



Energy & Environmental Research Center

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April 29, 2021

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

Dear Ms. Fine:

Subject: Quarterly Progress Report for the Period of January 1 – March 31, 2021, “Underground Storage of Produced Natural Gas – Conceptual Evaluation and Pilot Project(s) (HB 1014)”; Contract No. G-049-092; EERC Fund 23984

Attached please find the Energy & Environmental Research Center (EERC) Quarterly Progress Report for the subject project. If you have any questions, please contact me by phone at (701) 777-5050 or by e-mail at bkurz@undeerc.org.

Sincerely,

DocuSigned by:
Bethany Kurz
1518154149DD485...

Bethany A. Kurz
Assistant Director for Integrated Analytical
Solutions

BAK/kal

Attachment

c: Brent Brannan, NDIC



UNDERGROUND STORAGE OF PRODUCED NATURAL GAS – CONCEPTUAL EVALUATION AND PILOT PROJECT(S) (HB 1014)

Quarterly Progress Report

(for the period January 1 – March 31, 2021)

Prepared for:

Karlene Fine

North Dakota Industrial Commission
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April 2021

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**UNDERGROUND STORAGE OF PRODUCED NATURAL GAS – CONCEPTUAL
EVALUATION AND PILOT PROJECT(S) (HB 1014)
Quarterly Progress Report
January 1 – March 31, 2021**

EXECUTIVE SUMMARY

The Energy & Environmental Research Center (EERC) is performing a project to directly address the intent of Section 25 of House Bill 1014 of the Sixty-Sixth Legislative Assembly of North Dakota as signed into law by Governor Burgum, which states that funding will be made available to the EERC for “pilot projects relating to the underground storage of produced natural gas.” The overall goal of the proposed effort is to demonstrate the techno-economic feasibility of produced natural gas (“produced gas”) injection into non-hydrocarbon-producing subsurface formations in the Williston Basin for future recovery and use or for pressure maintenance and/or enhanced oil recovery (EOR) in a conventional or unconventional oil reservoir. To achieve the project goal, the EERC will partner with North Dakota oilfield producers on up to three pilot project efforts to define and assess the key technical, economic, and regulatory components of each approach. This progress report presents an overview of activities from January 1 through March 31, 2021.

A contract amendment was received from the North Dakota Industrial Commission (NDIC) on January 14, 2021, following approval of a plan involving partnership with four potential industry partners to evaluate different aspects of produced gas injection for geologic storage and/or EOR. The amendment provides for an anticipated extension of the project to June 30, 2023, pending legislative approval.

Marathon Oil Company (Marathon) continues to partner with the EERC on the project, participating in exploratory activities to evaluate the potential of Marathon to participate as a collaborator for a produced gas injection pilot project. Laboratory work was performed to generate data for modeling efforts. Geomodeling was completed with publicly available and Marathon-supplied information. Gas injection scenarios were evaluated with different well controls, number of wells, and well locations. Preliminary compressor sizing has been completed, and the project team is assessing compressor availability and cost.

Maroon Bells Partners, LLC (Maroon Bells) joined the project to collaborate with the EERC on the evaluation and potential implementation of a produced gas pilot program. A subcontract was finalized between the EERC and Maroon Bells in February 2021. Technical work was initiated. Efforts focused on creating a structural model.

The EERC holds an unwavering commitment to the health and well-being of its employees, partners and clients, and the 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 progressing with minimal disruption. Challenges posed by economic variability

will be met with open discussion between the EERC and project 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. In the event that any potential impacts to reporting, scope of work, schedule, or cost are identified, they will be discussed and addressed in cooperation with the project partners.

UNDERGROUND STORAGE OF PRODUCED NATURAL GAS – CONCEPTUAL EVALUATION AND PILOT PROJECT(S) (HB 1014)

Quarterly Progress Report

January 1 – March 31, 2021

INTRODUCTION

The Energy & Environmental Research Center (EERC) is performing a project to directly address the intent of Section 25 of House Bill (HB) 1014 of the Sixty-Sixth Legislative Assembly of North Dakota as signed into law by Governor Burgum, which states that funding will be made available to the EERC for “pilot projects relating to the underground storage of produced natural gas.” The overall goal of the proposed effort is to demonstrate the techno-economic feasibility of produced natural gas (“produced gas”) injection into non-hydrocarbon-producing subsurface formations in the Williston Basin for future recovery and use or for pressure maintenance and/or enhanced oil recovery (EOR) in a conventional or unconventional oil reservoir. To achieve the project goal, the EERC will partner with North Dakota oilfield producers on up to three pilot project efforts to define and assess the key technical, economic, and regulatory components of each approach.

The primary project objectives are to evaluate the viability of various subsurface formations as storage and/or injection targets, document the facilities and equipment needs and costs for produced gas injection, predict the subsurface storage footprint of the injected gas plume over time, predict gas recovery efficiencies, develop a monitoring plan, and summarize the required regulatory considerations for different injection/storage scenarios. The above information will be obtained from a combination of research activities performed at the EERC and from up to three pilot projects performed in partnership with and including substantial financial investment from oilfield operating companies.

