PCOR Partnership

Energy & Environmental Research Center

PCOR PARTNERSHIP INITIATIVE TO ACCELERATE CCUS DEPLOYMENT

Research Performance Progress Report (quarterly)

(for the period January 1 – March 31, 2022)

Prepared for:

AAD Document Control

National Energy Technology Laboratory
U.S. Department of Energy
626 Cochrans Mill Road
PO Box 10940, MS 921-107
Pittsburgh, PA 15236-0940

Project Period: October 1, 2019 – September 30, 2024
Cooperative Agreement No. DE-FE0031838
DUNS No. 102280781

Prepared by:

Kevin C. Connors
Nicholas W. Bosshart
Nicholas A. Azzolina
Wesley D. Peck
Kyle A. Glazewski
Katherine K. Anagnost
Scott C. Ayash
Loreal V. Heebink

Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018
Phone (701) 777-5236
kconnors@undeerc.org

DocuSigned by:
Kevin Connors
1D14EE7CE3CD456...

Kevin C. Connors, Principal Investigator

April 29, 2022

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 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

PCOR PARTNERSHIP INITIATIVE TO ACCELERATE CCUS DEPLOYMENT
Quarterly Progress Report
January 1 – March 31, 2022

EXECUTIVE SUMMARY

The Plains CO_2 Reduction (PCOR) Partnership Initiative is one of four Regional Carbon Sequestration Partnership projects competitively awarded by the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) under the Regional Initiative to Accelerate CCUS (carbon capture, utilization, and storage). The PCOR Partnership Initiative is led by the Energy & Environmental Research Center (EERC) with support from the University of Wyoming (UW) and the University of Alaska Fairbanks (UAF) and includes stakeholders from the public and private sectors. The PCOR Partnership Initiative region includes all or part of ten U.S. states and four Canadian provinces.

Presentations on the PCOR Partnership Initiative were given to ten prospective partners. Four new members were welcomed to the PCOR Partnership Initiative, bringing the membership to 218: Bakken Energy, LLC; Liberty Media Corporation; ND Venture Ltd.; and Sim Tech, LLC. An eblast was sent to partners to thank them for their membership and provide an update on the PCOR Partnership Initiative. Product highlights from 2021 and links to the public and partner websites were provided.

Budget Period 1 was completed March 31, 2022. The release of incremental cost-share funding was approved by the North Dakota Industrial Commission (NDIC) following the second DOE award increase (Contract Modification 005).

The first PCOR Partnership Initiative Invitational, bringing participants from UAF, UW, and EERC together, was held at the EERC. Planning continued for the 2022 PCOR Partnership Initiative Annual Meeting, which will be held in Anchorage, Alaska. The dates of May 24–25, 2022, were finalized. Many members have expressed interest in attending the annual meeting. A Technical Advisory Board (TAB) meeting was held in Houston, Texas, to discuss efforts in the PCOR Partnership Initiative.

One deliverable (D) was submitted, and two milestones (Ms) were met this reporting period. D3.B entitled "Technical Approaches to Stacked Storage: Geomechanics Supplement" was submitted for review. M6 entitled "GHGT-16 Abstract Submitted" was satisfied with the submission of four abstracts to the 16th International Conference on Greenhouse Gas Control Technologies (GHGT-16). M7 entitled "BP1 EDX Submitted" was met with the upload of

geologic models and reservoir simulations to the EERC workspace PCOR Partnership folder on the NETL Energy Data eXchange (EDX). In addition, three deliverables were finalized following review. D4 entitled "CCUS Business Models in the PCOR Partnership Region" was revised and approved. D5 entitled "Strategies for Storage Permanence: Well Integrity and Legacy Well Evaluations" was revised and approved. D15 entitled "PCOR Partnership Atlas, 6th Edition" was finalized and is available on the PCOR Partnership website. A white paper entitled "Pipeline Cost and CO_2 Transport Considerations Based on Three Hypothetical Pipelines in the PCOR Partnership Initiative Region" was provided to the DOE Project Manager and NDIC. The paper was written in cooperation with PCOR Partnership member Resolute Engineering.

Activities continued related to the field effort at the Red Trail Energy CCS (carbon capture and storage) site. Contracting with subcontractor SkyGeo Inc. to provide InSAR (interferometric synthetic aperture radar) deliverables for baseline and monitoring ground deformation was completed.

