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

June 1, 2021

Ms. Karlene Fine
Executive Director
North Dakota Industrial Commission
ATTN: Oil and Gas Research Program
State Capitol – 14th Floor
600 East Boulevard Avenue, Department 405
Bismarck, ND 58505-0840

Dear Ms. Fine:

Subject: EERC Proposal No. 2021-0187 Entitled "Field Study to Determine the Feasibility of Developing Salt Caverns for Hydrocarbon Storage in Western North Dakota"

The Energy & Environmental Research Center (EERC) is pleased to submit this proposal in accordance with the directive set forth in Section 14 of Senate Bill 2014 of the Sixty-Seventh Legislative Assembly of North Dakota, as signed into law by Governor Burgum.

Enclosed please find an original and one copy of the subject proposal along with a check for $100. The EERC, a research organization within the University of North Dakota, an institution of higher education within the state of North Dakota, is not a taxable entity; therefore, it has no tax liability.

This transmittal letter represents a binding commitment by the EERC to complete the project described in this proposal. If you have any questions, please contact me by telephone at (701) 777-5108, by fax at (701) 777-5181, or by e-mail at ssmith@undeerc.org.

Sincerely,

DocuSigned by:
Steve Smith
92138D2CF98E498...
Steven A. Smith
Principal Geologist, Integrated Analytical Solutions

Approved by:

DocuSigned by:
29499751F2B84D7...
Charles D. Gorecki, CEO
Energy & Environmental Research Center

SAS/kal

Enclosures

c/enc: Lynn Helms, North Dakota Industrial Commission
Brent Brannan, Oil and Gas Research Council

Oil and Gas Research Program

North Dakota

Industrial Commission

Application

Project Title: Field Study to Determine the Feasibility of Developing Salt Caverns for Hydrocarbon Storage in Western North Dakota

Applicant: Energy & Environmental Research Center

Principal Investigator: Steven A. Smith

Date of Application: June 1, 2021

Amount of Request: $9,500,000

Total Amount of Proposed Project: $10,000,000

Duration of Project: 2 years

Point of Contact (POC): Steven A. Smith

POC Telephone: 701.777.5108

POC E-Mail Address: ssmith@undeerc.org

POC Address:

15 North 23rd Street, Stop 9018

Grand Forks, ND 58202-9018

TABLE OF CONTENTS

ABSTRACT

Objective: The Energy & Environmental Research Center (EERC) proposes to directly address the intent of Section 14 of Senate Bill 2014 of the Sixty-Seventh Legislative Assembly of North Dakota, which states: "Pursuant to the continuing appropriation under section 57-51.1-07.3, the industrial commission shall use up to $9,500,000, or so much of the sum as may be necessary, from the oil and gas research fund to contract with the energy and environmental research center for an underground energy storage study. The study must include consideration of the potential capacity of salt caverns in geological formations in North Dakota for the development of underground storage of energy resources, including natural gas, liquified natural gas, NGLs, and hydrogen. The energy and environmental research center may collaborate with other entities as needed on the study. Prior to contracting with the energy and environmental research center, the commission must receive from at least one nonstate entity assurance of financial or other types of support that demonstrate a commitment to the study. During the 2021-22 interim, the energy and environmental research center shall provide quarterly reports to the industrial commission and at least one report to the legislative management regarding the results and recommendations of the study." The EERC proposes to validate the suitability of salt formations for cavern development. The project will use field-, laboratory-, and modeling-based efforts to assess the nature of selected salt formations and develop engineering design recommendations for future pilot studies.

Expected Results: Results will provide stakeholders with information needed to assess the techno-economic viability of storing hydrocarbon gases and hydrogen in engineered salt caverns in North Dakota.

Duration: The anticipated project duration is 2 years (July 1, 2021, to June 30, 2023).

Total Project Cost: $10,000,000

Participants: The EERC will partner with Bakken Midstream Natural Gas, LLC, hereafter Bakken Midstream, Neset Consulting Service, and the University of North Dakota Department of Petroleum Engineering to conduct this study.

PROJECT DESCRIPTION

The Energy & Environmental Research Center (EERC) proposes a project to directly address the intent of Section 14 of Senate Bill (SB) 2014 of the Sixty-Seventh Legislative Assembly of North Dakota as signed into law by Governor Burgum, which states: "Pursuant to the continuing appropriation under section 57-51.1-07.3, the industrial commission shall use up to $9,500,000, or so much of the sum as may be necessary, from the oil and gas research fund to contract with the energy and environmental research center for an underground energy storage study. The study must include consideration of the potential capacity of salt caverns in geological formations in North Dakota for the development of underground storage of energy resources, including natural gas, liquified natural gas, NGLs, and hydrogen. The energy and environmental research center may collaborate with other entities as needed on the study. Prior to contracting with the energy and environmental research center, the commission must receive from at least one nonstate entity assurance of financial or other types of support that demonstrate a commitment to the study. During the 2021-22 interim, the energy and environmental research center shall provide quarterly reports to the industrial commission and at least one report to the legislative management regarding the results and recommendations of the study." This study follows on a preliminary evaluation of the potential for salt cavern development completed by the EERC in December 2020.[1] The 2020 study identified three salt formations, at depths amenable for stable salt cavern operation, proximal to gas-processing and pipeline distribution networks, water resources, and rail infrastructure determined to be worthy of further investigation for characterization activities that inform future cavern development pilot studies. The overall goal of the proposed effort is to validate the

[1] Smith, S.A., Harju, J.A., Sorensen, J.A., Kurz, B.A., Abarghani, A., Bosshart, N.W., Connors, K.C., Doll, T.E., Glazewski, K.,A., Heebink, L.V., Regorrah, J.G., Strege, J.R., Wocken, C.W., and Rasouli, V., 2020, Study to determine the feasibility of developing salt caverns for hydrocarbon storage in western North Dakota: Report for North Dakota Industrial Commission Oil and Gas Research Program Contract No. G-040-080, Grand Forks, North Dakota, Energy & Environmental Research Center, December.

depth, thickness, and geologic and geomechanical suitability of the Pine, Dunham, and Opeche salt formations for salt cavern development.

Objectives: This study will be accomplished by carrying out several project objectives including an assessment of the presence, depth, and composition of identified salt formations; the sealing potential of overlying and underlying geologic strata; geomechanical stability modeling and simulation; and site-specific engineering design recommendations for future cavern development pilot studies. To perform an in-depth evaluation of the concept, the EERC will partner with Bakken Midstreamfor securing land options, surface and subsurface rights, and serve as project advisors. A letter of commitment is included in Appendix A.

Methodology: This project will incorporate field, laboratory, modeling/simulation, and engineering analysis and design to determine the potential for salt cavern development within the Dunham, Pine, and Opeche salts. The work will be conducted in seven tasks leading to the successful completion of the stated project goal. Specific activities to be conducted include the following:

- Site Screening and Characterization – Potential site locations with amenable salt formations will be identified and targeted for screening and characterization. Screening criteria will be based on the interpretation of wireline logs obtained from publicly available data sets. Salt formations at a nominal depth shallower than 6000 ft (below surface) will be identified, depth will be noted, and overall thickness will be determined and considered a key factor for potential cavern development. During this activity, it is anticipated that small-scale, localized geologic modeling will be performed to inform decision making.
- Site Selection/Land Permitting – The EERC will work with project partners to evaluate potential project site locations identified in the Site Screening and Characterization task. It is anticipated that securing land options and surface and subsurface rights, will be conducted by Bakken Midstream in close collaboration with the EERC.

