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June 9, 2016

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

Dear Ms. Fine:

Subject: EERC Proposal No. 2016-0143 Entitled "Integrated Carbon Capture and Storage for North Dakota Ethanol Production"

The Energy & Environmental Research Center (EERC) of the University of North Dakota (UND) in partnership with Red Trail Energy (RTE) is pleased to submit an original and one copy of the subject proposal. Also enclosed is the $100 application fee.

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 and RTE are 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
Senior Chemical Engineer
Oilfield Operations Team Lead

Approved by:

Thomas A. Erickson, CEO
Energy & Environmental Research Center

KML/kal

Enclosures

Renewable Energy Program

North Dakota Industrial Commission

Lead Organization: EERC Energy & Environmental Research Center®

Cost-Share Partners: Red Trail Energy LLC, Richardton, ND; Department of Energy, United States of America

Other Project Partners:

Trimeric Corporation

The CETER Group

CMG

Schlumberger Carbon Services

Application

Project Title: 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: June 9, 2016

Amount of Request: $490,000

Total Amount of Proposed Project: $980,000

Duration of Project: 6 months

Point of Contact (POC): Kerryanne M. Leroux

POC Telephone: (701) 777-5013

POC Email: kleroux@undeerc.org

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Grand Forks, ND 58202-9018

TABLE OF CONTENTS

ABSTRACT

The Energy & Environmental Research Center (EERC) and North Dakota (ND) ethanol producer Red Trail Energy (RTE) propose to conduct a feasibility study for integrating carbon capture and storage (CCS) of CO_2 emissions from a ND ethanol facility to reduce net CO_2 emissions associated with ethanol production. Using CCS to reduce the carbon footprint of ethanol production in ND will demonstrate the commitment of the ethanol industry to environmental stewardship as well as contribute to the long-term sustainability of ethanol production in the state. CCS may be an economical option for reducing carbon emissions to qualify for market credits by meeting low-carbon fuel programs in other states and/or tax credits from federal incentives. ND is well-situated to benefit from these incentives because it has both significant ethanol production capacity and geology ideally suited for carbon storage. An evaluation of CCS implementation will provide the ND ethanol industry with actionable data to assess the commercial viability of CCS in promoting ND renewable energy production. The proposed study will determine the technical and economic parameters of a commercial CCS effort associated with RTE's ethanol-manufacturing facility near Richardton, ND. It will provide insight into the technical challenges facing the commercial deployment of CCS at ND ethanol facilities and provide a template for implementation within the state. The work will also provide ND ethanol producers with a quantitative assessment of the economic impact of integrating commercial CCS technologies with their production operations.

Objective: To assess the technical and economic feasibility of expanding the marketability of ND ethanol through the commercial application of CCS. **Expected Results:** A technical and economic analysis of integrating CCS into ND ethanol production to achieve a competitive advantage in the marketplace by producing a reduced-carbon ethanol that capitalizes on low-carbon fuel programs and tax incentives. **Duration:** 6 months. **Total Project Cost:** $980,000. **Participants:** EERC, RTE, Trimeric Corporation (Trimeric), Schlumberger Carbon Services (Schlumberger), Computer Modelling Group (CMG), The CETER Group (CETER), and the U.S. Department of Energy (DOE).

PROJECT DESCRIPTION

Objectives: The goal of the proposed project is to determine the technical and economic feasibility of implementing commercial CCS at a ND ethanol production facility and proximate geologic injection site. Validation of the use of CCS to reduce the carbon footprint of ND ethanol production will allow producers to maintain current production rates and/or expand existing markets by meeting potential future greenhouse gas (GHG) emission regulations and low-carbon fuel programs. Specific objectives are to 1) assess the technical feasibility of carbon capture at a ND ethanol facility and subsequent geologic CO_2 storage at a proximate site; 2) develop a field implementation plan (FIP) determining the design and implementation steps needed to install a CCS system; and 3) evaluate the economic feasibility of CCS deployment, including installation and operating costs as well as potential revenue from low-carbon fuel markets and/or tax incentives to assess the benefits to ND ethanol producers.

Methodology: The RTE ethanol facility, located near Richardton, ND, produces approximately 63 MMgal of ethanol and 180,000 tons of CO_2 annually from the fermentation process. The Broom Creek Formation will be the target injection horizon for potential CO_2 geologic storage located approximately 6400 ft below the RTE facility. The Broom Creek and the overlying shales and salts of the Opeche, Piper, and Swift Formations are expected to make an ideal storage complex (1, 2). The following proposed scope of work addresses the stated objectives using the RTE site as an optimal case study location.

Task 1.0 – Feasibility Study. A feasibility study will be conducted to evaluate the potential for commercial CO_2 storage at the site of the RTE ethanol production facility.

Subtask 1.1 – CO_2 Capture. The criteria needed to design a CO_2 capture system for emissions generated at the RTE facility will be determined using site-specific ethanol production data. Commercially available technologies/systems for CO_2 capture that meet the design criteria will be assessed, and a recommendation will be made as to the most appropriate.

Subtask 1.2 – Site Characterization. Existing relevant geologic, geographic, and process characterization data for both the surface and subsurface environment in the vicinity of the RTE ethanol facility will be collected, evaluated, and used as the basis for site assessment and storage design. Types of data that may be evaluated include existing geologic well log data, seismic data, prior regional geologic evaluations, surface land use, presence of waterways, site access, and site-specific operational parameters, such as the consistency of CO_2 production.

Subtask 1.3 – Geologic Modeling and Simulation. The derived geologic site characterization data will be integrated into a geologic model that accounts for the properties of the storage complex, which comprises the injection horizon(s) and overlying sealing formation(s) that serve as barriers to prevent out-of-zone migration. The geologic model will also provide the foundation for dynamic simulations of potential injection scenarios. Dynamic simulations are required to predict how CO_2 would be distributed in the storage complex and the effectiveness of the sealing formation at the site during the CCS life cycle. Simulation results will provide key design and operational parameters for 1) the injection well and infrastructure; 2) a technical risk assessment; 3) area of review (AOR) determination; 4) a monitoring, verification, and accounting (MVA) plan; and 5) installation expenditures.

Subtask 1.4 – Risk Assessment. Project risks, as they relate to various aspects of the project (e.g., technical risks, etc.), will be identified, evaluated, and quantified. A preliminary, qualitative assessment will be performed at project start to identify potential risks that could threaten the success of the project. This initial assessment will guide the collection of data during the project, which will then be used to perform a quantitative assessment toward the conclusion of the project. The results of this quantitative assessment will be used to identify any potential risks requiring mitigation, which will provide the basis for incorporating appropriate risk mitigation strategies, if necessary, into the final FIP.

Subtask 1.5 – Life Cycle Analysis (LCA). California's Low Carbon Fuel Standard (LCFS) targets fuels that demonstrate a lower "carbon intensity value" (determined via LCA) than standard fuels (including ethanol),

with incentives through the LCFS Credit Market. Proof of lower carbon footprint may also provide access to market incentives under federal tax credits (e.g., 26 U.S. Code § 45Q). Therefore, an evaluation will be performed for the RTE site to estimate the carbon intensity of its ethanol with CCS implementation. This includes accounting for emissions from all aspects of ethanol production, distribution, and end use. The LCA will also incorporate generated CO_2 injection predictions prior to actual field implementation.

Task 2.0 – FIP*.* The FIP will describe the steps necessary to design and install infrastructure for the capture and secure storage of CO_2 at the RTE site.

Subtask 2.1 – Plant Infrastructure Design. The conceptual design of the aboveground infrastructure needed for capturing, dehydrating, and compressing the CO_2 stream generated at the RTE ethanol facility will include an evaluation of commercially available technologies and applicable methods, including major equipment and approximate sizing. The conceptual design of a pipeline to transport the purified, compressed CO_2 to the injection wellhead of the geologic storage site will also be performed.

Subtask 2.2 – Permitting Plan. Relevant ND and U.S. Environmental Protection Agency (EPA) requirements associated with the capture, injection, and storage of anthropogenic CO_2 will be identified for the CCS effort at the RTE site. A review of CA state regulations related to the LCFS will also be included. This information will influence designs for the injection well, infrastructure, and facilities to ensure compliance with applicable ND and federal regulatory requirements. Finally, a plan to acquire the necessary permits, including expected time lines, will be developed.

Subtask 2.3 – MVA Plan. An MVA plan will be developed that delineates the steps necessary to monitor, verify, and account for the secure injection and long-term containment of CO_2 in accordance with the requirements of appropriate ND and federal regulatory bodies, including EPA Class VI underground injection control (UIC) regulations. Any MVA requirements needed to specifically meet the LCFS program will also be included. MVA planning is also a critical component for the assignment/acquisition of potential credits that may be associated with a CCS effort.

Subtask 2.4 – Well Design. A conceptual design will be completed for the drilling and completion of an injection well at the RTE location that meets all relevant regulations and provides sufficient capacity for estimated CO_2 injection volumes. Approximate time lines will also be determined, and appropriate vendors will be identified for a turnkey solution to install and prepare a well for CO_2 injection.

Subtask 2.5 – Well Characterization and Testing Design. A conceptual design will be completed for characterizing and testing the injection well to address any regulator and other stakeholder requirements. These data can define MVA needs and improve CO_2 storage performance forecasts. Characterization and testing, required for the approval of any CCS and/or certification of associated credits, include collecting data related to the storage capacity of the chosen formation, determining the competency of the sealing formation to prevent out-of-zone migration, defining injection performance, and inspecting the mechanical integrity wellbore. A plan will thus be developed for geologic core collection, downhole wellbore geophysical testing, and laboratory testing of both rock and fluid samples.

Task 3.0 – Economic Analysis*.* A preliminary economic assessment will be performed to quantify the costs and benefits of combining commercial CCS with ethanol production at the RTE site. Potential revenue will be estimated based on the carbon intensity value determined by the LCA and its applicability for LCFS incentives. Other CO_2 potential revenue markets will also be considered (e.g., CO_2 enhanced oil recovery [EOR] opportunities, food and beverage industry). Estimated costs for permitting, equipment and infrastructure, installation, well characterization and testing, and operations (including MVA activities) will be determined based on the FIP conceptual designs. These costs will be compared to the potential revenue to evaluate the economic benefit of applying CCS to RTE ethanol production.

Task 4.0 – Management and Reporting*.* This task includes managing project activities and ensuring coordination and planning of the project with participants and sponsors (see the Management section for more detail). A final comprehensive report will be prepared to include the results of the feasibility study, details of the FIP, and outcomes of the economic analysis.

Anticipated Results: The overall result of this project is an evaluation of the viability of commercial CCS combined with ethanol production in ND. This will include a FIP for installing a CCS system at a ND ethanol facility and the potential economic benefits of programs such as LCFS and/or other CO_2 markets with regard to the ND ethanol industry. This study will advance the use of the significant geologic CO_2 storage resources in ND by the ethanol industry to take strategic advantage of low-carbon fuel programs, respond to new GHG emission reduction requirements, improve the sustainability of the industry, and potentially expand the ND ethanol market.

Facilities and Resources: The majority of work will be performed at the EERC in Grand Forks, ND. For nearly 70 years, the EERC has conducted research, testing, and evaluation of fossil and renewable fuels, emission control technologies, and CCS technologies. The engineering and scientific research staff is equipped with state-of-the-art analytical, modeling, and engineering facilities to address a wide variety of energy, environmental, and mineral resource research topics. The EERC is committed to providing all necessary personnel and resources to effectively carry out the activities outlined in this proposal.

The EERC led the Partnership for CO_2 Capture (PCO_2C) for the last 8 years, a partnership with DOE and over 25 industry partners to test and compare capture technologies using the EERC's pilot-scale carbon capture systems, and continues to perform CO_2 capture research for various clients (3–7). The EERC, therefore, has the data, resources, knowledge, and expertise to facilitate integration of a conceptual CCS system design into a facility to derive optimal economic and environmental benefit.

In addition, the EERC leads the Plains CO_2 Reduction (PCOR) Partnership, one of seven Regional Carbon Sequestration Partnerships (RCSPs) managed by DOE's National Energy Technology Laboratory (NETL), which includes over 100 partners developing and demonstrating technologies for geologic CO_2 storage (8–14). The EERC has extensive experience conducting geologic modeling and simulation for several completed and two ongoing storage demonstration projects (9, 15–22). The project team also has high proficiency with industry-standard geologic modeling and simulation software and database

capabilities for managing data that will be collected and generated during the project. These resources, which have been refined through decades of industry experience and research, will be used to conduct the characterization, geologic modeling, and simulation activities of the proposed tasks.

Techniques to Be Used, Their Availability, and Capability: Since 2003, the EERC has conducted extensive regional characterization of the Williston Basin for CO_2 storage (1, 2, 23–28). Site characterization activities specific to the RTE location will be completed using existing data (e.g., well logs, water quality reports, geologic reports and interpretations, structural interpretations, and core analysis), largely available from the state of ND. A host of commercially available CCS monitoring techniques have also been validated under the RCSP Program (29, 30); these technologies will be evaluated in the context of anticipated site design to best meet the requirements set forth by ND and federal regulations.