Copies of the atlas were shipped to DOE, NDIC, UW, UAF, and PCOR Partnership TAB members. Shipping copies to PCOR Partnership members began. Numerous presentations and posters were presented to a variety of audiences. At the invitation of the Midwest Regional Carbon Initiative, the PCOR Partnership participated in a podcast recording on January 18, 2022, focused on describing the regional programs, challenges, and opportunities within each region.

Numerous white papers continue to be under development by the EERC team as well as the subrecipient teams at UW and UAF. Topics include geomechanical and geochemical evaluations; CCUS and grid reliability, including a case study by Jackson Walker, LLP; a high-level road map that will summarize the near-term, midterm, and long-term opportunities for hydrogen with CCS; CO_2 specifications for pipeline transport; understanding pressure interference between neighboring projects; operational lessons learned from stratigraphic well drilling in Wyoming; pore space-leasing considerations on federal lands; geologic storage formation outlines;; and pore space-leasing considerations. Many of the white papers are anticipated to be provided to DOE and the PCOR Partnership members by the end of May 2022.

PCOR PARTNERSHIP INITIATIVE TO ACCELERATE CCUS DEPLOYMENT
Quarterly Progress Report
January 1 – March 31, 2022

INTRODUCTION

The Plains CO_2 Reduction (PCOR) Partnership Initiative is one of four Regional Carbon Sequestration Partnership projects operating under the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) Regional Initiative to Accelerate CCUS (carbon capture, utilization, and storage). The PCOR Partnership Initiative is led by the Energy & Environmental Research Center (EERC) with support from the University of Wyoming (UW) and the University of Alaska Fairbanks (UAF) and includes stakeholders from the public and private sectors. The membership, as of March 31, 2022, is at 218 members. The PCOR Partnership Initiative region includes all or part of ten states (Alaska, Iowa, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota, Wisconsin, and Wyoming) and four Canadian provinces (Alberta, British Columbia, Manitoba, and Saskatchewan).

The goal of the PCOR Partnership Initiative is to identify and address regional capture, transport, and storage challenges facing commercial deployment of CCUS in an expanded region, compared to past initiatives. To achieve this goal, the PCOR Partnership Initiative will meet the following objectives:

1. Address key technical challenges by advancing critical knowledge and capabilities.

2. Facilitate data collection, sharing, analysis, and collaboration.

3. Evaluate regional infrastructure challenges/needs and promote infrastructure development.

4. Promote regional technology transfer.

The project goal and objectives will be accomplished through five tasks over two budget periods (BPs), corresponding to a 5-year period of performance. The EERC and project partners will collaborate to identify and address technical challenges facing deployment of CCUS in multiple categories, including stacked storage opportunities, CO_2 storage performance and monitoring, and risk assessment. The EERC will work with PCOR Partnership Initiative members and regional stakeholders to promote the development of infrastructure and large projects within the PCOR Partnership Initiative region. This development will then provide best practices throughout the United States for wide-scale deployment of CCUS technologies. Existing data sets and technologies will be analyzed and evaluated to highlight current challenges limiting commercial adoption of CCUS as well as to identify potential solutions. The

project team will support DOE's National Risk Assessment Partnership (NRAP) and machine learning (ML) initiatives by drawing on data sets and experience available through the team. Assessments of infrastructure, site readiness, techno-economics, and socioeconomics will provide an overview of the CCUS landscape within the defined PCOR Partnership Initiative region. Potential business case scenarios will be evaluated, accounting for current economic incentives to identify opportunities in CCUS project development. Technology transfer activities will inform and educate CCUS stakeholders of project learnings through annual membership meetings, regulatory roundup meetings, Technical Advisory Board (TAB) meetings, webinars, reports, and conference presentations/papers. These activities will facilitate knowledge sharing and support DOE program goals.

ACCOMPLISHMENTS

Task 1.0 – Project Management and Planning

The objective of Task 1.0 is to manage and direct the project in accordance with a project management plan (PMP) to meet all technical, schedule, and budget objectives and requirements. Activities will be coordinated in order to effectively accomplish the work. The Project Manager (PM) will ensure that project plans, results, and decisions are appropriately documented and project reporting and briefing requirements are satisfied.