ACCOMPLISHMENTS DURING REPORTING PERIOD

Program Management and Reporting

The EERC will be responsible for managing and reporting its activities with respect to the implementation and assessment of the pilot projects. Quarterly reports will be submitted to the North Dakota Industrial Commission (NDIC) 1 month after the end of each calendar quarter to provide timely highlights of ongoing research activities. At least one report will be provided to legislative management regarding the results and recommendations of the pilot project(s).

In addition to progress reporting, the relevant data and results needed to assess the overall technical and economic performance of the approach will be compiled and analyzed. The results of the gas injection scenarios that are technically and economically feasible will be used to develop an implementation plan that highlights optimal locations and scenarios for produced gas storage, recovery, and reuse throughout the oil and gas production regions of North Dakota. Key lessons learned from the pilot project(s) will be incorporated into that plan for future development efforts.

A contract amendment was received from NDIC on January 14, 2021, following approval of a plan involving partnership with four potential industry partners to evaluate different aspects of produced gas injection for geologic storage and/or EOR. The amendment provides for an anticipated extension of the project to June 30, 2023, pending legislative approval. The amendment also revised the deliverables schedule (status reports and presentations to legislative interim committees and legislative committees), revised the proposed payment schedule, and approved new subcontracts to EOR ETC, LLC (EOR ETC) and Liberty Resources, LLC (Liberty).

Marathon Oil Company (Marathon) continues to partner with the EERC on the project, participating in exploratory activities to evaluate the potential of Marathon to participate as a collaborator for a produced gas injection pilot project. Technical work continued as described in the Marathon Gas Storage Pilot section.

Maroon Bells Partners, LLC (Maroon Bells) joined the project to collaborate with the EERC on the evaluation and potential implementation of a produced gas pilot program. A subcontract was finalized between the EERC and Maroon Bells in February 2021. Technical work was initiated as described in the Maroon Bells Gas Storage Pilot section.

EOR ETC and Liberty plan to demonstrate a new technology to facilitate produced gas injection for EOR and/or subsurface geologic storage. Contracting with EOR ETC and Liberty is ongoing.

In July 2020, XTO Energy (XTO) stopped work on evaluation of both pilot projects (referred to as the Minnelusa gas storage and Bakken EOR projects) indefinitely as a result of the downturn in oil prices. A report highlighting the key findings and lessons learned of the EERC's evaluation was reviewed and approved by XTO. The report is undergoing a final review by the EERC management team, after which it will be provided to NDIC.

Regulatory Considerations

The EERC will work closely with the project partners and NDIC's Department of Mineral Resources to define key regulatory considerations for each pilot. The EERC will work with project partners to obtain the necessary permits for each pilot project and to review and implement any site-monitoring requirements.

North Dakota Senate Bill (SB) 2065 was introduced and passed during the 2021 North Dakota legislative session. SB 2065 creates a new chapter of the North Dakota Century Code, grants NDIC's Oil and Gas Division the regulatory authority, and establishes a statutory framework for permitting gas storage. On March 4, 2021, EERC CEO Charles Gorecki provided written and verbal testimony on SB 2065. Currently, SB 2065 is pending North Dakota Governor's signature for final passage into law.

Marathon Gas Storage Pilot

Weekly technical meetings are held with team members from Marathon and the EERC. Working meetings between project team members are held on an as-needed basis.

The EERC visited the Wilson M. Laird Core and Sample Library, located on the campus of the University of North Dakota, to generate core description, determine the lithofacies, and determine intervals for sampling, focused on the Duperow Formation. The sampling was based on available well log responses and core description using the core gamma radiation (GR) for depth shifting. The selected ten samples were evaluated for mineralogical determination using x-ray diffraction, bulk chemical analysis using x-ray fluorescence, porosity, permeability, and pore data using high-pressure mercury injection (HPMI) analysis. The HPMI data help to characterize reservoir quality, pore-throat types and distributions, entry pressures, and capillary pressure, with which a series of synthetic relative permeability curves were generated for oil/water and CO₂/water systems. In addition, rock quality index and flow zone indicator, which are related to the effective pore throat radius, gave a better understanding of the Duperow reservoir in terms of fluid flow. The analyses highlighted five hydraulic flow units within the Duperow Formation.

Geomodeling was completed with publicly available and Marathon-supplied information. The model was updated with additional data received from Marathon, including seismic data and petrophysical logs. The geomodel grid and petrophysics log properties for the geomodeling process were supplied by Marathon. Porosity, permeability, and water saturation were distributed throughout the grid using Petrel Exploration and production software to characterize the Duperow Formation in the area of interest. Trend modeling of mineral fractions, including porosity, was first performed on a broader area of interest to incorporate more regionally available well log data. The trended porosity from the regional model (60 wells) was upscaled into the working model provide by Marathon. The trended porosity from the region model was used as a secondary attribute to guide the distribution of porosity in the working model. A correlative relationship between porosity and both water saturation and permeability were demonstrated for the area. The model porosity was then used as a secondary variable to stochastically model water saturation and permeability throughout the model area.