Project partner Trimeric will draw on nearly a decade of experience as process engineering lead for the Midwest Geological Sequestration Consortium RCSP demonstration project to develop a process design basis for a potential capture system at the RTE facility. Trimeric will also use industry-standard process simulation tools to develop a model for the CO_2 compression and purification process. The model will produce a material and energy balance at the design condition(s). Trimeric will then employ developed cost estimation methods for a budgetary (±30%) cost estimate of the capture, compression, and dehydration facilities. Trimeric holds an extensive in-house data set containing actual costs for various commercial capture system components that can be utilized for the proposed project.

The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model was developed by the Argonne National Laboratory and is the backbone for approved calculation of a fuel's carbon intensity value for the LCFS Program (31–33). The EERC and CETER have experience using the GREET model, as well as an Excel-based LCA model developed by CETER, to estimate CO_2 emissions for high-level fuel carbon intensity and carbon footprint determination (34). These tools will be available to the project team and used for optimum LCA results.

Environmental and Economic Impacts While Project Is Under Way: The proposed work is a paper study that will not pose any environmental or economic impacts to the study area or partner facilities. The EERC and/or other project partners plan to visit the RTE site to examine existing facilities and collect data required for simulation of the CO_2 capture process.

Ultimate Technological and Economic Impacts: The information generated by the proposed project will provide ND ethanol producers, such as RTE, with the knowledge necessary to appropriately respond to evolving GHG emission requirements and new low-carbon programs, such as the LCFS or federal 45Q tax credits. This will help position the ND ethanol industry as a national leader in developing reduced-carbon ethanol and provide strategic advantage over other states. In addition, ND ethanol producers will gain an understanding of the steps necessary to design, permit, and install a CCS system.

Why the Project Is Needed: Federal and state regulations are being developed for GHG emissions, offering incentives for fuels with reduced carbon intensity. ND is well positioned to respond to these changing market forces and regulations as it has both an established ethanol industry and ideal geology in the western half of the state for CO_2 storage on a commercial scale. However, detailed information to date of ND CCS capabilities, including the costs of such efforts, has been limited to the lignite-powered energy and oil industries. This project seeks to bring the EERC's experience with designing and implementing CCS together with a ND ethanol producer to close this knowledge gap for the entire ND ethanol industry on the potential economic benefits of CCS integration.

STANDARDS OF SUCCESS

This project will result in a comprehensive final report consisting of the technical and economic feasibility of CCS associated with a ND ethanol facility, including a LCA and FIP for permitting, designing, and installing a CCS system in ND. The generated report will provide ND ethanol producers with knowledge of 1) the CCS process as it applies to ethanol production and 2) the potential economics of

incorporating this business model into existing facilities with on-site geologic storage potential. These deliverables will also advance the state of knowledge of CCS in general for ND.

The ND renewable energy and agriculture industries will both directly benefit from the results of this study. If ND can produce a lower-carbon-intensity ethanol by implementing CCS at production facilities, industry in the state may be able to take advantage of sizable market incentives being developed in other states such as CA. While ethanol production is commonplace in the Great Plains, the geology of western ND is an ideal location for storing commercial volumes of anthropogenic CO_2, potentially allowing ND ethanol producers an advantage over ethanol producers in other states. This could incentivize the growth of biofuel production in western ND and, thus, agricultural feedstocks throughout the state as well as create new jobs for short-term construction and installation and for long-term implementation, operations, and maintenance of CCS installations.

BACKGROUND/QUALIFICATIONS

The EERC is home to the PCOR Partnership Program, the PCO_2C Program, and the National Alternative Fuels Center® (NAFC®). Through the PCOR Partnership, the EERC has proven expertise regarding geological characterization, reservoir simulation, risk assessment, MVA, LCA, and FIP development (8, 9, 15, 35–40), as well as significant experience conducting site characterization activities related to CCS (1, 2, 23–28). The EERC has also designed, drilled, and completed over one dozen wells for characterization and monitoring of CCS validation and demonstration projects, including all aspects of permitting. Through the PCO_2C Program and continuing research, the EERC objectively tests and compares CO_2 capture technologies at a pilot scale. With over 3600 hours of testing capture technologies, the EERC's capture and infrastructure engineering team is experienced and knowledgeable of the requirements for capture system design. NAFC improves production processes for ethanol and biodiesel from traditional and lower-value feedstocks, improves performance and emissions of ethanol- and biodiesel-blended gasoline and diesel fuels, and identifies fuel use effects on health and the environment. The EERC has

thus, established a strong network of technical expertise to advance alternative fuels production, blending, demonstration, and economic assessment.

Project partners include RTE, Trimeric, Schlumberger, CMG, and CETER. RTE is a ND-based investor group that operates the Richardton corn-based ethanol production facility, the proposed project study site. Trimeric has extensive experience with designing and implementing CO_2 capture, dehydration, and compression systems for a variety of industrial applications, including ethanol production as well as expertise in the use of process simulation tools to design systems for handling supercritical CO_2 (41). Schlumberger has more than 80 years of experience drilling, mapping, measuring, and modeling underground rock formations. CMG has developed GEM, an industry-standard reservoir simulation software package, which will be used to assess the RTE site. CETER specializes in statistical data analysis and environmental liability and has worked closely with the EERC through the PCOR Partnership on technical risk management associated with geologic CO_2 storage and LCA of CO_2 EOR operations.

Personnel: Ms. Kerryanne Leroux, EERC Senior Chemical Engineer, Oilfield Operations Team Lead, will serve as principal investigator (PI). Ms. Leroux currently leads a team of scientists and engineers implementing and evaluating MVA concepts for large-scale (>1 million tons per year) CO_2 storage and EOR operations as part of the PCOR Partnership Bell Creek project. Ms. Leroux has provided technical support for near-surface and downhole MVA as well as CO_2 capture technologies, transportation, and trading and commercial markets. Ms. Leroux has also participated in several research projects focused on coal, natural gas, petroleum, biomass, energy storage, biorefineries, biodiesel, ethanol, and butanol. Ms. Leroux's principal areas of expertise include resource assessments and LCAs; process design; pilot- and demonstration-scale testing; statistical interpretation, data processing, and modeling; technical feasibility; economic analysis; and market evaluation.

Mr. Charles Gorecki, Director of Subsurface R&D at the EERC, will serve as the project advisor. He has served as the PI/project manager on several projects, including projects funded by DOE, IEAGHG,

and private industry. Currently, Mr. Gorecki manages the multimillion-dollar, multiyear, multidisciplinary PCOR Partnership Program, established under the DOE NETL RCSP initiative in 2003. In addition, he currently oversees five other DOE research projects aimed at advancing CO_2 storage technology, demonstrating his ability to effectively manage multiple large-scale, multiyear projects.

Resumes of all key personnel from the EERC as well as leads from project partners RTE, Trimeric, and CETER can be found in Appendix A.

MANAGEMENT

Kerryanne Leroux has significant experience managing diverse and complex technical projects, providing valuable results on schedule and on budget. She will have the overall responsibility for the project and will communicate regularly with all project partners and participants. She will also be responsible for contractual reporting to all project partners.

The feasibility study and FIP will be conducted using the EERC's adaptive management approach to project design (9), which has been developed specifically for CCS projects to minimize project risks and maximize project efficiency and value. Planning meetings, conference calls, Webinars, and regular e-mail communication will occur to ensure coordination of all project partners and minimize risk. Internal review meetings will also be conducted regularly to further ensure that all project activities are completed in a timely manner, according to the project schedule. Progress reports will be prepared with updated results as well as a final report at project completion.

TIMETABLE

Figure 1 outlines the schedule of project activities. Initiation of the proposed work is contingent upon the execution of a mutually negotiated agreement with each project sponsor.

BUDGET

The estimated cost for the proposed effort is $980,000, as shown in Table 1. This proposal requests $490,000 from the Renewable Energy Development Program (REDP). Matching funds of $290,000

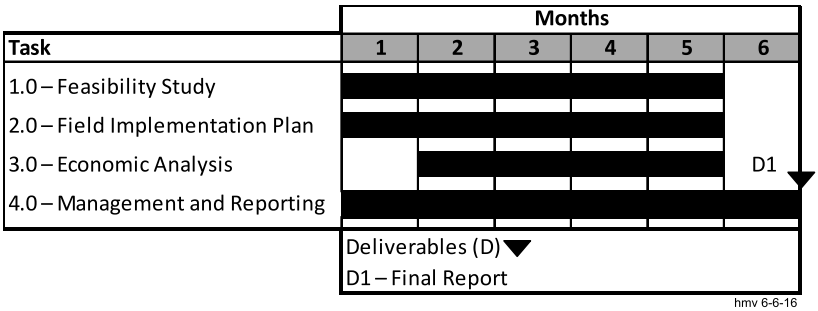

Figure 1. Project schedule.

Table 1. Budget Breakdown

Project Associated Expenses	NDIC Share (Cash)	RTE Share (Cash/In-kind)	DOE Share (Cash)	Total Program
Labor	$ 189,374	$ 55,906	$ 128,010	$ 373,290
Travel	$ 5,064	$ -	$ -	$ 5,064
Supplies	$ 744	$ 74	$ 282	$ 1,100
Consultant - CETER	$ 80,000	$ -	$ -	$ 80,000
Consultant - Trimeric	$ 35,000	$ -	$ -	$ 35,000
Consultant - Schlumberger	$ 15,000	$ -	$ -	$ 15,000
Other*	$ 399	$ 270	$ 438	$ 1,107
Laboratory Fees and Services				
Graphics Service	$ -	$ -	$ 4,160	$ 4,160
Facilities and Administrative	$ 164,419	$ 33,750	$ 67,110	$ 265,279
In-Kind Cost Share – RTE	$ -	$ 200,000	$ -	$ 200,000
Total Program	**$ 490,000**	**$ 290,000**	**$ 200,000**	**$ 980,000**

*May include costs such as food, printing, communications, or other miscellaneous expenses.

($90,000 cash and $200,000 in-kind) will be provided by RTE. The EERC, through its Fossil Energy Cooperative Agreement with DOE, will provide $200,000 in cash. Letters of commitment are provided in Appendix B. Budget justification can be found in Appendix C. If less REDP funding is available, adjustments to scope and/or participating companies would need to be considered.

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.

REFERENCES

All cited references are listed in Appendix E.

APPENDIX A

RESUMES OF KEY PERSONNEL

KERRYANNE M. LEROUX
Senior Chemical Engineer, 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
Phone: (701) 777-5013, Fax: (701) 777-5181, E-Mail: kleroux@undeerc.org

Principal Areas of Expertise

Ms. Leroux's principal areas of interest and expertise include renewable, alternative, and fossil energy and chemicals production; fossil industry monitoring, verification, and accounting (MVA) method assessment; resource and life-cycle assessments; process design; pilot- and demonstration-scale testing; statistical interpretation, data processing and modeling; 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: Senior Chemical Engineer, Oilfield Operations Team Lead, EERC, UND. Ms. Leroux leads a team of scientists and engineers implementing and evaluating MVA concepts for large-scale (>1 million tons per year) CO_2 storage and enhanced oil recovery (EOR) operations. Ms. Leroux has provided technical support for near-surface and downhole monitoring related to associated CO_2 storage with regard to commercial EOR as well as CO_2 capture technologies, transportation, and trading and commercial markets. Ms. Leroux's responsibilities include serving as a principal investigator or project manager on assigned tasks; 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 as contractually required; and collecting, reducing, analyzing, and interpreting data and ensuring quality control of personal work.

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 CO_2 storage associated with commercial EOR, capture technologies, transportation, trading and commercial markets).

1999–2001: Graduate Research/Education, Department of Chemical Engineering, UND. Ms. Leroux's work on two-phase flow models for low-pressure systems continued scarce research of pressure gradient models for various regimes, including a deriving model and writing a simulation program for annular flow and identified parameters for significance of liquid vaporization and acceleration. She also revised an air/water simulation program for hydrogen pressure drop, accommodating NASA's interest, and

altered parameters within a model applicable to all flow regimes for gradient estimation particular to stratified flow. In addition, she designed experiments for an industrial setting and performed statistical analysis of collected data.

Relevant Publications

Kay, J.P.; Azenkeng, A.; Fiala, N.J.; Jensen, M.D.; Laumb, J.D.; Leroux, K.M.; McCollor, D.P.; Stanislowski, J.J.; Tolbert, S.C.; Curran, T.J. *Subtask 2.18 – Advancing CO_2 Capture Technology: Partnership for CO_2 Capture (PCO_2C) Phase III*; Final Report (July 1, 2013 – March 31, 2016) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-08NT43291 and multiclients; EERC Publication 2016-EERC-03-13; Energy & Environmental Research Center: Grand Forks, ND, March 2016.

