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September 1, 2015

North Dakota Legislative Management
Legislative Council – Emily L. Thompson, Legal Counsel
State Capitol
600 East Boulevard Avenue
Bismarck, ND 58505-0360

Dear Ms. Thompson:

Subject: EERC Proposal No. 2016-0011 Entitled "North Dakota Carbon Capture and Enhanced Oil Recovery Economic Impact Study"

The Energy & Environmental Research Center (EERC) is pleased to provide the attached proposal to the North Dakota Legislative Council in response to Section 42 of 2015 Senate Bill No. 2015. Tertiary recovery methods such as carbon dioxide (CO_2) enhanced oil recovery (EOR) are expected to result in the recovery of significant incremental oil in North Dakota, starting in the near future. As incremental oil from CO_2 EOR is incentivized under current policy, an understanding of the future volume of incrementally recovered oil is essential for calculating expected future tax revenue and for formulating future oil industry tax policy.

The EERC is excited about the team assembled, including Corey Fong at Odney Public Affairs & Government Relations, a prior North Dakota Tax Commissioner; Dean Bangsund at North Dakota State University, with decades of professional experience in community economic impact assessments; Benjamin Cook at the University of Wyoming Enhanced Oil Recovery Institute, a noted economist with extensive experience in EOR development; and Nick Azzolina at The CETER Group, who specializes in statistical analysis and modeling of industrial and environmental data, combined with the EERC's extensive knowledge and experience in EOR and unconventional resources assessment.

Additionally, a technical advisory board consisting of Ron Ness, President of the North Dakota Petroleum Council; Lynn Helms, Director of the North Dakota Industrial Commission Oil and Gas Division; Mike Jones, Vice President of Research & Development for the Lignite Energy Council; and Vicky Steiner, Executive Director for the North Dakota Association of Oil and Gas Producing Counties, ensures that all aspects of the state, political subdivisions, the environment, and the fossil fuel energy production industry interests are understood and dequately represented in order to provide insight into the potential effects that recommended changes may have on various stakeholders.

This team is exceptionally well qualified to provide a clear picture of the current and future landscape of the oil and gas industry and the economic climate in North Dakota with an emphasis on carbon capture technologies and EOR. The picture provided will in turn allow for comprehensive legislative evaluation of existing, alternative, and potential future tax incentives that would best serve the interests of the state, political subdivisions, the environment, and the energy industry.

On behalf of the project team, the EERC would like to thank the North Dakota Legislative Management for the opportunity to be considered for providing these services that clearly have a direct and long-standing impact on the great state of North Dakota. If you have any questions, please contact me by phone at (701) 777-5157 or by e-mail at jharju@undeerc.org.

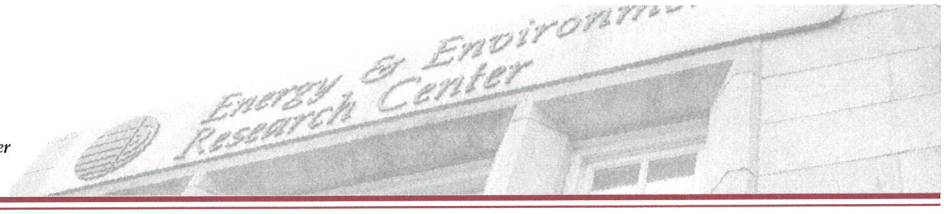
Sincerely,

John A. Harju
Associate Director for Strategic Partnerships

JAH/kal

Attachment

EERC
Energy & Environmental Research Center



NORTH DAKOTA CARBON CAPTURE AND ENHANCED OIL RECOVERY ECONOMIC IMPACT STUDY

EERC Proposal No. 2016-0011

Submitted to:

North Dakota Legislative Management
Legislative Council – Emily L. Thompson, Legal Counsel

State Capitol
600 East Boulevard Avenue
Bismarck, ND 58505-0360

Submitted by:

James A. Sorensen

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September 2015

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Grand Forks

TABLE OF CONTENTS

LIST OF FIGURES ii

LIST OF TABLES ii

EXECUTIVE SUMMARY iii

STATE OF THE INDUSTRY 1
- North Dakota Oil and Gas Reach 1
- Carbon Dioxide Enhanced Oil Recovery Potential 1
- Tax Incentives to Encourage Development 2

PROJECT TEAM EXPERIENCE AND EXPERTISE 2
- Energy & Environmental Research Center 2
- North Dakota State University, Department of Agribusiness and Applied Economics 4
- Odney, Public Affairs & Government Relations 4
- University of Wyoming College of Business, Department of Economics & Finance 5
- The CETER Group, Inc. 5
- Project Advisory Board 6

GOALS AND OBJECTIVES 7

SCOPE OF WORK 7
- Task 1 – A Scientific Study of Potential EOR in North Dakota 7
  - Task 1.1 – A Detailed Analysis of CO_2 EOR for North Dakota 7
  - Task 1.2 – The Technical Feasibility of Implementing Various EOR Methods 8
  - Task 1.3 – The Estimated Time Line for Implementation of EOR Techniques Identified 11
  - Task 1.4 – Evaluation of Identified Technically Feasible and Commercially Available EOR Techniques for North Dakota 11
- Task 2 – An Economic Study of Potential EOR in North Dakota 11
  - Task 2.1 – The Estimated Annual Economic Impacts, Near- and Long-Term, from Implementation of CO_2 EOR 11
  - Task 2.2 – Investigation of Current and Potential Tax Incentives to Encourage Implementation of CO_2 EOR 12
  - Task 2.3 – Evaluation of CO_2 EOR and Potential Tax Incentives for North Dakota 13
- Task 3 – Reporting and Travel 13

Continued . . .

TABLE OF CONTENTS (continued)

BUDGET AND SCHEDULE 13
Project Budget 13
Project Schedule 14

REFERENCES 14

BUDGET 19

RELEVANT PROJECTS AND REFERENCES ..... Appendix A

PROJECT TEAM RESUMES ..... Appendix B

ADVISORY BOARD COMMITMENT LETTERS ..... Appendix C

PROJECT TEAM COMMITMENT LETTERS ..... Appendix D

LIST OF FIGURES

1 Geographic distribution of units showing the ten highest-ranked potential CO_2 EOR targets based on the EERC's 2014 study 9

2 Stationary CO_2 sources in the study area 10

LIST OF TABLES

1 Milestones and Time Line 15

NORTH DAKOTA CARBON CAPTURE AND ENHANCED OIL RECOVERY ECONOMIC IMPACT STUDY

EXECUTIVE SUMMARY

The Energy & Environmental Research Center (EERC), in partnership with North Dakota State University, Department of Agribusiness and Applied Economics; Odney, Public Affairs & Government Relations; the University of Wyoming College of Business, Department of Economics & Finance; and The CETER Group, Inc., is proposing to conduct a scientific and economic study of oil and gas enhanced recovery techniques for applicability in North Dakota. The proposed project team is highly experienced in the fossil energy industry, bringing expertise in oil and gas technologies, economics, taxation policy, and environmental impacts. An advisory board comprising members with immense knowledge of the oil and gas industry and interests of the state will also be accessible throughout the study duration to ensure project success.

Oil and gas development has generated unprecedented growth in the North Dakota economy over the last decade, affecting numerous communities and industries within the region. While research suggests that the prospects for future carbon dioxide (CO_2)-based enhanced oil recovery (EOR) operations in the Bakken are encouraging, near-term CO_2 EOR operations will likely be focused on pilot-scale field tests. Therefore, CO_2 EOR should be recognized as part of a long-term production strategy for North Dakota oil fields. Taxation policies can also be used to both encourage development in North Dakota's oil and gas industry as well as provide income to the state for infrastructure needs to support community growth and, thus, a sustainable economy.

The goal of the proposed project is to determine the potential near- and long-term economic impacts of carbon capture technology and EOR development in North Dakota and the effect of potential tax incentives on development in the oil and gas industry, as well as affected industries, communities, and interest groups. This will be accomplished by conducting two main tasks:

1. A scientific study of potential EOR in North Dakota, including CO_2-based and other EOR methods, considering various North Dakota oil formations and implementation time lines.

2. An economic study of potential EOR in North Dakota, considering existing and alternative tax incentives, and the effect of implementation on affected industries, communities, and various interest groups.

Regular communication, in the form of quarterly updates and conference calls, will be conducted to keep the Taxation Committee informed of progress and findings throughout the duration of the project. A comprehensive final report summarizing project results will be generated and presented to the Taxation Committee upon study completion.

The estimated cost to perform the proposed project is $399,772. Completion will be within 11 months of project start. Milestones include quarterly reports and a final report to the Taxation Committee by Friday, August 19, 2016, as well as presentation of project findings.

