EERC
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018 • Grand Forks, ND 58202-9018 • P. 701.777.5000 • F. 701.777.5181
www.undeerc.org

January 31, 2020

Ms. Karlene Fine
Executive Director
ATTN: Renewable Energy Program
North Dakota Industrial Commission
600 East Boulevard Avenue
State Capitol, 14th Floor
Bismarck, ND 58505-0840

Dear Ms. Fine:

Subject: EERC Proposal No. 2020-0123 Entitled "Research in Support of Integrated Carbon Capture and Storage for North Dakota Ethanol Production"

The Energy & Environmental Research Center (EERC) of the University of North Dakota (UND) is pleased to submit an original and one copy of the subject proposal. The application fee for this proposal was submitted via ACH 204017 on January 21, 2020.

The EERC, a research organization within UND, an institution of higher education within the state of North Dakota, is not a taxable entity; therefore, it has no tax liability. The EERC is committed to completing the project on schedule and within budget should the Commission make the requested grant.

If you have any questions, please contact me by telephone at (701) 777-5013 or by e-mail at kleroux@undeerc.org.

Sincerely,

Kerryanne M. Leroux
Principal Engineer, Subsurface R&D

Approved by:

Charles D. Gorecki, CEO
Energy & Environmental Research Center

KML/bjr

Enclosures

# Application

Project Title: Research in Support of Integrated Carbon Capture and Storage for North Dakota Ethanol Production

Applicant: Energy & Environmental Research Center, University of North Dakota

Principal Investigator: Kerryanne M. Leroux

Date of Application: January 31, 2020

Amount of Request: $500,000

Total Amount of Proposed Project: $1,200,000

Duration of Project: 18 months

Expected Start: June 1, 2020

Point of Contact (POC): Kerryanne M. Leroux

POC Telephone: (701) 777-5013

POC E-Mail: kleroux@undeerc.org

POC Address: 15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

## Renewable Energy Program

North Dakota Industrial Commission

Lead Organization: EERC UND University of North Dakota

Cost-Share Partner: RTE

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**ABSTRACT**

The Energy & Environmental Research Center (EERC) proposes to conduct research in support of an effort to implement the first integrated ethanol and carbon capture and storage (CCS) facility in North Dakota (ND). This effort will serve as an example of commercial-scale CCS development for other ethanol producers in the state intending to reduce carbon emissions through geologic storage. Integrated CCS provides the opportunity to capitalize on Pacific Coast low-carbon fuel (LCF) markets and other incentives such as the Enhancement of Carbon Dioxide Sequestration Credit, a.k.a. Section 45Q. The proposed research project will use the Red Trail Energy (RTE) ethanol facility near Richardton, ND, as a case study, building on the successful outcomes of work since 2016. RTE plans to fund and drill at least one stratigraphic test well on its property by summer 2020. The EERC proposes to take advantage of this opportunity to conduct detailed on-site reservoir characterization through analysis of collected core and interpretation of downhole tests from the new well. This work will establish the necessary scientific data for the $CO_2$ storage predictions required to finalize ND Class VI carbon storage permits and pursue financial investments for CCS construction. Public outreach activities initiated in 2019 will continue to promote positive stakeholder engagement with ND communities and regional officials.

**Objective:** Development of a blueprint for the first integrated ND ethanol and CCS facility, compliant with ND Class VI regulations, to strategically maximize the marketability of ND ethanol through evolving CCS incentive programs. **Expected Results:** The anticipated outcomes of the proposed research are 1) a summary of site-specific geologic evaluation steps necessary to finalize CCS designs that ensure safe injection and storage; 2) contrasts–comparisons of federal and other state-level incentive requirements with the ND Class VI Program, to establish potential business cases and ensure economic viability; 3) detailed interpretations and documentation needs to ensure regulatory compliance for $CO_2$ injection and storage; 4) community engagement and information dissemination, assessing impact, to ensure public knowledge sharing; and 5) documentation of pertinent outcomes to generate a ND Class VI blueprint, to effectively assist implementation of CCS by other ND renewable energy or biofuel producers. **Duration:** 18 months. **Total Project Cost:** $1,200,000. **Participants:** EERC and RTE.

## PROJECT DESCRIPTION

**Introduction:** The Energy & Environmental Research Center (EERC) proposes to conduct research to support development of the first integrated ethanol and carbon capture and storage (CCS) facility in North Dakota (ND) to reduce $CO_2$ emissions, capitalize on evolving ethanol markets, and create new economic opportunities for ND. CCS is the process of capturing carbon dioxide ($CO_2$) from industrial sources and injecting it into suitable geologic formations, deep underground, for permanent storage. This process has been identified as an effective means of reducing the carbon intensity (CI) of fossil and renewable fuels. The proposed project will provide ND biofuel facilities with a blueprint for developing commercial CCS systems and navigating ND's Class VI Program,[1] to benefit from Pacific Coast low-carbon fuel (LCF) markets and federal carbon reduction incentives.

The Red Trail Energy (RTE) ethanol facility near Richardton, ND, is currently executing plans to drill at least one well on its site by summer 2020 to ultimately become an injection and/or monitoring well. Draft permitting documents are currently under development, and additional research and data needs have been identified as necessary to complete these documents. The EERC, therefore, proposes to take advantage of this opportunity to conduct essential on-site reservoir characterization using data from the new well to establish the necessary scientific confidence in $CO_2$ storage predictions required to finalize carbon storage permits (within the ND Class VI Program) and pursue financial investments for CCS construction. The business case implications of integrating the requirements of various state and federal incentive programs must be understood in order to ensure economic viability and to secure investments.

Programs incentivizing carbon storage, such as California's LCF Standard (LCFS) and the Enhancement of Carbon Dioxide Sequestration Credit (Section 45Q) through the Internal Revenue Service, as well as the ND Class VI Program, are newly official and thus still in development within respective agencies for application. In addition, continuation of public outreach activities to maximize

[1] North Dakota Industrial Commission (NDIC). ND Class VI Underground Injection Control Program (1422) Description, June 2013. In April 2018, NDIC was granted primacy over the regulation of $CO_2$ injection wells (Class VI) by the U.S. Environmental Protection Agency (EPA). ND Class VI primacy reduces uncertainty for future ND $CO_2$ storage projects, as the ND state agency will regulate all aspects of $CO_2$ injection, storage, and monitoring.

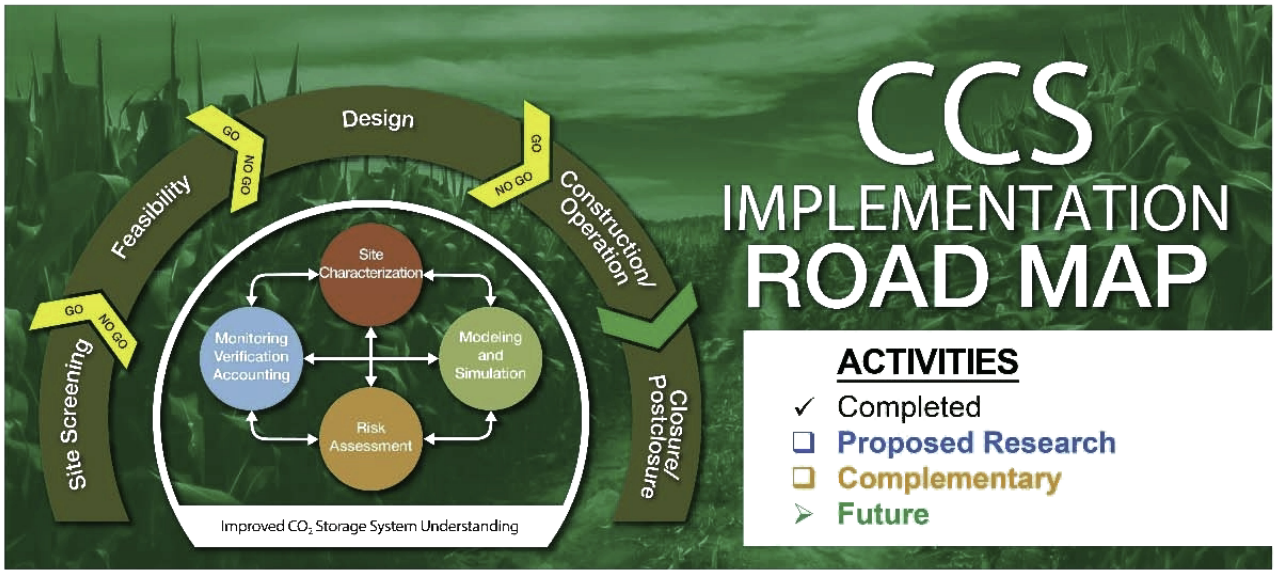
stakeholder and community engagement are integral to the success of CCS implementation, as public hearings and/or comment periods are part of the ND Class VI permitting process as well as California LCFS CCS certification.[2]

Figure 1 illustrates a summary of the work accomplished to date, the proposed research, RTE complementary activities, and how these support and lead directly to CCS implementation. Figure 1 also shows how public dollars are leveraged increasingly as research progresses toward commercialization. RTE is committed to serving as the case study and is prepared to contribute personnel and financial resources to continued development, including the unenumerated yet significant contribution in the form of a drilled well, as detailed in its letter of commitment in Appendix A. Letters of support from the ND Department of Mineral Resources (DMR) and the ND Ethanol Council are provided in Appendix A.

**Objectives:** The proposed research project will collect the data necessary to advance the RTE case study for ultimate implementation of the first integrated ethanol and CCS facility in ND. This will result in a carbon storage blueprint package that details effective approaches and lessons learned, including any public materials generated, as summarized in Table 1.

***Task 1 – Geologic Characterization and Evaluation.*** Task 1 comprises the remaining research activities needed to conduct an in-depth investigation of the geology of the RTE site, necessary for the preparation of a compliant ND carbon storage permit package (Task 4). Data and samples will be collected from a stratigraphic test well RTE will drill on its site. This activity will include core sampling with subsequent laboratory analyses (e.g., petrophysical, geomechanical, etc.), reservoir fluid sampling with subsequent laboratory analyses (e.g., chemistry, salinity, etc.), and downhole geophysical logging and formation testing (e.g., dipole sonic, pulsed-neutron logging, etc.); detailed procedures were described in the characterization plan developed during previous work (1). Results of these activities will also provide necessary inputs for Tasks 2–4. The process of data needs identification, subsequent collection, and logistics associated with these activities will be detailed in D1, as a guide to other biofuels producers.

[2] California Air Resources Board, 2018, Carbon Capture and Sequestration Protocol under the Low Carbon Fuel Standard, August 13, 2018, www.arb.ca.gov/fuels/lcfs/ccs_protocol_010919.pdf (accessed February 2019). The California LCFS CCS Protocol became effective as of January 1, 2019.