Significant accomplishments for Task 1.0 during the reporting period include the following:

- Completed BP1 on March 31, 2022.
- Presented to the North Dakota Industrial Commission (NDIC) Lignite Research Council on January 20, 2022, regarding a request submitted to project sponsor NDIC Lignite Research, Development, and Marketing Program for the release of incremental cost-share funding following the second DOE award increase (Contract Modification 005). Received NDIC approval.
- Presented to the NDIC Oil and Gas Research Council on February 23, 2022, regarding a request submitted to project sponsor NDIC Oil and Gas Research Program for the release of incremental cost-share funding following the second DOE award increase (Contract Modification 005). Received NDIC approval.
- Continued planning for the 2022 PCOR Partnership Initiative Annual Meeting, which will be held in Anchorage, Alaska. The dates of May 24–25, 2022, were secured. Registration and room block information were sent in an eblast on February 14, 2022.
- Held progress meetings with UW and UAF. Continued discussions of additional scopes of work for the third increment of funding.

- Held the first PCOR Partnership Initiative Invitational at the EERC on March 8, 2022. This in-person meeting brought participants from UAF, UW, and the EERC together to share activities that are occurring at each of the institutions under the PCOR Partnership Initiative.

- Held the TAB meeting February 16–17, 2022, in Houston, Texas, to discuss efforts in the PCOR Partnership Initiative. Those in attendance are in the photograph in Figure 1. Participants included the following:
  - Stacey Dahl, Minnkota Power Cooperative
  - Steve Melzer, Melzer Consulting
  - Lynn Helms, NDIC
  - Mike Holmes, Lignite Energy Council
  - Jim Erdle, Computer Modelling Group
  - Tom Olle, Technical Expert
  - Lon Whitman, Wyoming Enhanced Oil Recovery Institute
  - Kevin Connors, EERC
  - Kate Ryan, Denbury, Inc.

Figure 1. TAB members in attendance at the February 2022 TAB meeting.

- Engaged in conversations with current and prospective partners regarding their continued involvement in the PCOR Partnership Initiative.
  - Made contact with 30 prospective partners.
  - Presentations on the PCOR Partnership Initiative were given to ten prospective partners.
  - New members were welcomed:
    - Bakken Energy, LLC
    - Liberty Media Corporation
    - ND Ventures Ltd.
    - Sim Tech, LLC
  - Invoiced nine prospective partners that have not joined as of March 31, 2022.
  - Received 14 requests for information on how to join via the PCOR Partnership public website.
  - The PCOR Partnership currently has 218 members.

Next steps to accomplish the goals under Task 1.0 include the following:

- Complete contract modifications with UW and UAF to incorporate a revised scope and update the in-kind cost-share and subrecipient funding following the second DOE award increase (Contract Modification 005).

- Receive Contract Modification 006 authorizing continuation into BP2. Update the PMP to correspond with the modification.

- Continue planning for and hold the 2022 annual meeting May 24–25, 2022, in Anchorage, Alaska.

- Begin planning the next PCOR Partnership Invitational.

- Continue tracking progress on project deliverables (Ds) and milestones (Ms) (see Tables 1 and 2).

Task 2.0 – Technical Challenges

In Task 2.0, the project team will support regional deployment of CCUS programs by focusing on key technical challenges in the PCOR Partnership Initiative region related to stacked storage opportunities; storage performance; monitoring, verification, and accounting (MVA) technology; and subsurface integrity. The EERC will collaborate with PCOR Partnership Initiative members to identify knowledge gaps and address regional challenges through targeted webinars, workshops, reports, and papers.

Progress on Task 2.0 is as follows:

- Submitted D3.B entitled "Technical Approaches to Stacked Storage: Geomechanics Supplement" to the DOE PM for review on March 31, 2021.

- Received comments from the DOE PM on D5 entitled "Strategies for Storage Permanence: Well Integrity and Legacy Well Evaluations" on January 31, 2022. Addressed comments from the DOE PM. Received approval on March 31, 2022. Provided version marked approved on March 31, 2022, to DOE and NDIC. Added D5 to the PCOR Partnership partners-only website.

- Continued collaboration and planning for the field effort at the Red Trail Energy (RTE) carbon capture and storage (CCS) site near Richardton, North Dakota, to evaluate monitoring strategies with a focus on remote or autonomous operation as well as more frequent data acquisition and faster processing/interpretation. Activities included the following:
  - Completed contracting with subcontractor SkyGeo Inc. to provide InSAR (interferometric synthetic aperture radar) deliverables for baseline and monitoring ground deformation for the first 2 years of injection monitoring using public Sentinel 1 satellite imagery.
  - Supported vertical seismic profile (VSP) efforts. A VSP survey was conducted at the RTE site using vibroseis truck sourcing and recorded with a permanent distributed acoustic sensing (DAS) fiber installed in two wells. The Research Institute for Technology of the Earth (RITE) conducted the survey through separate research activities with RTE at the site. EERC staff working on PCOR Partnership activities supported the VSP survey as part of the ongoing evaluation of MVA technologies. The data collected through this VSP will be processed and compared to seismic monitoring data being collected by RITE using surface orbital vibrators (SOVs) to understand potential variances and utility of the different source types. The results will also be used to assess the feasibility of using a DAS VSP for monitoring CO_2 plume extents in a storage reservoir.
  - Prepared several outreach-related documents for RTE regarding the VSP monitoring activity, including a map of the proposed survey area and landowner notification letters for RTE to distribute.