NORTH DAKOTA CARBON CAPTURE AND ENHANCED OIL RECOVERY ECONOMIC IMPACT STUDY

The Energy & Environmental Research Center (EERC), in partnership with North Dakota State University (NDSU), Department of Agribusiness and Applied Economics; Odney, Public Affairs & Government Relations (Odney); the University of Wyoming College of Business (UW), Department of Economics & Finance; and The CETER Group, Inc. (CETER), is proposing to conduct a scientific and economic study of oil and gas enhanced recovery techniques for applicability in North Dakota.

STATE OF THE INDUSTRY

North Dakota Oil and Gas Reach

Oil and gas development has generated unprecedented growth in the North Dakota economy over the last decade, affecting numerous communities and industries within the region. Although it has slowed recently to 2010/2011 levels, growth is still occurring at a significant pace (Nowatzki, 2015). That said, increasing employment to support the affected industries is expected to continue, with significant increasing population projections estimated at 12%–27% from 2012 to 2036 (Bangsund and Hodur, 2013). In addition, electrical energy consumption is expected to increase more than threefold, from 7 million MWh in 2012 to an estimated 25 million MWh by 2032 (Kadrmas, Lee & Jackson, Inc., 2012). Oil and gas activity in western North Dakota also continues to require large amounts of water for production from the Bakken petroleum system; EERC projections estimate that freshwater demand will nearly triple by 2035 from 2014 levels (i.e., about 11 billion gallons to 30–34 billion gallons) for fracturing and well maintenance (Kurz and others, 2015). However, other factors such as community infrastructure (e.g., housing, roads, schools, etc.), pipelines, railways, and refineries are also clearly affected and require support to sustain industry and economic growth.

Carbon Dioxide (CO_2) Enhanced Oil Recovery (EOR) Potential

CO_2 EOR is a mature oil development tool that can be used to reinvigorate conventional oil fields currently under waterflood (a secondary oil extraction effort) or to extract oil from tight reservoirs where waterflood would be ineffective (Gunter and Longworth, 2013). Typically, a reservoir that has undergone a successful waterflood is a prime candidate, both technically and economically, for successful CO_2-based tertiary oil extraction efforts. There are currently 71 active waterflood efforts in North Dakota (Helms, 2015), which provides an indication of the potential evolution of long-term development in the Williston Basin regarding EOR. Although the Bakken Formation is by far the largest source of oil in North Dakota and comprises a vast majority of the state's production, research suggests that waterflooding may not be a technically viable approach to EOR in the Bakken petroleum system. While research also suggests that the prospects for future CO_2 EOR operations in the Bakken are encouraging, there is currently no proven strategy or existing projects for CO_2-based EOR in the Bakken system, and any near-term CO_2 EOR operations in the Bakken will likely be focused on pilot-scale field tests. EOR development should thus be recognized as part of a long-term production strategy for North

Dakota oil fields. The primary challenge to a CO_2 EOR strategy will be the acquisition of sufficient CO_2 supply (Burton-Kelly and others, 2014).

Tax Incentives to Encourage Development

Taxation policies can be used to both encourage development in North Dakota's oil and gas industry as well as provide income to the state for infrastructure needs to support community growth and, therefore, a sustainable economy. Current tax structures include base rates for oil production and extraction, with a high-price trigger to begin in January 2016 (North Dakota Petroleum Council, 2015). Incentives include exemptions for stripper wells (e.g., wells that produce less than 10 bbl of oil a day) and incremental oil, in addition to lower rates for non-Bakken and horizontal wells. Alternative options can be explored by reviewing tax policies of other oil-producing states. For example, Alaska, California, Louisiana, Montana, Texas, and Wyoming also levy ad valorem property taxes on equipment, flowlines, production, and/or minerals (Covenant Consulting Group, 2012). Examples of incentives in other states include exemptions for inactive, deep-drilled, research, and returned idle wells and EOR projects (secondary and/or tertiary efforts) (Dix, 2009). The current state of the North Dakota oil and gas industry thus provides an opportunity to optimize taxation policies for the greatest benefit to a sustainable economy.

PROJECT TEAM EXPERIENCE AND EXPERTISE

The proposed project team is highly experienced in the fossil energy industry, bringing expertise in oil and gas technologies, economics, taxation policy, and environmental impacts. Organizational and key personnel information is provided below. An advisory board comprising members with immense knowledge of the oil and gas industry and the interests of the state will also be accessible throughout the study duration to ensure project success. Examples of oil and gas and/or economics-related projects from the project team, resumes, advisory board letters of commitment, and project team letters of commitment are provided in Appendices A–D, respectively.

Energy & Environmental Research Center

The EERC, leader of the Plains CO_2 Reduction (PCOR) Partnership (for over 10 years) under the U.S. Department of Energy National Energy Technology Laboratory's Regional Carbon Sequestration Partnerships Initiative, has a history of success and a reputation of excellence in CO_2 EOR efforts (Smith and others, 2006, 2009, 2010; Steadman and others, 2006; and Sorensen and others, 2009, 2010). The EERC's efforts to characterize the EOR potential of the Bakken have also been documented (Kurtoglu and others, 2013; Liu and others, 2014; and Sorensen and others, 2014). The EERC has leveraged extensive data sets on the Williston Basin, covering over a half century of oil and gas exploration and production in the region, into several regional- and basin-scale characterization activities and geologic models and simulations that were used to grow the PCOR Partnership's understanding of the potential for CCS (carbon capture and storage) within the Williston Basin and the larger PCOR Partnership region (Peck and others, 2012, 2014). The EERC also has experience working with industry on commercial-scale CO_2 EOR projects at the Bell Creek oil field in Montana (Gorecki and others, 2012, 2013; Hamling and others, 2013; Saini and others, 2012), and the Zama oil field in Alberta (Gao and others, 2014). More recently, the EERC updated a previous study (Smith and others, 2005) to determine

the near-term potential for CO_2-based EOR in North Dakota's conventional oil fields. This updated study found that there continues to be significant opportunity in North Dakota to produce additional oil from well-established conventional oil fields through CO_2 EOR (Burton-Kelly and others, 2014).

James A. Sorensen will serve as Project Manager, leading the proposed EERC and project team activities. Mr. Sorensen is a Senior Research Manager at the EERC, where he is a principal investigator and task manager for projects related to the sequestration of CO_2 in geologic media and the sustainable development of tight oil resources. Mr. Sorensen's primary areas of interest and expertise are CO_2 utilization and storage in geologic formations, tight oil resource assessment and development, and environmental issues associated with the oil and gas industry. Since 2003, he has focused on the value-added use of CO_2 for EOR, including managing a pilot-scale CO_2 EOR test in the Northwest McGregor oil field in North Dakota. Since 2009, he has conducted a variety of research projects to develop an improved understanding of the Bakken petroleum system, including efforts to examine the potential to use CO_2 for EOR in the Bakken. In 2011, Mr. Sorensen conducted an assessment of North American tight oil resources that was included as a section in the National Petroleum Council's report to the U.S. Secretary of Energy on the potential of North America's abundant natural gas and oil resources (National Petroleum Council, 2011). Mr. Sorensen received his B.S. degree in Geology from the University of North Dakota (UND). He is a member of the Society of Petroleum Engineers and is an author or coauthor of over 200 published papers.

Wesley D. Peck is a Senior Research Manager at the EERC, where he currently oversees a staff of geologists and geomodelers involved in oil and gas research in the Williston Basin and the geologic characterization of central North America with respect to CO_2 sequestration. He received his M.S. degree in Geology from UND and his B.S. degree in Earth Science from North Dakota State University. Mr. Peck's principal areas of interest and expertise include sedimentary and petroleum geology, GIS (geographic information system), and petroleum resource assessment.

Lonny L. Jacobson is a Research Specialist in Oilfield Management at the EERC and holds a B.A. degree in Economics from the University of North Dakota. Mr. Jacobson's principal areas of interest and expertise include optimizing wellsite layout for well servicing/completions, hydraulic fracturing techniques, logistics, and site management. At the EERC, he leads field activities related to drilling, logging, coring, and completion; analyzes hydraulic fracturing practices; and conducts oil and gas pipeline evaluations and inspections in conjunction with EERC oilfield projects. Mr. Jacobson was previously employed by Bonetraill Rentals, LLC, in Williston, North Dakota, as Operations Manager/Consultant, where his duties included hydraulic fracturing procedures, workover operations, completions, drilling operations, coil tubing, wireline, installation and independent third-party inspection of gas and production water pipelines, invoicing, daily reports, and overseeing other consultants.

Two senior-level professionals, possessing industry knowledge and practical experience, have committed to providing valuable advisory and consulting services to the project. These individuals are EERC staff and work in the same office complex as Mr. Sorensen. They are John Harju, EERC Associate Director for Strategic Partnerships, and Edward Steadman, EERC

Associate Director for Research. Mr. Harju and Mr. Steadman have both pioneered and led numerous efforts, including the PCOR Partnership Program. They will provide oversight to the project, including review of publications and attendance at project meetings, and will ensure that Mr. Sorensen has all of the resources necessary to complete the proposed project in an efficient and timely manner.