- Drilling and Core Collection – The EERC will work with Neset Consulting Service (Neset) to execute the drilling and core collection activities. During this task, Neset will identify and supervise site preparation; secure a drilling contractor; advise, oversee, and document the drilling activities; provide wireline logging services; advise on core collection procedures and work with EERC geoscientists to select intervals for core collection; advise on and oversee openhole testing and wireline logging services; and oversee the safe and secure abandonment of the well.
- Core Testing and Interpretation – Once acquired, the core will be processed by Core Laboratories, Inc., in Denver, Colorado, and shipped to the EERC for sample selection and testing. Core testing will include routine analyses to identify the bulk characteristics of the formations, including lithology, thickness, porosity, permeability, and mineralogy. Samples will be tested to determine the geomechanical competency of the overlying and underlying sealing formations. Specific testing will be performed to inform the potential for salt creep or the ability for caverns to close due to overlying stresses. Additional testing will be performed to inform the dissolution properties of the salts encountered.
- Geologic and Geomechanical Modeling – Modeling and simulation will be performed based on site-specific data generated through the drilling and core collection process. Geologic models will be developed to inform the subsurface geologic regime and evaluate regional structural and stratigraphic trends that may impact cavern development. Geomechanical modeling will incorporate information derived from geologic modeling, wireline logging, formation testing, and laboratory data sets and will inform the overall cavern dimensions and operational stability.
- Engineering Analysis and Design – Detailed engineering design and analysis will be performed to identify surface equipment needs; design specifications; brine handling, use, and disposal practices; and monitoring needs. It is foreseeable that advisement will be sought from external

engineering teams with expertise in developing and operating salt caverns used for hydrocarbon storage. These consultants are yet to be determined.

Anticipated Results: The results of this effort will provide the state, the oil and gas industry, and other interested parties with the key information needed to assess the techno-economic viability of storing hydrocarbon gases and hydrogen in engineered salt caverns.

Facilities, Resources, and Techniques to Be Used, Their Availability, and Capability: The EERC employs a multidisciplinary staff of about 200 and has 254,000 square feet of state-of-the-art offices, laboratories, and technology demonstration facilities. EERC engineering and scientific research staff members are equipped with state-of-the-art analytical, modeling, and engineering facilities, which enable them to address a wide variety of energy, environmental, and mineral resource research topics. The EERC houses eight analytical laboratories dedicated to research, including water resource characterization; conventional and unconventional petroleum resources; environmental chemistry; and carbon capture, utilization, and storage. The EERC has extensive geologic modeling and reservoir simulation capabilities, including multiple high-end workstation computers and a dedicated high-performance parallel computing cluster. The project team has access to commercial-grade software for use in geologic modeling, process modeling, and numerical simulation; database capabilities for managing data that will be collected and generated during the project; and GIS (geographic information system) software for creating high-quality maps and images of results. The EERC has designed and implemented field activities that include the drilling of stratigraphic test wells; collection of core samples; industry-standard and advanced downhole geophysical logging; and downhole pressure and temperature monitoring. EERC laboratory facilities will be utilized through this effort for routine and advanced core analysis, including petrophysical, petrographic, geochemical, and geomechanical rock analysis.

The University of North Dakota (UND) Department of Petroleum Engineering has geomechanical testing equipment, modeling software, and expertise that will be utilized through this effort. Neset has over 70 wellsite geology and mudlogging teams working primarily in the Williston Basin. These crews are educated, trained, and skilled geosteering wellsite geologists and loggers. They provide on-site technical geological data to the operator and its office geology team using the latest technology available. Neset has the capacity to collaborate or independently carry out complete reservoir, production, drilling, and completions engineering.

Environmental and Economic Impacts while Project Is under Way: Environmental impacts will be relatively minimal during execution of this project. A new stratigraphic test well will be drilled, with acquisition of new core, fluid samples, and well log suites, followed by detailed analysis. Before drilling can begin, all necessary local, state, and federal environmental review and permitting processes will be completed. Lab-scale testing of the core at UND will be in a controlled environment, with insignificant amounts of material used that will be disposed of according to standard UND environmental health and safety practices once the testing is complete. Economic impacts will also be minimal and will not have appreciable effects on any of the organizations participating, apart from regular employment economic effects for those working on the project.

Ultimate Technological and Economic Impacts: The proposed effort will provide a detailed consideration of the potential capacity of salt caverns in geologic formations in North Dakota for the development of underground storage of energy resources, including natural gas, liquified natural gas, natural gas liquids (NGLs), and hydrogen. Economic impact can be significant considering the potential development of petrochemical industries within the state and possible beneficial use of associated produced gas for enhanced oil recovery (EOR) in the Bakken and/or electric generation.

Why the Project Is Needed: Extraction of oil and gas from the Bakken has dramatically increased over the past decade, which has resulted in elevated volumes of produced gas and specific NGLs. Gas capture

rates continue to increase as new gathering, processing, and distribution infrastructure are brought online. As such, there are several near-term opportunities that will expand the marketplace for gas utilization. Subsurface storage of hydrocarbon gases through the development and use of salt caverns is a mechanism that has the potential to be exploited for feedstock at petrochemical plants, EOR, and electric generation. Through this effort, the EERC will work closely with industry and the North Dakota Industrial Commission (NDIC) to evaluate the technical, economic, and regulatory aspects of hydrocarbon and hydrogen storage in salt caverns. By validating this concept through drilling, core collection, and laboratory analysis, the techno-economics of the process can be fully evaluated from start to finish and provide the baseline data and information to inform future field-scale implementation efforts.

STANDARDS OF SUCCESS

Success will be measured in the program's ability to evaluate and demonstrate the viability of North Dakota's salt formations for cavern development. Key measures of success will be the identification and characterization of salt accumulations that are at adequate depth, have sufficient thickness for cavern development, are geomechanically stable, and of a composition that will promote cost-effective dissolution. Success will also be measured by adhering to the established project plan, which will detail key project milestones and deliverables. Demonstration of the potential for value-added beneficial use of produced gases within the state would provide oil producers with options to address one of the oil and gas industry's critical issues, resulting in more efficient resource development and cost savings. Developing options to help ensure the success of the oil and gas industry in North Dakota while conserving the state's resources leads to a strong state economy and the creation of jobs to support all aspects of oil and gas development. Additionally, the validation of North Dakota's salt formations for development of caverns to store hydrocarbons has the potential to attract petrochemical industries to the state.

BACKGROUND/QUALIFICIATIONS

UND: The EERC is a high-tech, nonprofit branch of UND, exclusively conducting contract research for a multinational client base. The EERC was awarded a contract by the NDIC Oil and Gas Research Program (NDIC No. G-000-004) to conduct a study to evaluate the technical feasibility of the development and operation of salt caverns for the geologic storage of hydrocarbons, which was completed in December 2020 in collaboration with the UND Department of Petroleum Engineering. The EERC has expertise in several areas that are relevant to the proposed work, including data collection, management, and interpretation; petrophysical analysis; geostatistical analysis; geocellular modeling at field and regional scales; geologic characterization and reservoir evaluation; conducting predictive numerical injection and production simulations; performing fossil fuel and CO_2 storage resource assessments; creating GIS products; and working with project partners on field activities including coring programs and monitoring techniques. The UND Department of Petroleum Engineering has expertise in several areas of petroleum engineering, specifically in geomechanics for this effort.

Neset: Neset has been serving the Bakken for over 40 years. Neset provides many different services and expertise including engineering services; gas detection services; geology on wellsites during the drilling process; geological analysis; reservoir analysis; HSE (health, safety, and environment) analysis, inspection, and reporting; and air quality inspection and reporting.