**SITE SCREENING**

- ✓ Existing Data
- ✓ Technical Evaluation
- ✓ Economic Assessment

**FEASIBILITY**

- ✓ Site-Specific Investigation: Seismic Survey
- ✓ Techno-Economic Reassessment (with new seismic data)
- ❑ Site-Specific Investigation: Geologic Characterization
- ❑ Techno-Economic Reassessment (with new geologic data)

**DESIGN**

- ✓ Capture System
- ❑ Injection System
- ❑ Class VI Permits
- ❑ Baseline Monitoring
- ❑ Financing/ Contracts

**CONSTRUCTION/ OPERATION**

- ❑ Well Construction
- ➢ Capture Facility Construction
- ➢ Operations Optimization
- ➢ $CO_2$ Injection Start!
- ➢ Monitoring and Reporting

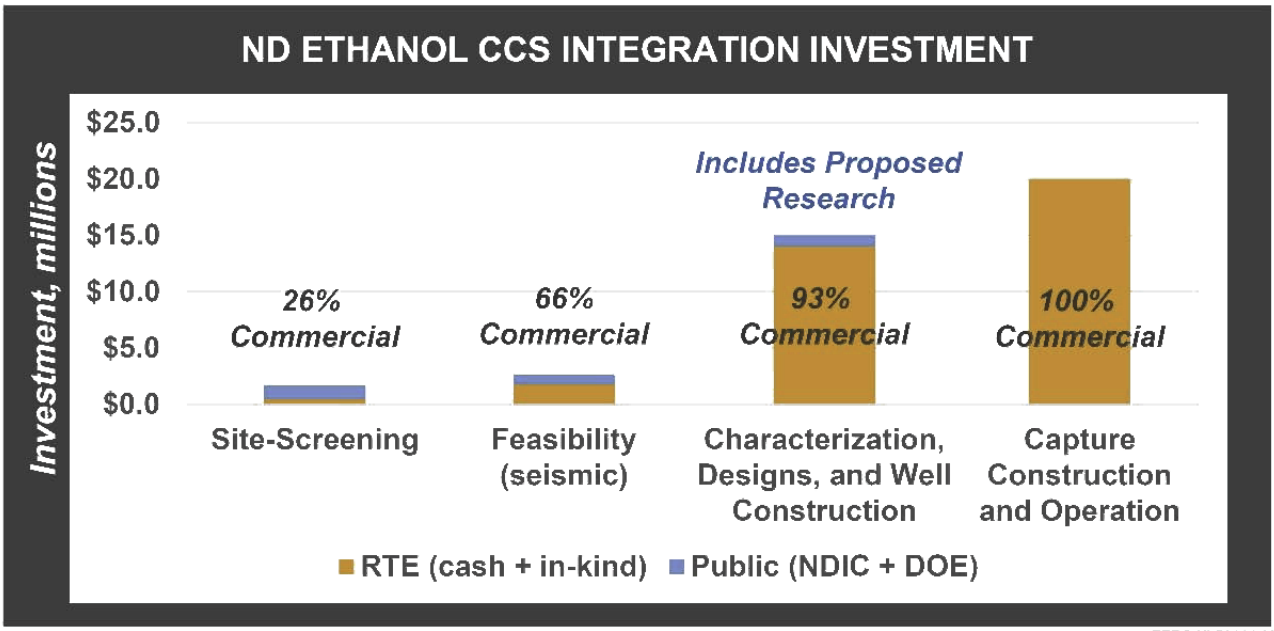



Figure 1. Activities and investments required for CCS integration with ethanol production.

**Table 1. Summary of Deliverables, Attendant Objectives, and Anticipated Outcomes**

| Deliverables (D) | Objectives | Outcomes |
|---|---|---|
| D1. $CO_2$ Storage Characterization Methodologies Report | • Site-specific geologic evaluation steps<br>• Modeling/simulation activity necessary to finalize CCS designs and permitting | Secure injection and storage |
| D2. CCS Business Crosswalk | • Contrasts–comparisons of Pacific Coast and federal incentives with ND Class VI Program<br>• Potential business strategies (e.g., California LCFS CCS Protocol, Section 45Q, etc.) | Economic viability |
| D3. $CO_2$ Storage Facility Permitting Guidance Document | • ND Class VI Program interpretations<br>• Summary of site assessment/data needs<br>• Permitting documentation needs | Regulatory compliance |
| D4. CCS Outreach Tool Kit | • Community engagement<br>• Information dissemination<br>• Impact assessment | Public knowledge sharing |
| D5. Final Report | • Documentation of pertinent results | ND Class VI blueprint |

***Task 2 – Modeling and Simulation.*** Task 1 results will be used to update geologic interpretations of the target $CO_2$ storage reservoir and seal(s) as well as refine injection designs and $CO_2$ plume predictions essential for permitting. Industry-standard software packages will be used in the updates of previous geologic models of the study area and development of new $CO_2$ injection simulation cases. If needed, revisions will also be made to capture and transport infrastructure designs to accommodate finalized injection designs. The processes by which data are integrated into geologic models and used to develop predictions of plume behavior will also be described in D1.

***Task 3 – Business Case Analysis.*** LCF programs and other CCS incentives (e.g., Section 45Q) will continue to be assessed to develop a business case analysis of ND ethanol CCS commercial application. Previous work investigated revenue and tax benefit potential from LCF and federal markets (1, 2). This task will include investigations of business cases implementing requirements from various LCF/incentive programs into ND carbon storage permits to establish synergistic relationships between multiple oversight authorities at state and federal levels. This integration will allow ND to provide verification for other oversight authorities through ND's established permitting and oversight process. Analysis of these synergies will include a "crosswalk," or contrast–comparison, of the various programs and recommendations for leveraging symbiotic opportunities while also ensuring full compliance (D2).

***Task 4 – Carbon Storage Permitting.*** Final documentation will be prepared to satisfy a ND $CO_2$ Storage Facility Permit as detailed in ND Administrative Code Chapter 43-05-01. The ND permit covers multiple design aspects developed to ensure safe and effective site assessments, carbon storage operations, and postinjection monitoring. The draft documents initiated to satisfy the ND $CO_2$ Storage Facility Permit application will be finalized with the proposed characterization results from Task 1 and reviewed with ND DMR such that RTE may submit for approval to start final CCS implementation (D3).

***Task 5 – CCS Community Outreach.*** The EERC will support local RTE efforts for public acceptance of ND CCS targeted to landowners, Richardton and adjacent communities, city/county commissions, and regional educators. Areas of focus include stakeholder engagement activities in support of research and fieldwork, production and dissemination of informational materials, community outreach, implementation of a system to track engagement activities and acquire feedback, and ongoing assessment of progress. Building on the outreach experience and materials from 2019 activities, the project team will develop additional outreach materials and media and update the project Web pages hosted on the EERC's Plains $CO_2$ Reduction (PCOR) Partnership website. The experience and materials developed will be incorporated into D4.

***Task 6 – Management and Reporting.*** Task 6 includes managing project activities and ensuring coordination and planning of the project with participants and sponsors (see the Management section for more detail). A detailed report will be prepared to disseminate final results (D5).

**Anticipated Results:** The proposed research and complementary RTE activities will advance the first ND integrated ethanol and CCS effort toward a financial investment decision on commercial implementation. As detailed in Table 1, the expected results of the proposed supporting research are to ensure secure injection and storage economic viability, regulatory compliance, public knowledge sharing, and generation of a ND Class VI blueprint to effectively assist implementation of CCS by other ND renewable energy or biofuel producers. These results will be developed in collaboration with project stakeholders and ND regulators, facilitating CCS implementation for ND ethanol production.

**Facilities and Resources:** The proposed research will be performed at the EERC in Grand Forks, ND, and

the RTE site near Richardton, ND. RTE will provide access for site-related work: reservoir characterization (e.g., core and sample collection) and outreach activities. Complementary activities include reservoir characterization and core sample collection at the RTE drilling site, with proposed activities involving subsequent sample analyses and evaluations at EERC facilities in Grand Forks. The EERC's extensive laboratory capabilities and $CO_2$ storage reservoir characterization experience are unique among North Dakota research facilities. Engineering and scientific research staff are equipped with state-of-the-art analytical, modeling, and engineering facilities to conduct the proposed monitoring, characterization, permit, and outreach activities. The proposed project team has high proficiency with industry-standard geologic modeling and simulation software and database capabilities for managing high-volume data. The EERC currently leads the PCOR Partnership, one of seven U.S. Department of Energy (DOE)-funded Regional Carbon Sequestration Partnerships, which includes over 120 partners developing and demonstrating technologies for geologic $CO_2$ storage (2–8). This expertise will be applied to the RTE effort, providing data, guidance, and practical experience with CCS, all necessary to implement commercial-scale $CO_2$ storage. For example, the EERC has been involved with permits, characterization, core analysis, and interpretation of several potential geologic $CO_2$ storage projects as well as the development of new strategies for CCS monitoring (2, 4, 9–13).

**Techniques to Be Used, Their Availability, and Capability:** The EERC–RTE team will lead all proposed research activities. Reservoir characterization will be conducted by analyzing samples and data collected from the well(s) drilled by RTE on its site by the summer of 2020. Collected core and fluid samples from formations of interest, such as the Inyan Kara, Opeche, and Broom Creek Formations, will be shipped to the EERC for laboratory analysis as detailed in the Task 1 description. In addition, a variety of downhole logging techniques will be deployed to evaluate and test in situ reservoir properties. These techniques are necessary to measure, characterize, and interpret a variety of geologic and reservoir properties that can influence injection/storage performance. The EERC has extensive experience conducting these types of field research efforts, including development of the required permitting documents and interfacing with regulatory agencies to ensure compliance is maintained (see Background/Qualifications). The EERC and

RTE will also work closely to maintain communications and ensure that business-permitting crosswalks accurately portray requirements to benefit from carbon markets and incentives.

The EERC will support RTE public outreach efforts in the community/region. The outreach plan, currently being executed with significant RTE involvement, is the basis for public engagement activities (e.g., local open house), production and dissemination of informational materials (e.g., project fact sheets), tracking involvement and feedback, and frequent assessment of progress. The proposed project will also leverage the EERC's PCOR Partnership outreach experience, e.g., public website development, social media, broadcast documentaries, workshops, and stakeholder engagement.

**Environmental and Economic Impacts While Project Is under Way:** The proposed scope of work will have minimal environmental impact, consisting primarily of laboratory and paper analyses conducted at the EERC's facility, with limited fieldwork at RTE's site for reservoir characterization. These field activities will follow industry-standard techniques with established safety protocols as well as all applicable state, county, and municipal regulations. Economic impacts will be similarly limited.

**Ultimate Technological and Economic Impacts:** Successful completion of the proposed work will position the ND ethanol industry as a national leader in developing reduced-carbon ethanol with a strategic first-to-market advantage over other states. Additional revenue paid through these programs will directly benefit ND communities in the vicinity of potential CCS efforts through increased tax revenue and new job opportunities for construction and operation of the expanded RTE facility. The proposed blueprint can then be utilized by other ND renewable energy or biofuel producers to implement CCS, generating further economic benefits. RTE's $CO_2$ capture system is also designed to enable $CO_2$ sales to ND oilfield operators for $CO_2$ EOR (enhanced oil recovery), expanding the economic benefits to stakeholders in the ND oil industry and blazing a new trail of synergistic opportunities in the ND energy marketplace.

**Why the Project Is Needed:** ND has a well-timed opportunity to gain a competitive advantage in LCF markets and for other CCS incentives (e.g., Section 45Q). North Dakota has an established ethanol industry, suitable geology, and Class VI primacy. Proposed activities will continue development of a case

study for ND ethanol producers or other industries, providing a detailed example for implementing CCS in ND. This proposed work also provides an opportunity to work through the details of the ND Class VI Program with NDIC and a technical partner to provide clarification during this first-time application. The EERC's experience with commercial CCS implementation (1–8, 14–24) will be applied to the proposed ND effort, ensuring the project's goals are successfully met.

## STANDARDS OF SUCCESS

This project will result in the essential on-site geologic data necessary to advance a case study toward the first commercial ND integrated ethanol and CCS facility that is compliant with evolving $CO_2$ incentives and/or market opportunities. The final deliverables for this project will include $CO_2$ Storage Characterization Methodologies Report (D1), a CCS Business Crosswalk (D2), a $CO_2$ Storage Facility Permitting Guidance Document (D3), and a CCS Outreach Tool Kit (D4). The Final Report (D5) and these deliverables will provide a comprehensive blueprint of the RTE effort for ND's ethanol industry.

The ND renewable energy and agriculture industries will directly benefit from the continuation of this program through the proposed project. This project will demonstrate that ND can produce a lower-carbon ethanol by implementing CCS at production facilities. The ND ethanol industry will be able to take advantage of sizable market incentives currently being implemented on the Pacific Coast. New federal incentives for CCS, such as Section 45Q, may also provide economic support for implementation. Although ethanol production is commonplace in the Great Plains, the geology of western ND is highly suitable for storing commercial volumes of anthropogenic $CO_2$, potentially affording ND ethanol producers an advantage over ethanol producers in other states. The new marketplace could also incentivize the growth of biofuel production in western ND and, thus, agricultural feedstocks throughout the state and create new jobs for short-term construction and installation and for long-term implementation, operation, and maintenance of CCS installations.

## BACKGROUND/QUALIFICATIONS

Project partner, RTE, is a ND-based investor group that operates the Richardton corn-based ethanol production facility. Since operation started in January 2007, the facility has gained significant energy and

processing efficiencies, now producing about 64 million gallons of ethanol annually. RTE has been pursuing CCS as a means for reducing the carbon footprint of ethanol production, preparing for potential commercial-scale CCS implementation by 2021.