- Continued preparation of the MVA strategies report (D6).

- Worked on white papers on approaches to geomechanical and geochemical evaluations.

Next steps to accomplish the goals under Task 2.0 in the coming quarter include the following:

- Additional RTE field activities: install scalable, automated, sparse seismic array (SASSA) sensors and collect baseline data using SOVs and InSAR data analysis.

- Continue work on the MVA strategies report (D6) and white papers.

Table 1. Project Deliverables

Deliverable No. and Title	Planned Completion Date	Actual Completion Date	Verification Method	Comments
D1 – PMP	30 days after contract definitization	2/21/2020	PMP file submitted to DOE PM	
D2 – Report – Storage Optimization	4/30/2021	4/30/2021	Topical report submitted to DOE PM	Moved from 12/31/2020.
D3.A – Report – Stacked Storage Opportunity Assessment	8/31/2021	8/31/2021 (Executive Summary) 11/12/2021 (Full report)	Topical report submitted to DOE PM	Moved from 6/30/2021. Full report due 11/1/2021 as discussed with DOE PM.
D3.B – Report – Stacked Storage Scenario Geomechanical Modeling	3/31/2022	3/31/2022	Topical report submitted to DOE PM	Created as second D3 report.
D4 – Report – Regional Business Case Assessment	12/31/2021	12/17/2021	Topical report submitted to DOE PM	Moved from 3/31/2021.
D5 – Report – Subsurface and Legacy Well Integrity	12/31/2021	12/30/2021	Topical report submitted to DOE PM	
D6 – Report – MVA Strategies	6/30/2022		Topical report submitted to DOE PM	
D7 – Report – Evaluation of Risk Management	9/30/2022		Topical report submitted to DOE PM	
D8 – Report – Regional Permitting Guidance	9/30/2022		Topical report submitted to DOE PM	
D9 – Report – Infrastructure, Scale-Up, and Techno-Economic Assessments	12/31/2022		Topical report submitted to DOE PM	
D10 – Report – NRAP Testing and Validation	3/31/2023	12/17/2021 (Part 1)	Topical report submitted to DOE PM	To be provided in two parts.
D11 – Report – Basement Faulting and Stress State, Induced Seismicity	9/30/2023		Topical report submitted to DOE PM	
D12 – Report – Regional Socioeconomic Assessments	9/30/2023		Topical report submitted to DOE PM	
D13 – Report – Updated Regional Business Case Assessment	12/31/2023		Topical report submitted to DOE PM	
D14 – Report – Risk-Based Area of Review	1/31/2021	1/29/2021	Topical report submitted to DOE PM	Moved from 12/31/2020.
D15 – PCOR Partnership Atlas	6/30/2021 and 3/31/2023	6/30/2021	Atlas submitted to DOE PM	Moved from 3/31/2021.
D16 – Enabling Sustainable Monitoring for CCUS	6/30/2024		Topical report submitted to DOE PM	
D17 – PCOR Partnership Initiative Road Map	5/31/2024		Topical report submitted to DOE PM	

Table 2. Milestone Status Report

Milestone No. and Title	Planned Completion Date	Actual Completion Date	Verification Method	Comments
M1 – Regulatory Roundup Scheduled	2/29/2020	3/31/2020	Reported in subsequent quarterly report	
M2 – Initial Techno-Economic Framework Established	4/30/2020	4/28/2020	Reported in subsequent quarterly report	
M3 –Annual Meeting Scheduled	3/31/2021	3/29/2021	Reported in subsequent quarterly report	
M4 – Regulatory Roundup Scheduled	3/31/2021	3/29/2021	Reported in subsequent quarterly report	
M5 – Data Share with National Lab for NRAP Assessment	6/30/2021	6/30/2021	Reported in subsequent quarterly report	Files added to EDX.[1]
M6 – GHGT-16[2] Abstract Submitted	1/31/2022	1/14/2022	Reported in subsequent quarterly report	
M7 – BP1 EDX Submitted	3/31/2022	3/31/2022	Reported in subsequent quarterly report	
M8 – Draft Journal Article Completed	11/30/2022		Reported in subsequent quarterly report	
M9 – Regulatory Roundup Scheduled	3/31/2023		Reported in subsequent quarterly report	
M10 – GHGT-17 Abstract Submitted	1/31/2024		Reported in subsequent quarterly report	
M11 – Annual Meeting Scheduled	3/31/2024		Reported in subsequent quarterly report	
M12 – BP2 EDX Submitted	6/30/2024		Reported in subsequent quarterly report	