North Dakota State University, Department of Agribusiness and Applied Economics

The NDSU Department of Agribusiness and Applied Economics supports an applied economic research program focusing on impact assessment. Work over the past decade has focused on measuring the fiscal, macro, and socioeconomic dimensions of policies, programs, and projects in the upper Great Plains. Examples of these efforts include fossil fuel and renewable energy development, composition of the state's various agricultural industries, growth and importance of tourism and related outdoor-based recreation in the state, impact of higher education and other government services on the state's economy, evaluation of numerous state and local initiatives targeting economic development and economic diversification of the state economy, and regional implications of changes in the use of natural or man-made resources. This impact assessment research is requested and used by policymakers, legislators, industry trade organizations, local and state government officials, economic and community development professionals, and extension outreach professionals.

Dean Bangsund will lead NDSU activities and has over 25 years of professional experience in the field of economic impact assessment. Over this period, Bangsund has completed numerous research and outreach projects pertaining to economic and fiscal impact assessment, community economic development, natural resource management, and rural socioeconomic issues pertinent to the Great Plains region of the United States. Bangsund also has been the architect of several economic models and analytical systems developed to address a wide range of issues for various constituent groups in the upper Midwest. Most recently, Bangsund developed a modeling process to forecast regional employment, housing demand, and population in the Williston Basin. His forecasts and recent research have been widely used to better understand the socioeconomic effects of shale oil development in North Dakota.

Odney, Public Affairs & Government Relations

Odney has provided grassroots and public relations services to clients since 1990 and has found that business and government work better when they work together. Therefore, it was a natural progression to add public affairs, government relations, and lobbying to its portfolio of services. Clients can take advantage of the "one-stop shop" aspect of having all marketing, public relations, public affairs, and government relations needs met under one roof. In addition, Odney's Public Affairs Division will take charge of project management needs and help plan, execute, and measure projects. Odney provides research, surveying, and polling; gathers comments from the public and stakeholders; conducts community meetings and facilitates focus groups; writes reports and presentations; and handles other related public relations needs as well.

Cory Fong will lead Odney activities and brings nearly 20 years of experience in state and local government, most recently during his 8 years as North Dakota Tax Commissioner. As Tax Commissioner, Mr. Fong oversaw the implementation of nearly $2.2 billion in broad-based tax

relief, delivering savings to hardworking North Dakota families, farmers, and ranchers and small business owners. Under Mr. Fong's leadership, the tax agency became a valued and trusted partner with the state's economic development community. Mr. Fong has also served as the Deputy Commissioner of the North Dakota Department of Commerce and as Deputy Secretary of State.

University of Wyoming College of Business, Department of Economics & Finance

The Enhanced Oil Recovery Institute (EORI) was created and is financially supported by the Wyoming State Legislature. The mission of EORI is to work with Wyoming oil producers to increase production and/or extend the economic life of Wyoming oil fields through the application of EOR/IOR (incremental oil recovery) techniques, or other operational improvements. In order to fulfill this mission, EORI and its staff maintain and continue to develop working relationships with a broad range of oil and gas industry partners and researchers. This includes technical oversight from an advisory board comprising leading experts from universities and energy companies.

Dr. Benjamin R. Cook is an economist with EORI at UW and also serves as a Visiting Assistant Professor of Economics & Finance with responsibilities in UW's Energy Management MBA program. Dr. Cook has been working on economic scoping and financial modeling for CO_2 EOR in Wyoming since 2007. This work has included a number of studies principally focused on estimating the potential incremental oil supply in Wyoming, the associated demand for injectable CO_2, and the current and forecasted economic impact for Wyoming in terms of mineral revenues and employment. Dr. Cook has also developed a publically available version of this core CO_2 EOR financial model known as CO_2Scope™ which is offered for free to Wyoming oil operators. In addition to his CO_2 work, Dr. Cook works closely with Wyoming oil operators and other energy industry agents to identify and address various challenges faced by individual companies or Wyoming operators generally. Past completed projects have included conducting an operating cost benchmarking study for five oil companies operating in the Wyoming Big Horn Basin, developing a financial model for a proposed 60,000-bpd oil refinery, and conducting a study on the CO_2 EOR market in northeastern Wyoming and a comparative cost of electricity assessment for coal-fired power with CO_2 capture for EOR.

The CETER Group, Inc.

CETER is a scientific consulting firm specializing in statistical data analysis, database mining, and environmental liability. CETER is a two-person firm comprising David V. Nakles, Ph.D., located in Gibsonia, Pennsylvania, and Nicholas A. Azzolina, Ph.D., located in Green Bay, Wisconsin. Since 2010, CETER has successfully completed nearly 40 projects in the United States and Canada for nine different industry, consulting, and legal clients. CETER is active in the energy sector, including the gas and electric utility industry (manufactured gas plant sites) and the oil and gas industry (shale oil/gas and CO_2 EOR). In addition, CETER is heavily involved in the geologic sequestration of CO_2 emissions through its work with the PCOR Partnership and the EERC. CETER's expertise specific to the oil and gas sector includes oil production decline-curve analysis; novel modeling approaches for CO_2 EOR; Monte Carlo simulation modeling to quantify uncertainty; project risk analysis; and life cycle analysis (LCA) of environmental impacts.

Dr. Azzolina will conduct all CETER activities and is a hydrogeologist and statistician with over 18 years of industrial and consulting experience. He specializes in statistical analysis and modeling of industrial and environmental data. Since 2010, Dr. Azzolina has worked with the EERC and supported the PCOR Partnership investigating associated CO_2 storage with regard to commercial EOR, LCA of greenhouse gas emissions associated with oil and gas development, and project risk analysis for large-scale geologic storage of CO_2. Dr. Azzolina received his B.A. in geological and geophysical sciences from Princeton University, his M.S. in hydrogeology from Syracuse University, and his Ph.D. in Environmental Management and Science from Carnegie Mellon University.

Project Advisory Board

Lynn Helms, Director, Department of Mineral Resources, North Dakota Industrial Commission, Oil and Gas Division

Lynn Helms has served as director of the North Dakota Industrial Commission Oil and Gas Division since July 1998 and director of the Department of Mineral Resources (the state's primary oil and gas regulator) since July 2005. He earned his Bachelor of Science degree in engineering from the South Dakota School of Mines and Technology in 1978. After graduation, Helms worked for 2 years as a production engineer for Texaco in all of the producing areas of Montana. In 1980, Helms joined Amerada Hess in Williston, North Dakota. While in Williston, he worked as a production engineer, reservoir engineer, and asset team leader on projects in Abu Dhabi, Alaska, Arkansas, Louisiana, Mississippi, New Mexico, North Dakota, Texas, and Wyoming.

Dr. Michael Jones, Vice President of Research and Development, North Dakota Lignite Energy Council

Mike Jones, Ph.D., is the Vice President of Research & Development for the Lignite Energy Council, which conducts programs to help maintain a strong lignite industry that currently employs more than 17,000 people, has an annual economic impact of $3.5 billion in North Dakota, and generates more than $100 million in state tax revenue each year. Members of the Lignite Energy Council include mining companies; major users that use lignite to generate electricity, synthetic natural gas, and other valuable by-products; and businesses that provide goods and services to the lignite industry.

With over 25 years in the industry, Dr. Jones was a senior research advisor at the EERC and an adjunct professor of physics at UND. A graduate of Bemidji (Minnesota) State University, he earned a master's degree and a doctorate in physics from UND. He has also authored and coauthored over 80 publications.

Ron Ness, President, North Dakota Petroleum Council

Ron Ness is president of the North Dakota Petroleum Council, where his primary function is governmental relations in North Dakota. He serves as the industry spokesperson and manages the association which represents more than 500 companies involved in all aspects of North Dakota's oil and gas industry, including oil and gas production, refining, pipeline, mineral leasing, consulting, legal work, and oilfield service activities in North Dakota, South Dakota, and the

Rocky Mountain region. Council members produced 98% of the 243 million barrels of oil produced in North Dakota in 2012.

Mr. Ness was appointed by Governor Dalrymple to the Interstate Oil and Gas Compact Commission, the Oil and Gas Research Council, and the Empower North Dakota Commission. He also serves on the EERC Foundation's Board of Directors and is Chairman of the Board of Leadership North Dakota. He was previously the President of the North Dakota Retail and Petroleum Marketers Association. Mr. Ness is a graduate of NSDU in Business and Economic, and received his master's degree in management from the University of Mary.

Vicky Steiner, Executive Director, North Dakota Association of Oil and Gas Producing Counties

Vicky Steiner's professional experience includes working as an executive director for the North Dakota Association of Oil and Gas Producing Counties, which is a 19-county member organization supporting North Dakota citizens and county membership, and the North Dakota Coal Conversion Counties Association. She has served as House Representative for North Dakota District 37 in Dickinson, North Dakota, since 2011. Ms. Steiner earned her B.S. in Mass Communications from Minnesota State University – Moorhead.

