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January 24, 2024

Mr. Reice Haase
Deputy Director
North Dakota Industrial Commission
600 East Boulevard Avenue, Department 405
State Capitol, 14th Floor
Bismarck, ND 58505-0840

Dear Mr. Haase:

Subject: Quarterly Progress Report for the Period of October 1 – December 31, 2023, "PCOR Partnership Initiative to Accelerate CCUS Deployment"; Contract Nos. FY20-XCI-226 and G-050-096

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) 777-5236 or by email at kconnors@undeerc.org.

Sincerely,

DocuSigned by:
Kevin Connors
1D14EF7CF3CD456...

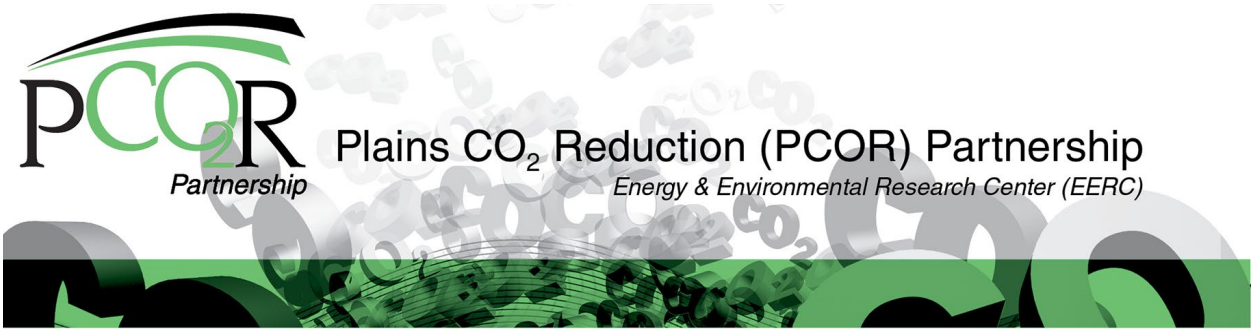
Kevin C. Connors
Assistant Director for Regulatory Compliance and Energy Policy
PCOR Partnership Program Manager

KCC/rlo

Attachment

c/att: Michael Holmes, Lignite Energy Council
Brent Brannan, North Dakota Industrial Commission (NDIC) Department of Mineral Resources, Oil and Gas Division
Brenna Jessen, NDIC

c: Jamie Mitzel, EERC



PCOR PARTNERSHIP INITIATIVE TO ACCELERATE CCUS DEPLOYMENT

Quarterly Technical Progress Report

(for the period October 1 – December 31, 2023)

Prepared for:

Reice Haase

North Dakota Industrial Commission
600 East Boulevard Avenue, Department 405
State Capitol, 14th Floor
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Contract Nos. FY20-XCI-226 and G-050-96

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January 24, 2024

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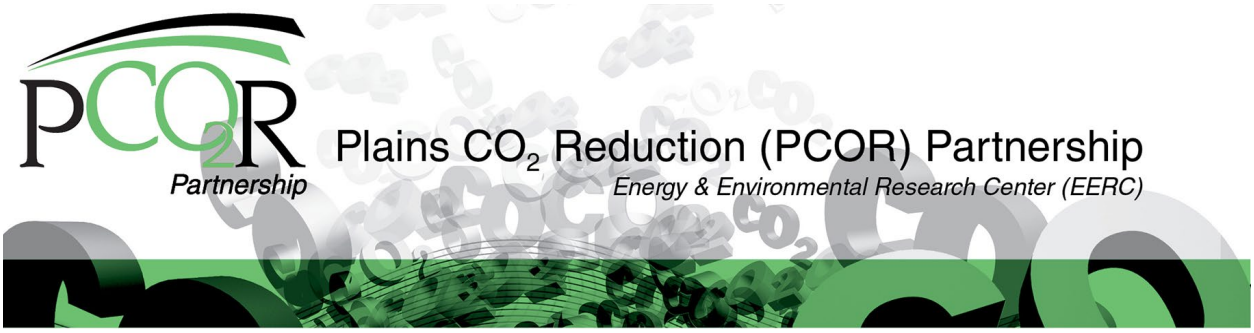