[1] Energy Data eXchange.
[2] 16th International Conference on Greenhouse Gas Control Technologies.

Task 3.0 – Data Collection, Sharing, and Analysis

In Task 3.0, the project team will collaborate with other DOE Fossil Energy Carbon Management (FECM)-funded researchers to improve understanding of CO_2 injection and storage impacts. The project team will work with national laboratories to facilitate data sharing, support the development and validation of NRAP tools with site-specific data, and participate in development of ML-based tools/methods in a commercial setting.

Progress on Task 3.0 is as follows:

- Subtask 3.1 – Data Sharing:
  - Completed uploading geologic models and reservoir simulations to the EERC workspace PCOR Partnership folder on the EDX, satisfying Milestone M7 entitled "BP1 EDX Submitted" on March 31, 2022. The set includes geologic models and reservoir simulations that were supported by NETL under Award No. DE-FE0009114 for i) dedicated storage in deep saline formations and ii) associated storage through CO_2 enhanced oil recovery (EOR) in clastic and carbonate reservoirs. In addition, the set includes 130 realizations of the SMART (Science-

Informed Machine Learning for Accelerating Real Time Decisions in Subsurface Applications) Initiative clastic shelf models that were supported by NETL under Contract No. 89243318CFE000003, passed through Leidos Inc., Subcontract No. P010227025, Task Order Release No. 7. The set of geologic models and reservoir simulations will provide a valuable resource to other DOE researchers studying geologic carbon storage or EOR.
  - Continued to identify synthetic data sets that will be generated through the PCOR Partnership and available for upload to the EDX for M12 – BP2 EDX Submitted.

- Subtask 3.2 – NRAP Validation:
  - Continued testing of the NRAP Open-Source Integrated Assessment Model (Open-IAM). The project team is comparing the results from NRAP-Open-IAM against the results for an identical storage complex and overburden stratigraphy in the Analytical Solution for Leakage in Multilayered Aquifers (ASLMA) FORTRAN-based semianalytical model.
  - Additional testing of the DREAM (Designs for Risk Evaluation and Management Tool, Version 2020.01-2.0) tool is ongoing and will be documented as part of a second NRAP testing report. Met with the NRAP team on February 4, 2022, to discuss DREAM testing.

- Subtask 3.3 – Machine Learning:
  - The EERC continued to support the SMART Initiative through the PCOR Partnership Initiative. The EERC is directly involved in Tasks 1, 2, 4, 5 (Carbon Storage Program), and 6 (Oil and Gas Program) of the SMART Initiative and is participating in the crosscutting groups for algorithms and data. SMART Phase 1 ended March 31, 2022.
  - Continued to explore the use of ML-based predictive modeling techniques to use geophysical well logs to classify aquifers located throughout the PCOR Partnership Initiative region into three groups based on their estimated total dissolved solids (TDS) concentrations: i) confidently less than 10,000 mg/L TDS, ii) confidently greater than 10,000 mg/L TDS, or iii) uncertain classification – not i or ii. Collaborating with UW on this effort.

Next steps to accomplish the goals under Task 3.0 in the coming quarter include the following:

- Continue to explore the use of ML-based predictive modeling techniques to use geophysical well logs to classify aquifers located throughout the PCOR Partnership Initiative region.

Task 4.0 – Regional Infrastructure

The objective of Task 4.0 is to evaluate the regional needs, challenges, and potential economic impacts related to the development of safe and environmentally sound CO_2 transportation infrastructure to accelerate commercial CCUS project deployment. This evaluation will be accomplished by assessing existing infrastructure, scale-up challenges and needs, and

techno-economic and socioeconomic impacts in the PCOR Partnership Initiative region and will be communicated through outreach activities.