Hamling, J.A.; Stepan, D.J.; Kalenze, N.S.; Klapperich, R.J.; Botnen, B.W.; Leroux, K.M. Baseline Soil Gas Monitoring at the Bell Creek Combined CO_2 Enhanced Oil Recovery and CO_2 Storage Project. Poster presented at the Carbon Management Technology Conference, Alexandria, VA, Oct 21–23, 2013.

Leroux, K.M.; Strege, J.R. *Chippewa Valley Ethanol Company (CVEC) Resource Assessment and Syngas Feasibility Study*; Final Report for Chippewa Valley Ethanol Company; EERC Publication 2012-EERC-12-16; Energy & Environmental Research Center: Grand Forks, ND, Dec 2012.

Jensen, M.D.; Pavlish, B.M.; Pei, P.; Leroux, K.M.B.; Steadman, E.N.; Harju, J.A. Estimating the Cost to Capture, Compress, and Transport CO_2 from Stationary Sources in the PCOR Partnership Region. Poster presented at the 9th Annual Carbon Capture & Sequestration Conference, Pittsburgh, PA, May 10–13, 2010.

Jensen, M.D.; Pavlish, B.M.; Pei, P.; Leroux, K.M.B.; Steadman, E.N.; Harju, J.A. *Regional Emissions and Capture Opportunities Assessment – Plains CO_2 Reduction (PCOR) Partnership (Phase II)*; Value-Added Report for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592; EERC Publication 2010-EERC-08-15; Energy & Environmental Research Center: Grand Forks, ND, Dec 2009.

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Leroux, K.M.B.; Olson, E.S.; Hanson, S.K. *Commercial Opportunities for Chemical Production from Biomass*; Final Report for Minn-Dak Farmers Cooperative; EERC Publication 2009-EERC-04-16; Energy & Environmental Research Center: Grand Forks, ND, April 2009.

Leroux, K.M.B. *Fuels for Schools – Minot and Dickinson Biomass Feasibility Studies*; Final Report (June 1, 2006 – June 30, 2008) for North Dakota Forest Service and Bottineau Chamber of Commerce; EERC Publication 2008-EERC-05-01; Energy & Environmental Research Center: Grand Forks, ND, June 2008.

Leroux, K.M.; Williams, K.D. *Energy Opportunities for Mayville State University – Phase II*; Final Report (Jan 1 – Feb 29, 2008) for Energy Services Group; EERC Publication 2008-EERC-02-04; Energy & Environmental Research Center: Grand Forks, ND, Feb 2008.

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Leroux, K.M.B. *North Dakota Biodiesel Workshop: March 29, 2007*; Final Demographic Report for North Dakota Department of Commerce Instrument No. 2008-SEP06-AF-EX; Energy & Environmental Research Center: Grand Forks, ND, July 2007.

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Principal Areas of Expertise
Mr. Gorecki's principal areas of interest and expertise include personnel and project management, reservoir engineering, enhanced oil recovery (EOR), unconventional oil and gas research, and the geologic storage of CO_2.

Qualifications
B.S., Geological Engineering, University of North Dakota, 2007.

Professional Experience
2015–Present: Director of Subsurface R&D, EERC, UND. Mr. Gorecki is responsible for developing and managing programs and projects focused on conventional, unconventional, and enhanced oil and gas production; the geologic storage of CO_2; geothermal; and other energy and environmental research. He currently serves as the Program Manager for the Plains CO_2 Reduction (PCOR) Partnership, one of seven regional partnerships funded by the U.S. Department of Energy's (DOE's) National Energy Technology Laboratory Regional Carbon Sequestration Partnership Program. The PCOR Partnership Program is a three-phase, multiyear, multimillion-dollar program, focused on assessing the technical and economic feasibility of capturing and storing CO_2 emissions from stationary sources in the northern Great Plains and adjacent area. Under this program, Mr. Gorecki leads a multidisciplinary team of researchers working primarily on developing monitoring, verification, and accounting concepts and technologies for large-scale CO_2 storage (>1 million tons per year) in deep saline formations and oil fields and the characterization of the geologic formations in the PCOR Partnership region in preparation for the implementation of the commercial deployment of carbon capture and storage (CCS). Through the PCOR partnership program, Mr. Gorecki has successfully overseen the execution of field activities including well drilling and completion, infrastructure development, monitoring systems deployment and operation, and the coordination of staff during these operations.

In addition to the PCOR Partnership Program, Mr. Gorecki also manages or oversees projects related to CO_2 storage capacity estimation, novel reservoir surveillance and CO_2 storage monitoring techniques, and unconventional oil and gas resource modeling, characterization, and testing. He has also led several other national and international projects associated with CO_2 storage, the nexus of water and CO_2, and CO_2 EOR. Mr. Gorecki also manages a group of more than 50 scientists and engineers at the EERC, focused on all aspects of research related to geologic, subsurface and environmental systems.

2011–2015: Senior Research Manager, EERC, UND. Mr. Gorecki was the manager of the PCOR Partnership and the technical lead for the Bell Creek CO_2 EOR field demonstration. Mr. Gorecki led the geologic modeling and simulation efforts for the EERC as well as national and international efforts associated with the nexus of water and carbon capture and storage. He led efforts focused on developing storage capacity estimates and methodologies for deep saline formations and hydrocarbon reservoirs. In addition, Mr. Gorecki has led and worked on detailed site characterization, modeling, risk assessment, and monitoring activities for both EOR projects and CO_2 storage operations in deep saline formations. He

participated in several expert review committees and was involved in developing a methodology for estimating CO_2 storage capacity in deep saline formations, oil and gas reservoirs, and shale formations for DOE.

2010–2011: Research Manager, EERC, UND. Mr. Gorecki led the modeling and monitoring and Water Working Group tasks for Phase III of the PCOR Partnership Program. He led the EERC's geologic modeling efforts, coordinating a multidisciplinary team to develop detailed geologic models and run predictive simulations for CO_2 storage, CO_2 EOR, and unconventional oil and gas plays. Mr. Gorecki was also the facilitator of the Regional Carbon Sequestration Partnership Water Working Group, where he led discussion on the nexus of water and carbon capture and storage.

2007–2010: Research Engineer, EERC, UND. Mr. Gorecki worked with the PCOR Partnership at the EERC to develop models to describe the behavior of CO_2 prior to injection into saline formations and oil fields. Mr. Gorecki led a joint venture funded by the IEA Greenhouse Gas R&D Programme and DOE to develop storage capacity/ resource coefficients to determine CO_2 storage capacity/resource estimates in saline formations. As a result of Mr. Gorecki's work in developing storage capacity/resource estimates, he served on the expert review panel on the U.S. Geological Survey's CO_2 Capacity Methodology; advised and helped to develop methodologies for the North American Energy Working Group's CO_2 storage capacity efforts between the United States, Canada, and Mexico; and advised the DOE National Energy Technology Laboratory on the third edition of the Carbon Sequestration Atlas of the United States and Canada.

Professional Memberships

American Association of Petroleum Geologists, 2009–Present
Society of Petroleum Engineers, 2007–Present
Member of European Association of Geoscientists and Engineers, 2014–Present

Relevant Publications

Levine, J.S., Fukai, I., Soeder, D.J., Bromhal, G., Dilmore, R.M., Guthrie, G.D., Rodosta, T., Sanguinito, S., Frailey, S., Gorecki, C., Peck, W., and Goodman, A.L., in press, U.S. DOE NETL methodology for estimating the prospective CO_2 storage resource of shales at the national and regional scale: International Journal of Greenhouse Gas Control.

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Gorecki, C.D., Liu, G., Bailey, T.P., Sorensen, J.A., Klapperich, R.J., Braunberger, J.R., Steadman, E.N., and Harju, J.A., 2013, The role of static and dynamic modeling in the Fort Nelson CCS Project: Energy Procedia, v. 37, p. 3733–3741.

Gorecki, C.D., Sorensen, J.A., Klapperich, R.J., Botnen, L.S., Steadman, E.N., and Harju, J.A., 2012, A risk-based monitoring plan for the Fort Nelson feasibility project, *in* 2012 Carbon Management Technology Conference, Orlando, Florida, February 7–9, 2012, Proceedings, CMTC 151349-PP.

Gorecki, C.D., Sorensen, J.A., Steadman, E.N. and, Harju, J.A., 2009, CO_2 storage risk minimization through systematic identification and assessment of faults—a Williston Basin case study: Energy Procedia, v. 1, no. 1, p. 2887–2894.

Gorecki, C.D., Sorensen, J.A., Bremer, J.M., Knudsen, D.J., Smith, S.A., Steadman, E.N., and Harju, J.A., 2009, Development of storage coefficients for determining the effective CO_2 storage resource in deep saline formations: Presented at the Society of Petroleum Engineers International Conference on CO_2 Capture, Storage, and Utilization, San Diego, California, November 2–4, 2009, SPE 126444.

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Principal Areas of Expertise

Mr. Hamling's principal areas of expertise include development, implementation, and oversight of surface, near-surface, deep subsurface, and reservoir characterization and monitoring programs for CO_2 storage and enhanced oil recovery operations. His expertise also includes reservoir measurement and well-logging principles and applications and the development, design, and implementation of new approaches that benefit the exploration, development, and production of oil and gas in unconventional reservoirs.

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

Mr. Hamling is a Principal Engineer who has over 10 years of experience in the oil and gas, enhanced oil recovery (EOR), and carbon capture, utilization, and storage (CCUS) industry. At the EERC, he leads the data analytics, operations, and reservoir surveillance groups focused on development, design, and implementation of approaches that benefit the exploration, development, and production of oil and gas and geologic CO_2 storage. Mr. Hamling serves as project manager and principal investigator, leading multidisciplinary teams and overseeing several U.S. Department of Energy multiyear, multimillion-dollar research projects and strategic partnerships, including the Plains CO_2 Reduction (PCOR) Partnership's Bell Creek project as well as projects related to novel automated geophysics techniques, intelligent reservoir surveillance systems, active reservoir management, tight oil EOR, and well stimulation in unconventional reservoirs. He served as PI and PM for a variety of complex DOEsponsored CCS projects including the DOE Phase 1 project entitled "Developing and Validating Pressure Management and Plume Control Strategies in the Williston Basin Through a Brine Extraction and Storage Test." This project included a design and implementation plan for a field validation of engineering strategies for managing formation pressure as well as predicting and monitoring differential pressure plume movement in the subsurface. The plan incorporated a testbed for evaluation of brine treatment technologies that may be capable of treating high-TDS extracted water for beneficial use as a means of managing and reducing extracted brine disposal volumes. Through these activities, Mr. Hamling has led all aspects of the design, planning, coordination, drilling, well logging, coring, well testing, completion, instrumentation, and workover operations of multiple deep wells for monitoring, injection, and production purposes.

PCOR Partnership Bell Creek Project Task Lead for Well Drilling and Completion and Operation Monitoring and Modeling and Assistant Task Lead for Site Characterization and Modeling. Mr. Hamling managed all aspects of design, preparation, service provider coordination, budget preparation, drilling, testing, data interpretation, on-site management, and completion of six new wells that were successfully drilled between December 2011 and April 2013 as part of the PCOR Partnership's study to demonstrate CO_2 storage potential in clastic formations in association with CO_2 EOR. Activities included

the acquisition of 64 pulsed-neutron logs, installation of a permanent 50-level multicomponent geophone array, acquisition of a +40-square-mile baseline and subsequent repeat 3-D seismic surveys, vertical seismic profile (VSP) surveys in two wells, collection of over 200 feet of 4-inch-diameter core, collection of 70 sidewall cores, installation of casing-conveyed pressure and temperature gauges and a distributed temperate system, casing-conveyed perforation, and acquisition and interpretation of a full suite of modern high-resolution well log data in multiple wells. Mr. Hamling has led all aspects of MVA for the PCOR Partnership Bell Creek project, which has been active since 20009. Mr. Hamling's experience with project management and field operations, including well drilling and completion techniques, downhole logging technologies, coring, and MVA, will be directly applicable to the proposed project.

Schlumberger Wireline Engineer. 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 a health, safety, and environmental (HSE) officer, loss prevention team lead, and explosives and radiation safety officer for wellsite activities.

Relevant Publications

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.

Burnison, S.A., Beddoe, C.J., Glazewski, K.A., Salako, O., Hamling, J.A., Ayash, S.C., and Gorecki, C.D., 2015, Technical design of a scalable, automated, semipermanent seismic array (SASSA) method for detecting CO_2 extent during geologic CO_2 injection: Deliverable D2 Interim Report on Completion of Technical Design (Oct 1, 2013 – Oct 31, 2015) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FE0012665, Grand Forks, North Dakota, Energy & Environmental Research Center, October 2015.