GOALS AND OBJECTIVES

The goal of the proposed project is to determine the potential near- and long-term economic impacts of carbon capture technology and EOR development in North Dakota and the effect of potential tax incentives on development in the oil and gas industry, as well as affected industries, communities, and interest groups. The following objectives will be performed to accomplish this goal:

1. To garner and compile technical information regarding potential EOR in North Dakota, including CO_2-based and other EOR methods, considering various North Dakota oil formations, and implementation time lines.

2. To garner and compile economic information regarding potential EOR in North Dakota, considering existing and alternative tax incentives, and the effect of implementation on affected industries, communities, and various interest groups.

SCOPE OF WORK

Task 1 – A Scientific Study of Potential EOR in North Dakota

Task 1.1 – A Detailed Analysis of CO_2 EOR for North Dakota. As mentioned previously, the EERC updated key data in 2014 from a previous study to determine the near-term potential (5 years) for CO_2-based EOR in North Dakota's conventional oil fields. The EERC used publicly available data to identify 86 unitized oil fields with the greatest potential for CO_2 EOR, with an estimated potential ranging from 280 to 630 million barrels of incremental oil

production for North Dakota (Figure 1). Under the proposed work plan, the EERC will expand findings from those 86 oil fields to determine their long-term potential (up to 20 years) for CO_2 EOR.

The 2014 study also included an examination of potential and likely near-term sources of CO_2 for EOR in North Dakota (Figure 2). Identified sources included an extension of Denbury's Greencore pipeline from Bell Creek, Montana, to the Cedar Creek Anticline for use in the Cedar Hills and Cedar Creek oil fields in southwestern North Dakota. The extension is currently planned for 2020 or later (Denbury Resources Inc., 2014). Some or all of Dakota Gasification Company's (DGC) CO_2 production could be diverted for EOR in Nesson Anticline oil fields along and near the existing pipeline route to Saskatchewan. In fact, the Boundary Dam Power Plant near Estevan, Saskatchewan, began delivering CO_2 to Saskatchewan oil fields in late 2014 (Monea, 2015), which may enable DGC to begin marketing CO_2 to North Dakota oilfield operators. Other potential sources identified included ethanol plants such as Red Trail in Richardton and Blue Flint near the Coal Creek power station in Underwood, North Dakota, and North Dakota-based natural gas-processing plants, which are rapidly increasing in number and capacity. Finally, federal policy continues to evolve toward either mandating or incentivizing CO_2 capture from coal-fired power facilities that collectively emit more than 30 million tons of CO_2 annually in North Dakota. The EERC will expand on these findings to determine their long-term potential for CO_2 supply to prospective North Dakota EOR sites.

Because the depletion of an oil field can change some of its critical characteristics, some oil fields have a limited "window of opportunity" during which CO_2-based EOR is feasible. With that in mind, some fields that were considered to be viable candidates for CO_2 EOR in one study may be found to have lost their viability in a later study, making rescreening a periodically necessary process. Rescreening the fields identified in previous studies for greatest EOR potential combined with the additional, long-term knowledge derived from the proposed study regarding the proximal and likely CO_2 sources should allow identification of which fields may be the most likely candidates for EOR. In addition, the EERC will investigate current and planned secondary waterflood efforts in North Dakota to further evaluate CO_2 EOR potential for tertiary oil extraction efforts. An estimate of the most likely incremental production over the 20-year time frame will be derived via extrapolation of near-term estimations and/or by comparison with analogous fields.

Task 1.2 – The Technical Feasibility of Implementing Various EOR Methods. Alternative EOR methods besides CO_2 injection will be examined as well, such as thermal, chemical, and gaseous. Thermal EOR utilizes steam as the injection fluid to deliver heat to the reservoir, lowering oil viscosity to increase flow and thus oil recovery (Office of Fossil Energy, 2015). Micellar–polymers may also be injected into the reservoir (chemical flooding) to potentially increase oil production by reducing interfacial tension between the oil and water in the reservoir rock (National Energy Technology Laboratory, 2015a). Other gaseous fluids such as nitrogen or ethane could be utilized in a similar manner as CO_2 for EOR by reaching previously bypassed areas within the reservoir (National Energy Technology Laboratory, 2015b). These methods will be investigated for technical feasibility to North Dakota oil fields as well as commercial availability and injection fluid supply.

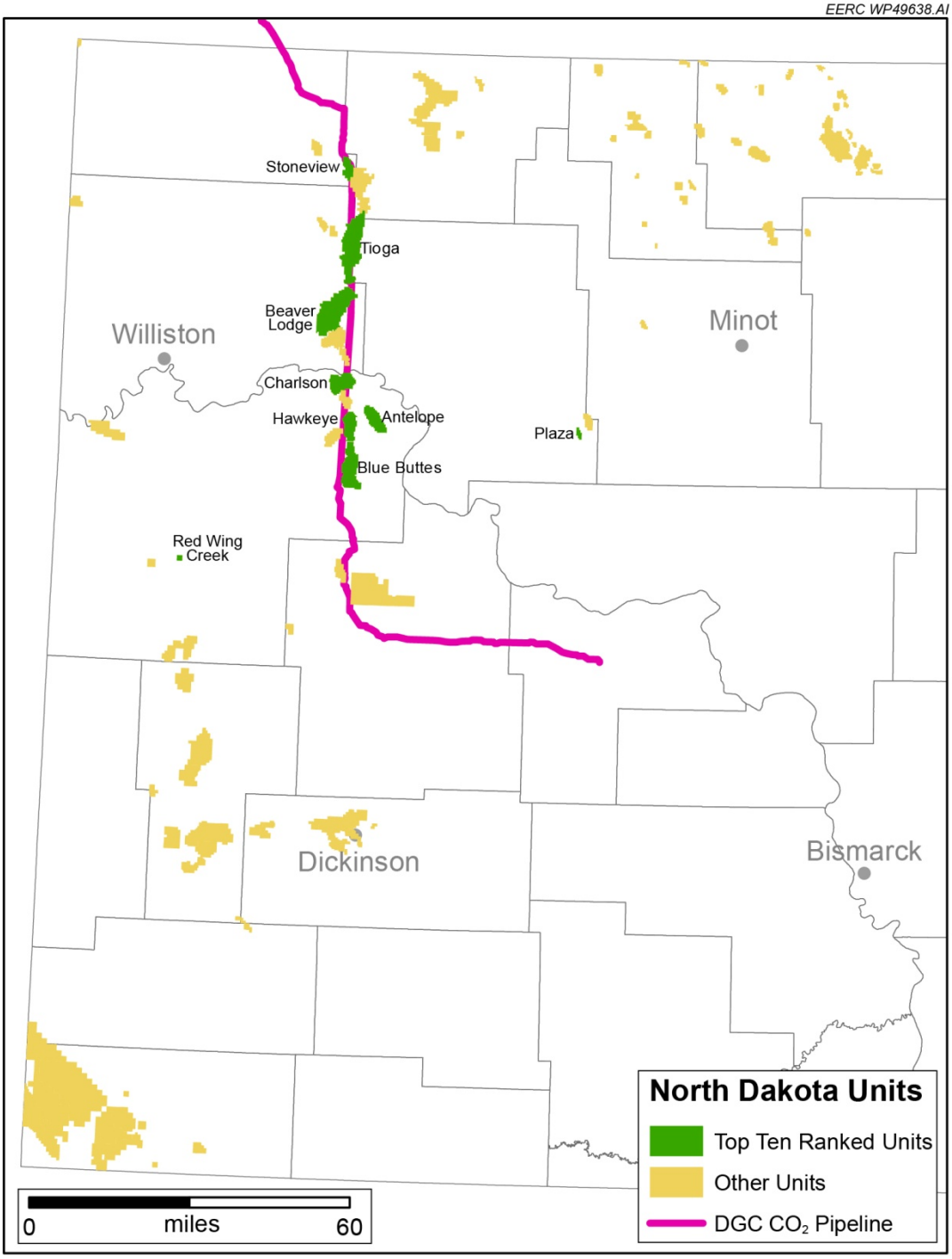

Figure 1. Geographic distribution of units showing the ten highest-ranked potential CO_2 EOR targets based on the EERC's 2014 study (Burton-Kelly and others, 2014).