Progress on Task 4.0 is as follows:

- Submitted the finalized PCOR Partnership Atlas, 6th Edition (D15) on January 11, 2022. The atlas is available on the PCOR Partnership website at https://undeerc.org/pcor/assets/PDFs/PCOR%20ATLAS%202021.pdf. The printed atlases arrived at the EERC on January 19, 2022. Shipped copies of the atlas to DOE, NDIC, UW, UAF, and PCOR Partnership TAB members. Began shipping copies to PCOR Partnership members.

- Completed M6 (GHGT-16 Abstract Submitted) on January 14, 2022, with the submission of four abstracts related to PCOR Partnership activities with the following titles:
  - PCOR Partnership: Breaking Down the Barriers in CCUS
  - Risk-Based Area of Review Estimation in Overpressured Reservoirs to Support Injection Well Storage Facility Permit Requirements for CO_2 Storage Projects
  - Stacked Carbon Dioxide Storage: Technical and Geomechanical Considerations
  - Demonstration of Novel Monitoring Techniques for a North Dakota Carbon Capture and Storage Project (content includes activities under a complementary project)

- Provided a white paper entitled "Pipeline Cost and CO_2 Transport Considerations Based on Three Hypothetical Pipelines in the PCOR Partnership Initiative Region" to the DOE PM and NDIC. The paper was written in cooperation with Resolute Engineering. The white paper was added to the PCOR Partnership partners-only website for partners to access.

- Continued a study on CCUS and grid reliability in the PCOR Partnership region. Prepared a white paper that includes an extensive literature review that discusses the North Dakota regional electric grid's historical, current, and future generation and transmission trends as well as the likely grid impacts of CCUS from a variety of perspectives, including renewable energy, technological limitations, and severe weather patterns. To understand the effect of CCUS on grid operation, preliminary simulations on unit commitment and economic dispatch models were performed using Hitachi Energy PROMOD software. Provided the white paper to a PCOR Partnership member for external review.

- Jackson Walker, LLP, provided a first draft of a case study on CCUS and grid reliability to the EERC for review. Met with representatives periodically to discuss review comments and updates.

- Preparation of a high-level road map that summarizes the near- to long-term opportunities for hydrogen production with CCUS in the PCOR Partnership region is progressing. Existing and future industrial hydrogen producers and consumers that include location, scale, and overall CO_2 emissions have been characterized, along with

potential CO_2 storage reservoirs. The work has allowed the team to identify opportunities for growing hydrogen production in the PCOR Partnership region and establish geographic criteria for hydrogen hubs and associated long-term storage of CO_2.

- Developing mass and energy balances around hydrogen plants of different designs and scales as part of the hydrogen CCUS road map. Depending on the hydrogen production technology and associated CO_2 capture approach employed, a portion of the CO_2 can be readily captured at high purity from pressurized process streams, while other CO_2 emissions would be considerably more difficult and costly to capture. The mass and energy balance data are being used to estimate how different levels of CO_2 capture and different plant scales might impact the cost of blue hydrogen production with CO_2 capture. This will advise optimal near-term opportunities for implementing blue hydrogen with CCUS and the prudent long-term opportunities for cost-effective hydrogen production with minimal carbon footprint.

- Collecting information about pipeline specifications, including stream qualities from different combustion processes (precombustion, postcombustion, and oxyfuels), constituents in a CO_2 stream generated from carbon capture, and methods and costs to add a gas-dehydrating system to a carbon capture setup.

- Continued internal review of a white paper on the concept of potential pressure interference during CO_2 injection and storage.

- Requested and received approval to subcontract Stress Engineering Services, Inc., to provide PCOR Partnership membership with a basic guideline on considerations for selecting corrosion-resistant alloy materials for use in CO_2 storage and utilization applications.

- At the invitation of the Midwest Regional Carbon Initiative, PCOR Partnership participated in a podcast recording on January 18, 2022, focused on describing the regional programs, challenges, and opportunities within each region. From the PCOR Partnership, Wes Peck was interviewed on behalf of Kevin Connors. The Season 2 Episode 2 eGeos podcast entitled "Region Carbon Sequestration Partnership" is available via SoundCloud at https://soundcloud.com/energy-geos/s2-e2-regional-carbon?si=700a4992f29d4f4fa77bf5cc57f700e9&utm_source=clipboard&utm_medium=text&utm_campaign=social_sharing and Apple at https://podcasts.apple.com/us/podcast/energy-geoscience/id1548154765?i=1000549612026.

Next steps to accomplish the goals under Task 4.0 in the coming quarter include the following:

- Continue to ship the PCOR Partnership Atlas (D15) to PCOR Partnership members when stock is replenished.