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Hamling, J.A., 2015, Bell Creek oil field—a study of associated CO_2 storage with a commercial CO_2 enhanced oil recovery project: Presented at the IEAGHG 10th Monitoring Network Meeting, San Francisco, California, June 10–12, 2015.

Kalenze, N.S., Klapperich, R.J., Hamling, J.A., Gorecki, C.D., Steadman, E.N., Harju, J.A., and Azzolina, N.A., 2015, Data management policy and procedures developed for the PCOR Partnership's Bell Creek study: Plains CO_2 Reduction (PCOR) Partnership Phase III value-added report for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2015-EERC-03-15, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

Laumb, J.D., Hamling, J.A., Eylands, K.E., Azenkeng, A., and Glazewski, K.A., 2015, Corrosion and failure assessment for CO_2 EOR and storage: Final report for Petroleum Technology Research Centre,

EERC Publication 2015-EERC-12-24, Grand Forks, North Dakota, Energy & Environmental Research Center, December.

Braunberger, J.R., Hamling, J.A., Gorecki, C.D., Miller, H., Rawson, J., Walsh, F., Pasternack, E., Rowe, W., Butsch, R., Steadman, E.N., and Harju, J.A., 2014, Characterization and time-lapse monitoring utilizing pulsed-neutron well logging—associated CO_2 storage at a commercial CO_2 EOR project: Energy Procedia, v. 63, p. 3935–3944.

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Principal Areas of Expertise

Mr. Pekot's principal areas of interest and expertise include unconventional reservoir engineering, including CO_2 storage and enhanced oil recovery (EOR), coalbed methane (CBM), enhanced CBM (ECBM), shale gas, natural gas storage, and hydraulic fracturing; integrated project management; numerical simulation; and field studies and reserve evaluations.

Qualifications

B.S., Civil Engineering, Pennsylvania State University, 1978.
B.S., Geological Science, Pennsylvania State University, 1978.

Professional Experience

September 2015–Present: Principal Engineer, Reservoir Engineering Group Lead, EERC, UND. Mr. Pekot's responsibilities include:

- Leads reservoir engineering evaluations for CO_2 enhanced oil recovery (EOR), CO_2 storage, unconventional hydrocarbon recovery, and produced water disposal projects.
- Leads a group of reservoir engineers on multiphase flow, geomechanical, thermal, and geochemical interaction simulations.

2013–2015: International Project Manager, Schlumberger Carbon Services, Denver, Colorado. Mr. Pekot's responsibilities included:

- Management of CO_2 evaluation projects outside of the United States.
- Supervision of site selection studies, simulation, appraisal planning, risk analysis, injection testing and monitoring technologies, regulatory compliance, cost estimation, and reporting.
- Supervision and mentoring of junior staff.

2008–2013: Technical Manager for Europe/Africa, Schlumberger Carbon Services, Paris, France. Mr. Pekot's responsibilities included:

- Technical oversight of carbon storage evaluation projects and opportunities in Europe and Africa, including work in the United Kingdom, Ireland, Spain, Italy, Poland, Romania, Bulgaria, Libya, South Africa, and Australia.
- Coordination of projects and resources between Schlumberger's Consulting and Carbon Services businesses.
- Strategic, technical, and business development assistance for unconventional reservoir problems, including natural gas storage, geothermal, CBM, and EOR.
- Management of corporate special projects and resource evaluations.
- Project peer reviews for other business units.
- Introduction of corporate project management procedures to Carbon Services.
- Junior staff mentoring and introduction to the corporate technical advancement system.

2004–2007: Principal Consultant, Schlumberger Data and Consulting Services, Pittsburgh, Pennsylvania. Mr. Pekot's responsibilities included:

- Engineering studies for tight gas, gas storage, shale, and coalbed methane (CBM) properties in the United States and Canada.
- Reserve reporting evaluations for conventional, CBM, and CO_2 flood properties.
- EOR CO_2 flood evaluations of Michigan Basin pinnacle reef reservoirs.
- Saline formation test site modeling for CO_2 storage in Ohio and Texas; one done for Schlumberger R&D.
- Initial evaluation and carbon sequestration site prescreening for carbon storage for the New York Clean Coal Power Initiative.
- Two CO_2 sequestration site screening evaluations for U.S. electric utility clients.
- A Pacific Basin overview study of CO_2 EOR and ECBM potential for a Japanese client.

1995–2003: Vice President, Advanced Resources International, Inc., Washington, D.C. Mr. Pekot's responsibilities included:

- Development, maintenance, and marketing of the firm's technical software programs, COMET for reservoir simulation and METEOR for analytic type curve evaluations.
- Serving as a reservoir engineering advisor for the U.S. Federal Energy Regulatory Commission.
- Performing or supervising well testing and numerical simulation evaluations of numerous gas, oil, gas storage, CBM, enhanced coalbed methane (ECBM), and other unconventional reservoirs, including projects in Australia, Canada, China, Czech Republic, India, Poland, South Africa, and the United States.
- Exploration, appraisal, and development planning.
- ECBM simulation.
- Evaluation of geologic storage options for greenhouse gas sequestration potential.
- Shale gas well performance evaluation.
- Estimated reserves for merger and acquisition economic evaluations.
- Field demonstration of advanced simulation technologies for gas storage wells.
- Well testing and evaluation methodologies for gas storage remediation candidate selection.
- Supervision of the reservoir simulation and design of the development plan for the first gas storage reservoir in the People's Republic of China.

1991–1995: Principal Consultant, Scandpower A/S (now known as SPT Group of Schlumberger), Oslo, Norway. Mr. Pekot's responsibilities included:

- Administrative supervision of a team of four engineering consultants.
- Project management.
- Technical assistance to junior staff.
- Software marketing and technical support.
- Consulting for
  - PEMEX (Mexico).
  - Norsk Hydro, where he used state-of-the-art engineering techniques and simulation software (ECLIPSE) to help optimize the $2 billion oil development plan for the Troll Field in the North Sea, edited the reservoir engineering proposal for a $150 million field expansion, and prepared and delivered numerous presentations to license holders and government authorities.
  - Saga Petroleum, where he developed an engineering and geologic database for the unitized Snorre Field to be used in field ownership redetermination and conducted a reservoir simulation study to determine optimum recovery techniques for the Gullfaks South reservoir.

1978–1991: Senior Petroleum Engineer, Phillips Petroleum Company, Stavanger, Norway, and Houston, Texas. Mr. Pekot's responsibilities included the following:

- Senior Joint Venture Engineer for Gulf of Mexico properties (3 years), including profit and loss accountability for a $20 million capital and expense budget; economic evaluation for $60 million development of a new gas field; technical and economic evaluations for rehabilitation of a large, old oil field, where production doubled and reserves increased 50%; evaluation of deep-water exploration leases; technical and economic analysis for drilling, well workovers, process equipment upgrades, platform construction, and rehabilitation, writing project justifications and obtaining approvals; and Reserves evaluations.
- Senior Engineer (4 years), including supervision of a team of engineers for numerical simulation of North Sea oil and gas fields; setting group objectives and scheduling and delegating assignments; junior staff performance evaluation and career counseling; drilling and workover proposal justifications; economic analysis; reservoir management plan maintenance and updates; evaluation of oil and gas reserves under depletion and various gas and water injection development proposals; and temporary section leader, supervising ten engineers.
- Associate Production Geologist (2 years), including wellsite geology; correlating geological and geophysical data and creating maps and cross sections, geological field study for the development of the Tommeliten gas fields, coauthoring and editing the geologic field study for the $1 billion Ekofisk Field waterflood project, and serving on the project team that developed a North Sea geological database.
- Staff Reservoir Engineer (3 years), including wellsite testing and analysis of new gas production wells, well test analysis and selection of new drilling locations, evaluation of field production problems, technical report writing, corrective action recommendations, and unitized field operations; found new reserves located in formations previously considered uneconomical.
- General land-based production (1 year), including EOR projects, drilling, and workover operations, and land surveying and piping design.

Professional Affiliations

Member, Society of Petroleum Engineers Distinguished Lecture Review Committee, 2006–2011
Technical Reviewer, *International Journal of Coal Geology, International Journal of Greenhouse Gas Control*

Relevant Publications

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.

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Ensrud, J.R., 2015, Annual assessment report: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 12 Deliverable D57 (October 1, 2014 – September 30, 2015) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, December.

Gendrin, A., Zen, D., Sosio, G., Pekot, L.J., Andres, R., Gonzalez, P., Gimenez, A., and Ballesteros, J.C., 2013, Seismic interpretation for carbon dioxide geologic storage—Duero Basin, Spain: European Association of Geoscientists and Engineers 75th Conference & Exhibition, London, June 10–13.

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Principal Areas of Expertise

Mr. Burnison's principal areas of interest and expertise include the application of geophysics and well log analysis to the efficient development of unconventional petroleum reservoirs and the application of geophysical methods for monitoring, verification, and accounting in CO_2 storage and enhanced oil recovery (EOR) operations. He is the co-principal investigator for a scalable, automated, semipermanent seismic array (SASSA) project that uses the seismic method in an unconventional manner to track subsurface CO_2 plume migration.

Qualifications

M.S., Exploration Geophysics, Stanford University, 1989
B.S., Geological Engineering, University of Minnesota, 1981

Professional Experience:

2012–Present: Principal Geophysicist, Geophysics Team Lead, EERC, UND. Mr. Burnison's responsibilities include leading a team of geophysicists on an array of projects involving interpretation of 3-D and 4-D seismic data at CO_2 EOR and CO_2 storage sites, geophysical modeling and inversion, field seismic data collection at the Bell Creek Field, processing of reflection seismic data, and well log analysis. These efforts are applied to characterize unconventional oil and gas reservoirs and monitor reservoirs for geologic CO_2 storage. He prepares technical reports and creatively applies geophysics to address research proposal objectives.

2010–2011: Project Controls/Earned Value Consultant, SLAC National Accelerator Laboratory. Mr. Burnison assisted preparing the schedule and cost estimate for the "Linac Coherent Light Source – II" project, a $400 million particle physics experiment. Scheduling development was done using Primavera P6 and costing using Deltek COBRA.

2007–2010: Senior Scientist – Program Management, NSTec. Mr. Burnison maintained and improved the Nevada Test Site Environmental Management Program's Risk Management Plan, identifying risks and computing impacts using Oracle Primavera Risk Analysis Monte Carlo software. He designed and updated the monthly project metrics for senior management and posted project financial and schedule data to the federal project management system. He earned four certifications in project management.

2005–2007: Field Lead – Environmental Restoration, NSTec. Mr. Burnison planned, coordinated, and directed field activities. He was an Occupational Safety and Health Administration (OSHA) supervisor under 40 Code of Federal Regulations 1910 and 830 and has 40-hr HAZWOPER credentials.

2003–2005: Task Manager – Environmental Restoration, Bechtel, Nevada. Mr. Burnison managed projects, tracked earned value, and managed compliance at the Nevada Test Site for the Environmental Restoration Project for over 20 postclosure sites.

2002–2003: Contract Auditor – Logistics Analyst, Innovative Logistics, Inc., McLean, Virginia. Mr. Burnison performed complicated reconciliations and financial analyses at the direction of the CFO employing Excel, Access, Deltek GCS, and Cognos Impromptu tools, working independently in support of a large government contract closeout; created reports for in-house clientele using Business Intelligence tools to enhance analysis; and worked shifts as part of a team on a 24/7 operation to produce a crucial daily deliverable report and management tool.

1994–2001: Investment Manager, Bali, Indonesia/Alexandria, Virginia. Mr. Burnison was a self-employed investment manager actively managing personal portfolios of stock investments and controlled costs, taxes, and market actions with financial management software.

1996: Consulting Geophysicist, Robertson Research International, Islamabad, Pakistan. Mr. Burnison initiated client relationships in Pakistan for an embryonic technical joint venture between British and Pakistani geophysical processing companies, trained local technical staff in digital processing theory, and designed and implemented production procedures for a start-up seismic data-processing center.

1992–1994: Geophysicist – Data Processing and Special Projects, Halliburton Geophysical Services, Jakarta, Indonesia. Mr. Burnison's responsibilities included serving as a geophysical guru for local office staffed with expatriate and Indonesian professionals serving national and major oil company clientele, performing wavelet analysis, designing filters, establishing parameters for key projects, performing exotic processing seismic inversions and prestack depth migrations, and designing land and marine 3-D seismic surveys to meet bid specifications.

1989–1992: Geophysicist – Data Processing and Data Collection, Halliburton Geophysical Services, Beijing and Ningxia Province, People's Republic of China. Mr. Burnison was a geophysicist for a local office staffed with expatriate and Chinese professionals, while ensuring the quality of geophysical data processing and data collection for a remote joint venture computing center and Gobi desert-based data collection crew, establishing data collection parameters based on modeling and field testing, designing data-processing procedures, and training Chinese technical staff.