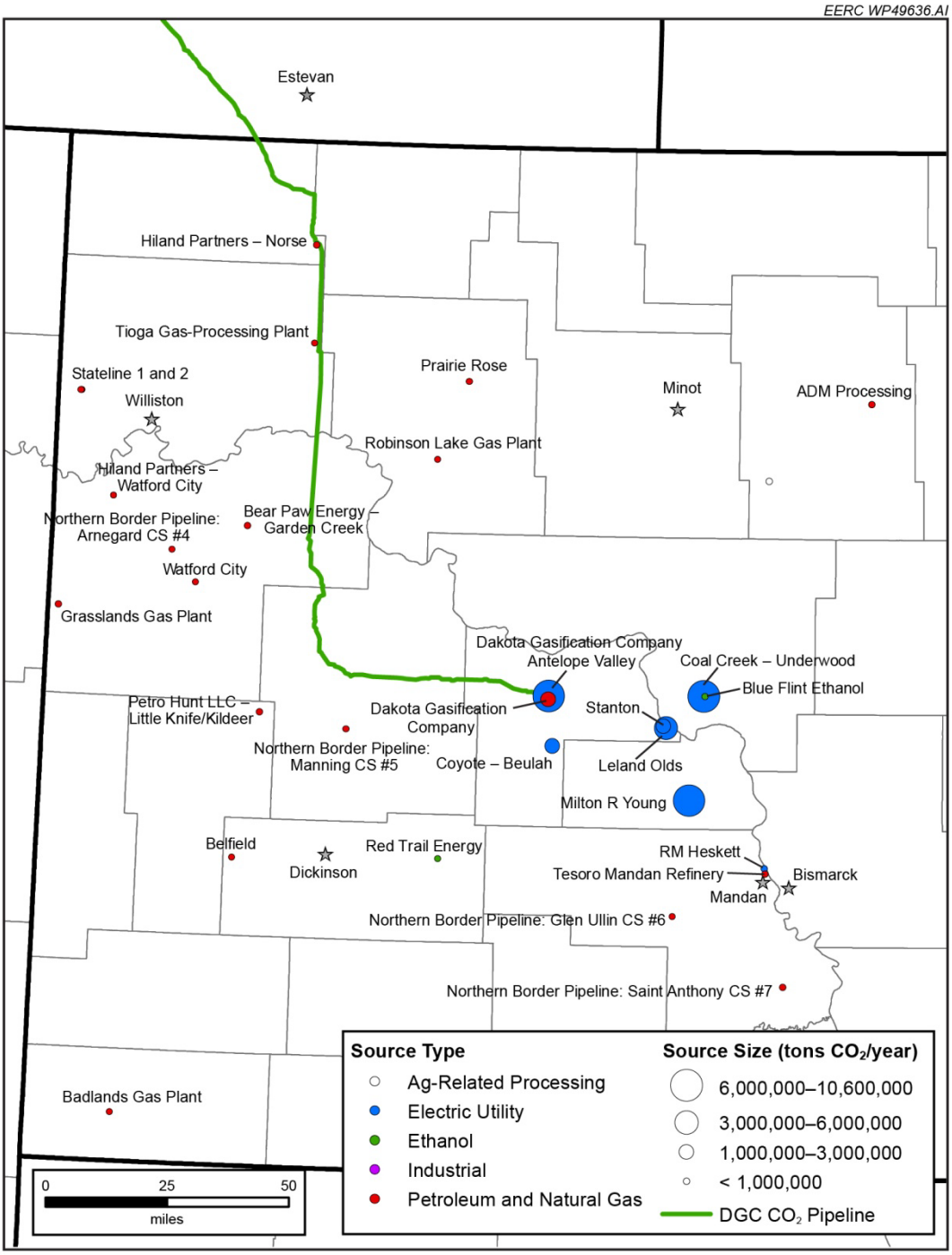

Figure 2. Stationary CO_2 sources in the study area (Burton-Kelly and others, 2014).

The estimated incremental oil production from Task 1.1 for CO_2 EOR will be assessed for improvement potential using the alternative EOR methods investigated. Published data from commercial practices and/or demonstrations will be garnered to generate a relative comparison of CO_2 EOR incremental production to alternative methods. An estimate of the incremental production over the 20-year time frame will then be derived.

The identified methods will also be assessed for sensitivity to oil formations in the North Dakota oil fields studied. As a hypothetical example, chemical flooding may be more feasible in the Bakken Formation than in the Three Forks Formation. Only statistically significant differences in estimated incremental oil production will be considered.

Task 1.3 – The Estimated Time Line for Implementation of EOR Techniques Identified. Based on findings from the previous activities, an estimated time line will be generated to identify when investigated technologies may become commercially available along with their respective durations of implementation. Separate time lines by formation will be provided, should previous findings indicate a significant variance in applicability of the technologies investigated. Any potential hindrances such as injection fluid supply and/or infrastructure needs to the site will also be identified.

Task 1.4 – Evaluation of Identified Technically Feasible and Commercially Available EOR Techniques for North Dakota. Although conventional CO_2 EOR may be the only commercial technology currently available, all EOR technologies investigated will be evaluated for applicability in North Dakota. Considerations will include but not be limited to sustainable oil production and CO_2 supply, as well as estimated time line for commercial readiness. Technologies will be ranked for recommendation to support the greatest benefit to North Dakota.

Task 2 – An Economic Study of Potential EOR in North Dakota

Task 2.1 – The Estimated Annual Economic Impacts, Near- and Long-Term, from Implementation of CO_2 EOR. The University of Wyoming CO_2Scope™ model will be employed to estimate economical oil production, CO_2 demand, and cash flows for application to the North Dakota oil and gas industry. IMPLAN, a computer software program used to generate regional estimates based on national data and coefficients developed by the U.S. Department of Commerce, will be utilized to generate economic data specific to North Dakota and oil-producing counties. The results will be used to estimate relative costs for capital and operating expenses for input into the CO_2Scope model. Where input values specific to North Dakota are not available, information from known EOR projects (e.g., Montana, Wyoming, Texas) will be garnered and adjusted to approximate costs for North Dakota's industry. Other required inputs include estimated original oil in place, well locations for the study region, and estimated injection flow rates. A base-case oil price as forecasted by the U.S. Energy Information Administration (EIA) will be implemented for determining economic viability. Annual economic impacts will be estimated for near- and long-term (up to 2035) projections.

Outputs of the CO_2Scope model will then be used to estimate economic impacts within the oil and gas industry, as well as related industries and affected communities. For example,

impacts of direct employment within the oil & gas industry as a result of projected oil production and the additional operational requirements of EOR will be estimated. Secondary employment impacts will also be investigated which relate to induced employment for goods and services supplying the oil and gas industry and indirect employment for personal goods and services supporting employees of the oil and gas industry. These findings will be evaluated to estimate how EOR implementation may affect population, potential revenue from key state-level taxes (e.g., income, sales, etc.), and community infrastructure needs (e.g., housing, roads, etc.).

A sensitivity analysis will be conducted to consider the effect of oil price on the estimated annual economic impacts. Two scenarios for oil price will be investigated using EIA-forecasted high and low oil prices above and below the base-case oil price, respectively. The magnitude of the effect from these changes in estimated economical annual oil production, CO_2 demand, and subsequent potential effects in employment and community infrastructure needs will be evaluated.

Task 2.2 – Investigation of Current and Potential Tax Incentives to Encourage Implementation of CO_2 EOR. Related FY2015 tax incentives currently in place will be examined and incorporated into the CO_2Scope model. Previously investigated scenarios for varying oil price points will be considered. Comparisons will then be made to the initial economic results to determine the potential effects that the existing tax incentives may have on the estimated annual economics for implementation of EOR in North Dakota.

Several additional options for alternative tax incentives will also be investigated. Considerations will include elimination of tax incentives and modification of and/or addition to the current tax incentive structure. The effectiveness of past and existing tax incentives thus far on industry development and stability of revenue for North Dakota will be evaluated. FY2017 tax incentives and examples from other states with significant oil and gas industries and/or EOR (e.g. Montana, Wyoming, Texas) will be considered as well. Options will be evaluated based on potential for improvement in industry development and stability of revenue for North Dakota.

Up to three alternative tax incentive options will be identified for incorporation into the CO_2Scope model. Previously investigated scenarios for varying oil price points will be considered. Comparisons will then be made to the initial economic results, as well as the results from investigating tax incentives currently in place, to determine the potential effects the identified alternative tax incentives may have on the estimated annual economics for implementation of EOR in North Dakota.

The identified alternative tax incentive options will then be examined for potential impacts to the interests of the state, political subdivisions, environment, and the fossil fuel energy industry. A sensitivity analysis of potential tax revenue that could affect the state/regional/local government expenditures from changes in oil volume and price for each of the tax-incentive scenarios investigated will be performed. A CO_2 LCA for North Dakota EOR will also be performed for the various scenarios investigated regarding estimated economical oil production and CO_2 demand. The potential effects of the identified scenarios on other fossil fuel-related industries will also be examined, such as oil refineries, electricity generation, carbon capture, rail or pipeline infrastructure, etc.

Task 2.3 – Evaluation of CO_2 EOR and Potential Tax Incentives for North Dakota. Findings from all scenarios and potential impacts investigated will be compiled and evaluated to identify tax incentive options for encouraging CO_2 EOR in North Dakota. Considerations will include but may not be limited to a sustainable increase in oil production, CO_2 supply, and community economy such as employment and required infrastructure; stability of revenue for North Dakota; minimal environmental impact; and sensitivity to changes in oil price. Tax incentive options will be ranked for recommendation to implement for greatest benefit to North Dakota.