The project team has specific experience conducting the types of activities required by the proposed work (reservoir characterization, outreach, and permitting) and is uniquely positioned to foster and support integration of the ND ethanol industry with CCS technology. The project team has established itself as a leader in CCS-related research and commercialization activities, including laboratory analyses, CCS implementation, and public outreach (1–3, 8, 14, 17–22). The EERC has conducted a wide variety of carbon storage characterization, monitoring, and outreach activities at several CCS research locations, including previous work at RTE (1, 2). The project team has developed, field-tested, and/or validated CCS strategies at demonstration and commercial $CO_2$ storage sites in the United States and Canada (14–16, 23–26). Through the PCOR Partnership Program, the EERC is a leading source for CCS public knowledge by providing both general and targeted public outreach and education related to CCS technology and its applications to various industries through a variety of traditional and new media products (27). The project team has also conducted regional characterization specific to the Williston Basin for $CO_2$ storage (28–31). The EERC is currently building on this regional knowledge by developing site-specific characterization and analyses at other locations in western ND through the DOE-funded CarbonSAFE and Brine Extraction and Storage Test Programs (12, 13).

**Personnel:** All EERC key personnel designated for the proposed research have successfully managed tasks for related work since 2016 and/or have substantial experience within CCS, renewable energy, economics, and regulatory landscapes. Their roles are summarized in Table 2; see Appendix B for detailed resumes of all EERC key personnel and the RTE team lead.

## MANAGEMENT

Ms. Kerryanne Leroux will serve as PI and have the overall responsibility for the project, communicating regularly with all project partners and participants. She will also be responsible for contractual reporting to project partners. Planning meetings, conference calls, webinars, and regular e-mail communication will

**Table 2. EERC Key Personnel**

| Name and Title | Proposed Research Role |
|---|---|
| Kerryanne Leroux, Principal Engineer, Subsurface R&D | Principal Investigator (PI) |
| Ryan Klapperich, Senior Hydrogeologist | Task 1 Lead, Geologic Characterization and Evaluation |
| Lu Jin, Principal Reservoir Engineer | Task 2 Lead, Modeling and Simulation |
| Nicholas Kalenze, PE, Civil Engineer | Task 3 Lead, Business Case Analysis |
| Kevin Connors, Principal Policy and Regulatory Strategist | Task 4 Lead, CCS Permitting |
| Charlene Crocker, Research Scientist | Task 5 Lead, CCS Community Outreach |
| John Hamling, Assistant Director for Integrated Projects | Project Advisor |

ensure coordination of all project partners and minimize risk. Internal review meetings will also be conducted regularly to ensure that all project activities are completed in a timely manner, according to the project schedule. Progress reports and a final report at project completion will be prepared.

## TIME TABLE

The proposed scope of work will be performed over an 18-month period (Figure 2). Initiation of the proposed work is contingent upon the execution of a mutually negotiated agreement with each project sponsor. Quarterly progress reports will be submitted 30 days following the end of each calendar quarter.

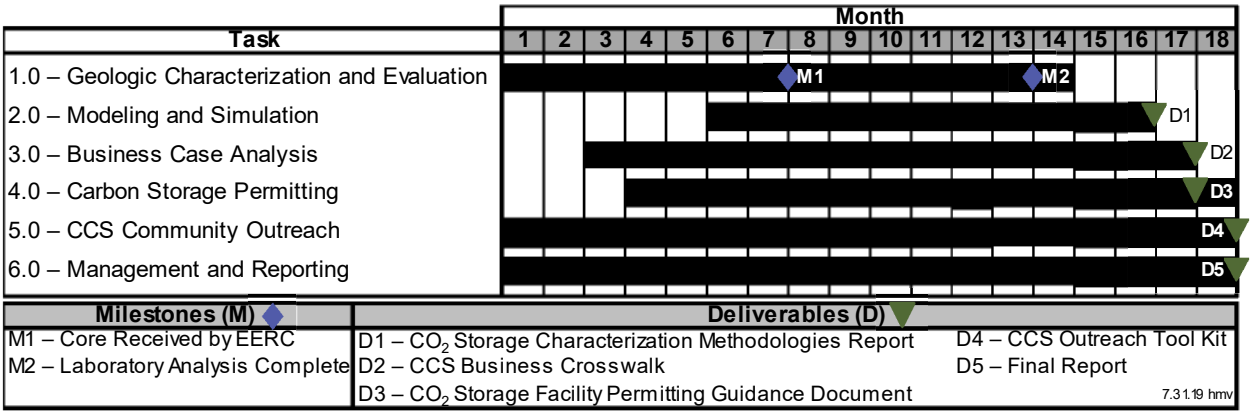



Figure 2. Project schedule.

## BUDGET

The estimated cost for the proposed project is $1,200,000, as shown in Table 3. The EERC requests $500,000 from the Renewable Energy Program (REP). Matching cash funds of $700,000, in addition to the unenumerated yet significant contribution of a drilled well that enables execution of the proposed project, will be provided by RTE (pending approval by RTE's Board of Directors); a letter of

commitment is provided in Appendix A. Budget notes can be found in Appendix C. If less REP funding is available, adjustments to scope will need to be considered.

**Table 3. Budget Breakdown**

| Project Associated Expense | NDIC Share (Cash) | RTE Share (Cash) | Total Project |
|---|---|---|---|
| **Labor** | $ 313,370 | $ 319,385 | $ 632,755 |
| **Travel** | $ 3,155 | $ 9,804 | $ 12,959 |
| **Supplies** | $ 1,192 | $ 4,484 | $ 5,676 |
| **Communications** | $ 730 | $ 1,600 | $ 2,330 |
| **Printing & Duplicating** | $ 329 | $ 356 | $ 685 |
| **Food** | $ - | $ 1,000 | $ 1,000 |
| **Laboratory Fees & Services** | | | |
| Natural Materials Analytical Research Lab | $ 1,043 | $ 35,810 | $ 36,853 |
| Analytical Research Lab | $ 405 | $ 13,911 | $ 14,316 |
| Graphics Services | $ 10,825 | $ 13,513 | $ 24,338 |
| Software Solution Services | $ 77 | $ 2,637 | $ 2,714 |
| Outside Lab | $ - | $ 35,000 | $ 35,000 |
| **Total Direct Costs** | $ 331,126 | $ 437,500 | $ 768,626 |
| **Facilities & Administration** | $ 168,874 | $ 262,500 | $ 431,374 |
| **Total Cash Requested** | $ 500,000 | $ 700,000 | $ 1,200,000 |

## TAX LIABILITY

The EERC is a business unit within UND, which is a state-controlled institution of higher education and is not a taxable entity; therefore, the EERC has no tax liability.

## CONFIDENTIAL INFORMATION

No confidential information is included in this proposal.

## PATENTS/RIGHTS TO TECHNICAL DATA

It is not anticipated that any patents will be generated during this project. The rights to technical data generated will be held jointly by the EERC and project sponsors.

## STATE PROGRAMS AND INCENTIVES

A listing of EERC projects funded by NDIC in the last 5 years can be found in Appendix D.

## REFERENCES

All references cited are in Appendix E.

# APPENDIX A

# LETTERS OF COMMITMENT AND SUPPORT

# RED TRAIL ENERGY, LLC

**"Our Farms, Our Fuel, Our Future"**

PO Box 11 Richardton, ND 58652 (701)-974-3308 FAX (701)-974-3309


January 16, 2020

Ms. Kerryanne Leroux
Principal Engineer, Subsurface R&D
Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear Kerryanne:

Subject: EERC Proposal No. 2020-0123 Entitled "Research in Support of Integrated Carbon Capture and Storage for North Dakota Ethanol Production"

Red Trail Energy (RTE) is excited to continue working with the Energy & Environmental Research Center (EERC) on the proposed subject project submitted to the North Dakota Renewable Energy Program. RTE operates a corn-based ethanol production facility located near Richardton, North Dakota, producing approximately 64 MMgal/yr of ethanol and generating 180,000 tons of $CO_2$ annually. RTE has been pursuing carbon capture and storage (CCS) as a means for reducing the carbon footprint of ethanol production since 2016, preparing for potential commercial-scale CCS implementation by 2021.

Contingent upon award by the Renewable Energy Council (REC) and approval by RTE's Board of Directors, RTE commits to support this project through a variety of means. A cash contribution of $700,000 will be provided to support completion of all activities as proposed. In addition, RTE plans to fund and drill at least one stratigraphic test well on its property by summer 2020 in support of the proposed research. These wells will be used to collect essential on-site geologic data and will ultimately become the injection and/or monitoring well(s). RTE will provide the EERC with access to the field location as needed. We will continue to work closely with the EERC to ensure the business and permitting components of the project accurately portray requirements to benefit from carbon markets and incentives. RTE also commits to lead all outreach activities by acting as the "public face" of the outreach plan, which is currently being executed with significant RTE involvement (e.g., open houses, county and city commission meetings, etc.).

We look forward to another excellent collaboration with REC and the EERC on this proposed research in support of a commercial effort toward developing the first integrated ethanol CCS effort in North Dakota to maximize the marketability of North Dakota ethanol.

Sincerely,

Dustin Willett
Chief Operating Officer
Red Trail Energy, LLC

DW

NORTH Dakota | Mineral Resources
Be Legendary.™

NORTH DAKOTA
OIL AND GAS DIVISION

January 17, 2020

Mr. Gerald Bachmeier
CEO
Red Trail Energy, LLC
3682 Highway 8 South
PO Box 11
Richardton, ND 58652

Dear Gerald:

Subject: EERC Proposal No. 2020-0123 Entitled "Research in Support of Integrated Carbon Capture and Storage for North Dakota Ethanol Production"

The North Dakota Industrial Commission's (NDIC's) Department of Mineral Resources (DMR) Oil and Gas Division is pleased to provide Red Trail Energy (RTE) with this letter of support regarding the subject proposal.

North Dakota has promulgated a comprehensive set of regulations for all aspects of $CO_2$ injection and storage operations as part of the North Dakota Underground Injection Control (UIC) Class VI Program. On April 24, 2018, North Dakota's Class VI primacy became effective upon EPA final rule publication in the Federal Register. The final approval issued by EPA grants NDIC's Oil and Gas Division primary regulatory authority for all Class VI injection well activities in North Dakota.

These North Dakota regulations are at least as stringent as EPA's Class VI requirements, addressing some factors that fall outside the scope of EPA and the federal UIC program (e.g., pore space ownership, project certification, long-term liability of stored $CO_2$, etc.). Therefore, the North Dakota Class VI UIC Program is tailored specifically for North Dakota, and RTE has the opportunity to be the first to apply for a Class VI permit in North Dakota. For North Dakota ethanol facilities seeking to implement carbon capture and storage (CCS) in particular, reporting and validation options may become available to coordinate with approval pathways from out-of-state low-carbon fuel programs.

We are thus supportive of RTE's continued CCS efforts and look forward to working with RTE as they draft and submit a North Dakota Class VI permit application. NDIC also looks forward to engaging with RTE and the Energy & Environmental Research Center (EERC) of the University of North Dakota on generating a working blueprint that supports low-carbon energy production in North Dakota.

Sincerely,

Stephen Fried
Geologist
NDIC Oil and Gas Division

North Dakota Ethanol Council

January 20, 2020

Mr. Gerald Bachmeier
CEO
Red Trail Energy, LLC
3682 Highway 8 South
PO Box 11
Richardton, ND 58652

Dear Gerald:

Subject: EERC Proposal No. 2020-0123 Entitled "Research in Support of Integrated Carbon Capture and Storage for North Dakota Ethanol Production"

The North Dakota Ethanol Council (NDEC) is pleased to provide Red Trail Energy (RTE) with this letter of support for its efforts to investigate the commercial geologic storage of carbon dioxide ($CO_2$) generated during the production of ethanol in North Dakota. The project proposed by the Energy & Environmental Research Center (EERC) offers a route to expanded opportunities for the state's renewable energy industries.