PCOR PARTNERSHIP INITIATIVE TO ACCELERATE CCUS DEPLOYMENT
Quarterly Progress Report
October 1 – December 31, 2023

EXECUTIVE SUMMARY

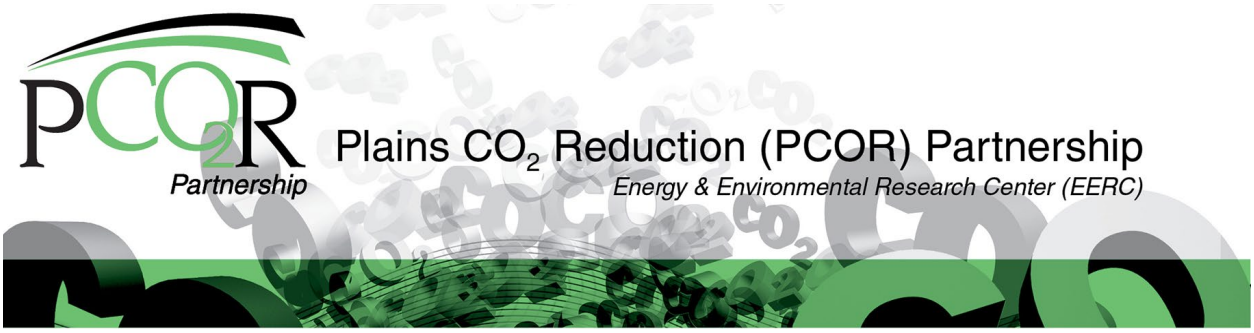
The Plains CO_2 Reduction (PCOR) Partnership, funded by the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL), the North Dakota Industrial Commission Oil and Gas Research Program and Lignite Research Program, and more than 250 public and private partners, is accelerating the deployment of carbon capture, utilization, and storage (CCUS) technology. The PCOR Partnership is focused on a region comprising ten U.S. states and four Canadian provinces in the upper Great Plains and northwestern regions of North America. It is led by the University of North Dakota Energy & Environmental Research Center (EERC), with support from the University of Wyoming (UW) and the University of Alaska Fairbanks (UAF).

The EERC welcomed four new members to the PCOR Partnership this quarter, bringing the membership to 261. The EERC held introductory meetings to engage and welcome Goodnight Midstream, Subsurface AI, Ikon Science, and Delta Constructors.

The EERC hosted an important meeting on December 4–5, 2023, in Bismarck, North Dakota, to a group comprising staff from UAF, Alaskan legislators, and legislative and regulatory staff to learn more about CCUS and associated policy/regulations prior to the start of the 2024 legislative session. The meeting was very successful and active engagement was held with staff from the EERC, Lignite Energy Council, and Department of Mineral Resources Oil & Gas Division. The meeting included a field trip to the Blue Flint Ethanol Plant and the Coal Creek Station, a coal-fired electric generating plant.

Work was executed, finalized, and submitted for three deliverables (Ds): D11 – Basement Faulting and Stress State, Induced Seismicity; D12 – Regional Socioeconomic Assessments; and D13 – Updated Regional Business Model Assessment.

The PCOR Partnership sent its fourth newsletter to project partners on December 20, 2023. The focus this quarter was an overview of the PCOR Partnership annual meeting and the CCUS value chain workshop, highlighted work performed by Stress Engineering, the journal article on the guidelines developed, new partners, and a recap of recent events and meetings attended. There were several LinkedIn shoutouts to the PCOR Partnership about the great annual meeting, and snippets of these were also included.



PCOR PARTNERSHIP INITIATIVE TO ACCELERATE CCUS DEPLOYMENT
Quarterly Progress Report
October 1 – December 31, 2023

INTRODUCTION

The Plains CO_2 Reduction (PCOR) Partnership, funded by the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL), the North Dakota Industrial Commission (NDIC) Oil and Gas Research Program and Lignite Research Program, and more than 250 public and private partners, is accelerating the deployment of carbon capture, utilization, and storage (CCUS) technology. The PCOR Partnership is focused on a region comprising ten U.S. states and four Canadian provinces in the upper Great Plains and northwestern regions of North America. It is led by the University of North Dakota Energy & Environmental Research Center (EERC), with support from the University of Wyoming (UW) and the University of Alaska Fairbanks (UAF).