1981–1987: General Field Engineer – Openhole Well-Logging and Borehole Seismic Specialist, Schlumberger Well Services, Sacramento and Bakersfield, California. Mr. Burnison performed openhole wireline logging on over 200 oil and gas wells in California and other states. He was directly responsible for the safety and performance of a three-man crew and a million-dollar mobile wireline unit and ensured regulatory compliance, handling and transporting explosive and radioactive materials. He specialized in borehole seismic methods, including vertical seismic profiles on land and sea.

Relevant Publications

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.

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Principal Areas of Expertise

Mr. Bosshart's principal areas of interest and expertise include well log, core, and thin-section petrophysical analysis; geologic characterization and data management; geostatistical applications; geocellular reservoir modeling; enhanced oil recovery utilizing CO_2; and geologic storage of CO_2.

Qualifications

M.S., Geology, University of North Dakota, 2014.
B.S., Geology, University of Northern Iowa, 2012.
Proficient in the use of Microsoft Office Suite, ArcGIS: ArcMap, Surfer, Petra, Petrel, Neuralog, CMG, and JewelSuite.

Professional Experience

June 2014–Present: Senior Geologist, Geomodeling Team Lead, EERC, UND. Mr. Bosshart's responsibilities include developing geophysical reservoir models for hydrocarbon resource assessment and geologic CO_2 storage analyses.

2013–June 2014: Graduate Student Research Assistant, EERC, UND. Mr. Bosshart's responsibilities included CO_2 geologic storage modeling, Petra software projects, and Petrel software-based 3-D modeling.

2013: Internship, EERC, UND. Mr. Bosshart's responsibilities included CO_2 geologic storage modeling, Petra software projects, Petrel software-based 3-D modeling, and over 120 hours of software and geostatistics training.

May–June 2013: Graduate Student Teaching Assistant, South Dakota School of Mines and Technology, Annapurna Region, Himalayas, Nepal. Mr. Bosshart was a graduate student teaching assistant for geologic field studies of the Himalayas. His responsibilities included identification and mapping of metamorphic rocks associated with the Main Central Thrust Zone of the Himalayas, mapping and developing reports discussing active geomorphic agents in the region, and mapping of glacial sediments.

August 2012−May 2013: Graduate Student Teaching Assistant, Harold Hamm School of Geology and Geologic Engineering, UND. Mr. Bosshart instructed introductory geology laboratory courses.

2006–2014: Unit Supply Specialist, Iowa National Guard, United States Army, Camp Dodge, Johnston, Iowa.

Relevant Publications

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.,

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Heinzel, C.E., Bosshart, N., Madsen, E., and Shultz, J., 2012, The surficial geology of the Waterloo South Quadrangle (7.5'), Blackhawk County, Iowa: United States Geological Survey (EDMAP).

Heinzel, C.E., Bosshart, N., and Vastine, J., 2011, The surficial geology of the Dunkerton Quadrangle (7.5'), Blackhawk County, Iowa: United States Geological Survey (EDMAP).

Heinzel, C.E., Schmitz, J., Bosshart, N., and Vastine, J., 2010, The surficial geology of the Readlyn Quadrangle (7.5'), Bremer County, Iowa: United States Geological Survey (EDMAP).

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Principal Areas of Expertise

Mr. Jacobson's principal areas of interest and expertise include 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, 2014; OSHA 10-hour Hazard Recognition Training, 2013; Well Control Training, Workover and Completion, 2015.

Professional Experience

August 2015–Present: Senior Operations Specialist, EERC, UND. Mr. Jacobson's responsibilities include designing field implementation plans and leading 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.

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.

Relevant Publications

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.

MELANIE D. JENSEN
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Principal Areas of Expertise

Ms. Jensen's principal areas of expertise include carbon capture and CO_2 transport infrastructure, high-pressure/high-temperature processes, production of fuels from coal and renewables, waste cleanup technologies, adsorption system design and operation, low-temperature plasma technologies, photocatalytic processes, statistical experimental design, and system modeling.

Education and Training

B.S., Chemical Engineering, University of North Dakota, 1983.
B.A., Anthropology, University of North Dakota, 1978.

Professional Experience

2011–Present: Senior Chemical Engineer, CO_2 Capture and Infrastructure Engineering Team Lead, EERC, UND. Ms. Jensen's responsibilities include supervising a team of engineers and scientists who perform research in the areas of CO_2 capture, compression, and transport via pipeline as well as document surface facility design at regional CO_2 storage sites. Specific activities in this area include matching CO_2 capture technologies with utility and industrial sources, suggesting appropriate compression technologies, and developing theoretical pipeline networks to optimize the transport of the CO_2 for storage or beneficial use. Ms. Jensen and her team also perform life cycle analyses of products to determine their carbon intensities. The engineering team studies and evaluates coal combustion, water treatment, and photocatalytic processes and develops carbon management plans. Ms. Jensen assists with the advancement and demonstration of advanced compression processes and advises on direct liquefaction projects. She works to develop fuels from biomass or CO_2. Ms. Jensen designs, develops, operates, and/or evaluates complex processes and equipment, including CO_2 capture systems. She develops statistically designed experimental matrices; tracks, reduces, and interprets data generated during research projects; and derives empirical models describing system behavior. Ms. Jensen develops integrated, multiproject programs to meet both the immediate and long-term needs of clients; prepares or assists with the preparation of proposals and supporting documentation; develops comprehensive QA/QC plans; and prepares patent applications. Her project management activities include detailed program planning; scheduling of equipment and personnel; budget monitoring; maintenance of project schedules, dissemination of research results through reports, papers, and presentations; and communication with clients.

1985–2011: Research Engineer, EERC, UND. Ms. Jensen performed research in the areas of CO_2 capture and storage, reaction engineering, coal combustion, reburning, hazardous waste treatment, gas-phase particulate and mercury collection, photocatalytic processes, fuel production from biomass, contaminated water cleanup, and phytoremediation. She designed, developed, operated, and/or evaluated complex processes and equipment, including column CO_2 capture systems, high-pressure/high-temperature coal conversion systems, low-temperature plasma systems, and multicolumn sorption systems. She identified promising carbon sequestration opportunities by matching CO_2 capture technologies with point sources, pairing those combinations with nearby geologic sinks, and performing the preliminary compressor and

pipeline specifications. She evaluated and compared characterization, remediation, and decontamination technologies for application to waste treatment/cleanup programs. Ms. Jensen developed statistically designed experimental matrices; tracked, reduced, and interpreted data generated during research projects; and derived empirical models describing system behavior. Ms. Jensen also developed integrated, multiproject programs to meet both the immediate and long-term needs of clients; prepared or assisted with the preparation of proposals and supporting documentation; developed comprehensive QA/QC plans; and prepared patent applications. Her project management activities included detailed program planning; scheduling of equipment and personnel; budget monitoring; maintenance of project schedules, dissemination of research results through reports, papers, and presentations; and communicating with clients.

Patents

Rindt, J.R.; Hetland (Jensen), M.D. Direct Coal Liquefaction Process. U.S. Patent No. 5256278, October 26, 1993.

Relevant Publications

Kay, J.P.; Azenkeng, A.; Fiala, N.J.; Jensen, M.D.; Laumb, J.D.; Leroux, K.M.; McCollor, D.P.; Stanislowski, J.J.; Tolbert, S.C.; Curran, T.J. *Subtask 2.18 – Advancing CO_2 Capture Technology: Partnership for CO_2 Capture (PCO_2C) Phase III*; Final Report (July 1, 2013 – March 31, 2016) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-08NT43291 and multiclients; EERC Publication 2016-EERC-03-13; Energy & Environmental Research Center: Grand Forks, ND, March 2016.

Jensen, M.D. The Effects of Variation in CO_2 Stream Composition and Flow Rate on Enhanced Oil Recovery and Geologic Storage. Presented at the 2015 AIChE Annual Meeting, Salt Lake City, UT, Nov 8–13, 2015.

Jensen, M.D.; Gorecki, C.D.; Steadman, E.N.; Harju, J.A. *Opportunities and Challenges Associated with CO_2 Compression and Transportation During CCS Activities*; Plains CO_2 Reduction Partnership Phase III Task 6 Deliverable D85 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592; EERC Publication 2015-EERC-06-08; Energy & Environmental Research Center: Grand Forks, ND, May 2015.

Jensen, M.D.; Hamling, J.A.; Gorecki, C.D. *Bell Creek Test Site – Transportation and Injection Operations Report*; Plains CO_2 Reduction Partnership Phase III Task 8 Deliverable D49 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592; EERC Publication 2016-EERC-04-03; Energy & Environmental Research Center: Grand Forks, ND, Sept 2015.

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Laumb, J.D.; Cowan, R.M.; Azenkeng, A.; Hanson, S.K.; Heebink, L.V.; Letvin, P.A.; Jensen, M.D.; Raymond, L.J. *Subtask 2.14 – Beneficial Use of CO_2 for North Dakota Lignite-Fired Plants*; Final Report (Oct 1, 2011 – Jan 31, 2012) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-08NT43291; EERC Publication 2012-EERC-01-27; Energy & Environmental Research Center: Grand Forks, ND, Jan 2012.

Bliss, K.; Eugene, D.; Harms, R.W.; Carrillo, V.G.; Coddington, K.; Moore, M.; Harju, J.A.; Jensen, M.D.; Botnen, L.S.; Marston, P.; Louis, D.; Melzer, S.; Drechsel, C.; Whitman, L.; Moody, J. *A Policy, Legal, and Regulatory Evaluation of the Feasibility of a National Pipeline Infrastructure for the Transport and Storage of Carbon Dioxide*; Topical Report for Southern States Energy Board; Interstate Oil and Gas Compact Commission: Oklahoma City, OK, Dec 2010.

Jensen, M.D. Risks Associated with Capture, Compression, and Transport of CO_2. Presented at the Risk Management for CCS Projects Training Seminar, Calgary, AB, May 18, 2010.

Jensen, M.D.; Pavlish, B.M.; Pei, P.; Leroux, K.M.B.; Steadman, E.N.; Harju, J.A. Estimating the Cost to Capture, Compress, and Transport CO_2 from Stationary Sources in the PCOR Partnership Region. Poster presented at the 9th Annual Carbon Capture & Sequestration Conference, Pittsburgh, PA, May 10–13, 2010.

Jensen, M.D.; Steadman, E.N.; Harju, J.A.; Belshaw, K.L. *Preliminary Design of Advanced Compression Technology*; Plains CO_2 Reduction (PCOR) Partnership Phase III Task 6 Deliverable D47 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592; EERC Publication 2011-EERC-03-05; Energy & Environmental Research Center: Grand Forks, ND, Sept 2009.

Jensen, M.D.; Botnen, L.A.; Botnen, B.W.; Sorensen, J.A.; Wolfe, S.L.; Kurz, B.A.; Steadman, E.N.; Harju, J.A. *Carbon Management Plan for Excelsior Energy (Phase II)*; Task 9 Final Deliverable for Excelsior Energy, Inc.; Energy & Environmental Research Center, Grand Forks, ND, Jan 2008.

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Principal Areas of Expertise
Dr. Schlasner's principal areas of interest and expertise include hydrogen, CO_2 capture, petroleum processing and microbial bioprocess technologies, and advanced process control.

Qualifications
Ph.D., Chemical Engineering, The Ohio State University, 1987
M.S., Chemical Engineering, The Ohio State University, 1983
M.B.A., University of South Dakota, 1977
B.S., Chemical Engineering, South Dakota School of Mines & Technology, 1980
B.A., Chemistry and Mathematics, St. Olaf College, 1974
Registered/Licensed Professional Engineer, Ohio and Oklahoma

Professional Experience
2010–Present: Research Engineer, EERC, UND, Grand Forks, North Dakota. Dr. Schlasner conceptualizes, develops and evaluates hydrogen production, carbon dioxide capture, petroleum processing, bioprocess, and advanced process monitoring and control technologies from early concept development through demonstration and production evaluation. His work includes process conceptualization, process modeling and simulation using spreadsheet and process simulators (e.g. Aspen Plus®, HYSYS®, ChemCAD™, and IECM), process development at laboratory through production demonstration scales, process testing and evaluation, and life cycle analysis (for example applying GREET™ and H2A).

2001–2009: R&D Team Lead and Chief Engineer, CO_2 Capture/H_2 Production Team, ConocoPhillips Company, Bartlesville Technology Center, Oklahoma. Dr. Schlasner led internal R&D focused on novel CO_2 capture technologies, served on the Executive Board of a €13 million international research consortium that developed advanced pre-combustion CO_2 capture technologies, was the technical lead for sorbent-based CO_2 capture in a $55 million R&D consortium funded by eight major energy companies, and was the co-lead of a Department of Energy hydrogen production technical team.