Ethanol is an important piece of the state's energy production for multiple reasons. Not only do the five North Dakota ethanol plants have the capacity to produce 520 million gallons of ethanol for use as fuel but, in addition, the ethanol industry is a large contributor to the state's economy. The ethanol industry contributes $623 million annually to the state's economy and an additional $11 million in state and local tax revenues each year. Our state continues to investigate long-term strategies that incorporate all energy resources—traditional and emerging—to meet the nation's growing energy demand in an environmentally responsible manner, and this project will further that aim.

NDEC looks forward to engaging with both RTE and the EERC to generate a working blueprint that bolsters low-carbon energy production in North Dakota. We are pleased to support the exciting opportunities the proposed project will bring to both the state of North Dakota and the nation in addressing our energy challenges.

Sincerely,

Deana Wiese

Deana Wiese
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# APPENDIX B

# RESUMES OF KEY PERSONNEL

**KERRYANNE M. LEROUX**
Principal Engineer, Subsurface R&D
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
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***Principal Areas of Expertise***

Ms. Leroux's principal areas of interest and expertise include fossil, alternative, and renewable energy and chemicals production systems; $CO_2$ storage monitoring, verification, and accounting (MVA) methods; resource and life cycle assessments; process design and integration; pilot-, demonstration-, and commercial-scale testing; statistical interpretation, data processing, and modeling; and technical feasibility, economic analysis, and market evaluation.

***Qualifications***

M.S., Chemical Engineering, University of North Dakota, 2001.
B.S., Chemical Engineering, University of North Dakota, 1999.

***Professional Experience***

**2015–Present:** Principal Engineer, Subsurface R&D, EERC, UND. Ms. Leroux leads teams of scientists and engineers integrating carbon capture and storage (CCS) systems with fossil and renewable energy, such as enhanced oil recovery (EOR), coal-generated electricity, and ethanol fuel production. Specific technical support has included assessment of $CO_2$ capture technologies and transportation; implementing and evaluating near-surface and downhole MVA concepts for large-scale (>1 million tons/year) carbon storage; and techno-economic evaluation of CCS applicability for state and federal $CO_2$ reduction incentive programs. Ms. Leroux's main responsibilities include serving as a principal investigator or project manager; providing project support and guidance and regularly assessing activities and progress; effectively reporting results and conclusions of research activities to clients through technical reports, publications, papers, posters, and personal communication; and collecting, reducing, analyzing, and interpreting data and ensuring quality control of project work. Specific activities include the following:

- Project Manager for Integrated Carbon Capture and Storage for North Dakota Ethanol Production – Phases I–III (November 2016 – May 2020; $4,320,000), sponsored by the North Dakota Industrial Commission (NDIC); North Dakota ethanol producer, Red Trail Energy (RTE); and the U.S. Department of Energy (DOE). Additional partners: Trimeric Corporation, Schlumberger, Computer Modelling Group (CMG).
- Project Manager/Project Advisor for Nebraska Integrated Carbon Capture and Storage Pre-Feasibility Study (January 2017 – June 2018; $1,786,000), sponsored by DOE (CarbonSAFE), Nebraska Public Power District (NPPD), Schlumberger, and CMG.
- Lead for operational monitoring activities for Plains $CO_2$ Reduction (PCOR) Partnership Phase III, Task 9 (July 2015 – December 2017), sponsored by DOE, Denbury, Schlumberger, and CMG.

**2001–2015:** Research Engineer, EERC, UND. Ms. Leroux has researched coal, natural gas, petroleum (diesel, gasoline), biomass (wood, agricultural residues, grasses/straws, municipal solid waste [MSW]), combustion, gasification, syngas clean-up (tars, membrane separation), catalysis (steam methane reforming, water–gas shift, Fischer–Tropsch), cogeneration/combined heat and power, fuel cells, electrolysis, energy storage, wind hybrid systems, biorefineries, pyrolysis, bio-oil, biodiesel, ethanol, butanol, hydrogen, ammonia, biogas and landfill gas, and densification (pellets, torrefaction). Ms. Leroux

has also provided technical support for management of solid waste (MSW and inert waste recycling and reduction), water (drinking water and wastewater treatment, processing water management [e.g., cooling water systems], flood mitigation), and $CO_2$ (near-surface groundwater and soil gas monitoring related to EOR-associated storage, capture technologies, transportation, trading and commercial markets).

***Relevant Publications***

Leroux, K.L.; Azzolina, N.A.; Glazewski, K.A.; Kalenze, N.S.; Botnen, B.W.; Kovacevich, J.T.; Abongwa, P.T.; Thompson, J.S.; Zacher, E.J.; Hamling, J.A.; Gorecki, C.D. Lessons learned and best practices derived from environmental monitoring at a large-scale $CO_2$ injection project. *International Journal of Greenhouse Gas Control* **2018,** *78,* 254–270.

Leroux, K.M., Klapperich, R.J., Jensen, M.D., Kalenze, N.S., Daly, D.J., Crocker, C.R., Ayash, S.C., Azzolina, N.A., Crossland, J.L., Doll, T.E., Gorecki, C.D., Stevens, B.G., Schlasner, S.M., Botnen, B.W., Foerster, C.L., Hamling, J.A., Nakles, D.V., Peck, W.D., Glazewski, K.A., Harju, J.A., Piggott, B., and Vance, A.E., 2018, Integrated carbon capture and storage for North Dakota ethanol production – Phase II: Final report (November 1, 2017 – July 31, 2018) for North Dakota Industrial Commission and Red Trail Energy, Grand Forks, North Dakota, Energy & Environmental Research Center, July.

**RYAN J. KLAPPERICH**
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***Principal Areas of Expertise***

Mr. Klapperich's principal areas of interest and expertise focus on $CO_2$ enhanced oil recovery (EOR) and storage, including geologic site characterization, monitoring program assessments, design and implementation of near-surface monitoring programs, and interpretation of monitoring data. Other areas of interest include hydrogeology, geographic information systems (GIS), $CO_2$ sequestration, and related environmental issues.

***Qualifications***

M.S., Geology, University of North Dakota, 2008.
Graduate Certificate, Geographic Information Science, 2007.
B.S., Geology, University of North Dakota, 2005.
B.A., Honors Program, University of North Dakota, 2005.

***Professional Experience***

**2009–Present:** Senior Hydrogeologist, EERC, UND. Mr. Klapperich works with the Oil and Gas Group and the Plains $CO_2$ Reduction (PCOR) Partnership at the EERC, where he is actively involved in site characterization and $CO_2$-monitoring activities including the following:

- Serves as Co-PI and task lead for active reservoir management (ARM) operations on the U.S. Department of Energy (DOE)-sponsored brine extraction and storage test (BEST) project. The BEST project will demonstrate the use of ARM techniques to improve reservoir storage potential in saline formations. In this role, Mr. Klapperich directs field activities and data analysis to assess the performance of various ARM strategies at the BEST project site.
- Serves as task lead for site characterization on the DOE-sponsored CarbonSAFE-North Dakota integrated carbon storage complex feasibility study to develop a technical and economic case for commercial $CO_2$ storage from coal-fired power plants in North Dakota. In this role, Mr. Klapperich leads the effort to drill and characterize two new wells in western North Dakota to characterize the $CO_2$ storage potential of the Broom Creek Formation.
- Serves as task lead for permitting on the integrated carbon capture and storage for North Dakota ethanol study to develop a pathway for implementation of commercial $CO_2$ storage for North Dakota ethanol facilities.
- Serves as task lead on the recently awarded DOE-sponsored $CO_2$ EOR in conventional fields using rich gas project.
- Served as co-principal investigator (PI) on a project principally funded by the IEA Greenhouse Gas R&D Programme (IEAGHG) focused on understanding the use of ARM schemes to enhance $CO_2$ storage and reduce monitoring, verification, and accounting (MVA) costs.
- Served as task lead for the PCOR Partnership's Water Working Group, a working group comprising members of DOE's Regional Carbon Sequestration Partnership (RCSP) Program focused on developing an understanding and solutions for issues at the nexus of carbon capture and storage (CCS) and water.

- Conducts geologic and hydrogeologic evaluations, processes data, communicates results through reports and presentations, conducts client meetings, manages project budgets and time lines, and participates in professional conferences.

**2007–2009:** Laboratory Technician, North Dakota Geological Survey Core and Sample Library, Grand Forks, North Dakota. Mr. Klapperich's responsibilities included staging and taking digital photographs of core sample inventory; processing and manipulating digital photographs; updating, cataloging, and reboxing core and sample inventory; cutting unprocessed cores into slabs; processing and cataloging new inventory; assisting clients with retrieving and handling samples; and operating a forklift.

**2006–2007:** Research Assistant, Geology and Geological Engineering, UND.

**2005–2006:** Teaching Assistant, Department of Geology and Geological Engineering, UND.

***Professional Memberships***

Society of Petroleum Engineers, 2009–present
American Geophysical Union, 2007–2009

***Relevant Publications***


Klapperich, R.J., Wildgust, N., and Nakles, D.V., eds., 2018, PCOR Partnership assessment of $CO_2$ geological storage associated with enhanced oil recovery: Special virtual issue of International Journal of Greenhouse Gas Control, v. 79, p. 34–37.

Liu, G., Gorecki, C.D., Bremer, J.M., Klapperich, R.J., and Braunberger, J.R., 2015, Storage capacity enhancement and reservoir management using water extraction—four site case studies: International Journal of Greenhouse Gas Control, v. 35, p. 82–95.

Hamling, J.A,, Sorensen, J.A., Klapperich, R.J., and Kalenze, N.S., 2018, The role of $CO_2$ enhanced oil recovery in domestic oil production and reduction of the nation's carbon intensity: Presented at the National Association of State Legislatures Conference, Los Angeles, California, July 29, 2018.

Hamling, J.A., Klapperich, R.A., Stepan, D.J., and Jacobson, L., 2018, Implementing and validating reservoir pressure management strategies in the Willison Basin: Poster presented at the IEAGHG Modelling and Risk Management Network Meeting, Grand Forks, North Dakota, June 18–22, 2018.

Leroux, K.M., Ayash, S.C., Klapperich, R.J., Jensen, M.D., Kalenze, N.S., Azzolina, N.A., Bosshart, N.W., Torres Rivero, J.A., Jacobson, L.L., Stevens, B.G., Nakles, D.V., Jiang, T., Oster, B.S., Feole, I.K., Fiala, N.J., Schlasner, S.M., Doll, T.A., Wilson IV, W.I., Gorecki, C.D., Pekot, L.J., Hamling, J.A., Burnison, S.A., Smith, S.A., Botnen, B.W., Foerster, C.L., Piggott, B., Vance, A.E., 2018, Integrating carbon capture and storage with ethanol production for potential economic benefit: Presented at the 14th International Conference on Greenhouse Gas Control Technologies (GHGT-14), Melbourne, Australia, October 21–25, 2018.

Peck, W.D., Ayash, S.C., Klapperich, R.J., and Gorecki, C.D., 2018, The North Dakota integrated carbon storage complex feasibility study: Paper presented at the 14th International Conference on Greenhouse Gas Control Technologies (GHGT-14), Melbourne, Australia, October 21–25, 2018.

Peck, W.D., Wildgust, N., Gorecki, C.D., Ayash, S.C., Hamling, J.A., Sorensen, J.A., Pekot, L.J., Daly, D.J., Klapperich, R.J., Jensen, M.D., Steadman, E.N., and Harju, J.A., 2018, PCOR Partnership Program lessons learned: Paper presented at the 14th International Conference on Greenhouse Gas Control Technologies (GHGT-14), Melbourne, Australia, October 21–25, 2018.

Hamling, J.A., Glazewski, K.A., Leroux, K.M., Kalenze, N.S., Bosshart, N.W., Burnison, S.A., Klapperich, R.J., Stepan, D.J., Gorecki, C.D., and Richards, T.L., 2017, Monitoring 3.2 million tonnes of $CO_2$ at the Bell Creek oil field: Energy Procedia, v. 114, p. 5553–5561.

Hamling, J.A., Stepan, D.J., and Klapperich, R.J., 2017, Integrating monitoring data—understanding reservoir behavior and $CO_2$ movement at the Bell Creek commercial $CO_2$ EOR project: Presented at the IEAGHG Monitoring Network Meeting, Traverse City, Michigan, June 13–15, 2017.