The goal of the PCOR Partnership is to identify and address regional capture, transport, and storage challenges facing commercial deployment of CCUS in an expanded region, compared to past Regional Carbon Sequestration Partnership project phases. To achieve this goal, the PCOR Partnership 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 members and regional stakeholders to promote the development of infrastructure and large projects within the PCOR Partnership 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 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 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:

- Held progress meetings with subrecipients UAF and UW.
- Held regular progress update meetings with the federal PM.
- Held discussions with prospective members on a regular basis. The PCOR Partnership currently has 261 members. The PCOR Partnership welcomed new partners and held introductory meetings for:
  - Goodnight Midstream.
  - Subsurface AI.
  - Ikon Science.
  - Delta Constructors.

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

- Continue tracking progress on project deliverables and milestones (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 region related to stacked storage opportunities; storage performance; monitoring, verification, and accounting (MVA) technology;

Table 1. Project Deliverables

Deliverable (D) 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 (E.S.) 11/12/2021 (full report)	Topical report submitted to DOE PM	Moved from 6/30/2021.
D3.B – Report – Stacked Storage Scenario Geomechanical Modeling	3/31/2022	3/31/2022	Topical report submitted to DOE PM	Created a 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	6/30/2022	Topical report submitted to DOE PM	
D7 – Report – Evaluation of Risk Management	9/30/2022	9/30/2022	Topical report submitted to DOE PM	
D8 – Report – Regional Permitting Guidance	9/30/2022	9/30/2022	Topical report submitted to DOE PM	Two reports submitted for D8.
D9 – Report – Infrastructure, Scale-Up, and Techno-Economic Assessments	3/31/2023	3/31/2023	Topical report submitted to DOE PM	
D10 – Report – NRAP Testing and Validation	3/31/2023	12/17/2021 (Part 1) 3/31/2023 (Part 2)	Topical report submitted to DOE PM	Provided in two parts.
D11 – Report – Basement Faulting and Stress State, Induced Seismicity	~~9/30/2023~~ Extended to 12/1/2023		Topical report submitted to DOE PM	A request to move the due date to 12/1/23 was made; a revised PMP was submitted to DOE on 9/29/23.
D12 – Report – Regional Socioeconomic Assessments	~~9/30/2023~~ Extended to 12/1/2023	11/27/2023	Topical report submitted to DOE PM	A request to move the due date to 12/1/23 was made; a revised PMP was submitted to DOE on 9/29/23.
D13 – Report – Updated Regional Business Case Assessment	12/31/2023	12/22/2023	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 3/31/2024	6/30/2021	Atlas submitted to DOE PM	
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 (M) 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	9/30/2022	Reported in subsequent quarterly report	
M9 – Regulatory Roundup Scheduled	3/31/2023	3/31/2023	Reported in subsequent quarterly report	
M10 – GHGT-17 Abstract Submitted	1/31/2024		Reported in subsequent quarterly report	Abstract to be submitted on 1/12/2024.
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.

and subsurface integrity. The EERC will collaborate with PCOR Partnership 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 D 11 – Basement Faulting and Stress State, Induced Seismicity to the U.S. Department of Energy (DOE) on November 27, 2023. The deliverable included addressing comments made by PCOR Partnership partner ConocoPhillips.

- The abstract *Toward More Efficient and Cost-Effective CO_2 Monitoring Using a Sparse Surface Seismic Array: Example from an Industrial Site in North Dakota* was submitted to the American Association of Petroleum Geologists–Society of Exploration Geophysicists (AAPG–SEG) CCUS 2024 conference and was accepted for an oral presentation.

- Continued collaboration for the field effort at the Red Trail Energy (RTE) carbon capture and storage (CCS) site. Activities included the following:
  - Compiling and processing all data collected thus far.