1992–2001: Refinery Senior Engineer, Phillips Petroleum Company, Sweeny Petrochemical Complex, Texas. At various times, Dr. Schlasner served as process engineer for a benzene hydrogenation, a pentane isomerization and two aromatic extraction units, operating engineer for terminals, product pipelines, water and wastewater treatment units, and advanced control engineer for several major refinery production units as well as terminals and pipelines. During his tenure, the benzene and aromatic extraction units set production records, he resolved a wastewater treatment issue that had received a Notice of Violation from Texas environmental regulators and, in so doing, avoided a fine, and reduced emissions and annual operating cost, and he supervised contractor design, configuration, programming, installation and testing of basic and advanced control systems for his units, terminals and pipeline.

1991–1992: Plastics Engineer, Corporate Engineering, Phillips Petroleum Company, Bartlesville, Oklahoma. Dr. Schlasner developed software to automate high density polyethylene plant design so as to

provide quick-turnaround process design information for clients who wish to license Phillips proprietary technology. The software reduced design time and cost by more than 60% on its first application.

1988–1991: Process Engineer, Advanced Composites, Plastics Division, Phillips Petroleum Company, Bartlesville Research Center, Oklahoma. At various times, Dr. Schlasner led R&D focused on improving properties, processing and cost of stampable-sheet thermoplastic prepreg, he troubleshot and resolved issues with unidirectional tape manufacture, and he automated ten manufacturing lines.

1987–1988: Bioprocess Research Engineer, Phillips Petroleum Company, Bartlesville Research Center, Oklahoma. Dr. Schlasner supervised the fermentation pilot plant which performed high-density microbial-based drug and enzyme development and toll fermentations in a Biosafety Level 2 facility.

1999–2004: Officer, U.S. Air Force Reserve, Air Force Research Laboratory (AFRL), Ohio. At various times as a Reservist, Col Schlasner served as acting Deputy Director of the Sensors Directorate, performed management studies for the directorate, advised the directorate on management of its reservists, and served on the Laboratory's Reserve Board which oversaw activities of 210 Reservists.

1980–1999: Officer, U.S. Air Force Reserve, Air Force Research Laboratory (AFRL), Ohio. In various grades from First Lieutenant through Lieutenant Colonel, Dr. Schlasner performed and supervised laboratory automation, hazardous waste bioremediation and other projects, led a source selection technical review, as well as performed energy efficiency audits of two bases.

1974–1978: Second Lieutenant – First Lieutenant, U.S. Air Force Active Duty, 44th Strategic Missile Wing (SAC), South Dakota. At various times as an active duty officer, Lt Schlasner served as the Assistant Wing Operations Scheduling Officer, commanded an Alternate Command Post-qualified missile crew, and instructed and served as a Deputy Missile Combat Crew Commander.

Professional Memberships

National Hydrogen Association, Director (2006–2007)
American Chemical Society
American Society for Microbiology
Tau Beta Pi
Beta Gamma Sigma

Relevant Publications

Energy & Environmental Research Center. *Liquids Gathering Pipelines: A Comprehensive Analysis*; Report for the North Dakota Industrial Commission and the North Dakota Legislative Energy Development and Transmission Committee; Energy & Environmental Research Center: Grand Forks, ND, Dec 2015.

Jensen, M.D.; Schlasner, S.M.; Sorensen, J.A.; Hamling, J.A. *Subtask 2.19 – Operational Flexibility of CO_2 Transport and Storage*; Final Report (Feb 3 – Dec 31, 2014) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-08NT43291; EERC Publication 2014-EERC-12-17; Energy & Environmental Research Center: Grand Forks, ND, Dec 2014.

Miracca, I.; Ingvar Åsen, K.; Assink, J.; Coulter, C.; Curran, L.; Lowe, C.; Torres Moure, G.; Schlasner, S. The CO_2 Capture Project (CCP): Results from Phase II (2004–2009). *Energy Proc.* **2009**, *1* (1), 55–62.

Garland, R.; Schlasner, S.M. Hydrogen Production: Pathways and Status. Presented at the 234th American Chemical Society National Meeting, Boston, MA, Aug 19–23, 2007.

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

RAY MCKASKLE, P.E., Senior Engineer
Trimeric Corporation
Buda, TX 78610

Biographical Sketch

Mr. McKaskle has over 24 years of engineering experience, including 17 years of process engineering services for clients from the oil and gas, electric power utility, coal gasification, wood products, petrochemical, and semiconductor industries. Recent project experience includes lead engineer and project manager roles for a 1,000 tonne per day (21 MMSCFD) carbon dioxide (CO_2) compression and dehydration system for a Department of Energy Regional Sequestration Partnership Phase III Demonstration project, for a 2,600 (50 MMSCFD) tonne per day CO_2 compression and dehydration system for a commercial client, and for capacity evaluations, process improvements, and expansions for an 850 tonne (16 MMSCFD) per day CO_2 compression, liquefaction, distillation, and pumping facility for a commercial client. He is also leading a multi-year effort for a U.S. oil producer to convert their fleet of drilling rigs to run on LNG in order to reduce diesel usage, which includes Life Cycle Assessment of system costs and environmental benefits.

Mr. McKaskle has performed and managed emissions testing projects at facilities across his industry experience base using standard EPA approved and specially developed testing protocols to suit the application. He has firsthand experience with numerous product flow rate and emissions measurement testing efforts and with evaluation of measurement test results.

With more than seven years of process engineering experience in the semiconductor industry, Mr. McKaskle has also developed expertise in complex troubleshooting of existing processes, process reactors, and abatement systems. He was a proven performer in systematic and statistically based troubleshooting and root cause analysis of process and reactor issues.

Education

B.S., Chemical Engineering, Oklahoma State University, 1992
Graduated in top 10% of College of Engineering

Professional Experience

Senior Engineer, Trimeric Corporation, 2005 – Present
Chemical Systems Engineer – Senior Field Process Engineer, Novellus Systems Inc., 1999 – 2005
Associate Engineer – Staff Engineer, Radian International, 1992 – 1999

Professional Registrations/Certifications

Registered Professional Engineer in Texas
Registered Professional Engineer in California

Selected Publications

McKaskle, R. and B. Piggott, "Design, Construction, and Commissioning of a New 50 MMscfd (1 Million Tonne / Year) CO_2 Compression and Dehydration Facility for EOR", Presented at Twelfth Annual Carbon Capture, Utilization & Sequestration Conference and Published in Conference Proceedings, Pittsburgh, Pennsylvania, May 14, 2013.

McKaskle, R., K. Fisher, R. Jones, S. Frailey, "Design, Startup, and Operation of a 50 MWe CO_2 Sequestration System, Presented at Eleventh Annual Carbon Capture, Utilization & Sequestration Conference and Published in Conference Proceedings, May 2012.

McKaskle, R., and A. Sexton, "Design and Performance of CO_2 Injection Equipment: MGSC Validation Phase Enhanced Oil Recovery Sites II and III", Illinois State Geological Survey, Open File Series 2012-7, 17 pp., 2012.

Finley, Robert, Kevin Fisher, Ray McKaskle, "Evaluation of CO_2 Capture Options from Ethanol Plants", Illinois State Geological Survey, DOE Award #: DE-FC26-05NT42588, 2006.

McKaskle, R., K. Fisher, A. Sexton, "Comparison of Source Specific CO_2 Capture Processes", Presented at Society of Petroleum Engineers International Conference on CO_2 Capture, Storage, and Utilization, San Diego, California, Nov. 3, 2009.

Synergistic Activities

The following items highlight Mr. McKaskle's project experience in related technical areas:

Project Manager and Lead Engineer for Design of 1,000 tonne per day CO_2 Compression and Dehydration System

- Served as project manager and lead engineer for an engineering team that designed the 1,000 tonne per day (50 MWe) CO_2 compression and dehydration system for the DOE Midwest Geological Sequestration Consortium Regional Partnership Phase III Demonstration.
- Managed the project from development of the initial design basis through commissioning, startup, 3-year injection operations completing the one million tonne injection phase of the project, and subsequent data analysis and reporting tasks.

Prepared and delivered "A New Look at Impurities in CO_2 for EOR and their Consequences" presentation at Midland CO_2 Conference on December 11, 2014

Taught course at DOE offices in Morgantown, WV on CO_2 Purification and Processing Equipment Used for Enhanced Oil Recovery in February 2013

Prepared and delivered "Comparison of Source Specific CO_2 Capture Processes" presentation at Society of Petroleum Engineers International Conference on CO_2 Capture, Storage, and Utilization in San Diego, CA on November 3, 2009

BRAD PIGGOTT, P.E., Senior Engineer

Trimeric Corporation
Buda, TX 78610

Biographical Sketch

Mr. Piggott is a chemical engineer with over 14 years of experience in diverse industries such as hydrogen production, air separation, natural gas treating, and specialty chemicals. As a process engineer, Mr. Piggott has provided services from the concept phase of a project through commissioning and start up and has specific experience commissioning, operating, and troubleshooting carbon dioxide (CO_2) compression and purification facilities. He was a lead process engineer for a 50 MMSCFD CO_2 compression and purification facility from the initial process design phase through start up and initial operation of the facility. Mr. Piggott has extensive experience specifying equipment for CO_2 service including compressors, dehydration units, and multistage centrifugal pumps. He has developed process control documentation for several dense phase CO_2 pump applications and overall control strategy documentation for CO_2 compression and dehydration facilities. He has also sized and specified relief devices in acid gas service at a wide range of pressures and designed relief device vent headers for CO_2 service. Mr. Piggott routinely develops operating procedures for new and existing process facilities and has written operating procedures for several CO_2 compression and purification facilities.

Education and Training

B.S., Chemical Engineering with a Minor in Economics, Colorado School of Mines, Golden, Colorado, 2002.

Research and Professional Experience

Senior Engineer, Trimeric Corporation, 2008-Present
Positions up to Syngas Tech Engineer, Air Liquide America, 2002-2008

Professional Registrations/Certifications

Registered Professional Engineer in Texas
Registered Professional Engineer inMississippi

Selected Publications

Marsh, M.J., J.P. Farone, B.D. Piggott, C.B. Wallace, “Evaluation, Selection, and Implementation of CO_2 Removal Technology at a Complex Gas Production Site”, Proceedings of the 60th Annual Laurance Reid Gas Conditioning Conference, Norman, Oklahoma, 21-24 February 2010, pp. 221-232.

McKaskle, R. and B. Piggott, “Design, Construction, and Commissioning of a New 50 MMscfd (1 Million Tonne / Year) CO_2 Compression and Dehydration Facility for EOR”, Presented at Twelfth Annual Carbon Capture, Utilization & Sequestration Conference and Published in Conference Proceedings, Pittsburgh, Pennsylvania, May 14, 2013.

Piggott, B., R. McKaskle, T. Kerr, A. Ryan, “Acid Gas Relief Challenges in the Natural Gas Treatment Industry”, Laurence Reid Gas Conditioning Conference, February 2016, Norman, OK, pp. 365-381.

Synergistic Activities

The following highlights Mr. Piggott’s project experience in related technical areas:

CO_2 Compression and Purification

- Process engineer for 21 MMSCFD CO_2 compression and dehydration facility.
  - Sized and specified control valves.
  - Developed control system documentation for dense phase CO_2 pump.

    - Developed operating procedures for entire facility including inlet multistage blower, reciprocating compressors, dehydration unit, multistage centrifugal pump, injection pipeline, and utilities.
    - Attended Factory Acceptance Test of CO_2 dense phase pump control loops.
    - Supported start up and initial operation of facility.
- Process engineer for 42 MMSCFD CO_2 compression and dehydration facility.
    - Provided process engineering review for entire facility prior to facility start up.
    - Developed control system documentation for dense phase CO_2 pumps.
    - Sized and specified back pressure control valve for dense phase CO_2 pumps.
    - Developed operating procedures for entire facility including inlet multistage blower, reciprocating compressors, dehydration unit, multistage centrifugal pump, injection pipeline, and utilities.
- Process engineer for 50 MMSCFD CO_2 compression and dehydration facility.
    - Evaluated bids for rotating compression equipment and developed technical and economic justification for equipment selection.
        - Investigated alternate process configurations with host fertilizer facility to minimize operating costs of facility.
    - Sized and specified high pressure vent control valves and facility back pressure control valves.
    - Worked with detailed engineering firm and equipment vendors during detailed design phase, responsible for review and approval of process datasheets and vendor submissions.
    - Developed overall facility control philosophy and control documentation for entire facility and each major unit operation.
    - Developed cold weather cooling tower operating procedures.
    - Developed operating procedures for entire facility including inlet multistage blower, reciprocating compressors, dehydration unit, multistage centrifugal pump, injection pipeline, and utilities.
        - Trained facility operators.
    - Led loop check and functional test team for facility.
        - Responsible for validating control systems at facility against control system documentation.
    - Supported start up and initial operation of facility.
        - Compared actual facility performance with original process design.
- Process engineer for large enhanced oil recovery client utilizing naturally occurring CO_2.
    - Process engineering support of field compressor installation.
        - Analyzed reciprocating compressor operations at a variety of inlet conditions to set suction pressure and temperature limitations for compressor operation.
        - Sized and specified relief valves and recycle control valves for reciprocating compressor installation.
        - Developed compressor start up sequence with PLC programmer to enable safe and reliable automatic compressor startup.