Bakken Midstream: Bakken Midstream was founded in 2018 to develop and own value-added natural gas infrastructure in North Dakota. North Dakota has been successful developing value-added agricultural products and is currently exporting agricultural commodities and products throughout the US and to over 80 countries. Bakken Midstream believes that the State has the potential to become a world-class leader in value-added natural gas related products. North Dakota has tremendous natural gas resources. What's lacking is natural gas infrastructure, in particular infrastructure for value-added products. The mission of Bakken Midstream is to develop and own that infrastructure.

Personnel: Resumes of key personnel are provided in Appendix B. Steven Smith, EERC Principal Geologist, Integrated Analytical Solutions, will serve as Project Manager. John Harju, EERC Vice President for Strategic Partnerships, will serve as Senior Program Advisor. Other key personnel include James Sorensen, EERC Director of Subsurface R&D; Bethany Kurz, EERC Director of Analytical Solutions; John Hamling, EERC Director of Subsurface Initiatives; Lonny Jacobson, EERC Principal Operations Specialist; Chad Wocken, EERC Assistant Director of Clean Energy Solutions; Joshua Strege, EERC Assistant Director of Energy Systems; and Vamegh Rasouli, UND Department of Petroleum Engineering Department Chair/Continental Resources Distinguished Professor.

MANAGEMENT

The EERC manages over 200 contracts a year, with a total of more than 1300 clients in 53 countries. Systems are in place to ensure that projects are managed within budget, schedule, and scope. Steven Smith, EERC Principal Geologist, will oversee the entire program. He will be responsible for program coordination, guidance, and supervision to ensure consistent progress and adherence to budget and schedule constraints. Mr. Smith will be assisted in management of program activities and tasks by Mr. Sorensen, Ms. Kurz, Mr. Hamling, Mr. Jacobson, Mr. Strege, Mr. Wocken, and Dr. Rasouli. Quarterly reports will be submitted to NDIC 30 days after the end of each calendar quarter to provide timely highlights of ongoing research activities. During the 2021–2022 interim, at least one report will be provided to legislative management regarding the results and recommendations of the study.

TIMETABLE

This effort is proposed as a 2-year project (July 1, 2021 – June 30, 2023) (see Figure 1).

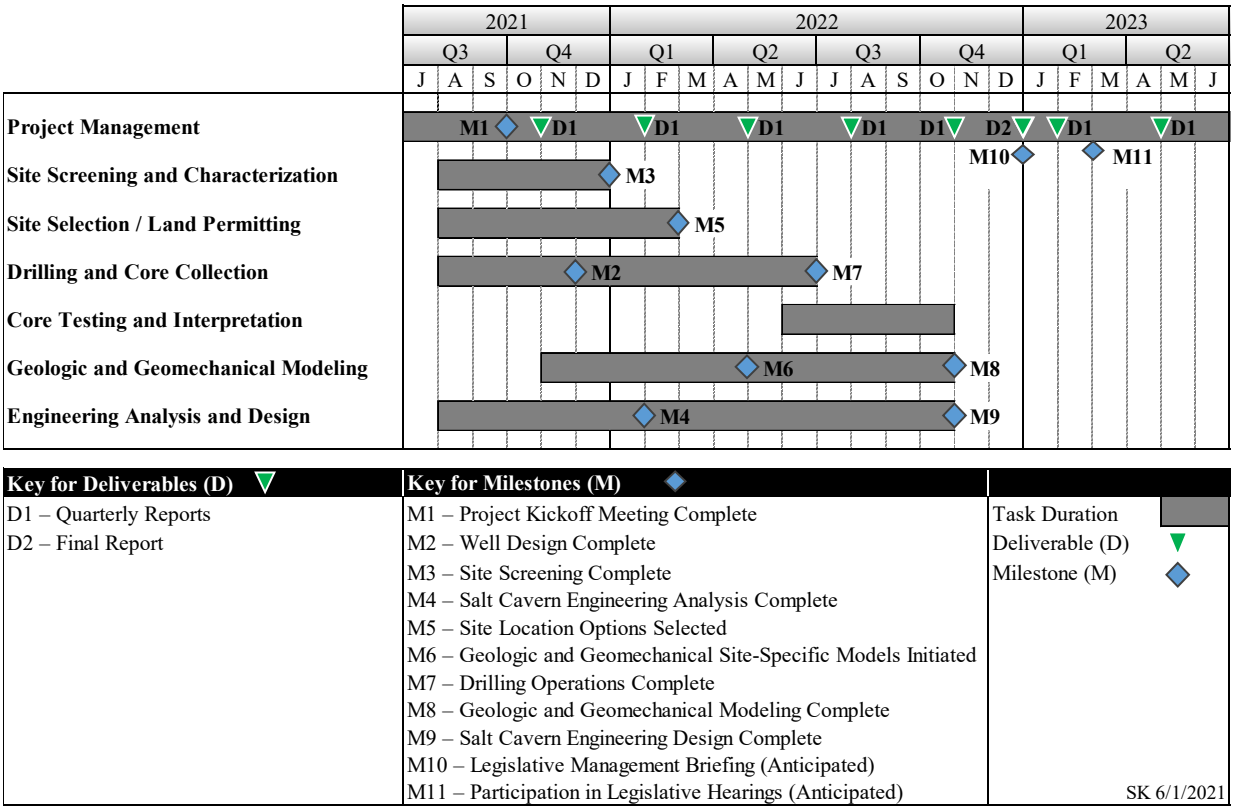

Figure 1. Project timetable.

BUDGET

The total estimated cost for the proposed scope of work is $10,000,000. The request from OGRP, as listed in SB 2014, is $9.5 million. Bakken Midstream will provide in-kind cost share valued at $500,000. The in-kind cost share consists of securing land options, surface and subsurface rights, and serve as project advisors. The budget provided in the table was developed based on past experience with similar projects. Letters of support are provided in Appendix A. Budget notes are included in Appendix C.

Project Associated Expense	NDIC Share (Cash)	Industry Share (Cash)	Total Project
Labor	$3,016,919	$0	$3,016,919
Travel	$35,969	$0	$35,969
Equipment > $5000	$16,300	$0	$16,300
Supplies	$14,515	$0	$14,515
Subcontractor – Neset Consulting	$4,000,000	$0	$4,000,000
Consultant – Engineering Design Advisement (TBD)	$250,000	$0	$250,000
Communications	$500	$0	$500
Printing & Duplicating	$1,010	$0	$1,010
Laboratory Fees & Services			
EERC Natural Materials Analytical Research Lab	$112,392	$0	$112,392
EERC Graphics Services	$19,382	$0	$19,382
EERC Engineering Services Fee	$1,507	$0	$1,507
EERC Field Safety Fee	$20,448	$0	$20,448
Petroleum Engineering – Triaxial Testing	$67,200	$0	$67,200
Outside Lab – Core Labs	$80,000	$0	$80,000
Outside Lab – Wagner Petrographic	$8,000	$0	$8,000
Total Direct Costs	$7,644,142	$0	$7,644,142
Facilities & Administration	$1,855,858	$0	$1,855,858
Total Cash Requested	**$9,500,000**	**$0**	**$9,500,000**
In-Kind Cost Share			
Bakken Midstream	$0	$500,000	$500,000
Total Project Costs	**$9,500,000**	**$500,000**	**$10,000,000**

CONFIDENTIAL INFORMATION

There is no confidential information included in this proposal.

TAX LIABILITY

The EERC, a department within UND, is a state-controlled institution of higher education and is not a taxable entity; therefore, it has no tax liability to the state of North Dakota or any of its political subdivisions.

PATENTS/RIGHTS TO TECHNICAL DATA

No patentable technologies are expected to be created during this work.

STATUS OF ONGOING PROJECTS

The EERC is currently engaged in seven NDIC projects funded through the Oil & Gas Research Program, as shown in the table below. These projects are ongoing and are current on all deliverables.