**DR. LU JIN**
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***Principal Areas of Expertise***

Dr. Jin's principal areas of interest and expertise include reservoir modeling and simulation, $CO_2$ enhanced oil recovery (EOR) and associated $CO_2$ storage in both conventional and unconventional reservoirs, water coning control, and multiphase flow in porous media. He is particularly interested in subsurface oil–water–gas interactions, EOR techniques and development of old oil fields/unconventional resources.

***Qualifications***

Ph.D., Petroleum Engineering, Louisiana State University, 2013.
M.S., Petroleum Engineering, Louisiana State University, 2009.
B.S., Petroleum Engineering, Northeast Petroleum University, 2005.

***Professional Experience***

**January 2020–Present:** Principal Reservoir Engineer, EERC, UND. Dr. Jin develops dynamic numerical models for $CO_2$/rich gas EOR in different reservoirs and oversees technical areas in reservoir engineering, including conventional, unconventional, and enhanced oil and gas production; the geologic storage of $CO_2$ and natural gas; natural resource development; geocellular modeling; and numerical simulation. Specific activities include the following:

- Serves as task lead and key reservoir engineer for an $8 million U.S. Department of Energy (DOE)-sponsored project, "$CO_2$ Enhanced Oil Recovery Improvement in Conventional Fields Using Rich Gas."
- Serves as task lead and key reservoir engineer for an $8 million DOE-sponsored project, "Improving Enhanced Oil Recovery Performance Through Data Analytics and Next-Generation Controllable Completions."
- Serves as key reservoir engineer for a $2 million DOE-sponsored project, "Bakken Rich Gas Enhanced Oil Recovery Project."

**July 2018–December 2019:** Senior Reservoir Engineer, EERC, UND. Dr. Jin develops dynamic numerical models for $CO_2$ flow monitoring and prediction in different reservoirs, designs well testing plans for both producers and injectors to support the long-term success of field operations, develops innovative fractured reservoir models for the Bakken unconventional petroleum system and serves as a simulation task lead for a variety of seismic projects. Specific activities include the following:

- Served as task lead and key reservoir engineer for a DOE-sponsored project, "Joint Inversion of Time-Lapse Seismic Data."
- Served as key reservoir engineer for a DOE-sponsored project, "Scalable, Automated, Semi-permanent Seismic Method for Detecting $CO_2$ Plume Extent During Geological $CO_2$ Injection – Phase II."

**2015–July 2018**: Reservoir Engineer, Reservoir Modeling and Simulation, EERC, UND. Dr. Jin's responsibilities include developing geophysical models of the subsurface and running dynamic simulations to determine the long-term fate of produced/injected fluids, including hydrocarbons, $CO_2$ storage, and brine, using oil and gas industry simulation software.

**2014–2015**: Reservoir Engineer, InPetro Technologies, Inc., Houston, Texas. Dr. Jin's responsibilities included developing simulation and analytical models for unconventional reservoir development, especially for shale oil reservoirs; analyzing fluid PVT (pressure, volume, temperature) change during depletion and considering pore-size distribution (PSD) in simulations. Application of a new model in the Eagle Ford and Bakken Formations shows that oil reserves could be improved as much as 30% by integrating PVT and PSD effects.

**2013–2014**: Reservoir Consultant, Joint Industrial Program (JIP), Louisiana State University, and Pluspetrol, Baton Rouge, Louisiana. Dr. Jin's responsibilities included simulating cold production of heavy oil in Massambala Field, Angola, identifying the mechanisms of high water cut in current wells, optimizing the perforation length for conventional wells, and proposing two well systems, which could improve cumulative oil up to 80% or reduce produced water 75%, respectively.

**2011–2013**: Senior Teaching Assistant, Drilling Fluids Laboratory, Louisiana State University, Baton Rouge, Louisiana. Served as lecturer and oversaw four teaching assistants and 80–100 students each year as well as supervised three senior students completing their senior design projects.

**2007–2013**: Research Assistant, Department of Petroleum Engineering, Louisiana State University, Baton Rouge, Louisiana. Dr. Jin's responsibilities included modeling and evaluating the performance of Downhole Water Loop (DWL) well system in different oil fields, developing economical models for evaluation of the DWL system in various reservoir and market conditions, and identifying best reservoir candidates for the system; oil production rate could be improved as much as 200%. Constructed software (toolbox) using ECLIPSE and VBA for complex well system simulation, applied batch processing technology in simulation, achieved automatic task queuing, and reduced simulation time 67%.

**Summer 2012**: Internship, High Plains Operating Company, LLC (HPOC), San Francisco, California. Dr. Jin's responsibilities included simulating and analyzing the extra water production problems in the Ojo Encino Field, New Mexico, designing a DWS well system to produce oil from the thick transition zone, which could improve oil production rate by up to 20%.

**Summer 2011**: Internship, JIP, Louisiana State University, and HPOC, Baton Rouge, Louisiana. Dr. Jin's responsibilities included simulating performance of vertical and horizontal wells in the Ojo Encino Field, New Mexico, diagnosing water coning/cresting problems in the thick transition zone, determining the best location for water injection to minimize pressure interference, and suggesting well type to develop the field, which saved costs up to 30%.

**2005–2007**: Production Consultant, JIP, China University of Petroleum, and CNPC. Dr. Jin's responsibilities included optimizing a large gas pipeline network in China, proposing new optimization algorithm and programming a software package for best operation in different conditions, reducing operational cost up to 23% (more than $20,000/day).

***Professional Memberships***
Society of Petroleum Engineers

***Relevant Publications***


Jin, L., Pekot, L.J., Hawthorne, S.B., Salako, O., Peterson, K.J., Bosshart, N.W., Jiang, T., Hamling, J.A., Wildgust, N., and Gorecki, C.D., 2018, Evaluation of recycle gas injection on $CO_2$ enhanced oil recovery and associated storage performance: International Journal of Greenhouse Gas Control, v. 75, p. 151–161.

Jin, L., Pekot, L.J., Smith, S.A., Salako, O., Peterson, K.J., Bosshart, N.W., Hamling, J.A., Mibeck, B.A.F., Hurley, J.P., Beddoe, C.J., and Gorecki, C.D., 2018, Effects of gas relative permeability hysteresis and solubility on associated $CO_2$ storage performance: International Journal of Greenhouse Gas Control, v. 75, p. 140–150.

Jin, L., Sorensen, J.A., Hawthorne, S.B., Smith, S.A., Pekot, L.J., Bosshart, N.W., Burton-Kelly, M.E., Miller, D.J., Grabanski, C.B., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2018, Improving oil recovery by use of carbon dioxide in the Bakken unconventional system—a laboratory investigation: SPE Reservoir Evaluation & Engineering, v. 20, no. 3, p. 602–612.

Salako, O., Jin, L., Barajas-Olalde, C., Hamling, J.A., and Gorecki, C.D., 2018, Implementing adaptive scaling and dynamic well-tie for quantitative 4-D seismic evaluation of a reservoir subjected to $CO_2$ enhanced oil recovery and associated storage: International Journal of Greenhouse Gas Control, v. 78, p. 306–326.

Smith, S.A., Mibeck, B.A.F., Hurley, J.P., Beddoe, C.J., Jin, L., Hamling, J.A., and Gorecki, C.D., 2018, Laboratory determination of oil draining $CO_2$ hysteresis effects during multiple floods of a conventional clastic oil reservoir: International Journal of Greenhouse Gas Control, v. 78, p. 1–6.

Jin, L., Hawthorne, S.B., Sorensen, J.A., Pekot, L.J., Kurz, B.A., Smith, S.A., Heebink, L.V., Herdegen, V., Bosshart, N.W., Torres, J., Dalkhaa, C., Peterson, K.J., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2017, Advancing $CO_2$ enhanced oil recovery and storage in unconventional oil play—experimental studies on Bakken shales: Applied Energy, v. 208, p. 171–183.

Hawthorne, S.B., Miller, D.J., Jin, L., and Gorecki, C.D., 2016, Rapid and simple capillary-rise/vanishing interfacial tension method to determine crude oil minimum miscibility pressure—pure and mixed $CO_2$, methane, and ethane: Energy & Fuels, v. 30, no. 8, p. 6365–6372.

Jin, L., Jiang, T., Dotzenrod, N., Patil, S.B., Klenner, R.C.L., Sorensen, J.A., Bosshart, N.W. Modeling Study of the Unconventional Bakken Formation for Gas Injection EOR. Proceedings of Fourth EAGE Conference on Petroleum Geostatistics, Florence, Italy, Sep. 2-6, 2019.

Jin, L., Peterson, K.J., Bosshart, N.W., Pekot, L.J., Salako, O., Burnison, S.A., Smith, S.A., Mibeck, B.A.F., Oster, B.S., He, J., Peck, W.D., Hamling, J.A., Ayash, S.C., and Gorecki, C.D., 2017, Bell Creek test site – simulation report: Plains $CO_2$ Reduction (PCOR) Partnership Phase III draft Task 9 Deliverable D66 (Update 6). For U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, October.

Jin, L., Bosshart, N.W., Oster, B.S., Hawthorne, S.B., Peterson, K.J., Burton-Kelly, M.E., Feole, I.K., Jiang, T., Pekot, L.J., Peck, W.D., Ayash, S.C., and Gorecki, C.D., 2016, Bell Creek test site – simulation report: Plains $CO_2$ Reduction (PCOR) Partnership Phase III draft Task 9 Deliverable D66 (Update 5). For U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, August.

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***Qualifications***

M.Engr., Environmental Engineering, UND, 2008; B.S., Civil Engineering, Florida State University, 2006; Licensed Professional Engineer, North Dakota, ND PE-10400.

***Professional Experience***

**2009–Present:** Civil Engineer, EERC. Mr. Kalenze's responsibilities include economic assessments, financial forecasting, and data management for a variety of subsurface operations projects. He has experience in economic analysis for low-carbon fuels and investigating business case scenarios for large-scale (>1 million tons per year) carbon capture and storage (CCS) projects. Specific activities include the following:

- Generating budgets, cost estimates, and economic analysis for work on Phases I–III of the integrated carbon capture and storage for North Dakota ethanol production project, funded by the North Dakota Industrial Commission (NDIC).
- Compiling capital and operating estimates, performing a techno-economic evaluation, and investigating business case scenarios for $CO_2$ capture and enhanced oil recovery in North Dakota.
- Performing economic assessments for a prefeasibility study for the U.S. Department of Energy (DOE)-funded CarbonSAFE work on $CO_2$ capture and storage in Nebraska and feasibility studies of large-scale CCS in North Dakota.

***Professional Memberships***

American Society of Civil Engineers (ASCE); North Dakota (ND) Section; Secretary (2016–2019); and Environmental & Water Resources Institute.

***Relevant Publications***

Leroux, K.M., Klapperich, R.J., Kalenze, N.S., Jensen, M.D., Daly, D.J., Crocker, C.R., Ayash, S.C., Azzolina, N.A., Crossland, J.L., Doll, T.A., Gorecki, C.D., Stevens, B.G., Botnen, B.W., Foerster, C.L., Schlasner, S.M., Hamling, J.A., Nakles, D.V., Peck, W.D., Glazewski, K.A., Harju, J.A., Piggott, B.D., and Vance, A.E. 2018, Integrated carbon capture and storage for North Dakota ethanol production – Phase II: Final report (November 1, 2017 – July 31, 2018) for North Dakota Industrial Commission Contract No. R-034-043, EERC Publication 2018-EERC-07-11, Grand Forks, North Dakota, Energy & Environmental Research Center, July.

Leroux, K.M., Klapperich, R.J., Kalenze, N.S., Jensen, M.D., Daly, D.J., Crocker, C.R., Ayash, S.C., Azzolina, N.A., Crossland, J.L., Doll, T.A., Gorecki, C.D., Stevens, B.G., Botnen, B.W., Foerster, C.L., Schlasner, S.M., Hamling, J.A., Nakles, D.V., Peck, W.D., Glazewski, K.A., Harju, J.A., Piggott, B.D., and Vance, A.E., 2018, Integrated carbon capture and storage for North Dakota ethanol production – phase II: Final report (November 1, 2017 – July 31, 2018) for Red Trail Energy, LLC, EERC Publication 2018-EERC-07-12, Grand Forks, North Dakota, Energy & Environmental Research Center, July.