- Complete white papers on the North Dakota CCUS grid impact study, Jackson Walker, LLP, CCUS and grid stability study, and pressure interference and provide to DOE and PCOR Partnership members.

Task 5.0 – Technology Transfer

Task 5.0 will inform and educate stakeholders about CCUS technologies. Nontechnical challenges to CCUS deployment in the PCOR Partnership Initiative region will be identified and assessed, with an emphasis on regulatory issues and solutions. Business case scenarios for CCUS projects will be identified, reviewed, and developed. Outcomes of this task will be transferred to stakeholders through meetings, presentations, and webinars. Developed materials will be shared with DOE to support its broader FECM program goals.

Progress on Task 5.0 is as follows:

- Received comments from the DOE PM on D4 entitled "CCUS Business Models in the PCOR Partnership Region" on January 6, 2022. Submitted the final approved version to DOE on January 11, 2022.

- Sent an eblast on January 18, 2022, to partners to thank them for their membership and provide an update on the PCOR Partnership Initiative. Links were provided to the public and partner websites and product highlights from 2021.

- At the invitation of the University of North Dakota (UND) SPE (Society of Petroleum Engineers) Student Chapter, staff presented at the Carbon Capture, Utilization and Storage Workshop at UND on January 26, 2022.

- Presented "U.S. Leadership in CCUS" at the 2022 Touchstone Energy Cooperative NEXT Conference held January 31 – February 2, 2022, in Indian Wells, California.

- Presented at the 2022 Energy Transition e-meeting organized by the European Association of Geoscientists and Engineers (EAGE) Local Chapter Houston and EAGE Local Chapter London on February 15, 2022. The presentation was entitled "The Role of Geophysics in Carbon Capture Utilization and Storage (CCUS): Examples from Plains CO_2 Reduction Partnership (PCOR)."

- Presented "Balancing CO_2 Pipeline Infrastructure Challenges" at the American Association of Petroleum Geologists (AAPG) CCUS Conference held March 29–31, 2022, in Houston, Texas.

- Presented "Monitoring, Verification, and Accounting (MVA) Strategy for a North Dakota Carbon Capture and Storage Project Integrated with Ethanol Production" at the AAPG CCUS Conference held March 29–31, 2022, in Houston, Texas.

- Presented a poster entitled "Low-Environmental-Impact Seismic CO_2 Monitoring in a North Dakota Carbon Capture and Storage Project Integrated with Ethanol Production" at the AAPG CCUS Conference held March 29–31, 2022, in Houston, Texas.

- Presented a poster entitled "First Wave of Incentive-Driven CCS Projects in North Dakota" at the AAPG CCUS Conference held March 29–31, 2022, in Houston, Texas.

- Reviewed products from UAF and UW and worked with the teams on updates.

- Continued efforts to upgrade the functionality and update content on the PCOR Partnership Initiative partner website. Began updates to the public website based on the most recent version of the PCOR Partnership Atlas.

- Provided comments and suggestions to DOE on March 11, 2022, for the finalization of the DOE Class VI rules and tools crosswalk report. Provided PCOR Partnership author names to DOE, as requested.

- Continued development of a white paper on pore space leasing considerations and several white papers focused on various lessons learned through the PCOR Partnership.

Next steps to accomplish the goals under Task 5.0 in the coming quarter include the following:

- Continue updating the PCOR Partnership Initiative public and partner websites.

- White papers are expected to be completed on the topics of Class VI wellbore construction and design; lessons learned from coring programs, wireline logging, and seismic surveys; pore space leasing considerations; evaluation of geophysical technologies; corrosion-resistant materials; and stabilized plume evaluations.

CHANGES/PROBLEMS

No changes or problems at this time.

SPECIAL REPORTING REQUIREMENTS

None.

