefits of CO2-based EOR in the Bakken. Private industry is expected to use the study to inform decisions on when and where to invest in CO2 capture, conditioning, and transport infrastructure to create long-term value. Likewise, policymakers and regulators can use the results to forecast the potential extent of Bakken EOR and guide decision-making accordingly. As such, the specific standards of success will be measured by the dissemination of project findings in technical reports, presentations, and workshops over the course of the project.

BACKGROUND/QUALIFICATIONS

The EERC has a proven record of leading and managing projects of large complexity and scope in the multiple million-dollar range. For example, the EERC previously led a retrofit pre-FEED study and FEED study at Coal Creek Station. The pre-FEED study for Coal Creek Station included design packages, cost and performance estimates, and a process hazard analysis (commonly called a HAZOP) for both the capture facility and for balance of plant systems, including, among others, the following:

- Flue gas extraction and handling.
- Steam extraction and power recovery.
- Cooling water supply.
- Electrical distribution systems.
- Fire protection.
- Plant and instrument air.
- Process control systems.
- Demineralized water supply.

An additional example of related work by the EERC is a prior engineering study of sulfur removal from CO2 produced at GPSP (Stanislowski and others, 2019). Under that study, the EERC reviewed process options and consulted with technology vendors and other experts to identify a subset of approaches for more detailed evaluation. This study will be

updated under Task 3.0 of the proposed effort and developed further into feasibility-level and potentially pre-FEED-level assessments of CO2 conditioning technology.

Qualifications: Resumes of key personnel are in Appendix A. The EERC is a nonprofit branch of the UND. James Sorensen, Director of Subsurface Research and Development, will serve as program manager. Dr. John Harju, Vice President for Strategic Partnerships, will serve as senior program advisor. Other key EERC personnel will include Joshua Stanislowski, Director of Energy Systems Development; Michael Hillix, Principal Geoscientist and Energy Advisor; and Dr. Lu Jin, Distinguished Reservoir Engineer.

MANAGEMENT

The EERC manages over 200 contracts a year with over 1300 clients in 53 countries. Systems are in place to ensure that projects are managed within budget, schedule, and scope. The EERC is the lead organization for this project and will oversee all tasks and management activities associated with this project. The EERC will schedule regular internal and external meetings with project staff and advisors to ensure that the project uses acceptable scientific methodologies and practices in accordance with the project plan (budget, schedule, deliverables, and milestones) and is meeting quality objectives. Mr. Sorensen will oversee the entire program, with assistance in the management of program activities and tasks by Mr. Stanislowski. A program kickoff meeting will be scheduled in 2026 to prioritize research areas with input from the state and industry.

Project progress will be monitored using a series of evaluation points defined for each task (Table 1). Since the timing to achieve these criteria correlates with, and in some cases depends on, the activities of the larger Cracking the Code Program, an evaluation schedule will be established once the entire program is underway.

Table 1. Project Progress Evaluation Criteria

Task

Criteria

- 1.0 – Feasibility Study and Pre-Front-End Engineering Design Studies

Transport system design parameters identified

Feasibility or pre-FEED study complete

- 2.0 – At-Large Recycling and Distribution Facilities Feasibility and Pre-FEED Studies

CO2 distribution and recycle parameters identified

Feasibility or pre-FEED study complete

- 3.0 – Dakota Gasification Plant CO2 Conditioning and Upgrade Feasibility and Pre-FEED Studies

Review of CO2 sweetening processes complete

Feasibility or pre-FEED study complete

- 4.0 – Regional Injectate Supply Assessment and Development

Injectate source inventory complete

Regional injectate supply curve forecast complete

TIMETABLE

The proposed period of performance is 30 months. Figure 1 summarizes the preliminary timetable. The anticipated start date is April 1, 2026. Interim reports will be submitted biannually 30 days after the end of each appropriate calendar quarter to highlight ongoing research and anticipated future activities. The start and end dates of each subtask will depend on the contractual start date, but none are anticipated to exceed the 30 months proposed for this project.

Please see full proposal under other appendices for Figure 1.

BUDGET

The proposed budget is $10,000,000, with $5,000,000 from NDIC and $5,000,000 of cash from DOE. The budget includes subcontracts for two engineering firms that will be determined once the project is initiated to support the EERC with pre-FEED studies. The budget justification can be found in Appendix C.

Please see full proposal under other appendices for Table 2.

PATENTS/RIGHTS TO TECHNICAL DATA

Any patents or rights that the applicant wishes to reserve must be identified in the application.

N/A

STATUS OF ONGOING PROJECTS (IF ANY)

The EERC is the lead entity for ongoing NDIC-sponsored projects that are separate from this proposed effort. These ongoing projects are in good standing with respect to reporting and deliverables, and any deviations from their original planned scope of work or timeline have been communicated to NDIC in advance.

OTHER STATE PROGRAMS AND INCENTIVES

The EERC has participated in several programs administered by NDIC, including the Lignite Research Program (LRP), the Oil and Gas Research Program (OGRP), the State Energy Research Center (SERC), the Renewable Energy Program (REP), the Clean Sustainable Energy Authority Program (CSEA), and the North Dakota Pipeline Authority (NDPA). The EERC has also participated in efforts administered by the Lignite Energy Council (LEC), the North Dakota Transmission Authority (NDTA), and the North Dakota Department of Commerce. Table 3 lists funding received by the EERC from these state programs in the last 5 years.

Please see full proposal under other appendices for Table 3.