The CETER Group, Inc.

DR. NICHOLAS A. AZZOLINA
Principal/Co-Founder/Senior Scientist
The CETER Group, Inc.
1027 Faversham Way, Green Bay, Wisconsin 54313 USA
Phone: (920) 857-6032, E-Mail: nick.azzolina@gmail.com

Principal Areas of Expertise

Dr. Azzolina is a hydrogeologist and statistician with over 19 years of industry and consulting experience for a broad range of projects across the United States and Canada. He specializes in large, complex data set analysis and integrates robust statistical methods, with expertise in several aspects of environment data, including hydrogeology, chemistry, and reservoir engineering. Since 2010, Dr. Azzolina has worked closely with the Energy & Environmental Research Center (EERC) through the U.S. Department of Energy (DOE) and the Plains CO_2 Reduction (PCOR) Partnership on subsurface technical risk management associated with geologic CO_2 storage and life cycle analysis of CO_2 enhanced oil recovery (EOR) operations.

Qualifications

Ph.D., Environmental Management and Science, Carnegie Mellon University, 2015
M.S., Hydrogeology, Syracuse University, 2005
A.B., Geology, Princeton University, 1997

Professional Experience

2010–Present: Senior Scientist, The CETER Group, Inc. (CETER). Dr. Azzolina's principal areas of interest and expertise are statistical inference and modeling, with expertise in Monte Carlo simulation and probabilistic methods. Since 2010, he has applied these statistical techniques to a host of industry and environmental projects, including geologic CO_2 storage, oil and gas exploration and production, nonferrous mining water quality studies, and the environmental management of contaminated soil, sediment, and groundwater. While at CETER, Dr. Azzolina has supported the EERC and the PCOR Partnership with subsurface technical risk management. In addition, he provides assistance with an EERC project focused on developing and refining the field methods used to quantify and optimize CO_2 storage capacity in all major reservoir classes for CO_2 EOR sites. Dr. Azzolina codeveloped with the EERC a detailed life cycle analysis of greenhouse gas (GHG) emissions associated with CO_2 EOR where the CO_2 is sourced from a coal-fired power plant. The results show that CO_2 EOR produces oil with a lower GHG emission factor than conventional oil. This model may be used to explore optimization scenarios to design electricity–oil systems that produce lower-GHG emission oil. Dr. Azzolina and the EERC are currently tailoring this life cycle analysis to the Bell Creek oil field in southeastern Montana, where the CO_2 is sourced from a natural gas-processing facility.

2008–2010: Scientist, Foth Infrastructure & Environment, LLC, Green Bay, Wisconsin
2005–2008: Scientist, The RETEC Group, Inc., Ithaca, New York
2003–2005: Research Assistant, Syracuse University, Syracuse, New York
2000–2003: Supervisor, McMaster-Carr Supply Company, Dayton, New Jersey
1997–2000: Senior Field Engineer, Schlumberger, Edinburg, Texas
Prior to cofounding CETER, Dr. Azzolina worked as a wireline engineer, logistics and supply-chain supervisor for a large distributor, university research assistant, and finally as a scientist for two different

national environmental consulting firms. Throughout his career, Dr. Azzolina has applied his scientific background to solving problems and helping clients maximize the information value of limited data sets. He has published 17 articles in the peer-reviewed literature, several of which are focused on various aspects of geologic CO_2 storage and life cycle analysis.

Relevant Publications

Azzolina, N.A., Kreitinger, J.P., Skorobogatov, Y., Shaw, R.K., Mascuch, L., and Ripp, J.A., in press, Background concentrations of PAHs and metals in surface and subsurface soils collected throughout Manhattan, New York: Environmental Forensics.

Azzolina, N.A., Peck, W.D., Hamling, J.A., Gorecki, C.D., Ayash, S.C., Doll, T.E., Nakles, D.V., and Melzer, L.S., in press, How green is my oil? a detailed look at greenhouse gas accounting for CO_2-enhanced oil recovery (CO_2-EOR) sites: International Journal of Greenhouse Gas Control.

Azzolina, N.A., Nakles, D.V., Gorecki, C.D., Peck, W.D., Ayash, S.C., Melzer, L.S., and Chatterjee, S., 2015, CO_2 storage associated with CO_2 enhanced oil recovery – a statistical analysis of historical operations: International Journal of Greenhouse Gas Control, v. 37, p. 384–397.

Siegel, D.I., Azzolina, N.A., Smith, B.J., Perry, A.E., and Bothun, R.L., 2015, Methane concentrations in water wells unrelated to proximity to existing oil and gas wells in northeastern Pennsylvania: Environmental Science and Technology, v. 49, no. 7, p. 4106–4112.

Azzolina, N.A., Small, M.J., Nakles, D.V., Glazewski, K.A., Peck, W.D., Gorecki, C., Bromhal, G.S., and Dilmore, R.M., 2015, Quantifying the benefit of wellbore leakage potential estimates for prioritizing long-term MVA well sampling at a CO_2 storage site: Environmental Science and Technology, v. 49, no. 2, p.1215–1224.

Azzolina, N.A., Neuhauser, E.F., Finn, J.T., Crawford, T.R., Anders, K.A., Doroski, M.A., Perretta, A.C., Distler; M.A., and Heitzman, G.W., 2014, Volatile organic compounds from coal tar and soil vapor samples at manufactured gas plant (MGP) sites: Environmental Forensics, v. 15, no. 3, p. 225–233.

Azzolina, N.A., Small, M.J., Nakles, D.V., and Bromhal, G.S., 2014, Effectiveness of subsurface pressure monitoring for brine leakage detection in an uncertain CO_2 sequestration system: Stochastic Environmental Research and Risk Assessment, v. 28, p. 895–909.

The CETER Group, Inc.

DR. DAVID V. NAKLES
Principal/Cofounder
The CETER Group, Inc.
4952 Oakhurst Avenue, Gibsonia, Pennsylvania 15044 USA
Phone: (412) 486-6242; E-Mail: david.nakles@gmail.com

Principal Areas of Expertise

Dr. Nakles is a chemical engineer with over 40 years of experience in the environmental consulting business. His career has emphasized the risk-based environmental management of soil and sediment impacted with residuals generated during the extraction and processing of coal, oil, and natural gas. A common theme of this work is the development of risk-based site characterization and remediation strategies that will yield the most cost-effective approaches for the reduction of risks to human health and ecological receptors.

Qualifications

Ph.D., Chemical Engineering/Engineering and Public Policy, Carnegie Mellon University, 1977
B.S., Chemical Engineering, Pennsylvania State University, 1971

Professional Experience

2009–Present: Cofounder/Principal, The CETER Group, Inc./Adjunct Professor, Department of Civil and Environmental Engineering, Carnegie Mellon University, Pittsburgh, Pennsylvania.
2007–2009: Senior Vice President, ENSR Corporation (AECOM), Pittsburgh, Pennsylvania.
1985–2007: Cofounder/Principal/Senior Vice President, The RETEC Group, Inc. (formerly known as Remediation Technologies, Inc.), Pittsburgh, Pennsylvania.
1977–1985: Research Engineer to Manager of Regional Operations, Environmental Research and Technology, Pittsburgh, Pennsylvania.
1974–1977: Research Chemical Engineer, Pittsburgh Energy Research Center, Bruceton, Pennsylvania.
1971–1974: Product Development Engineer, Dow Chemical Company, Midland, Michigan.

Over his 40+ years in the environmental consulting business, Dr. Nakles has worked on a variety of environmental projects that have included the management of several multiyear, multidisciplinary environmental research programs; development of risk-based work plans and analytical strategies for environmental site characterization and closure of contaminated sites; development of environmental liability management strategies associated with historically contaminated sites; and a broad range of technical topics associated with the geologic storage of CO_2 including site-specific risk assessments and development of monitoring, verification, and accounting (MVA) plans. An overview of a subset of these projects is provided as follows:

- **Gas Research Institute (GRI) (1986–1994):** Manager of a multicontractor project team to investigate the environmental impacts associated with the historic processes that converted coal to gas in the 1800s to produce heat and light, i.e., manufactured gas plants (MGPs).

- **GRI (1990–1994):** Manager of multiyear project to evaluate environmental control strategies in the natural gas production industry.

- **Total Petroleum Hydrocarbon (TPH) Criteria Working Group (GRI and U.S. Department of Energy [DOE]):** Served as GRI representative on an industry consortium that was focused on the development of risk-based strategies for sites contaminated with TPHs.

- **Bioavailable Polynuclear Aromatic Hydrocarbons (PAHs) in Sediment (GRI, National Grid, Alcoa, and Northeast Gas Association)**: Led a research initiative that focused on defining the bioavailable fraction of PAHs in impacted sediment for the purpose of defining risk-based remedial action levels.

- **Speciation of Cyanide Complexes in Soil and Groundwater (Electric Power Research Institute [EPRI], Alcoa, and GRI):** Led a multicontractor research initiative to develop a risk-based approach for the management of cyanide impacts in soil and groundwater at MGP sites.

- **DOE (Subcontractor to Energy & Environmental Research Center, University of North Dakota).** Technical consultant to the Plains CO_2 Reduction (PCOR) Partnership Regional Carbon Sequestration Partnership of DOE since 2009. Provided technical support covering a broad range of topics including site-specific risk assessments; MVA plan development; and review, analysis, and reporting of technical results of field demonstration projects.

Relevant Publications

The results of several of the research initiatives led by Dr. Nakles were incorporated into textbooks that serve as reference materials for environmental practitioners:

Nakles, D.V. et al., 2006, Cyanide in water and soil – chemistry, risk and management: CRC Press, chaps. 4, 10, 13, 26, and 27.

Nakles, D.V. et al., 2001, Risk-based decision making for assessing petroleum impacts at exploration and production sites: Government Printing Office, chaps. 1, 3, and 4.

Linz, D.G., and D. V. Nakles, eds., 1997, Environmentally acceptable endpoints in soil—risk-based approach to contaminated site management based on the availability of chemicals in soil: American Academy of Environmental Engineers.

Hayes, T.D., Linz, D.G., Nakles, D.V., and Leuschner, A.P., eds., 1996, Management of manufactured gas plant sites – two-volume practical reference guide of the Gas Research Institute: Amherst, Massachusetts, Amherst Scientific Publishers.

Nakles, D.V., Ortiz, I., and Frank, J.R., 1992, An analysis of management strategies for produced waters from natural gas production, chapter *in* Ray, J.P., and Engelhardt, F.R., eds., Produced water – technological/environmental issues and solutions: New York, Plenum Press.

APPENDIX B

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

June 8, 2016

Ms. Kerryanne Leroux
Senior Chemical Engineer, Oilfield Operations Team Lead
Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear Kerryanne:

Subject: EERC/Red Trail Energy (RTE) Proposal No. 2016-0143 Entitled "Integrated Carbon Capture and Storage for North Dakota Ethanol Production"

Red Trail Energy (RTE) is excited to partner with the Energy & Environmental Research Center (EERC) in the proposed subject project submitted to the North Dakota Renewable Energy Council (REC). RTE operates a corn-based ethanol production facility located near Richardton, North Dakota, producing approximately 63 MMgal/yr of ethanol and generating 180,000 tons of CO_2 annually. We look forward to the results of this proposed work, anticipated to provide RTE with key scientific data to make informed business decisions regarding economic implementation of carbon capture and storage (CCS) as a means for reducing the carbon footprint of ethanol production.

RTE will be providing support via cash and in-kind contributions. In-kind match funding includes technical support for Task 1.0 – Feasibility Study, Task 2.0 – Field Implementation Plan, and Task 3.0 – Economic Analysis. Specifically, RTE's in-kind support will consist of contributing to the following subtasks:

- Subtask 1.1 – CO_2 Capture: RTE will provide engineering support and guidance regarding the current design, layout, and capabilities of the existing RTE facility to the project team to assist with determination of capture system criteria.
- Subtask 1.4 – Risk Assessment: RTE will contribute to risk assessment activities as they pertain to the RTE facility and evaluation of recommended alterations to the facility and/or operations required by the implementation plan.
- Subtask 1.5 – Life Cycle Assessment (LCA): RTE will contribute data pertaining to the facility process flow and energy consumption, including feedstock production and transportation to assist with accurate accounting in the LCA.
- Subtask 2.1 – Plant Infrastructure Design: RTE will work with the project team on the conceptual capture system design to ensure compatibility with the existing facility and operations.
- Subtask 2.2 – Permitting Plan: RTE will work with the project team to develop the permitting plan specific to RTE site requirements.
- Task 3.0 – Economic Analysis: RTE will work with the project team to identify and assess the various economic drivers and incentive programs available to North Dakota ethanol producers with a demonstrated low-carbon-intensity value. RTE will help quantify the value of these incentive programs and the implementation costs based on the findings from Task 2.0.