Project	Contract Award No.
NDIC Emerging Issues	G-000-004
iPIPE: The Intelligent Pipeline Integrity Program	G-046-88
Underground Storage of Produced Natural Gas – Conceptual Evaluation	G-049-092
Improving EOR Performance Through Data Analytics and Next-Generation Controllable Completions	G-050-97
PCOR Initiative to Accelerate CCUS Deployment	G-050-96
Produced Water Management Through Geologic Homogenization	G-051-101
Bakken Production Optimization Program 3.0	G-051-98

APPENDIX A

LETTERS OF SUPPORT

BAKKEN MIDSTREAM

May 27, 2021

John Harju
Vice President for Strategic Partnerships
Energy & Environmental Research Center
15 North 23rd St, Stop 9018
Grand Forks, ND 58202-9018

Dear John,

Bakken Midstream is pleased to provide our support for the Energy & Environmental Research Center's (EERC) pending effort focused on an evaluation of salt cavern storage opportunities in North Dakota. In addition to our financial support of the effort, we would agree to serve as advisors to the project as appropriate.

Bakken Midstream was formed to develop value-added natural gas infrastructure in North Dakota's vibrant Bakken play. Specifically, Bakken Midstream is highly interested in verifying the utility of subsurface cavern storage for NGLs, hydrogen and other product and intermediate process streams that would facilitate the realization of maximum value of North Dakota's abundant natural resource production. With respect to EERC's current proposal to NDIC, and subject to final documentation, Bakken Midstream would be willing to secure land options and surface rights, as well as subsurface rights (salt minerals, pore space), and act as the "Project Developer" as contemplated.

Bakken Midstream would absorb the costs and risks associated with the acquisition of these property rights, and provide access thereto in order to directly support the study. We anticipate the value of these contributions to be on the order of $500,000. Also, as mentioned above, Bakken Midstream and its advisors will work closely with EERC and its team of contractors as advisors and provide the required input to ensure the optimal storage location is identified with the highest degree of commercial viability in order to fully develop its planned project(s).

As always, please feel free to reach out directly if there is anything further that I might provide to facilitate the kickoff and execution of this timely study.

Sincerely,

Steve Lebow
Founder and Chairman

844.823.2664 | www.bakkenmidstream.com

P.O. Box 2035 117 W. Front Ave | Bismarck, North Dakota 58504

NESET

6844 Highway 40, Tioga, ND 58852 701-664-1492

May 26, 2021

Mr. Steven Smith
Energy & Environmental Research Center (EERC)
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202

Dear Mr. Smith:

NESET is pleased to partner with the Energy & Environmental Research Center to support the "Study to Determine the Feasibility of Developing Salt Caverns for Hydrocarbon Storage in Western North Dakota - Phase II". In the past 70 years it has been proven that the Williston Basin possesses a vast amount of energy potential. The petroleum resource of the Williston Basin continues to provide our society with energy needed to fuel our economy. We are honored to support and assist in the project in the following capacity.

NESET will work as a subcontractor to the EERC and serve as the General Contractor during the well drilling and core collection portion of the project. Activities will include planning and development of procedures with EERC, Gantt chart development, AFE development, competitive bidding process, vendor selection in conjunction with EERC, vendor management, development, and management of master service agreements (MSAs) with all vendors, payment to all vendors, daily activity reporting, daily cost reporting, and invoice development for EERC. The anticipated cost of these services is estimated to be $4,000,000.

NESET has successfully operated in the Williston Basin from its headquarters in Tioga, ND for 40 years providing a wide range of drilling, production, and geological services to over 170 oil and gas companies. Operating on as many as 99 rigs simultaneously during the height of the latest Bakken boom, NESET has successfully contributed to the completion of over 6,125 wells in the Williston Basin. NESET is well positioned to meet or exceed every requirement in this contract.

We wish the EERC the best of luck in this project and we support the important work being done in the Feasibility of Developing Salt Caverns Phase II - as outlined by Section 14 of Senate Bill 2014 of the Sixty-Seventh Legislative Assembly of North Dakota, as signed into law by Governor Burgum.

Sincerely,

Kathleen Neset

Kathleen Neset
President, Geologist

APPENDIX B

RESUMES OF KEY PERSONNEL

STEVEN A. SMITH
Principal Geologist, Integrated Analytical Solutions
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
701.777.5108 (phone), 701.777.5181 (fax), ssmith@undeerc.org

Principal Areas of Expertise
Mr. Smith's principal areas of interest and expertise are petroleum geology, CO_2 enhanced oil recovery (EOR), laboratory investigation of fluid flow in conventional and unconventional reservoirs, and geological sequestration of CO_2.

Qualifications
B.S., Geology, University of North Dakota, 2001.

Professional Experience
2018–Present: Principal Geologist, Integrated Analytical Solutions, EERC, UND. Mr. Smith's responsibilities include the development of new business opportunities related to laboratory- and field-based investigations of EOR, CO_2 storage, and resource assessment of unconventional oil plays. In addition, Mr. Smith is focused on research opportunities and methods development for core-scale rock characterization, fluid behavior, and organic petrology.

2010–2018: Senior Geologist, AGL Team Lead, EERC, UND. Mr. Smith worked with a multidisciplinary team collaborating on research activities devoted to furthering our understanding of the subsurface geological environment. He managed the Applied Geology Laboratory (AGL), which is actively pursuing research into the derivation of the physical properties of rocks and encompasses the disciplines of petrophysics, geochemistry, and geomechanics. The primary focus of the laboratory is the oil and gas industry and carbon capture and storage marketplace.

2004–2010: Research Scientist, EERC, UND. Mr. Smith's responsibilities included developing and implementing a work plan for acid gas monitoring, verification, and accounting (MVA) for the Zama acid gas disposal and enhanced oil recovery (EOR) project in Alberta; coordinating engineering, geological, geomechanical, and geochemical characterization activities for the Zama project; developing and maintaining a database of oil-bearing geologic reservoir characteristics as they pertain to CO_2 storage in the states and provinces of the Plains CO_2 Reduction (PCOR) Partnership region; evaluating saline aquifer systems and determining their potential for CO_2 sequestration; and developing estimates of the CO_2 storage capacity within oil-bearing and saline strata of the Williston, Alberta, Powder River, and Denver–Julesberg Basins. He also worked as a well site geologist in the Williston Basin.

2001–2003: Wellsite Geologist, Subcontractor, Baker, Montana. Mr. Smith's responsibilities included overseeing all of the oil company's interests, with respect to the geologic decisions on

location; preparing morning report and geologic strip logs to summarize well progression; directing interaction with oil company upper management; evaluating sample cuttings, gas, and drill times while project well was drilling; performing structural geologic correlation with offset wells; and working in close communication with directional driller and rig crew to maintain accuracy in completion of well.

1994: Staff Geologist Intern, R.E. Wight Associates, Inc., Middletown, Pennsylvania. Mr. Smith's responsibilities included system checks and operation at groundwater remediation sites, hazardous materials sampling and preparation, well purging, sampling, and recharge calculations.

Professional Membership
Society of Petroleum Engineers
Society of Organic Petrology

Publications and Presentations
Has coauthored several publications.

JAMES A. SORENSEN
Director for Subsurface R&D
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
701.777.5287 (phone), 701.777.5181 (fax), jsorensen@undeerc.org

Principal Areas of Expertise
Mr. Sorensen's primary areas of interest and expertise are enhanced oil recovery (EOR) in unconventional tight oil formations, CO_2 utilization and storage in geologic formations, and tight oil resource assessment and development.

Education
B.S., Geology, University of North Dakota, 1991.
Postgraduate course work in Geology and Hydrogeology, 1993–1995.