Wildgust, N., Leroux, K.M., Botnen, B.W., Daly, D.J., Jensen, M.D., Glazewski, K.A., Kalenze, N.S., Burton-Kelly, M.E., Dalkhaa, C., Torres, J.A., Doll, T.E., Vettleson, H.M., Wilson, W.I., Crocker,

C.R., and Gorecki, C.D., 2018, Nebraska integrated carbon capture and storage pre-feasibility study: Final report (Jan 1, 2017 – June 30, 2018) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FE0029186, EERC Publication 2018-EERC-06-12, Grand Forks, North Dakota, Energy & Environmental Research Center, June.

Leroux, K.M., Klapperich, R.J., Azzolina, N.A., Jensen, M.D., Kalenze, N.S., Bosshart, N.W., Torres Rivero, J.A., Jacobson, L.L., Ayash, S.C., Nakles, D.V., Jiang, T., Oster, B.S., Feole, I.K., Fiala, N.J., Schlasner, S.M., Wilson IV, W.I., Doll, T.E., Hamling, J.A., Gorecki, C.D., Pekot, L.J., Peck, W.D., Harju, J.A., Burnison, S.A., Stevens, B.G., Smith, S.A., Butler, S.K., Glazewski, K.A., Piggott, B., and Vance, A.E., 2017, Integrated carbon capture and storage for North Dakota ethanol production: Final report (November 1, 2016 – May 31, 2017) for North Dakota Industrial Commission and Red Trail Energy, Grand Forks, North Dakota, Energy & Environmental Research Center, May.

Leroux, K.M., Ayash, S.C., Klapperich, R.J., Jensen, M.D., Kalenze, N.S., Azzolina, N.A., Bosshart, N.W., Torres Rivero, J.A., Jacobson, L.L., Stevens, B.G., Nakles, D.V., Jiang, T., Oster, B.S., Feole, I.K., Fiala, N.J., Schlasner, S.M., Doll, T.A., Wilson IV, W.I., Gorecki, C.D., Pekot, L.J., Hamling, J.A., Burnison, S.A., Smith, S.A., Botnen, B.W., Foerster, C.L., Piggott, B., Vance, A.E., 2018, Integrating carbon capture and storage with ethanol production for potential economic benefit: Presented at the 14th International Conference on Greenhouse Gas Control Technologies (GHGT-14), Melbourne, Australia, October 21–25, 2018.

Leroux, K.M., Azzolina, N.A., Glazewski, K.A., Kalenze, N.S., Botnen, B.W., Kovacevich, J.T., Abongwa, P.T., Thompson, J.S., Zacher, E.J., Hamling, J.A., and Gorecki, C.D., 2018, Lessons learned and best practices derived from environmental monitoring at a large-scale $CO_2$ injection project: International Journal of Greenhouse Gas Control, v. 78. p. 254–270.

Wildgust, N., Botnen, B.W., Daly, D.J., Jensen, M.D., Kalenze, N.S., Burton-Kelly, M.E., Dalkhaa, C., and Doll, T.E., 2018, Integrated CCS pre-feasibility study for western Nebraska: Poster presented at the 14th International Conference on Greenhouse Gas Control Technologies (GHGT-14), Melbourne, Australia, October 21–25, 2018.

Hamling, J.A., Klapperich, R.J., Stepan, D.J., Sorensen, J.A., Pekot, L.J., Peck, W.D., Jacobson, L.L., Bosshart, N.W., Hurley, J.P., Wilson IV, W.I., Kurz, M.D., Burnison, S.A., Salako, O., Musich, M.A., Botnen, B.W., Kalenze, N.S., Ayash, S.C., Ge, J., Jiang, T., Dalkhaa, C., Oster, B.S., Peterson, K.J., Feole, I.K., Gorecki, C.D., and Steadman, E.N., 2016, Field implementation plan for a Williston Basin brine extraction and storage test: Phase I topical report for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FE0026160, Grand Forks, North Dakota, Energy & Environmental Research Center, April.

Leroux, K.M., Stepan, D.J., Wilson, W.I., Kalenze, N.S., Crossland, J.L., Tillotson, S.J., and Trussell, D.A., 2013, Assessment of inert solid waste landfills – recycling and reduction options in rural North Dakota: Final report for North Dakota Solid Waste and Recycling Association, EERC Publication 2013-EERC-09-11, Grand Forks, North Dakota.

**KEVIN C. CONNORS**
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***Principal Areas of Expertise***
Mr. Connors' principal areas of interest and expertise include regulatory policy, permitting, and regulatory interpretation related to the geologic storage of $CO_2$, enhanced oil recovery, and unconventional oil and gas development.

***Qualifications***
B.S., Geology, University of Montana, 2009.

***Professional Experience***
**July 2019–Present:** Principal Policy and Regulatory Strategist, EERC, UND. Mr. Connors works with a multidisciplinary team of scientists, engineers, and business professionals to integrate legal and regulatory policy, economics, and tax perspectives with applied research related to incremental oil recovery, unconventional oil recovery, and $CO_2$ capture and geologic storage.

**November 2018–June 2019:** Principal Consultant Drilling and Well Operations, Equinor Energy, Austin, Texas. Mr. Connors worked as a regulatory advisor for Equinor's Williston Basin Bakken asset. He gained experience in securing federal and state permits to drill, advising Equinor stakeholders on regulatory issues, and maintaining compliance in a multi-jurisdictional regulatory environment. Mr. Connors worked on special projects with Equinor's research and technology teams as the lead regulatory advisor in developing solutions to gas flaring and $CO_2$ emissions in the Bakken.

**October 2010–October 2018:** North Dakota Industrial Commission (NDIC) Oil and Gas Division. October 2015–October 2018: Pipeline Program Supervisor. This position was created by the North Dakota Legislature to develop North Dakota's first Underground Gathering Pipeline Program to improve pipeline integrity. The development of the pipeline program included administrative rule making, hiring and managing office and field staff, developing a data management system (database), and meeting with industry leaders and academic researchers. Mr. Connors created guidance documents for program staff, regulatory inspectors, and the regulated community; testified before the North Dakota Legislature; and presented at public events throughout western North Dakota.

July 2011–October 2018: CCS Supervisor. This position was created by the North Dakota Legislature to provide a timely response to the U.S. Environmental Protection Agency (EPA) rules relating to the geologic sequestration of $CO_2$ (Class VI). Mr. Connors successfully led North Dakota's efforts to obtain Class VI primacy for the state of North Dakota. He gained expertise in the EPA Underground Injection Control (UIC) Program and North Dakota's geologic storage of $CO_2$ statutes and authored and adopted North Dakota's $CO_2$ storage rules through the administrative rule-making process. In this position, he participated in the North Dakota Carbon Dioxide Storage Workgroup, testified before the North Dakota Administrative Rules Committee, authored publications, and presented at technical conferences on carbon capture and storage regulatory frameworks. He also has expertise in North Dakota's pore space amalgamation process for $CO_2$ storage and gas storage. In 2018, he developed guidelines for gas storage

in North Dakota. The guidance document was intended to provide a pathway forward for permitting and storing Bakken produced gas to mitigate flaring.

October 2013–October 2015: UIC Supervisor. Mr. Connors administered the North Dakota Class II UIC Program. During his time as UIC Supervisor, he issued over 100 UIC permits, revised and updated program technical guidelines, evaluated regulatory filings, performed technical evaluations of UIC permit applications, and processed well completion reports, workover reports, and various other regulatory filings. He prepared and submitted quarterly reports to EPA as part of the UIC program primacy agreement between North Dakota and EPA. In spring 2015, Mr. Connors created a regulatory comparison table using North Dakota Statutes and regulations in comparison to the Bureau of Land Management (BLM) proposed rules on hydraulic fracturing. The regulatory comparison was key evidence in the state of North Dakota's lawsuit against the BLM.

October 2010–July 2011: Petroleum Engineer. As an oil and gas inspector, Mr. Connors conducted enforcement and compliance inspections in the field during a time of increasing oil and gas activity.

**January–September 2010:** Wellsite Geologist, Weatherford. Mr. Connors provided geological services for the drilling and completion of horizontal wells in the Bakken and Three Forks Formations.

**CHARLENE R. CROCKER**
Research Scientist
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
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***Principal Areas of Expertise***

Ms. Crocker's principal areas of interest and expertise span public outreach and scientific research activities. Public outreach programs have focused on fossil energy transformations, carbon dioxide emissions and management, water quality and use, and fish consumption advisories and include general public and K–12 education and documentary development, writing, and production. Research areas have focused on trace element emissions and control for fossil fuel combustion systems, with a particular emphasis on air pollution issues related to mercury and fine particulates. This includes developing carbon-based mercury control sorbents; mercury and halogens in coal combustion; and airborne particulate matter instrumentation. Ms. Crocker has experience in water quality monitoring, analytical methods, and education; development and implementation of fish consumption surveys.

***Qualifications***

B.S., Chemistry, UND, 1994; B.A., French, Colby College, Waterville, ME, 1986.

***Professional Experience***

**2002–Present:** Research Scientist, EERC, UND. Ms. Crocker's responsibilities include managerial and principal investigator duties for projects related to public outreach and scientific research. With respect to outreach, this included the development of public outreach programs for $CO_2$ sequestration, water, and fish advisories and the development of $CO_2$ sequestration public outreach materials, water quality education, and a water-based geoscience education program and outreach activities for middle and high school students. Research responsibilities included projects related to development of sorbents for emission control strategies in fossil fuel-fired energy systems; projects related to environmental management and air quality; collaborating with other scientists on the development of carbon-based flue gas sorbents, particulate matter (PM) sampling, evaluation of bioassessment tools, fish consumption survey development, proposal and report writing, data analysis, presentation of results, and budget tracking; developing PM-sampling protocols; and directing the activities of student assistants. Specific roles and activities include the following:

- Outreach Task Lead for the U.S. Department of Energy (DOE)–North Dakota Industrial Commission (NDIC)–Red Trail Energy (RTE)-funded Phase III Integrated Carbon Capture and Storage for North Dakota Ethanol Production project. Activities include public outreach materials development and support for research and fieldwork associated with project activities in Stark County, North Dakota.
- Outreach Task Lead and team member for the North Dakota CarbonSAFE Phase II project, funded by DOE, NDIC, Minnkota Power Cooperative, Basin Electric Power Cooperative, BNI Energy, North American Coal, and ALLETE Clean Energy. Activities include public outreach materials development and support for research and fieldwork associated with project activities in central North Dakota.
- Outreach Team member for the Wyoming CarbonSAFE Phase II project, funded by DOE, Basin Electric Power Cooperative, et al. Activities include public outreach materials development and consulting for research and fieldwork associated with project activities in central North Dakota.
- Program Coordinator and student supervisor for the EERC Energy Hawks internship program, funded by the State Energy Research Center at the EERC. Activities include development and implementation

of an energy literacy syllabus for a multidisciplinary team of graduate and undergraduate students during a 10-week internship; supervision of student activities; and guidance in the development of white papers focused on value-added energy topics for North Dakota.

**1994–2002:** Research Chemist, EERC, UND. Ms. Crocker's responsibilities included managing projects relating to environmental management and air quality; collaborating with other scientists on fish consumption survey development, PM sampling, corrosion of ceramic and alloy materials, coal ash, water purification, and surface decontamination research; proposal and report writing, data analysis, presentation of results, and budget tracking; developing PM sampling protocols; participating in development of a water-based geoscience education program and outreach activities for school children; directing activities of student assistants; developing and implementing analytical methods employing LIBS. Previous duties performed in the Analytical Research Laboratory focused on water quality and energy-related analyses. Responsibilities included preparing and analyzing ultratrace element samples in aqueous and inorganic media using AAS, ICP, and IC; recording and disseminating analytical results and quality control checks; performing research on ultratrace elemental analysis of mercury using AFS; and preparing reagents and solutions.

**1993–1994:** Research Assistant, EERC, UND. Ms. Crocker's responsibilities included preparing and analyzing ultratrace element samples in inorganic media; performing research on ultratrace element analysis of mercury in air using AFS; and preparing reagents and solutions.

**1990:** Naturalist, Deep Portage Conservation Reserve, Hackensack, Minnesota. Ms. Crocker's responsibilities included planning and conducting environmental education programs for children and adults; evaluating curriculum; and organizing lending of educational learning stations.