Task 3 – Reporting and Travel

Regular communication, such as quarterly updates and conference calls, will also be conducted to keep the Taxation Committee informed of progress and findings throughout the duration of the project. A comprehensive final report summarizing project results will be generated and presented to the Taxation Committee upon study completion.

Three visits to Bismarck, North Dakota, will be conducted to meet with the proposed Advisory Board and/or the Taxation Committee. A project kickoff meeting with the Advisory Board will be scheduled shortly following project start to summarize proposed activities and provide opportunities for input and guidance from the Advisory Board. A meeting with the Taxation Committee may also be arranged. Participation in the 2016 Williston Basin Petroleum Conference is anticipated, with an Advisory Board meeting to coincide. A meeting with the Taxation Committee to present final project results will be scheduled at project conclusion.

BUDGET AND SCHEDULE

The cost to perform the proposed project is estimated at $399,772. A detailed breakdown of cost is provided in the enclosed budget. Completion will be within 11 months of project start.

Project Budget

The estimated costs include labor hours and supplies for all project team members to provide due diligence on proposed project activities. The EERC will conduct all activities in Task 1, coordinate and manage activities in Task 2, compile all generated information for progress and final reports for Task 3, participate in all project meetings, and ensure that the entire effort is completed on time, and within budget. UW will modify the CO_2Scope model for applicability to North Dakota oil fields, incorporating tax incentives and conducting sensitivity analyses for oil price and various tax incentive options as detailed in Task 2. NDSU will generate economic data using IMPLAN to provide the necessary inputs for the CO_2Scope model. NDSU will also estimate economic impacts for oil- and gas-affected industries and communities, conducting sensitivity analyses for oil price and various tax incentive options as well (Task 2). Odney will identify current tax incentives and potential alternative options for input into the CO_2Scope model, in addition to determining potential impacts to the interests of the state and political subdivisions, as detailed in Task 2.2. CETER will integrate information on upstream, operational, and downstream components of the oil and gas life cycle from application of potential EOR development in North Dakota (Task 2.2). All project team members will assist in summarizing work conducted for progress reports and the final report.

Travel expenses for EERC personnel to hold the kickoff advisory board meeting, participate in the 2016 Williston Basin Petroleum Conference, and present final project results to the Taxation Committee are also incorporated into the budget estimate.

Project Schedule

The anticipated schedule is shown in Table 1. Much of Tasks 1 and 2 will be conducted simultaneously, as some of the activities will be iterative, particularly derivation of CO_2 demand required for estimated economical oil production from EOR and technical feasibility of CO_2 supply for EOR in North Dakota. Milestones include quarterly reports and a final report to the Taxation Committee by Friday, August 19, 2016, as well as presentation of project findings.

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Table 1. Milestones and Time Line

Tasks and Activities	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	July-16	Aug-16
Task 1. EOR Scientific Study											
Task 1.1. CO_2 EOR Technical Analysis											
Task 1.2. Other EOR Methods											
Task 1.3. EOR Time Line											
Task 1.4. Technical Evaluation of EOR											
Task 2. EOR Economic Study											
Task 2.1. CO_2 EOR Economic Analysis											
Task 2.2. Tax Incentives											
Task 2.3. Economic Evaluation of EOR											
Task 3. Reporting and Travel	◆			◆			◆	◆		◆	◆
Progress and Final Reports				◇			◇			◇	◇
Advisory Board Meetings	◇							◇			

◆ Updates/meetings.

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NORTH DAKOTA CARBON CAPTURE AND ENHANCED OIL RECOVERY ECONOMIC IMPACT STUDY
ND LEGISLATIVE MANAGEMENT
PROPOSED PROJECT START DATE: 10/1/15
EERC PROPOSAL #2016-0011

BUDGET

CATEGORY	TECHNICAL STUDY	ECONOMIC STUDY	TOTAL
Total Labor	$ 120,413	$ 51,395	$ 171,808
Travel	$ 2,413	$ 563	$ 2,976
Supplies	$ 75	$ 75	$ 150
Subcontractor – University of Wyoming	$ -	$ 29,745	$ 29,745
Subcontractor – NDSU	$ -	$ 49,697	$ 49,697
Subcontractor – CETER Group	$ -	$ 15,200	$ 15,200
Subcontractor – Odney	$ -	$ 80,000	$ 80,000
Facilities & Admin. Rate – Subcontractors	$ -	$ 45,551	$ 45,551
Other*	$ 301	$ 452	$ 753
Laboratory Fees & Services			
Graphics Service	$ 1,946	$ 1,946	$ 3,892
Total Project Cost – U.S. Dollars	$ 125,148	$ 274,624	$ 399,772

	Labor Hours		
Labor Categories	**Task 1**	**Task 2**	**Total per Category**
Research Scientists/Engineers	830	204	1,034
Research Technicians	105	74	179
Senior Management	20	39	59
Technical Support Services	60	59	119
Total per Task	**1,015**	**376**	**1,391**

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

APPENDIX A

RELEVANT PROJECTS AND REFERENCES

APPENDIX A-1
EERC CO_2 STORAGE AND EOR PROJECTS

APPENDIX A-2
UW CO_2 EOR ECONOMIC MODELING

APPENDIX A-3
NDSU PROJECT TEAM AND OIL AND GAS RESEARCH ACTIVITIES

APPENDIX A-4
ODNEY PROJECT TEAM AND TAX AND POLICY PROJECT EXAMPLES

APPENDIX A-5
CETER OIL AND GAS PROJECTS AND LCA MODEL

APPENDIX A-1

EERC CO_2 STORAGE AND EOR PROJECTS

EERC CO_2 STORAGE AND EOR PROJECTS

The Energy & Environmental Research Center (EERC) has led the Plains CO_2 Reduction (PCOR) Partnership Program for a decade, which has a very practical goal of providing regional industry with high-quality information for making decisions regarding carbon management. The PCOR Partnership is a collaborative effort of public and private sector stakeholders working toward a better understanding of the technical and economic feasibility of capturing and storing (sequestering) anthropogenic CO_2 emissions from stationary sources in the central interior of North America. It is one of seven regional partnerships funded by the U.S. Department of Energy's (DOE's) National Energy Technology Laboratory (NETL) Regional Carbon Sequestration Partnerships (RCSPs) Program. The following select studies were conducted as part of the PCOR Partnership Program.

UPDATED REGIONAL TECHNOLOGY IMPLEMENTATION PLAN FOR ZAMA

The Zama oil field in northwestern Alberta, Canada, has been the site of acid gas (approximately 70% CO_2 and 30% hydrogen sulfide [H_2S]) injection since the early 2000s for the simultaneous purpose of EOR, acid gas disposal, and CO_2 storage. Activities included laboratory studies of the effects of acid gas on storage integrity and modeling efforts to develop improved predictions of both oil recovery and CO_2 storage capacity at Zama. Laboratory results indicate that the injection of a CO_2–H_2S mixed gas stream into a carbonate formation for enhanced oil recovery (EOR) and CO_2 storage is not likely to be more deleterious to wellbore integrity than the injection of pure CO_2 and may, in fact, help maintain wellbore integrity against degradation. The modeling results confirm that miscible flooding with sour acid gas is an excellent means of storing large volumes of CO_2 while improving oil recovery. The results indicate that CO_2 streams do not have to be "pure" to be considered for use in carbon capture, utilization, and storage projects and that some impurities may even be desirable under certain circumstances.

Gao, P., Sorensen, J.A., Braunberger, J.R., Doll, T.E., Smith, S.A., Gorecki, C.D., Hawthorne, S.B., Steadman, E.N., and Harju, J.A., 2014, Updated regional technology implementation plan for Zama: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 15 Deliverable D86 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2014-EERC-05-14, Grand Forks, North Dakota, Energy & Environmental Research Center, February.

OVERVIEW OF THE BELL CREEK COMBINED CO_2 STORAGE AND CO_2 ENHANCED OIL RECOVERY PROJECT

Through the PCOR Partnership, the EERC is working with Denbury Onshore LLC (Denbury) to determine the effect of large-scale injection of CO_2 into a deep clastic reservoir for the purpose of CO_2 storage in conjunction with EOR at the Bell Creek oil field located in southeastern Montana. A technical team that includes Denbury, the EERC, and others are developing an integrated approach to site characterization, geologic modeling, predictive

simulation, risk assessment, and monitoring to facilitate assessment of various potential injection schemes, guide monitoring strategies, and determine the ultimate fate of injected CO_2. The Bell Creek project will demonstrate that 1) CO_2 storage can be safely and permanently achieved on a commercial scale in conjunction with an EOR operation, 2) oil-bearing sandstone formations are viable sinks for CO_2, 3) monitoring, verification, and accounting (MVA) methods can be established to effectively monitor commercial-scale simultaneous CO_2 EOR and CO_2 storage projects and provide a technical framework for the accounting of CO_2, and 4) the lessons learned and best practices employed can provide the data, information, and knowledge needed to develop similar EOR CO_2 storage projects across the region.