Professional Experience
October 2019–Present: Director of Subsurface R&D, EERC, UND. Mr. Sorensen is responsible for developing and managing programs and projects focused on conventional, unconventional, and enhanced oil and gas production; the geological storage of CO_2; geothermal; and other energy and environmental research.

July 2018–September 2019: Assistant Director for Subsurface Strategies, EERC, UND. Mr. Sorensen developed business opportunities, provided technical support and guidance regarding emerging areas of research, and served as a principal investigator and task manager for projects related to the sequestration of CO_2 in geologic media and the sustainable development of tight oil resources.

1999–July 2018: Principal Geologist, EERC, UND. Mr. Sorensen served as manager and co-principal investigator for programs to develop strategies for CO_2 utilization and storage. He also led research focused on enhanced oil recovery (EOR) in the Bakken.

1997–1999: Program Manager, EERC, UND. Mr. Sorensen managed projects focused on produced water management and environmental fate of natural gas-processing chemicals.

1993–1997: Geologist, EERC, UND. Mr. Sorensen conducted field-based hydrogeologic investigations focused on natural gas production sites.

1991–1993: Research Specialist, EERC, UND. Mr. Sorensen assembled and maintained comprehensive databases related to oil and gas drilling, production, and waste management.

Professional Memberships
Society of Petroleum Engineers

Publications and Presentations
Has coauthored nearly 200 publications.

BETHANY A. KURZ
Director of Analytical Solutions
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5050, Fax: (701) 777-5181, E-Mail: bkurz@undeerc.org

Principal Areas of Expertise

Ms. Kurz's principal areas of interest and technical expertise include carbon capture, utilization, and storage (CCUS); produced natural gas storage; enhanced oil recovery (EOR) in conventional and unconventional oil and gas reservoirs; application of machine learning and data analytics to CCUS and oil and gas development; produced water and drilling waste management; assessment of critical materials in coal and produced brine; and resource management related to energy development.

Qualifications

M.S., Hydrogeology, University of North Dakota, Grand Forks, ND, 1998.
B.S., Geochemistry, Bridgewater State University, Bridgewater, MA, 1995.

Professional Experience

May 2021–Present: Director of Analytical Solutions, EERC, UND. Ms. Kurz is responsible for developing business and research opportunities to address challenges in all areas of energy and natural resources development and management. She leads programs and projects related to CCUS; application of machine learning and artificial intelligence to CCUS and conventional and unconventional oil and gas development; EOR; produced water and drilling waste management; and critical materials resource assessments. Ms. Kurz also leads the EERC's research laboratories and a multidisciplinary team of scientists and engineers focused on addressing the needs of our partners and clients in areas related to energy development and management and environmental stewardship.

July 2018–April 2021: Assistant Director of Integrated Analytical Solutions, EERC, UND. Ms. Kurz was responsible for assisting the EERC's leadership team with developing business opportunities and successfully executing research projects related to oil and gas; natural resource management; and carbon capture, utilization, and storage. She oversaw a multidisciplinary team of scientists and engineers who work in the EERC's applied research laboratories. In that role, she was responsible for ensuring the quality assurance/quality control of data and results generated by the EERC's laboratories and integrating those results into the applied research efforts conducted by the Subsurface R&D team.

2011–July 2018: Principal Hydrogeologist, Laboratory Analysis Group Lead, EERC, UND. Ms. Kurz oversaw a multidisciplinary team of scientists and engineers and several of the EERC's analytical research laboratories that focus on classical and advanced wet-chemistry analyses; petrochemical, geochemical and geomechanical evaluation of rocks and soils; and advanced

characterization of various materials, including metals, alloys, catalysts, and corrosion and scale products. Her primary areas of interest included the evaluation of water supply sources for the oil and gas industry, produced water management, characterization of geologic media for carbon storage and development and testing of proppants for use in hydraulic fracturing.

2002–2011: Senior Research Manager, Water Management and Flood Mitigation Strategies, EERC, UND. Ms. Kurz's responsibilities included project management, technical report and proposal writing, public outreach, and the development of new research focus areas. Research activities included the evaluation of nontraditional water supply sources for municipal and industrial use, flood and drought mitigation, watershed-scale water quality assessments using hydrologic models, and public education and outreach on various water and energy issues.

1998–2002: Research Scientist, Subsurface Remediation Research, EERC, UND. Ms. Kurz's responsibilities included managing and conducting research involving remediation technologies for contaminated groundwater and soils, groundwater sampling and analysis, technical report writing, and proposal research and preparation.

Publications and Presentations

Has coauthored numerous professional publications and presentations.

JOHN A. HAMLING
Director of Subsurface Initiatives
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

Principal Areas of Expertise

Mr. Hamling has over 14 years of combined experience in unconventional oil and gas development, enhanced oil recovery (EOR), and carbon capture and storage (CCS). Mr. Hamling brings scientific and engineering innovation to catalyze and implement pioneering solutions that facilitate the prudent development and use of low-carbon and fossil energy. His primary focus is on advancing technologies and concepts that enable commercial application of geologic carbon storage, unconventional oil and gas production, and improved oil recovery (IOR) in conventional and unconventional oil plays.

Mr. Hamling led efforts resulting in the development, proof-of concept, and validation of several improved monitoring techniques applicable to both dedicated and associated geologic CO_2 storage and EOR applications. His experience extends to the design, implementation, and oversight of surface, near-surface, deep subsurface, and reservoir characterization and surveillance programs.

Mr. Hamling oversees a policy and regulatory team focused on CCS, gas storage, IOR/EOR, and unconventional oil and gas development, with extensive experience conducting risk assessments and developing monitoring, mitigation, and verification (MMV)/monitoring, reporting, and verification (MRV) programs compliant with the California Air Resources Board (CARB) Low Carbon Fuel Standard (LCFS) CCS Protocol, MRV plan provisions of the U.S. Environmental Protection Agency (EPA) greenhouse gas reporting (GHGR) rule Subpart RR compliant with the Internal Revenue Service (IRS) 45Q tax credit program, EPA underground injection control (UIC) Class II and Class VI programs, state/provincial regulatory programs, and emerging carbon markets/incentive programs.

Mr. Hamling serves as a project advisor for site screening, characterization, design, qualification, and permitting efforts for multiple commercial CCS projects ranging in scale from 150,000 to 10 million tonnes of CO_2 per year. He also serves as advisor for several unconventional tight oil EOR pilots. His experience includes well-logging principals and applications, well drilling, well completions, wellbore integrity, risk assessment, logistics, well stimulation and enhanced recovery in tight oil plays, and health, safety, and environmental (HSE) programs.

Mr. Hamling has served as project manager (PM), principal investigator (PI), and task lead for several multiyear, multimillion-dollar research and demonstration projects. He has led data analytics, operations, and reservoir surveillance groups at the EERC alongside several adaptive, multidisciplinary project teams. These activities encompass both contract research as well as

several strategic partnership programs between the state of North Dakota, the U.S. Department of Energy (DOE), and private industry designed to propel the development and implementation of approaches that benefit practical energy development. Mr. Hamling is an adjunct lecturer in the Department of Petroleum Engineering at UND and a board member for the Williston Basin Society of Petroleum Engineers since 2012. Prior to joining the EERC, Mr. Hamling worked as a Reservoir Evaluation Engineer with Schlumberger.

Qualifications

B.S., Mechanical Engineering, University of North Dakota, 2007.
Associate of Science, Associate of Arts, Williston State College, 2004.
Certified Engineer in Training (EIT)

Professional Experience

May 2021–Present: Director of Subsurface Initiatives, EERC, UND. In this role, Mr. Hamling brings scientific and engineering innovation to catalyze and implement pioneering solutions that facilitate the prudent development and use of low-carbon and fossil energy. His primary focus is on advancing technologies and concepts that enable commercial application of geologic carbon storage, unconventional oil and gas production and IOR in conventional and unconventional oil plays.