  - Operation of the Instrumental Software Technologies, Inc. (ISTI) 6C seismic station for recording waveform data to complement the scalable, automated, sparse seismic array (SASSA) processing effort.
  - The Research Institute of Innovative Technology for the Earth (RITE) completed maintenance on SOV2, and the EERC continued recording SASSA data with the Zland nodes in Quarter (Q)4 2023. The last of the Stryde data were harvested and organized for processing.
  - An assessment of the repeatability of the eVibe signals was conducted. A good repeatability was observed.
  - Initial tests of using passive noise data for near-surface velocity estimation were conducted.
  - Data from 6C station acquired during VSP monitoring survey were gathered.
  - The data from the updated SOV1 and SOV2 were collected.
  - The EERC continues collaboration with NETL seismicity stations at the RTE site. Discussions continued about potential upgrades to stations to allow for real-time continuous data transmission.

- UW continued work on draft documents to advance the PCOR Partnership knowledge in topics under Task 2.0, including the following:
  - Formation Outlines for Minnelusa, Hulett, and Lakota Formations and Associated Seals – UW incorporated the EERC's feedback into updated versions of the formation outlines. UW submitted the final versions to the EERC on October 11, 2023.
  - Formation Outlines for Storage Reservoirs and Seals in the Rock Springs Uplift – UW incorporated feedback from the EERC into formation outlines for the Rock Springs Uplift. UW submitted the final version of this deliverable to the EERC on October 11, 2023.

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

- The eVibe was transported back to the EERC in Grand Forks, North Dakota, for decommissioning and is awaiting shipment back to the Netherlands.

- Finalize white papers.

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
  - The EERC continues to identify and catalog data sets that will be generated through the PCOR Partnership and available for upload to EDX for M12 – BP2 EDX Submitted.

- Subtask 3.3 – Machine Learning
  - The EERC continues to track ongoing work conducted under the SMART (Science-Informed Machine Learning for Accelerating Real-Time Decisions in Subsurface Applications) Initiative and look for ways to incorporate these learnings into the PCOR Partnership region.

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 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 region and will be communicated through outreach activities.

Progress on Task 4.0 is as follows:

- Submitted D12 – Regional Socioeconomic Assessments report on December 1, 2023.

- The EERC addressed comments by Jim Kirksey (DOE) for Stress Engineering Services, Inc.'s (Stress Engineering's) white paper: The Need for Corrosion-Resistant Alloys in CO_2 Injection Wells for CCS and CCUS.
  - The EERC submitted the tracked changes and final copies of addressed comments to DOE on December 22, 2023.

- Continued internal reviews of the white papers on the PCOR Partnership hydrogen CCUS road map and CO_2 stream impurities.

- UW work continued on draft documents to advance the PCOR Partnership knowledge in topics under Task 4.0, including the following:
  - Updated Wyoming Pipeline Initiative Summary – This deliverable will include an assessment of steps for operators seeking to develop pipelines within the Wyoming Pipeline Corridor to obtain the necessary permits and regulatory review. Work on this deliverable has begun and is expected to be completed by March 1, 2024.

- UAF continued work to advance the PCOR Partnership knowledge in topics under Task 4.0, including the following:
  - Laboratory experiments on CO_2-induced corrosion continued. UAF shared presentation slides entailing the CO_2-induced corrosion results with the EERC on November 30, 2023. A report with the data collected in the experiments will be delivered to the EERC.
  - Investigation continues on a new set of core floods for CO_2 storage in an oil reservoir following oil production and will be designed to develop a correlation for predicting CO_2 storage efficiency in oil reservoirs.
  - Shared overview of Susitna Low-Carbon Power Plant with the Alaska Department of Natural Resources (DNR).
  - Completed draft of nonconfidential version of UAF/PCOR Partnership techno-economic study for Susitna Low-Carbon Power Plant.
  - Alaska DNR coordinated with the PCOR Partnership to arrange a meeting between Alaska and North Dakota state governments to discuss state and federal CCUS policies, North Dakota's carbon management philosophy, and current CCUS project activity. The meeting was held on December 4-5, 2023.
  - Hosted CCUS workgroup meeting on December 19, 2023. ExxonMobil Corp. to share on CCUS.

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

- Continue to work on PCOR Partnership Atlas 6th edition update.