Hamling, J.A., Gorecki, C.D., Klapperich, R.J., Saini, D., and Steadman, E.N., 2013, Overview of the Bell Creek combined CO_2 storage and CO_2 enhanced oil recovery project: Paper presented at GHGT-11, Kyoto, Japan, Energy Procedia, v. 37, p. 6402–6411, Elsevier.

GEOLOGICAL CHARACTERIZATION OF THE BASAL CAMBRIAN SYSTEM IN THE WILLISTON BASIN

A binational effort, between the United States and Canada, characterized the lowermost saline system in the Williston and Alberta Basins of the northern Great Plains–Prairie region of North America in the United States and Canada. The 3-year project was conducted with the goal of determining the potential for geologic storage of CO_2 in rock formations of the 517,000 sq mi Cambro-Ordovician saline system (COSS). Phase I focused on delineating and characterizing separately the Canadian and U.S. portions of the COSS. These were subsequently brought together into a single model during Phase II. The completed 2-D model incorporates the geologic data collected in the baseline characterization effort and distributes the various rock properties throughout the study region through geostatistical methods. This novel approach worked well for joining the two data sets, and the resulting 2-D model indicated a storage resource of 113 Gt. This work also provided the groundwork for Phase III, the development of a massive 3-D geologic model encompassing the entire study area (described further below).

Peck, W.D., Crotty, C.M., Knudsen, D.J., Sorensen, J.A., Gorecki, C.D., and Steadman, E.N., 2012, Geological characterization of the Basal Cambrian system in the Williston Basin: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 16 Deliverable D91 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2012-EERC-04-19, Grand Forks, North Dakota, Energy & Environmental Research Center, February.

STORAGE CAPACITY AND REGIONAL IMPLICATIONS FOR LARGE-SCALE STORAGE IN THE BASAL CAMBRIAN SYSTEM

In Phase III of the study described above, a 3-D geocellular model was created and used to determine the static CO_2 storage resource and the dynamic storage capacity of the COSS. The results of the storage resource estimate indicated that there is sufficient CO_2 storage potential in the COSS to store all of the current point-source CO_2 emissions in the study region for at least

the next 50 years. However, more than the 210 wells studied will likely be needed and spread out over more of the COSS to achieve this goal.

Peck, W.D., Liu, G., Klenner, R.C.L., Grove, M.M., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2014, Storage capacity and regional implications for large-scale storage in the Basal Cambrian system: Plains CO_2 Reduction Partnership Phase III Draft Task 16 Deliverable D92 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2014-EERC-05-12, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

ESTIMATES OF CO_2 STORAGE CAPACITY IN SALINE AQUIFERS AND OIL FIELDS OF THE PCOR PARTNERSHIP REGION

Characterization of the subsurface to determine storage capacity of saline aquifers and producing and depleted oil reservoirs is a critical component when geologic storage of anthropogenic CO_2 is considered. Sequestration capacity estimates were developed for two saline aquifer systems and over 1000 oil fields in north-central North America. The Mississippian Madison Formation in the U.S. portions of the Williston and Powder River Basins was calculated to have a maximum capacity of 54 billion metric tons. The Lower Cretaceous Aquifer Systems in the Alberta, Williston, Powder River, and Denver–Julesberg Basins were calculated to have a maximum capacity of 145 billion metric tons. With respect to oil fields, the results generated by the volumetric method indicate that there may be over 9 billion metric tons of CO_2 storage capacity in the 1091 fields evaluated. The results of the EOR-based evaluations for 80 fields in the Williston, Powder River, and Denver–Julesberg Basins suggest that over 635 million metric tons of CO_2 could be sequestered by CO_2 flood EOR operations, possibly resulting in over 1.4 billion barrels of incremental oil production. The estimates generated during Phase I of the PCOR Partnership provide order-of-magnitude-level CO_2 capacity estimates for over 1000 geologic locations in the PCOR Partnership region that were previously unavailable.

Smith, S.A., Sorensen, J.A., Fischer, D.W., O'Leary, E.M., Peck, W.D., Steadman, E.N., and Harju, J.A., 2006, Estimates of CO_2 storage capacity in saline aquifers and oil fields of the PCOR Partnership region, *in* International Conference on Greenhouse Gas Control Technologies (GHGT-8), 8th, Trondheim, Norway, June 19–22, 2006, Proceedings.

ESTIMATES OF CO_2 STORAGE CAPACITY IN SELECTED OIL FIELDS OF THE NORTHERN GREAT PLAINS REGION OF NORTH AMERICA

The CO_2 sequestration capacities of selected oil fields in the Williston Basin, Powder River Basin, and Denver–Julesberg Basin in the northern Great Plains region of North America were estimated as part of the PCOR Partnership regional characterization. The estimates were developed using readily available reservoir characterization data obtained from the petroleum regulatory agencies and/or geological surveys from the oil-producing states and provinces of the PCOR Partnership region. Reconnaissance-level sequestration capacities were calculated using two methods, depending on the nature of the readily available reservoir characterization data for

each field. Maximum storage capacities were estimated for reservoirs where detailed data on original-oil-in-place, cumulative production, reservoir thickness, porosity, temperature, pressure, and water saturation were available. The initial reconnaissance-level estimates indicate that over 1100 oil fields within the three basins have a capacity to sequester nearly 10 billion tons of CO_2, with the potential to produce over 2 billion barrels of incremental oil through CO_2 flood enhanced oil recovery activities.

Smith, S.A., Sorensen, J.A., Steadman, E.N., Harju, J.A., and Fischer, D.W., 2009, Estimates of CO_2 storage capacity in selected oil fields of the northern Great Plains region of North America, *in* Grobe, M., Pashin, J.C., and Dodge, R.L., eds., Carbon dioxide sequestration in geological media—state of the science: AAPG Studies in Geology 59, Tulsa, OK, American Association of Petroleum Geologists, p. 87–97.

CO_2 STORAGE AND UTILIZATION IN TIGHT HYDROCARBON-BEARING FORMATIONS: A CASE STUDY OF THE BAKKEN FORMATION IN THE WILLISTON BASIN

Little work has been done to examine the ability of tight hydrocarbon-bearing formations to serve as targets for CO_2 storage and utilization. The Bakken Formation is one of the largest tight oil formations in North America. Laboratory experiments using Bakken rocks and fluids, evaluation of reservoir characterization data, and geomodeling activities were conducted to understand the potential for CO_2 utilization and storage in tight oil formations. Results suggest that tight oil formations may serve as targets for geologic storage of CO_2 and that the injection of CO_2 may be effective in enhancing the productivity of oil from those formations.

Sorensen, J.A., Braunberger, J.R., Liu, G., Smith, S.A., Klenner, R.C.L., Steadman, E.N., and Harju, J.A., 2014, CO_2 storage and utilization in tight hydrocarbon-bearing formations—a case study of the Bakken Formation in the Williston Basin: Paper presented at GHGT-12, Austin, Texas, Energy Procedia, v. 63, p. 7852–7860, Elsevier.

UNITIZATION OF GEOLOGIC MEDIA FOR THE PURPOSE OF MONETIZING GEOLOGIC SEQUESTRATION CREDITS

The development of carbon credit markets for geological sequestration will require a framework for accounting of injected CO_2 that is based on detailed characterization data, sound engineering design, and an equitable legal and regulatory process. The monetization of CO_2 credits associated with geologic sequestration will require a streamlined process that addresses the technical aspects of a project and also considers the interests of the public and the rights of individuals who may own subsurface mineral and water rights. Such a system has already been established in the oilfield unitization process under which the U.S. petroleum industry currently operates. Oil and gas regulatory agencies in the United States use a process commonly referred to as “unitization” to organize oil fields into units for the purpose of secondary and tertiary recovery operations. The process by which petroleum fields become unitized may provide a useful model for the selection of appropriate injection target formations and the governing of

geologic sequestration projects. Although petroleum reservoirs, saline aquifers, and coal seams generally utilize different mechanisms for sequestration (for example, dissolution into oil vs. dissolution into saline water vs. adsorption onto coal), the unitization process may be adapted and applied to all types of geologic formations. Application of the unitization process to CO_2 sequestration may result in the establishment of geologic sequestration units.

Sorensen, J.A., Botnen, L.S., Steadman, E.N., Harju, J.A., Helms, L.D., and Fischer, D.W., 2009, Unitization of geologic media for the purpose of monetizing geologic sequestration credits, *in* Grobe, M., Pashin, J.C., and Dodge, R.L., eds., Carbon dioxide sequestration in geological media—state of the science: AAPG Studies in Geology 59, Tulsa, OK, American Association of Petroleum, p. 707–715.