2018–April 2021: Assistant Director of Integrated Projects, EERC, UND. In this role, Mr. Hamling advanced innovation and technologies to enable commercial application of geologic carbon storage, unconventional oil and gas production, and IOR in both conventional and unconventional oil plays.

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

2012–2018: Principal Engineer, Oilfield Operations Group Lead, EERC, UND. Mr. Hamling served as PM, PI, and task lead for several multiyear, multimillion-dollar projects, where he led a multidisciplinary team of scientists and engineers working to develop and implement MVA concepts for large-scale (>1 million tons per year) CO_2 storage and EOR operations. He also worked with a multidisciplinary team in the development, design, and implementation of new approaches that benefit the economical exploration, development, and production of oil and gas.

2011–2012: Research Manager, EERC, UND. Mr. Hamling's responsibilities included managing characterization and monitoring research activities and operations for large-scale (>1 million tons per year) combined EOR and CO_2 storage projects for the Plains CO_2 Reduction (PCOR) Partnership. He also led various research activities related to oil and gas production, infrastructure, and development from unconventional reservoirs.

2009–2011: Research Engineer, EERC, UND. Mr. Hamling's focus was on the design and implementation of new approaches that benefit the exploration, development, and production of oil and gas and with the PCOR Partnership, where he evaluated the potential for CO_2 storage in geologic formations. Specific responsibilities included field operations design, deployment, and interpretation relating to oilfield technologies applicable to the CCS industry; laboratory functions relating to the Applied Geology Laboratory (AGL); data analysis; regulatory

compliance; and communication of operations between service providers, management teams, industry partners, and governmental organizations. Additional responsibilities included 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 the environmental footprint of drilling and production operations.

2007–2009: Reservoir Evaluation Engineer; HSE Representative; and Loss Prevention Team Leader, Reservoir Evaluation segment, Schlumberger Limited. Mr. Hamling was responsible for providing tailored geophysical solutions for specific and unique oilfield applications, executing basic and advanced reservoir evaluations utilizing real-time wellbore measurement technologies, reservoir pressure and fluid sampling, and interpretation of reservoir measurement data. In this role, Mr. Hamling designed and oversaw all aspects of openhole and cased-hole logging operations for over 300 wells in both conventional and unconventional oil and gas plays. He also served as an HSE officer, loss prevention team lead, and explosives and radiation safety officer for wellsite activities.

2004–2007: Student Research Scientist/Engineer, EERC, UND. Mr. Hamling was responsible for conducting research related to the development of new methods to join high-temperature, creep-resistant alloys and advanced processing and manufacture techniques for silicon carbide ceramic composites; materials testing in accordance with ASME (American Society of Mechanical Engineers), ASTM International, and ISO (International Organization for Standardization) standards; analyzing scanning electron microscopy micrographs; designing and fabricating composite micrometeorite shielding; and literature and patent review.

Professional Activities

Society of Petroleum Engineers International Williston Basin Section – have continuously served as a section officer and board member since 2012. Positions include Acting Chairperson, Vice-Chairperson, and Communications Chairperson.

Served as PCOR Partnership representative on the writing committee for two U.S. Department of Energy Regional Carbon Sequestration Partnership (RCSP) Program BPMs entitled *Best Practices for Monitoring, Verification, and Accounting of CO_2 Stored in Deep Geologic Formations – Version 3* and *Best Practices for Operating Carbon Storage Projects*.

Publications and Presentations

Has authored and coauthored numerous technical publications.

LONNY L. JACOBSON
Principal Operations Specialist and Oilfield Operations Team Lead
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
701.777.5331 (phone), 701.777.5181 (fax), ljacobson@undeerc.org

Principal Areas of Expertise

Mr. Jacobson's principal areas of interest and expertise include drilling and completion design; logging; coring; monitoring, verification, and accounting (MVA) plans; permit preparation for Class I, II, and VI wells; optimizing wellsite layout for well servicing/completions; hydraulic fracturing techniques; logistics; field implementation planning; site management; and economic cost–benefit analysis of projects.

Qualifications

B.A., Economics, University of North Dakota, 2007.
H_2S Certification, 2019; OSHA 10-hour Hazard Recognition Training, 2017; Well Control Training, Workover and Completion, 2015.

Professional Experience

January 2020 – Present: Principal Operations Specialist and Oilfield Operations Team Lead, EERC, UND. Mr. Jacobson's responsibilities include leading a team of scientists and engineers in the design and conduct of field activities for the EERC related to drilling, logging, coring, and completion. He also analyzes hydraulic fracturing practices and conducts oil and gas pipeline evaluations and inspections in conjunction with EERC oilfield projects. In addition, Mr. Jacobson performs economic evaluations (e.g., cost–benefit analysis) of projects.

August 2015–December 2019: Senior Operations Specialist and Oilfield Operations Team Lead, EERC, UND. Mr. Jacobson's responsibilities included designing and leading field activities for the EERC related to drilling, logging, coring, and completion. He also analyzed hydraulic fracturing practices and conducted oil and gas pipeline evaluations and inspections in conjunction with EERC oilfield projects. In addition, Mr. Jacobson he performed economic evaluations (e.g., cost–benefit analysis) of projects.

2007–2015: Operation Manager/Consultant, Bonetraill Rentals, LLC, Williston, North Dakota. Mr. Jacobson's responsibilities included hydraulic fracturing procedures, workover operations, completions, drilling operations, coil tubing, wireline, installation, independent third-party inspection of gas and production water pipelines, invoicing, daily reports, and overseeing other consultants for an oilfield service company that provides services to some of the largest oilfield operations in the Williston Basin region.

Mr. Jacobson took projects from concept through to production. He worked as a site manager for over 100 workover operations and has experience working in multiple formations, including the

Bakken/Three Forks, Midale, Spearfish, Dakota, Red River, and Mission Canyon. He also has experience in the completion of produced-water disposal wells in the state of North Dakota. Mr. Jacobson typically managed health, safety, and environment (HSE) during all operations, except in extreme sour/H_2S environments. Specific site management projects included the following:

- Site Manager, Sundance Energy, Inc., which included site acquisition; site management during site preparation, drilling, completion (hydraulic fracturing, drill outs/cleanouts), and flow testing; site facilities and equipment installation; daily reporting; and site restoration.

- Site Manager, Cornerstone Natural Resources, LLC, which included site management during completion (hydraulic fracturing, drillout/cleanouts), flow testing, site facilities and equipment installation, and daily reporting.

- Site Manager, Crescent Point Energy US Corporation, which included site management during completion (hydraulic fracturing, drillout/cleanouts), flow testing, and daily reporting.

Site management for these projects also included controlling site access, serving as first point of contact for on-site contractors performing work, coordinating on-site activities among all on-site contractors, scheduling equipment deliveries and services, participating in daily phone conferences, ensuring maintenance/snow removal of pad and access roads, arranging fueling services, managing on-site analysis of fluids, arranging and managing off-site analysis of fluids, and scheduling and supervising water hauling and proper disposal of fluids. Mr. Jacobson was in charge of all scheduling and work performed on-site during well activities, ensuring all testing/ work did not impact/damage the formation or future testing procedures.

2010–2011: Shop Supervisor, R&M Energy Systems, Oklahoma City, Oklahoma. Mr. Jacobson's responsibilities included manufacturing of sucker rod guides, overseeing a small work staff, maintenance of machinery, inventory, orders from different companies, and quality control procedures. Maintained the second-best profit margin in the company within the first year of operations.