BUDGETARY INFORMATION

ENERGY & ENVIRONMENTAL RESEARCH CENTER

PLAINS CO_2 REDUCTION PARTNERSHIP INITIATIVE TO ACCELERATE CARBON CAPTURE, UTILIZATION, AND STORAGE DEPLOYMENT

DE-FE0031838

Project-to-Date Financial Report at March 31, 2022

($K)	Q4 Oct - Dec 2019	Q1 Jan - Mar 2020	Q2 Apr - Jun 2020	Q3 Jul - Sep 2020	Q4 Oct - Dec 2020	Q1 Jan - Mar 2021	Q2 Apr - Jun 2021	Q3 Jul - Sep 2021	Q4 Oct - Dec 2021	Q1 Jan - Mar 2022
Baseline Cost Plan										
Federal Share	63.8	81.4	213.9	239.6	914.0	914.0	914.0	914.0	914.0	914.0
Nonfederal Share	0.0	6.5	49.7	40.6	237.5	237.5	237.5	237.5	237.5	237.6
Total Planned	63.8	87.9	263.6	280.2	1151.5	1151.5	1151.5	1151.5	1151.5	1151.6
Cumulative Federal	63.8	145.2	359.1	598.7	1512.7	2426.7	3340.7	4254.7	5168.7	6082.7
Cumulative Nonfederal	0.0	6.5	56.2	96.8	334.3	571.8	809.3	1046.8	1284.3	1521.9
Cumulative Baseline Costs	63.8	151.7	415.3	695.5	1847.0	2998.5	4150.0	5301.5	6453.0	7604.6
Actual Incurred Cost										
Federal Share	63.8	81.4	213.9	239.6	296.8	376.4	1230.8	1402.3	814.6	1388.5
Nonfederal Share	0.0	6.5	49.7	40.6	83.0	81.9	179.1	82.8	488.4	495.0
Total Incurred Costs	63.8	87.9	263.6	280.2	379.8	458.3	1409.9	1485.1	1303.1	1883.5
Cumulative Federal	63.8	145.2	359.2	598.8	895.6	1272.0	2502.8	3905.1	4719.7	6108.2
Cumulative Nonfederal	0.0	6.5	56.2	96.7	179.8	261.6	440.7	523.5	1011.9	1506.9
Cumulative Incurred Costs	63.8	151.7	415.4	695.5	1075.3	1533.6	2943.5	4428.6	5731.7	7615.2
Variance										
Federal Share	0.0	(0.0)	(0.0)	0.0	617.2	537.6	(316.8)	(488.3)	99.4	(474.5)
Nonfederal Share	0.0	0.0	0.0	0.0	154.5	155.6	58.4	154.7	(250.9)	(257.4)
Total Variance	0.0	(0.0)	(0.0)	0.0	771.7	693.2	(258.4)	(333.6)	(151.6)	(731.9)
Cumulative Federal	0.0	(0.0)	(0.1)	(0.1)	617.1	1154.7	837.9	349.6	449.0	(25.5)
Cumulative Nonfederal	0.0	0.0	0.0	0.1	154.5	310.2	368.6	523.3	272.4	15.0
Cumulative Variance	0.0	(0.0)	(0.1)	(0.0)	771.7	1464.9	1206.5	872.9	721.3	(10.6)

ENERGY & ENVIRONMENTAL RESEARCH CENTER

PLAINS CO_2 REDUCTION PARTNERSHIP INITIATIVE TO ACCELERATE CARBON CAPTURE, UTILIZATION, AND STORAGE DEPLOYMENT

DE-FE0031838

Project-to-Date Financial Report at March 31, 2022

($K)	Q2 Apr - Jun 2022	Q3 Jul - Sep 2022	Q4 Oct - Dec 2022	Q1 Jan - Mar 2023	Q2 Apr - Jun 2023	Q3 Jul - Sep 2023	Q4 Oct - Dec 2023	Q1 Jan - Mar 2024	Q2 Apr - Jun 2024	Q3 Jul - Sep 2024
Baseline Cost Plan										
Federal Share	424.3	424.3	424.3	424.3	424.3	424.3	343.1	342.9	342.9	342.9
Nonfederal Share	109.2	109.2	109.2	109.2	109.2	109.0	81.8	81.9	81.9	81.9
Total Planned	533.5	533.5	533.5	533.5	533.5	533.3	424.9	424.8	424.8	424.8
Cumulative Federal	6507.0	6931.2	7355.5	7779.7	8204.0	8628.2	8971.3	9314.2	9657.1	10000.0
Cumulative Nonfederal	1631.1	1740.3	1849.5	1958.7	2067.9	2176.9	2258.7	2340.6	2422.5	2504.4
Cumulative Baseline Costs	8138.1	8671.5	9205.0	9738.4	10271.9	10805.1	11230.0	11654.8	12079.6	12504.4
Actual Incurred Cost										
Federal Share										
Nonfederal Share										
Total Incurred Costs										
Cumulative Federal										
Cumulative Nonfederal										
Cumulative Incurred Costs										
Variance										
Federal Share										
Nonfederal Share										
Total Variance										
Cumulative Federal										
Cumulative Nonfederal										
Cumulative Variance										