The model was exported for dynamic simulation. An EOS (equation-of-state)-tuned PVT (pressure-volume-temperature) model was created using lab-tested PVT data provided by Marathon. Cases were run to history-match the Killdeer Field production using the tuned PVT model. After the history matching, gas injection scenarios were evaluated with different well controls, number of wells, and well locations. A new wellbore model was incorporated with input from Marathon for better estimating the wellhead pressure response with the given injection volume constraint. The simulation effort will continue based on new data, such as expected field gas production, from Marathon to estimate the injection schedule for achieving the desired target.

Gas compression is an important component of any gas storage project and requires equipment specifically designed for the gas composition and pressure requirements of the application. The project team has reviewed available gas composition data, anticipated gas injection rate data, and simulation results consisting of required compression pressure to

establish a design basis for gas compressors. Preliminary compressor sizing has been completed, and the project team is assessing compressor availability and cost. As injection plans are refined and injection rate and pressure requirements are better defined, a more detailed equipment specification will be prepared.

Maroon Bells Gas Storage Pilot

Two meetings were held with Maroon Bells to discuss project goals and to review potential structures in the target formation resulting from initial structural modeling. EERC technical personnel meet weekly to discuss modeling progress and challenges.

Efforts focused on creating a structural model. Key wells were identified within the study area, and associated data (well logs, rasters, etc.) were downloaded from the NDIC website. Raster well log data were digitized to provide additional control points and formation top picks within areas of sparse data. Petrophysical analyses were performed using readily available and digitized data, producing derived logs including porosity, permeability, and facies logs. This information will be used to assist with geologic property distributions.

Formation tops including those obtained from the NDIC database (including the Mowry, Inyan Kara, and Swift Formations) were reviewed by the technical modeling team and utilized to generate structural surfaces. A brief variogram mapping exercise was performed, and a vertical variogram was determined; however, data in the horizontal direction were deemed too sparse to find a suitable variogram. Facies and petrophysical modeling activities are currently ongoing.

FUTURE ACTIVITIES

The planned activities for the next quarter are detailed as follows.

Program Management and Reporting

The report highlighting the key findings and lessons learned from the evaluation of the XTO pilot projects is undergoing a final review by the EERC management team, after which it will be provided to NDIC.

The EERC has been asked to provide a presentation on this project at the upcoming Williston Basin Petroleum Conference in May 2021. A summary of the key findings to date and ongoing work will be presented.

It is anticipated that contracting will be completed with EOR ETC and Liberty and planning activities initiated.

Regulatory Considerations

The EERC will begin developing a permit application for produced gas storage in collaboration with Marathon. The development of a produced gas storage permit will be based on guidance provided by NDIC's Oil and Gas Division.

Marathon Gas Storage Pilot

Exploratory activities will continue to aid Marathon in its decision-making process to determine whether to participate as a collaborator for a produced gas injection pilot project. Activities are anticipated to include ongoing simulation of various gas injection scenarios, evaluation of the availability and costs for the surface equipment (i.e., compressors) needed to achieve sufficient gas injection rates and pressures into the formation, and discussion of the impacts of the recent regulatory-related items in SB 2065 that affect produced gas storage projects in the state.

Maroon Bells Gas Storage Pilot

Facies and petrophysical property modeling for the geologic model will be completed. A simulation-ready model will be generated for future use with CMG (Computer Modelling Group) simulation software. The project team will meet with Maroon Bells personnel to discuss next steps and project activities.

PARTNERS AND FINANCIAL INFORMATION

The project is sponsored by NDIC's Oil and Gas Research Program. Table 1 shows the budget of \$6,000,000 from NDIC, as listed in HB 1014, and expenses through the reporting period. Once specific pilot project(s) are identified, attendant detailed budgets will be developed. It is expected that pilot project partner(s) will provide substantial cost share that will be documented to the greatest degree possible.

Table 1. Budget and Expenses to Date

Sponsors	Budget	Actual Expenses	
		as of 3/31/2021	Balance
NDIC	\$6,000,000	\$908,044	\$5,091,956
Industry Share – In-Kind	\$6,000,000	—	\$4,237,067
XTO – In-Kind	—*	\$1,028,120	—
Marathon – In-Kind	—*	\$734,813	—
Maroon Bells – In-Kind	—*	\$0	—
Total	\$12,000,000	\$2,670,977	\$9,329,023

* An estimate for the total expected in-kind cost share from industry partners is not available. Industry partners will periodically report actual costs to the EERC, which will be subsequently presented in the quarterly report.