Over the course of the 6-month project, RTE anticipates its consultants and employees will spend a cumulative 1000 hours on these activities at a rate of approximately $200/hr for a total in-kind value of $200,000. A cash contribution of $90,000 will also be provided should the project be awarded. It is understood that this cost share will also be applied to a US Department of Energy proposal; therefore, RTE certifies that its cost-share funding will comprise nonfederal dollars and will not be used as federal match on any other project. RTE will report actual in-kind cost share to the EERC on a regular basis to be determined at the time of contract negotiations.

We are pleased to collaborate with REC, the EERC, the U.S. Department of Energy, Schlumberger, Computer Modelling Group, Trimeric Corporation, and The CETER Group on the development of a detailed feasibility study and implementation plan for installing CCS at a North Dakota ethanol production facility.

Sincerely,

Dustin Willet
Project Manager
Red Trail Energy, LLC

EERC
Energy & Environmental Research Center®
Putting Research into Practice

University of North Dakota
15 North 23rd Street, Stop 9018 • Grand Forks, ND 58202-9018 • P. 701.777.5000 • F. 701.777.5181
www.undeerc.org

June 9, 2016

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

Dear Ms. Fine

Subject: Cost Share for EERC Proposal No 2016-0143, Entitled "Integrated Carbon Capture and Storage for North Dakota Ethanol Production"

The Energy & Environmental Research Center (EERC) is conducting complementary research and development efforts under a multi-million 5-year Cooperative Agreement with the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) entitled "Joint Program on Research and Development for Fossil Energy-Related Resources." Through this joint program, nonfederal entities can team with EERC and DOE in projects that address the goals and objectives of DOE's Office of Fossil Energy.

The proposed project to the North Dakota Industrial Commission (NDIC) Renewable Energy Council entitled "Integrated Carbon Capture and Storage for North Dakota Ethanol Production" is a viable candidate for funding under this program. Therefore, the EERC intends to secure $200,000 of cash cost share for the proposed project through its Cooperative Agreement with DOE providing that NDIC commits $490,000 of cash cost share and Red Trail Energy provides $90,000 in cash and $200,000 of in-kind contribution.

Once the EERC has commitment from all nonfederal partners to the project, the EERC will submit a proposal to DOE for its concurrence. Proposals submitted to DOE under this program receive expeditious consideration, and success rate is traditionally very high. However, there is no guarantee of approval.

As a cosponsor of the project, DOE would require access to all data generated and a royalty-free right to practice. However, certain project details can often be held confidential for some period of time.

Initiation of the proposed work is contingent upon the execution of a mutually negotiated agreement between EERC and each of the project sponsors.

If you have any questions, please contact me by phone at (701) 777-5157 or by e-mail at jharju@undeerc.org.

Sincerely,

John A. Harju
Vice President for Strategic Partnerships

JAH/kal

June 1, 2016

Ms. Kerryanne M. Leroux
Senior Chemical Engineer
Oilfield Operations Team Lead
Energy and Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

RE: EERC Proposal No. 2016-0143 Entitled "Integrated Carbon Capture and Storage for North Dakota Ethanol Production"

Dear Ms. Leroux:

We are writing to confirm our commitment to provide consulting services in the form of risk assessment and life-cycle analysis technical support for the project described in the above-referenced proposal.

Over the course of this six-month project, we anticipate working 200 hours for the risk assessment task and 200 hours for the life-cycle analysis task, for a total of 400 hours for the entire project. These hours will be charged at our standard consulting rate of $200 per hour, which represents a budget estimate of $80,000 for the entire project.

Thank you again for including The CETER Group, Inc. in this project. If you have any questions, please contact either of us at the contact information listed below.

Sincerely,

David V. Nakles

Principal/Co-Founder
The CETER Group, Inc.
4952 Oakhurst Avenue
Gibsonia, PA 15044
(412) 486-6242
david.nakles@gmail.com

Nicholas A. Azzolina

Principal/Co-Founder
The CETER Group, Inc.
1027 Faversham Way
Green Bay, WI 54313-7491
(920) 857-6032
nick.azzolina@gmail.com

TRIMERIC CORPORATION

P.O. Box 826
Buda, TX 78610

June 3, 2016

Kerryanne Leroux
Senior Chemical Engineer, Oilfield Operations Team Lead
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. 2016-0143 Entitled "Integrated Carbon Capture and Storage for North Dakota Ethanol Production"

I am writing to confirm Trimeric Corporation's commitment to provide technical support for the feasibility design of a CO_2 capture and transport system for the subject project, which is being proposed by the Energy & Environmental Research Center and Red Trail Energy (RTE) to the North Dakota Industrial Commission's Renewable Energy Council (REC) and the U.S. Department of Energy (DOE).

Trimeric is an engineering firm with a technical staff made up exclusively of chemical process engineers with a vast range of experience and expertise regarding purification, compression, dehydration, and other processing of CO_2. We have supported several large CO_2 compression and purification facilities that purify CO_2 either by simple dehydration or through liquefaction and then distillation.

We will bring this experience to bear to help complete Subtask 1.1 – CO_2 Capture, Subtask 2.1 – Plant Infrastructure Design, and Task 3.0 – Economic Analysis of the proposed scope of work. Specifically, Subtask 1.1 includes defining the process design basis for capture, dehydration, compression, and pipeline transport of the CO_2 produced by RTE's ethanol plant. This design basis will be used to generate the initial design work and process configuration required for Subtask 2.1. Cost estimations for the resulting design will be provided to EERC and incorporated into Task 3.0.

Over the course of the 6-month project we estimate approximately 200 labor hours of effort will be required to complete these tasks, with a cost estimate of $35,000.

We are pleased to collaborate with REC, EERC, RTE, and DOE on the development of a feasibility study and implementation plan for installing carbon capture and storage at a North Dakota ethanol production facility.

Sincerely,

Ken McIntush, P.E.
President
Trimeric Corporation

COMPUTER MODELLING GROUP INC.

Paragon Center One
450 Gears Road, Suite 860
Houston, Texas
U.S.A. 77067

Phone: (281) 872-8500
Fax: (281) 872-8577
E-mail: cmgl@cmgl.ca
Website: www.cmgl.ca

June 3, 2016

Ms. Kerryanne Leroux
Senior Chemical Engineer and Oilfield Operations Team Lead
Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear Ms. Leroux:

Subject: EERC Proposal No. 2016-0143 Entitled "Integrated Carbon Capture and Storage for North Dakota Ethanol Production"

I am writing to confirm Computer Modelling Group Inc.'s (CMG's) commitment to participate in the subject project, which the Energy & Environmental Research Center (EERC) in partnership with Red Trail Energy LLC (RTE) is proposing to the North Dakota Industrial Commission's (NDIC's) Renewable Energy Council and the U.S. Department of Energy (DOE).

CMG is focused on providing practical solutions for modeling and simulation of saline formations and oil and gas reservoirs to assist in answering challenging questions associated with the long-term fate of injected CO_2. As such, we have great interest in the proposed effort, which will be the first of its kind in North Dakota. We believe this project will provide crucial information needed to advance the deployment of carbon capture and storage (CCS) as a viable technology for reduced carbon energy production.

CMG and the EERC have collaborated on numerous research projects, including several focused on CCS, and have a well-established working relationship. Through this relationship, the EERC currently has access to CMG's powerful reservoir simulation software packages and tools, as well as technical support. As indicated in the subject proposal, CMG is pleased to allow the EERC continued use of these existing licenses and services for the duration of the proposed project. CMG's software, coupled with the EERC's research capabilities, proven expertise in CCS, wealth of knowledge with regard to the geology of the Williston Basin, and subsurface static and dynamic modeling proficiency, creates an ideal formula to successfully conduct the proposed feasibility study.

We welcome the opportunity to work with the EERC, RTE, NDIC, and DOE on this exciting project focused on integrating CCS with an ethanol production facility in North Dakota.

Sincerely,

James C. Erdle, PhD
Vice President – USA and Latin America

Schlumberger
Carbon Services

Wayne Rowe
Schlumberger Carbon Services
1875 Lawrence Street, Suite 810
Denver, CO 80202, USA

June 08, 2016

Ms. Kerryanne Leroux
Senior Chemical Engineer and Oilfield Operations Team Lead
Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Re: EERC Proposal No. 2016-0143 Entitled "Integrated Carbon Capture and Storage for North Dakota Ethanol Production"

Dear Ms. Leroux:

I am writing to confirm Schlumberger's commitment to participate in the subject project, which the Energy & Environmental Research Center (EERC) in partnership with Red Trail Energy LLC is proposing to the North Dakota Industrial Commission's (NDIC's) Renewable Energy Council and the U.S. Department of Energy (DOE).

Schlumberger is a recognized leader in reservoir evaluations, well drilling and completion, and the management of CO_2, with decades of experience in field testing for the oil and gas industry. With more than 80 years of experience drilling, mapping, measuring, and modeling underground rock formations, Schlumberger has proven expertise and leading drilling technologies to support every phase of well design, planning, and operations. Schlumberger capabilities encompass offset well analysis and design of the well, BHA, and fluids systems, through to drilling performance monitoring and optimization in real time. The goal is increasing drilling efficiency, reducing nonproductive time, mitigating risk, and maximizing daily footage, while maintaining wellbore stability and quality.

A key component of any CO_2 storage project is ensuring injection wells meet regulatory requirements while also operating safely, effectively, and efficiently. Schlumberger has demonstrated experience in drilling and completing wells for CO_2 injection and storage, including wells for the Illinois Industrial Carbon Capture and Storage Project, which successfully meets the stringent Underground Injection Control Class VI regulations. As indicated in the subject proposal, Schlumberger is committed to providing services in the form of well design, including drilling and completions, as well as technical support to contribute to achieving project goals (valued at $15,000). In addition, Schlumberger is pleased to allow the EERC use of its existing Schlumberger software packages and licenses for the duration of the project.

We welcome the opportunity to collaborate with the EERC, Red Trail Energy, NDIC, and DOE on this exciting project focused on advancing technologies aimed at producing reduced carbon renewable energy. If you have any questions, please contact me by telephone at (303) 594-1219 or by e-mail at rowe5@slb.com.

Sincerely,

Wayne Rowe

Wayne Rowe
Operations Manager

APPENDIX C

BUDGET JUSTIFICATION

BUDGET JUSTIFICATION

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 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.

Labor: Estimated labor includes direct salaries and fringe benefits. 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 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.

Labor Categories	No. Labor Hours
Research Scientist/Engineers	4113
Research Technicians	187
Senior Management	111
Technical Support Services	302
	4713

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, etc., are based on historical costs. Miscellaneous travel costs may include taxis, 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.

Consultants:

The CETER Group will be providing consulting services for the risk assessment and life cycle analysis activities of the proposed work. The CETER group will collect and analyze the majority of the data for both of these activities and provide regular updates and detailed summary documentation to the EERC which will be used for creation of the final project report. A letter of commitment from the CETER Group is included with the proposal.

Schlumberger Carbon Services will provide consulting services for the well design and testing activities for the proposed work. Schlumberger will develop well design, drilling and completion plans, and associated technical aspects of wellbore evaluations, based upon input provided by the EERC. Schlumberger's designs and plans will also include cost estimates for each of these activities to be used by the EERC for completing the proposed work. A letter of commitment from Schlumberger is included with the proposal.

Trimeric Corporation will provide consulting services in the form of evaluation of CO_2 capture technology evaluation and selection, conceptual design and process configuration of capture technology for the Red Trail Energy ethanol facility, and evaluation of costs of implementation. These designs and evaluations will be reported to the EERC for inclusion in the final project report. A letter of commitment from Trimeric is included with the proposal.

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.

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 expenses of a designated group of individuals whose roles require specialized safety training and personal safety items. These individuals perform project activities in a pilot plant facility, remote location or laboratory and are also responsible for preserving a safe working environment in those areas. The rate includes such things as training for use of fall protection harnesses and respirators, CPR certification, annual physicals, protective clothing/eyewear, hazardous waste disposal fees, and labor for personnel to direct group activities. The estimated cost is based on the number of hours budgeted for this group of individuals.

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.

Cost Share:

Red Trail Energy's in-kind cost-share contribution will consist of evaluations and engineering support by its consultants and employees to various tasks for both the proposed feasibility study and implementation plan. They will contribute to technology selection and design, evaluation of project risks, assessment of needed permits, and economic evaluations of the impact of the resulting plan. These contributions are key to the success of the proposed work as RTE's consultants and employees have detailed site-specific knowledge of their ethanol production facility and processes. A letter of commitment from Red Trail Energy is included with the proposal.

APPENDIX D

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