2006–2006: Consultant, Bonetraill Rentals, LLC, Williston, North Dakota. Mr. Jacobson's responsibilities included hydraulic fracturing procedures, workover operations, drilling operations, daily reports, and invoicing.

Publications and Presentations

Has coauthored several technical publications.

JOSHUA R. STREGE
Assistant Director of Energy Systems
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5080, Fax: (701) 777-5181, E-Mail: jstrege@undeerc.org

Principal Areas of Expertise

Mr. Strege's principal areas of interest and expertise include biomass and fossil fuel conversion for energy production, with an emphasis on CO_2 capture and storage in power generation and in industrial applications. He is certified in Aspen Plus and Aspen HYSYS and is proficient in process modeling and techno-economic assessments. He also has significant experience in the design, fabrication, and operation of bench- and pilot-scale equipment for combustion, gasification, synthetic and renewable fuel production, and CO_2 capture.

Qualifications

M.S., Chemical Engineering, University of North Dakota, 2005. Thesis: High-Temperature Corrosion of Potential Heat Exchange Alloys under Simulated Coal Combustion Conditions.

B.S., Chemical Engineering, University of North Dakota, 2005.

Training: Project Management training through PM College, Six-Sigma Green Belt, and Design Flow Technology (DFT).

Skills: Microsoft Office suite (Excel, MS Project, Word, and Access) and advanced VBA macro programming and SQL server integration; CAD design and engineering drawing creation (PTC Creo Parametric).

Certifications: Aspen Plus- and Aspen HYSYS-certified.

Professional Experience

May 2021–Present: Assistant Director of Energy Systems, EERC, UND. Mr. Strege leads a multidisciplinary team of engineers and scientists in evaluating and demonstrating energy processes from the initial modeling phase through physical testing at the bench, pilot, and demonstration scales. Specific areas of interest include CO_2 capture and transport, process modeling and techno-economic analysis, gasification and combustion technology development and demonstration, and other energy conversion technologies. Current research activities are focused on low-carbon-intensity power cycles for fossil fuel- and biomass-fired systems.

October 2019–April 2021: Principal Process Engineer, Energy Systems Development, EERC, UND. Mr. Strege led the process engineering team in process modeling and techno-economic analysis efforts across applied research projects encompassing CO_2 capture and transport, advanced power cycle technology development, and other energy conversion technologies.

2013–September 2019: Project Manager and Senior Engineer, Cirrus Aircraft. Mr. Strege's responsibilities as Project Manager included building an 80-member team to develop and manufacture composite products for small aircraft under contract with an outside client. As

Senior Engineer, he led a team of engineers and technicians responsible for reducing waste, implementing root cause and corrective actions on product defects and downstream issues, and developing and implementing software solutions for improved tracking and accountability across all departments.

2005–2013: Research Engineer, EERC, UND. Mr. Strege participated in and managed several multiyear, multiclient projects aimed at researching and developing alternative energy and fuel sources. Specific projects included hydrotreating of waste vegetable oils for conversion to drop-in-compatible JP-8 jet fuel, assessing the feasibility of modern warm-gas cleanup technologies for liquid fuel synthesis via the Fischer–Tropsch process, and design and testing of cold-gas cleanup reactors for syngas. He also participated in pilot-scale studies comparing the postcombustion CO_2 capture efficiency of a variety of proprietary and conventional amine-based solvents.

2000–2005: Student Research Assistant, EERC, UND. Mr. Strege's responsibilities included design and development of instrument control software. In addition, he studied corrosion rates and mechanisms of high-temperature alloys as part of his master's research.

Publications and Presentations

Has authored and coauthored numerous professional publications and presentations.

CHAD A. WOCKEN
Assistant Director for Clean Energy Solutions
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
701.777.5273 (phone), 701.777.5181 (fax), cwocken@undeerc.org

Principal Areas of Expertise

Mr. Wocken's principal areas of research include developing alternative fuel and chemical processes and innovative energy technologies. Currently, he leads projects focused on developing and advancing alternative chemical and fuel production processes at the bench, lab, and pilot scale and optimizing processes associated with oil and gas production and midstream operations. In addition, Mr. Wocken manages a group of researchers and a lab facility containing batch and continuous reactor systems capable of testing a variety of thermochemical processes.

Qualifications

B.S., Chemical Engineering, University of North Dakota, 1994

Professional Experience

2001–Present: EERC, UND.

Assistant Director for Clean Energy Solutions (September 2019–Present). Mr. Wocken leads a multidisciplinary team of engineers and scientists focused on applying scientific principles to address the challenges to energy production. His team's applied research activities include process modeling; engineering studies; and technology evaluation and development at the bench, pilot, and demonstration scale. Mr. Wocken has over 25 years of experience spanning work in oil and gas production, fuel processing, electricity generation, emission control, environmental remediation, and process engineering. Drawing on his engineering training and diverse experience, he enjoys defining problems and developing innovative solutions to promote clean energy solutions.

Principal Engineer, Transformational Energy Group Lead (2015–August 2019); Senior Research Manager (2009–2015); Research Engineer (2001–2009).

<u>Project/Program Management</u>

- Developed a new research program and managed the design and fabrication of a facility to test and evaluate solid-oxide fuel cells with a variety of gaseous fuels including actual syngas produced from the EERC's pilot-scale gasification systems.
- Led a process-modeling team within the EERC's Bakken Production Optimization Program, focused on applying computational modeling expertise to crude oil production processes and addressing emission reduction and gas flaring while also reducing crude oil volatility.

- Directed the EERC's associated gas-flaring mitigation activities, aiding industry partners in their efforts to identify technologies to reduce flaring. These efforts led to the creation of the Flaring Solutions Database, a clearinghouse of business and technology solutions that have the potential to utilize gas at the wellhead and reduce flaring.
- Managed a Defense Advanced Research Projects Agency (DARPA)-funded project that successfully developed technology to produce drop-in-compatible jet fuel for the military from renewable feedstock. Activities included planning work activities, developing and executing a risk-based project management plan, coordinating activities of five project partners to meet project goals, and communicating with the DARPA project manager.
- Managed the scale-up and design of a 300-barrel/day renewable fuel pilot plant capable of producing specification-compliant jet and diesel fuels from renewable oil feedstock.

Technology Development and Research

- Designed and executed an oil and gas gathering pipeline leak detection demonstration project, resulting in tangible performance improvements for three pipeline operators.
- Conducted a technical and economic assessment of alternative uses for associated gas in an effort to reduce the amount of gas being flared in the Williston Basin. Technologies evaluated included gas-processing operations to recover natural gas liquids, gas-fired power generation, transportation fuel, and traditional petrochemical unit operations.
- Performed a system-level engineering evaluation of integrated algae production at a coal-fired power plant to assess carbon uptake, emission control requirements, relative scale, and the viability of water and waste heat utilization.
- Designed, fabricated, and operated several fixed-catalyst bed reactor systems to evaluate a variety of thermocatalytic processes to produce renewable fuels and chemicals.
- Conducted testing at coal-fired power plants, and developed control technologies to reduce atmospheric emission of particulate matter, mercury, and other contaminants.

1995–2001: Project Engineer, URS/Radian International, Salt Lake City, Utah (1997–2001), and Milwaukee, Wisconsin (1995–1997).

Process Design, Operation, and Optimization

- Designed remediation systems to remove BTEX compounds and chlorinated solvents from groundwater. Project tasks included site evaluation, technology selection, system design, and creation of specifications.
- Performed start-up and long-term operations of groundwater remediation systems. Responsibilities included troubleshooting equipment/system malfunctions, process optimization, writing operations and maintenance manuals, establishing performance verification criteria, defining operational cost, and directing technicians' work.
- Conducted detailed reviews of industrial wastewater treatment systems to identify alternative treatment technologies, process optimizations, and water reuse alternatives.