**1988–1990:** Sanctuary Manager, Wetlands, Pines & Prairie Audubon Sanctuary, Warren, Minnesota. Ms. Crocker's responsibilities included planning and conducting environmental education programs; organizing chapter meetings; publishing the Sanctuary newsletter; and performing administrative tasks.

**1988:** Park Ranger/Interpreter, Boston Harbor Islands State Park, Boston, Massachusetts. Ms. Crocker's responsibilities included interpreting natural and human history; developing special programs and leading walking tours of the islands; and conducting school programs.

***Relevant Publications***

Daly, D.J.; Crocker, C.R. Energy and $CO_2$ Management: Carbon Capture and Storage. Presented at the 2019 Lignite Education Seminar, Bismarck, ND, June 11, 2019.

Daly, D.J.; Crocker, C.R.; Gorecki, C.D. Regionwide Outreach in a Project-Level World – Lessons from the PCOR Partnership. *Energy Procedia* **2017,** *114*, 7224–7236.

**JOHN A. HAMLING**
Assistant Director for Integrated Projects
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
701.777.5472 (phone), 701.777.5181 (fax), jhamling@undeerc.org

***Education and Training***
B.S., Mechanical Engineering, UND, 2007. A.S./A.A., Williston State College, 2004. Certified EIT.

***Research and Professional Experience***
**2018–Present:** Assistant Director for Integrated Projects, EERC. Brings scientific and engineering innovation to field demonstrations, catalyzing and implementing pioneering solutions to facilitate prudent development and use of fossil energy. Focus is to advance commercial application of geologic $CO_2$ use and improved oil recovery in conventional and unconventional oil plays. Experience includes design, implementation, and oversight of surface, near-surface, deep subsurface, and reservoir characterization and surveillance programs for commercial geologic $CO_2$ storage and EOR. Led efforts resulting in development, proof-of concept, and validation of improved monitoring techniques applicable to dedicated and associated geologic $CO_2$ storage and EOR applications. Advises development, testing, and commercial demonstration of IOR techniques to improve EUR of oil in conventional and unconventional tight oil plays. Led and advised development and field demonstration of novel advanced geophysics techniques for commercial surveillance of EOR and IOR. Led evaluation of emerging and novel wellbore stimulation techniques to improve EUR in Williston Basin (WB). Expertise includes well-logging principals and applica-tions; produced water treatment; saltwater disposal; well drilling; well completions; wellbore integrity; risk assessment; logistics; well stimulation; IOR; enhanced recovery in tight oil plays; and HSE programs. PM/PI/task lead for multiyear, multimillion-dollar R&D projects. Leads multidisciplinary team of geophysics, data analytics, operations, and reservoir surveillance experts. Activities encompass contract research and strategic partnership programs with state of North Dakota, DOE, and private industry to propel development and implementation of approaches to benefit practical energy development. Specific activities include the following:

- Continuous collaboration with Denbury Onshore LLC since 2009 focused on Bell Creek oil field, including geologic characterization and modeling, reservoir simulation, and field testing of >16 research-monitoring techniques through PCOR Partnership large-scale field demonstration and other DOE-funded projects. Activities included drilling/recompletion of five wells, collection of >90 PNL logs, deployment/processing of permeant geophone array and casing-conveyed downhole P/T gauges.
- Senior project advisor for two WB unconventional tight oil rich gas/$CO_2$ EOR field injection tests.
- Managed drilling and completion of ten new wells; design, construction, and operation of million-dollar brine treatment and produced water test bed facility; deployment of casing-conveyed pressure/temperature systems; installation, operation, and interpretation of permanent geophone array for passive and active seismic monitoring; acquisition and interpretation of time-lapse 3-D seismic surveys in active commercial EOR project covering >40 $mi^2$; development and field testing of novel geophysical monitoring systems for commercial EOR floods; collection and analysis of over 500 ft of core; and collection and interpretation of well logs for over 400 wells for characterization and time-lapse monitoring (including production log to evaluate well performance (i.e., time-lapse corrosion logs, time-lapse fluid saturation logs, flow logs, pressure and fluid sampling).
- Schlumberger Wireline Engineer. Designed and oversaw open and cased-hole logging operations for >300 wells in both conventional and unconventional oil and gas plays. Field testing and validation of

pre-commercialization applications of logging tools for unconventional reservoirs. Also served as HSE officer, loss prevention team lead, and explosives and radiation safety officer for wellsite activities.

- Vice-Chair and Communications Chair, Society of Petroleum Engineers International WB Section since 2012. Developed and coordinated technical program on evolving drilling and stimulation practices and emerging technologies in WB.

**2017–Present:** Adjunct Lecturer, Department of Petroleum Engineering, UND.

**2009–2018:** Principal Engineer/Oilfield Operations Group Lead (2012–2018), Research Manager (2011–2012), Research Engineer (2009–2011), EERC. PM/PI/task lead for multiyear, multimillion-dollar projects, leading multidisciplinary team of scientists and engineers working to develop and implement MVA concepts for large-scale (>1 MT/yr) $CO_2$ storage and EOR operations. Worked with teams to develop, design, and implement new approaches to benefit economic exploration, development, and production of oil and gas. Worked on design and implementation of new approaches to benefit exploration, development, and production of oil and gas and with PCOR Partnership, evaluating potential for $CO_2$ storage in geologic formations. Responsibilities included field operations design, deployment, and interpretation related to oilfield technologies applicable to the $CO_2$ capture and storage industry; laboratory functions related to Applied Geology Laboratory; data analysis; regulatory compliance; communication of operations between service providers, management teams, industry partners, and governmental organizations, and investigation and/or demonstration of techniques and/or technologies that can enhance oil and gas production or economically benefit the oil and gas industry while reducing environmental footprint of drilling and production operations.

**2007–2009**: Reservoir Evaluation Engineer/HSE Rep/Loss Prevention Team Lead, Schlumberger Ltd.

***Relevant Publications***


Azzolina, N.A., Bosshart, N.W., Burton-Kelly, M.E., Hamling, J.A., and Peck, W.D., 2018, Statistical analysis of pulsed-neutron well logs in monitoring injected carbon dioxide: IJGGC, v. 75, p. 125–133.

Hawthorne, S.B., Miller, D.J., Jin, L., and Gorecki, C.D., 2018, Lab and reservoir study of produced hydrocarbon molecular weight selectivity during $CO_2$ enhanced oil recovery: Energy Fuels, v. 32, no. 9, p. 9070–9080.

Jin, L., Pekot, L.J., Hawthorne, S.B., Salako, O., Peterson, K.J., Bosshart, N.W., Jiang, T., Hamling, J.A., Wildgust, N., and Gorecki, C.D., 2018, Evaluation of recycle gas injection on $CO_2$ enhanced oil recovery and associated storage performance: IJGGC, v.75, p. 151–161.

Smith, S.A., Mibeck, B.A.F., Hurley, J.P., Beddoe, C.J., Jin, L., Hamling, J.A., and Gorecki, C.D., 2018, Laboratory determination of oil draining $CO_2$ hysteresis effects during multiple floods of a conventional clastic oil reservoir: IJGGC, v. 78, p. 1–6.

Schnacke, J.G., Harju, J.A., Hamling, J.A., Sorensen, J.A., and Wildgust, N., 2018, Carbon capture boosting oil recovery: The American Oil & Gas Reporter, v. 61, no. 9, p. 95–99.

Hamling, J.A., 2017, Developments in $CO_2$, ethane, and rich gas EOR—A Williston Basin perspective: Presented at $CO_2$ & ROZ Conference Carbon Management Workshop, Midland, TX, Dec 4–7, 2017.

Hamling, J.A., Glazewski, K.A., Leroux, K.M., Kalenze, N.S., Bosshart, N.W., Burnison, S.A., Klapperich, R.J., Stepan, D.J., Gorecki, C.D., and Richards, T.L., 2017, Monitoring 3.2 million tonnes of $CO_2$ at the Bell Creek oil field: Energy Procedia, v. 114, p. 5553–5561.

Hamling, J.A., Stepan, D.J., and Klapperich, R.J., 2017, Integrating monitoring data—understanding reservoir behavior and $CO_2$ movement at the Bell Creek commercial $CO_2$ EOR project: Presented at IEAGHG Monitoring Network Meeting, Traverse City, MI, June 13–15, 2017.

Jin, L., Pekot, L.J., Hawthorne, S.B., Gobran, B., Greeves, A., Bosshart, N.W., Jiang, T., Hamling, J.A., and Gorecki, C.D., 2017, Impact of $CO_2$ impurity on MMP and oil recovery performance of the Bell Creek oil field: Energy Procedia, v. 114, p. 6997–7008.

Daly, D.J., Crocker, C.R., and Hamling, J.A., 2013, Installing a casing-conveyed permanent downhole monitoring system [DVD]: Steadman, E.N., and Dambach, B., executive producers, Prairie Public Broadcasting and Energy & Environmental Research Center.

**GERALD BACHMEIER**

3128 Bay Shore Bend SE
Mandan, ND 58554

Home (701) 751-0771
Work (701) 974-3308

## Qualifications Summary

An effective, driven, confident professional with extensive supervisory experience. Leadership shown in workplace as employee in upper and middle management positions. Capable of coordinating multiple projects and organizing communications to meet deadlines. A strong work ethic and ability to inspire others to reach team objectives. Respected consultant with reputation for integrity in business. Particular strengths in business development, alliance building, employee relationships, project management and cross training

### Areas of Strength

DIRECTION – SUPERVISION – PROJECT ASSESSMENT – LEADERSHIP DEVELOPMENT – CONTRACT NEGOTIATION – BUSINESS DEVELOPMENT – BUSINESS ALLIANCE BUILDING- CROSS TRAINING – MARKETING

### Professional Board Memberships

Chaired multiple boards involved in facility production, planning, and marketing.

- Executive Board of Renewable Products Marketing group
- President – North Dakota Ethanol Producers Association
- North Dakota Ethanol Council

### Professional Experience

Chief Executive Officer

- Red Trail Energy, LLC. – Richardton, ND July 2010 – Present
  Administration of Red Trail Energy ethanol facility. Utilize expertise to oversee and manage daily operations of Plant, Lab and Financial activities. Identify opportunities for growth in the financial and production sectors. Promote positive attitudes regarding company policies, employees and customers. Maintain and monitor risk management procedures. Recommend grain policies as well as oversee and maintain all grain hedging, grain bids and grain settlement activity. Assist in hiring, supervising, and termination of employees as necessary. Strategic planning and preparation of all department budgets and financials.
  - Assess needs in staffing, policies and procedures to maximize the growth of Red Trail Energy.
  - Calculate risk and return in market, maximizing profit as markets change.
  - Communicate with total Risk Management Program.

Chief Manager

- DENCO – Morris, MN 1999 – 2010
  Administration of DENCO ethanol facility, advisor to Red Trail Energy in Richardton, ND. Coordinated activities of Plant management, Lab management, and Financial sections. Maintained employee retention program. Identified opportunities of growth as major contributor to the ethanol industry. Advocated for ethanol industry at state and federal levels. Utilized industry expertise and plant management expertise to influence construction and engineering of new generation high capacity plants. Evaluated probable success of projects brought to Greenway consulting, and instruct principles on modifications needed. Facilitated contact between interested investors, project managers and

contractor. Promote use of E-85 and higher level blends on a local and state environment.

- Designed business development plan for DENCO allowing for exit strategy and eight-fold profit for investors.
- Created Greenway Consulting and Golden Lyk subsidiary companies, creating profit for DENCO and providing training and experience for staff.
- Established contractual relationship with eleven other MN ethanol plants, creating RPMG, improving marketing and enzyme purchasing capabilities of DENCO.
- Assessed need of key staff, developed individual benefit programs resulting in highly trained and motivated staff, with excellent staff retention
- Directed leadership development events, and prioritized training, including external sources such as the Carnegie program.
- Calculate risk and return in financial markets, maximizing profits as seasons and markets change.
- Invest in internal and external projects to provide security and growth.