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 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:

- EERC representatives traveled to meet with UW School of Energy Resources (SER) staff for in-person meetings on October 12, 2023, to discuss its current scope of work as well as opportunities for future collaboration within the PCOR Partnership.

- Development of new fact sheets continued, covering the topics listed below:
  - The importance of regulatory frameworks and Class VI primacy
  - Pore space ownership and CCS projects
  - CO_2 concentrations
  - Aquifer exemption

- The PCOR Partnership principal investigator (PI) presented at the Labor and Management Public Affairs Committee (LAMPAC) meeting in Minneapolis, Minnesota, on November 14, 2023.

- The PCOR Partnership PI traveled to Park City, Utah, to attend the Interstate Oil and Gas Compact Commission (IOGCC) Annual Meeting and participate on the IOGCC working group evaluating and updating the model statute and regulations for geologic storage of carbon dioxide.

- Completed the update to the 45Q fact sheet, and uploaded to the partners-only site on November 30, 2023.

- Held meeting on December 4–5, 2023, in Bismarck, North Dakota, to host a group comprising staff from UAF, Alaskan legislators, and legislative and regulatory staff to learn more about CCUS and associated policy/regulations prior to the start of the 2024 legislative session (Figure 1). North Dakota invitees include staff from the EERC, Lignite Energy Council, and Department of Mineral Resources Oil & Gas Division. The meeting included a field trip to the Blue Flint Ethanol Plant (Figure 2), where CO_2 injections began in October 2023 (Figure 3), and the Coal Creek Station, a coal-fired electric generating plant (Figure 4).

- Held a combined virtual meeting between staff from the EERC, UW SER, and UAF on December 14, 2023, where each entity shared updated activities.

- The December issue of the *PCOR Pioneer* newsletter was completed and distributed on December 20, 2023. This issue provides an overview of the PCOR Partnership annual meeting and the CCUS value chain workshop, highlights work performed by Stress Engineering, features the journal article on the guidelines developed, presents new partners, and recaps recent events and meetings attended. There were several LinkedIn shoutouts to the PCOR Partnership about the great annual meeting, and snippets of these were also included.

- Submitted D13 – Updated Regional Business Model Assessment to DOE on December 22, 2023.

- The UW SER and the Wyoming Department of Environmental Quality (WDEQ), with support from the PCOR Partnership, released a publication titled “Regulatory Considerations for Carbon Dioxide Storage and Plume Migration on Interstate and Federal Lands,” along with an associated research brief. Both publications are available on the UW Center for Energy Regulation and Policy Analysis (CERPA) website located here: www.uwyo.edu/ser/research/centers-of-excellence/energy-regulation-policy/publications.html and were uploaded to the partners-only site.

- UAF continued work on a topical report: Regional Business Case Assessment for CCUS on the North Slope.

Figure 1. Kevin Connors (PCOR Partnership PI) at the Bismarck meeting, providing a PCOR Partnership and CCUS overview to UAF, Alaskan legislators, and legislative and regulatory staff.

Figure 2. Tour held by Midwest AgEnergy at Blue Flint Ethanol Plant on December 4, 2023.

Figure 3. Tour held by Midwest AgEnergy at Blue Flint Ethanol Plant injection site on December 4, 2023.

Figure 4. Tour held by Rainbow Energy's Coal Creek Station on December 4, 2023.

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

- Continue progress on fact sheets, covering the topics listed below:
  - Pore space ownership and CCS projects
  - CO_2 concentrations
  - Aquifer exemptions

- Continued reviews and development of white papers focusing on lessons learned through PCOR Partnership efforts with topics on North Dakota reporting requirements and pipeline specifications through UW SER.

- Continue UW and the EERC collaborative activities.

- Complete UW Regional Permitting Guidance white paper, currently under EERC review.

- Complete Federal Land Challenges with CCS white paper; UW plans to publish this deliverable through UW SER's CERPA, combined with UW SER's contributions to "Regulation and Permitting of Interstate CO_2 Plumes."

- Begin work on D17 – PCOR Partnership Initiative Road Map, due May 31, 2024.

CHANGES/PROBLEMS

No changes or problems at this time.

SPECIAL REPORTING REQUIREMENTS

None.