Construction Oversight

- Provided on-site oversight for several construction projects consisting of mechanical equipment installation, instrumentation and process control, building and road construction, excavation, and underground utility installation. Daily responsibilities included evaluating work for conformance with construction drawings and specifications; coordinating work activities; and facilitating communication between the design firm, client, and contractors.

Project Management

- Served as project manager for several large projects that were completed successfully. Activities included developing cost proposals, managing budget and schedule, equipment and subcontractor acquisition, and maintaining effective communication with the client.

1994–1995: Process Engineer, Archer Daniels Midland, Clinton, Iowa.

Plant Operation

- Supervised operations and personnel at a wet corn mill oil extraction and refining plant. Tasks consisted of prioritizing work activities, scheduling maintenance of process equipment, monitoring product quality, and extensive system troubleshooting and failure analysis.

Publications and Presentations

Has authored or coauthored numerous publications.

DR. VAMEGH RASOULI
Department Chair, Continental Resources Distinguished Professor
Department of Petroleum Engineering, University of North Dakota (UND)
Collaborative Energy Complex, Room 113K, Grand Forks, North Dakota 58202-6116 USA
701.777.2131 (phone), 701.335.3601 (cell), vamegh.rasouli@und.edu

Professional Timeline (all-inclusive 18 years old to present, in reverse chronological order)

July 2017–Present: Director, Jodsaas Centre for Leadership and Entrepreneurship, College of Engineering & Mines, UND. Responsibilities include offering different activities for nearly 3,000 Engineering students in the College to learn set up and run small business, practice teamwork and leadership skills and do collaborative projects within the College and other Schools in cluing the business School.

March 2015–Present: Department Chair, Continental Resources Distinguished Professor, Department of Petroleum Engineering, UND. In addition to teaching courses at undergrad and grad level and advising grad students and doing research project, the Chair responsibilities include quality assessment of the program, ABET accreditation coordination, hiring faculty, staff and grad students, fundraising and securing scholarship, engage the industry advisory council to support the department, attract industry and research fund, increase enrolment and retention for both undergrad and grad programs, expand on existing teaching and research labs and add new labs and manage all financial aspects of the department. Overall budget management including all the external fund change from $5M-$10M per annum. Total student numbers of nearly 250 in the department and 12 faculty and staff plus over 15 visiting scholars and researchers are working in the department on average on an annual basis.

January–February 2015: Perth, Australia. Preparing for move to the USA to join my new job appointment at UND as the Chair of Petroleum Engineering program.

August 2012–Present: Part-Time Instructor, Schlumberger's Network of Excellence Training (NExT) Program. The courses delivered face to face and online. Delivering industry short courses for international oil and gas companies worldwide.

July 2008–July 2010: Part-Time Consulting Engineer, Schlumberger Oil and Gas Service Company, Perth, Australia. Conducted several industry projects related to oil and gas drilling and Geomechanics.

August 2006–December 2014: Senior Lecturer, Associate and Full Professor (Acting Head and Head of Department), Department of Petroleum Engineering, Curtin University, Perth, Australia. Similar responsibilities to my current position at UND in terms of teaching and research and duties as the department Chair. Total number of students 500, faculty and staff and visitors 20 in the department.

November 2004–August 2006: Part-Time Consulting Engineer, Schlumberger Oil and Gas Service Company, Tehran, Iran. Conducted several industry projects related to oil and gas drilling and Geomechanics.

February 2003–August 2006: Assistant Professor, Acting Head of Department, Amirkabir University, Tehran, Iran. In addition to teaching undergrad and grad level courses to Mining, Chemical and Petroleum Engineering students, I was appointed as the Deputy of the newly established Petroleum Engineering Department to build the Undergraduate and graduate program, raise fund to build a new building and labs, and other responsibilities similar to my current Chair position at UND. Total number of students 300, faculty and staff 40 in the department.

September 2002–January 2003: Traveled from United Kingdom to Tehran, Iran, after completing Ph.D. and settling down before commencing new job.
January 2000–August 2002: Ph.D. Candidate, Imperial College, University of London, London, United Kingdom.
March 1997–December 1999: Preparation for overseas Ph.D. exam competition and move to United Kingdom, Tehran, Iran.
September 1995–February 1997: M.Sc. Candidate, Engineering Rock Mechanics, Tehran Polytechnic University, Tehran, Iran.
September 1991–August 1995: B.Sc. Candidate, Mining Engineering, Yazd University, Yazd, Iran.
July 1990–September 1991: Preparation for university entrance exam, Tehran, Iran.

Qualifications
Ph.D., Imperial College, University of London, London, United Kingdom, 2002.
M.Sc., Engineering Rock Mechanics, Tehran Polytechnic University, Tehran, Iran, 1997.
B.Sc., Mining Engineering, Yazd University, Yazd, Iran, 1995.

Professional Experience
July 2017–Present: Director, Jodsaas Centre for Leadership and Entrepreneurship, College of Engineering & Mines, UND.
March 2015–Present: Department Chair, Continental Resources Distinguished Professor, Department of Petroleum Engineering, UND.
August 2012–Present: Instructor, Schlumberger's Network of Excellence Training (NExT) Program.
July 2008–July 2010: Part-Time Consulting Engineer, Schlumberger Oil and Gas Service Company, Perth, Australia.
August 2006–December 2014: Senior Lecturer, Associate and Full Professor (Acting Head and Head of Department), Department of Petroleum Engineering, Curtin University, Perth, Australia.
November 2004–August 2006: Part-Time Consulting Engineer, Schlumberger Oil and Gas Service Company, Tehran, Iran.
February 2003–August 2006: Assistant Professor, Acting Head of Department, Amirkabir University, Tehran, Iran.

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 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 Code of Federal Regulations (CFR) 200.

Escalation of labor and EERC recharge center rates is 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 includes fieldwork, project review meetings, presentations at technical conferences and core review with Core Labs. 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: There are three pieces of equipment to be purchased for this project. Two Hassler type core holders valued at $9,800 each for core plug analysis. Also, a fluid transfer vessel valued at $6,500 will be purchased for core plug analysis.

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. For this project specifically, the budget reflects 3 laptops and a high-end modeling workstation; each with the value under $5,000, therefore will be considered minor equipment.

Subcontract – Neset Consulting: A contract will be executed with Neset Consulting to serve as the general contractor during the well-drilling and core collection portion of the project. Activities will include planning and development of procedures with the EERC, Gantt chart development, authority for expenditures (AFE) development, competitive bidding process, vendor selection in conjunction with the EERC, vendor management, development, and management of master service agreements (MSAs) with all vendors, payment to all vendors, daily activity reporting, daily cost reporting, and invoice development for the EERC. The anticipated cost of these services is estimated to be $4,000,000.

Consultant – Engineering Design Advisement (TBD): A contract will be executed with a to-be-determined engineering design advisement firm to advise on the geologic characterization, well design, well testing, and development of embedded salt formations. Cost is estimated based on past experience.

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: Not applicable.

Professional Development: Not applicable.

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, Web site 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 Web sites 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.

UND Department of Petroleum Engineering – Triaxial testing is a fee at the Petroleum Engineering lab to run triaxial testing on an estimated 40 samples at 12 hours per sample at $140 per hour.

Outside labs – Core Labs will conduct core processing and laboratory testing of core samples.

Outside labs – Wagner Petrographic will prepare thin-section samples.

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.

In-Kind Cost Share – Project partner, Bakken Midstream, will provide in-kind cost share in the form of property right acquisition and provide access thereto in order to directly support the study. The value of these contributions is estimated to be $500,000.