Plant Manager, Ethanol Marketing Manager- Milsolv Minnesota Corporation

- MORRIS AG-ENERGY COMPANY, INC. – MORRIS, MN 1990–1999
  Oversaw equipment procurement and installation during construction phase. Morris Ag- Energy representative for negotiating labor agreement with Allied Industrial Worker Union. Employee organization, hiring, termination and training. Total plant financial overview, corn procurement, chemical and energy procurement, plant process operations. Improvement of efficiency and expansion in production.
  - Improved profitability from $80,000 loss to net profit of $69,000 in one year.
  - Expanded Ethanol Marketing Division from $6 million to $47 million in three years.
  - Developed relationship with all major Refiners in the upper Midwest and West coast.
  - Negotiated contracts and developed market strategies for Milsolv and Heartland Corn Products, Winthrop MN, through start-up.

## Education

BISMARCK STATE COLLEGE, Bismarck, ND 1990
Associates Degree in Process Plant Technology

Dale Carnegie Graduate 1996
STATE OF MONTANA

Certified Developmental Disabilities Teaching Program 1986
COUR D' ALENE, IDAHO

Scott and Fetzer Fortune 500- Professional Sales and Management 1982

Carson High School 1972

# APPENDIX C

# BUDGET NOTES

## BUDGET NOTES

## ENERGY & ENVIRONMENTAL RESEARCH CENTER (EERC)

### BACKGROUND

The EERC is an independently organized multidisciplinary research center within the University of North Dakota (UND). The EERC is funded through federal and nonfederal grants, contracts, and other agreements. Although the EERC is not affiliated with any one academic department, university faculty may participate in a project, depending on the scope of work and expertise required to perform the project.

### INTELLECTUAL PROPERTY

The applicable federal intellectual property (IP) regulations will govern any resulting research agreement(s). In the event that IP with the potential to generate revenue to which the EERC is entitled is developed under this project, such IP, including rights, title, interest, and obligations, may be transferred to the EERC Foundation®, a separate legal entity.

### BUDGET INFORMATION

The proposed work will be done on a cost-reimbursable basis. The distribution of costs between budget categories (labor, travel, supplies, equipment, etc.) and among funding sources of the same scope of work is for planning purposes only. The principal investigator, project manager may incur and allocate allowable project costs among the funding sources for this scope of work in accordance with Office of Management and Budget (OMB) Uniform Guidance 2 CFR 200.

Escalation of labor and EERC recharge center rates are incorporated into the budget when a project's duration extends beyond the university's current fiscal year (July 1 – June 30). Escalation is calculated by prorating an average annual increase over the anticipated life of the project.

The cost of this project is based on a specific start date indicated at the top of the EERC budget. Any delay in the start of this project may result in a budget increase. Budget category descriptions presented below are for informational purposes; some categories may not appear in the budget.

**Salaries:** Salary estimates are based on the scope of work and prior experience on projects of similar scope. The labor rate used for specifically identified personnel is the current hourly rate for that individual. The labor category rate is the average rate of a personnel group with similar job descriptions. Salary costs incurred are based on direct hourly effort on the project. Faculty who work on this project may be paid an amount over the normal base salary, creating an overload which is subject to limitation in accordance with university policy. As noted in the UND EERC Cost Accounting Standards Board Disclosure Statement, administrative salary and support costs which can be specifically identified to the project are direct-charged and not charged as facilities and administrative (F&A) costs. Costs for general support services such as contracts and IP, accounting, human resources, procurement, and clerical support of these functions are charged as F&A costs.

**Fringe Benefits:** Fringe benefits consist of two components which are budgeted as a percentage of direct labor. The first component is a fixed percentage approved annually by the UND cognizant audit agency, the Department of Health and Human Services. This portion of the rate covers vacation, holiday, and sick leave (VSL) and is applied to direct labor for permanent staff eligible for VSL benefits. Only the actual approved rate will be charged to the project. The second component is estimated on the basis of historical

data and is charged as actual expenses for items such as health, life, and unemployment insurance; social security; worker's compensation; and UND retirement contributions.

**Travel:** Travel may include site visits, fieldwork, meetings, and conferences. Travel costs are estimated and paid in accordance with OMB Uniform Guidance 2 CFR 200, Section 474, and UND travel policies, which can be found at http://und.edu/finance-operations (Policies & Procedures, A–Z Policy Index, Travel). Daily meal rates are based on U.S. General Services Administration (GSA) rates unless further limited by UND travel policies; other estimates such as airfare, lodging, ground transportation, and miscellaneous costs are based on a combination of historical costs and current market prices. Miscellaneous travel costs may include parking fees, Internet charges, long-distance phone, copies, faxes, shipping, and postage.

**Equipment:** If equipment (value of $5000 or more) is budgeted, it is discussed in the text of the proposal and/or identified more specifically in the accompanying budget detail.

**Supplies:** Supplies include items and materials that are necessary for the research project and can be directly identified to the project. Supply and material estimates are based on prior experience with similar projects. Examples of supply items are chemicals, gases, glassware, nuts, bolts, piping, data storage, paper, memory, software, toner cartridges, maps, sample containers, minor equipment (value less than $5000), signage, safety items, subscriptions, books, and reference materials. General purpose office supplies (pencils, pens, paper clips, staples, Post-it notes, etc.) are included in the F&A cost.

**Subcontracts:** Not applicable.

**Professional Fees:** Not applicable.

**Communications:** Telephone, cell phone, and fax line charges are included in the F&A cost; however, direct project costs may include line charges at remote locations, long-distance telephone charges, postage, and other data or document transportation costs that can be directly identified to a project. Estimated costs are based on prior experience with similar projects.

**Printing and Duplicating:** Page rates are established annually by the university's duplicating center. Printing and duplicating costs are allocated to the appropriate funding source. Estimated costs are based on prior experience with similar projects.

**Food:** Expenditures for project partner meetings where the primary purpose is dissemination of technical information may include the cost of food. The project will not be charged for any costs exceeding the applicable GSA meal rate. EERC employees in attendance will not receive per diem reimbursement for meals that are paid by project funds. The estimated cost is based on the number and location of project partner meetings.

**Professional Development:** Fees are for memberships in technical areas directly related to work on this project. Technical journals and newsletters received as a result of a membership are used throughout the development and execution of the project by the research team.

**Operating Fees:** Operating fees generally include EERC recharge centers, outside laboratories, and freight.

EERC recharge center rates are established annually and approved by the university.

Laboratory and analytical recharge fees are charged on a per-sample, hourly, or daily rate. Additionally, laboratory analyses may be performed outside the university when necessary. The estimated cost is based on the test protocol required for the scope of work.

Graphics recharge fees are based on an hourly rate for production of such items as report figures, posters, and/or images for presentations, maps, schematics, website design, brochures, and photographs. The estimated cost is based on prior experience with similar projects.

Shop and operations recharge fees cover specific expenses related to the pilot plant and the required expertise of individuals who perform related activities. Fees may be incurred in the pilot plant, at remote locations, or in EERC laboratories whenever these particular skills are required. The rate includes such items as specialized safety training, personal safety items, fall protection harnesses and respirators, CPR certification, annual physicals, protective clothing/eyewear, research by-product disposal, equipment repairs, equipment safety inspections, and labor to direct these activities. The estimated cost is based on the number of hours budgeted for this group of individuals.

Engineering services recharge fees cover specific expenses related to retaining qualified and certified design and engineering personnel. The rate includes training to enhance skill sets and maintain certifications using webinars and workshops. The rate also includes specialized safety training and related physicals. The estimated cost is based on the number of hours budgeted for this group of individuals.

Software solutions services recharge fees are for development of customized websites and interfaces, software applications development, data and financial management systems for comprehensive reporting and predictive analysis tools, and custom integration with existing systems. The estimated cost is based on prior experience with similar projects.

Freight expenditures generally occur for outgoing items and field sample shipments.

**Facilities and Administrative Cost:** The F&A rate proposed herein is approved by the U.S. Department of Health and Human Services and is applied to modified total direct costs (MTDC). MTDC is defined as total direct costs less individual capital expenditures, such as equipment or software costing $5000 or more with a useful life of greater than 1 year, as well as subawards in excess of the first $25,000 for each award.

# APPENDIX D

# EERC PROJECTS FUNDED BY NDIC IN THE LAST 5 YEARS

## STATE PROGRAMS AND INCENTIVES

| Project Name | Start Date | End Date | Total Contracted |
|---|---|---|---|
| PCOR Partnership – Phase III | 6/23/2008 | 12/31/2019 | $500,000 |
| PCOR Partnership – Phase III | 6/23/2008 | 12/31/2019 | $2,400,000 |
| CATM Yr7-20 Program Affiliates | 1/1/2011 | 12/31/2015 | $45,000 |
| Program to Determine the Uniqueness of Three Forks, Optimal Density in Bakken, and Optimize Bakken Production | 6/1/2013 | 1/31/2017 | $8,554,500 |
| OGRC Quarterly Newsletter | 1/1/2014 | 6/30/2016 | $15,706 |
| CC-2.18-Advancing $CO_2$ Capture Technology: Partnership for $CO_2$ Capture Phase III | 2/4/2014 | 3/31/2016 | $500,000 |
| Validation of Multielement Sorbent Trap Method for Measurement of HC1 and Metals | 10/1/2014 | 7/31/2018 | $245,000 |
| NDIC Resource Characterization | 2/1/2015 | 8/31/2019 | $150,000 |
| Pipeline Construction and Monitoring Study | 4/20/2015 | 6/30/2017 | $1,500,000 |
| Design, Scale-Up, and Testing of Advanced Palladium Membranes – Phase II | 7/1/2015 | 1/31/2016 | $225,000 |
| Pilot Project to Remediate Soil Surrounding Legacy Brine Pits | 9/1/2015 | 6/30/2017 | $500,000 |
| Improved Characterization and Modeling of Tight Oil Formation for $CO_2$ EOR | 10/14/2015 | 12/1/2017 | $400,000 |
| FERR-2.1-Pathway to Low-Carbon Lignite Utilization | 12/1/2015 | 11/30/2016 | $1,480,000 |
| Expansion of EERC's Gathering Pipeline Leak Demonstration Project | 6/1/2016 | 7/31/2017 | $248,559 |
| FERR-2.3-Support of DOE Carbon Capture Systems Development and Modeling | 6/1/2016 | 7/31/2017 | $270,447 |
| Pathway to Low-Carbon Lignite Utilization – Phase 1B and 2A | 6/1/2016 | 12/31/2019 | $3,500,000 |
| FERR-1.3-Integrated Carbon Capture and Storage for North Dakota Ethanol Production | 8/30/2016 | 5/31/2017 | $490,000 |
| Bakken Production Optimization Program 2.0 | 11/1/2016 | 5/31/2020 | $6,000,000 |
| NDIC Emerging Issues | 12/12/2016 | 12/31/2020 | $500,000 |
| Pipeline Study Phase III (HB 1347) | 7/1/2017 | 6/30/2019 | $500,000 |
| North Dakota Integrated Carbon Storage Complex Feasibility Study | 7/17/2017 | 2/8/2020 | $1,500,000 |
| Initial Engineering, Testing, and Design of a Commercial-Scale $CO_2$ Capture System | 9/1/2017 | 12/31/2019 | $3,200,000 |
| FERR-1.3-Integrated Carbon Capture and Storage for North Dakota Ethanol Production | 11/1/2017 | 7/31/2018 | $345,000 |
| iPIPE: The Intelligent Pipeline Integrity Program | 4/1/2018 | 12/31/2022 | $1,600,000 |
| Economical Extract. and Recov. of REEs and Production of Clean Value-Added Products from Low-Rank Coal Fly Ash | 6/16/2018 | 2/15/2020 | $30,000 |
| Low-Pressure Electrolytic Ammonia Production | 6/16/2018 | 6/14/2021 | $437,000 |
| FERR-1.3-Integrated Carbon Capture and Storage for North Dakota Ethanol Production | 12/1/2018 | 5/31/2020 | $500,000 |
| Underground Storage of Produced Natural Gas – Conceptual Evaluation and Pilot Project(s) | 6/1/2019 | 6/30/2021 | $6,000,000 |
| State Energy Research Center | 7/1/2019 | 6/30/2021 | $5,000,000 |
| Assessment of Bakken and Three Forks Natural Gas Compositions | 11/1/2019 | 4/30/2020 | $300,650 |

# APPENDIX E

# REFERENCES CITED

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