RESULTS OF THE PLAINS CO_2 REDUCTION PARTNERSHIP'S PHASE II DEMONSTRATION IN THE NORTHWEST MCGREGOR OIL FIELD

The PCOR Partnership has conducted activities to determine the effects of injecting CO_2 into a deep carbonate oil reservoir. The purpose of the project was to evaluate the effectiveness of CO_2 storage and EOR in carbonate rocks deeper than 2440 m. Specifically, 440 tons of CO_2 was injected into a carbonate reservoir at a depth of approximately 2454 m as part of a huff 'n' puff (HnP) test conducted on a well in the Northwest McGregor oil field in North Dakota. Unique elements of the Northwest McGregor reservoir as compared to other HnP operations in the literature, include the following: 1) At a depth of 2454 m, it is among the deepest; 2) pressure (20.7 MPa) and temperature (82°C) are among the highest for a HnP; and 3) most HnPs in the literature are in clastic reservoirs. A combination of tracers, reservoir dynamics data, and downhole and surface geophysical technologies (Schlumberger's Reservoir Saturation Tool [RST] and Vertical Seismic Profile [VSP]) before and after injection were used to monitor the fate of the CO_2. Productivity of the oil well more than doubled over the course of a 3-month production period. Overall, the results of the field demonstration indicate that 1) CO_2-based HnP operations may be a viable option for EOR in deep carbonate oil reservoirs and 2) the RST and VSP technologies may be effective MVA tools for deep carbonate oil reservoirs.

Sorensen, J.A., Schmidt, D.D., Knudsen, D.J., Smith, S.A., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2010, Results of the Plains CO_2 Reduction Partnership's Phase II demonstration in the Northwest McGregor oil field, North Dakota, *in* 9th Annual Conference on Carbon Capture and Sequestration: Pittsburgh, Pennsylvania, May 10–13, 2010, Proceedings.

DEVELOPING CO_2 SEQUESTRATION OPPORTUNITIES FOR THE CENTRAL INTERIOR OF NORTH AMERICA

A detailed characterization of the region's major stationary CO_2 sources and potential CO_2 sinks was performed and used to develop a prioritized listing of specific field-based CO_2 sequestration validation projects to be performed. Sequestration capacity estimates for oil and gas fields, saline formations, and coalfields were developed for the PCOR Partnership region. Because of more favorable economics, EOR is one of the few types of geologic sequestration

projects to be developed Four field validation tests were begun during Phase II. Each field validation test was designed to gather the data required to monetize carbon credits for the respective activities, and each will result in a series of best practices manuals to serve as guides for the large-scale development of CO_2 sequestration in the future.

Steadman, E.N., Harju, J.A., Fischer, D.W., Botnen, L.S., Daly, D.J., Jensen, M.D., O'Leary, E.M., Smith, S.A., and Sorensen, J.A., 2006, The Plains CO_2 Reduction (PCOR) Partnership—developing CO_2 sequestration opportunities for the central interior of North America, *in* International Conference on Greenhouse Gas Control Technologies (GHGT-8), 8th, Trondheim, Norway, June 19–22, 2006, Proceedings.

APPENDIX A-2

UW CO_2 EOR ECONOMIC MODELING

UW CO_2 EOR ECONOMIC MODELING

The various CO_2 EOR studies for Wyoming have been used to inform both Wyoming lawmakers and industry participants about Wyoming's future with respect to CO_2. Some notable impacts of this work include working with various oil companies to identify promising CO_2 targets for further research or acquisition, working with both Kinder Morgan and ExxonMobil to help them understand the overall market potential for CO_2 in Wyoming for potential investments in CO_2 supply and infrastructure, and supporting information for the Wyoming Pipeline Corridor initiative which is trying to prepermit a statewide network of pipeline corridors to accelerate the development of CO_2 pipelines in Wyoming.

SELECT CO_2 EOR PROJECT EXAMPLES AND SUMMARIES

Cook, Benjamin R. (September 2013), "Wyoming's Miscible CO_2 Enhanced Oil Recovery Potential from Main Pay Zones," University of Wyoming, Enhanced Oil Recovery Institute (EORI) Working Papers & Reports (in author revision for submission).

Abstract: The state of Wyoming is heavily dependent on mineral wealth, with an estimated 65% of state and local revenues coming from mineral payments and 20% of employment tied directly or indirectly to the oil and gas industry. Wyoming's exposure to mineral price risk has been evident in recent years with falling natural gas prices and lower coal demand. While Wyoming oil production has been in decline since the late 1970s, newer technologies and methods such as CO_2 enhanced oil recovery (CO_2 EOR) are helping reverse this trend with the benefit of relatively higher crude prices. Applying the "analog" method outlined by van 't Veld and Phillips (2010) to a data set of 723 oil field-reservoir units, this study explores Wyoming's CO_2 EOR potential, the demand for injectable CO_2 volumes, and the geographical distribution of economically promising oil fields. Such studies are important to industry participants and policy makers in planning for future developments.

Cook, Benjamin R. (July 2013, posted March 2014), "The Economic Contribution of CO_2 Enhanced Oil Recovery in Wyoming: 2010-2012," USAEE Working Paper 14-159

Abstract: Wyoming's economy and state and local government budgets depend heavily on the state's mineral wealth. Mineral-related payments are roughly 65% of Wyoming state revenues, with severance taxes and royalties alone accounting for 51% of the state budget. The recent strength of oil prices relative to other minerals has brought the importance of Wyoming's CO_2 EOR industry to the forefront, with state oil production trending higher after decades of decline. Collectively, the WY oil units with active CO_2 floods produced 23.35 million barrels of oil from 2010 to 2012, 14% of Wyoming crude production during that time, of which 20.43 million or 12.2% of production is attributable to the CO_2 injection. Utilizing the regional input–output (IO) economic model, IMPLAN, we estimate that from 2010 to 2012 the CO_2 EOR projects in Wyoming supported an average of 1914 jobs annually. Ignoring the capital investments and thinking in terms of ongoing oil production, 188 jobs were supported for every 1 million barrels of incremental oil produced.

Cook, Benjamin R. (January 2014), "The Future Economic Contribution of Wyoming's CO_2-EOR Potential," University of Wyoming, Enhanced Oil Recovery Institute (EORI) Working Papers & Reports.

Abstract: From 2010 to 2012, CO_2 EOR in Wyoming produced roughly 20.43 million barrels of oil and injected an average of 192 MMscf of CO_2 daily. Further still, it is estimated that Wyoming may yet be able to produce 0.7 to 1.0 billion barrels of additional oil from existing developments with CO_2. This study attempts to estimate the future economic contributions (jobs, labor income, etc.) of the potential oil production coming from CO_2 EOR in the future. If the baseline scenario of 0.7 to 1 billion barrels of additional oil is realized, we find that future CO_2 EOR in Wyoming may be able to support a 40-year average of 2967 to 8278 jobs annually. This translates into a gross total of $6.1 to $17.5 billion in additional government mineral payments and adds $34.2 to $100.2 billion to Wyoming's gross state product.

CITATIONS FOR OTHER RELATED RESEARCH & PRESENTATIONS

Cook, Benjamin R. and Mason, Charles F. (fall 2012), "Enhanced Oil Recovery: Going Beyond Conventional Extraction," *IAEE Energy Forum*, Fall 2012, 21–23.

Cook, Benjamin R. (May 2012). "The Economic Contribution of CO_2 Enhanced Oil Recovery in Wyoming's Economy," University of Wyoming, Enhanced Oil Recovery Institute (EORI) Working Papers & Reports.

Cook, Benjamin R., Phillips, Owen R., Menkhaus, Dale J. and Bastian, Christopher T., (December 2012), "Impacts of Subsidies and Taxes on Private Bargaining: Experimental Insights on Carbon Sequestration Markets" (drafted and in author revision for submission).

Cook, Benjamin R. and van 't Veld, Klaas (December 2013), CO_2Scope™ (An Economic Scoping Tool for CO_2-EOR), Wyoming Research Products Center, University of Wyoming, Laramie, Wyoming.

"Exploring Economic Criteria for EOR Projects: A Capital Budgeting Workshop," Two 90-Minute Workshops, 9th Annual EOR/CO_2 Conference, Casper, Wyoming, July 2015.

"CO_2Scope: EORI's Economic Scoping Model," 8th Annual CO_2 Conference, Casper, Wyoming, July 2014.

"CO_2Scope: EORI's Economic Scoping Model," 19th Annual CO_2 Flooding Conference, Midland, Texas, December 2013.

APPENDIX A-3

NDSU PROJECT TEAM AND OIL AND GAS RESEARCH ACTIVITIES

NDSU PROJECT TEAM AND OIL AND GAS RESEARCH ACTIVITIES

Nancy Hodur and Dean Bangsund
Department of Agribusiness and Applied Economics
North Dakota State University

Dean Bangsund will lead NDSU activities and has over 25 years of professional experience in the field of economic impact assessment. Over this period, Bangsund has completed numerous research and outreach projects pertaining to economic and fiscal impact assessment, community economic development, natural resource management, and rural socio-economic issues pertinent to the Great Plains region of the United States. Bangsund also has been the architect of several economic models and analytical systems developed to address a wide range of issues for various constituent groups in the upper Midwest. Most recently, Bangsund developed a modeling process to forecast regional employment, housing demand, and population in the Williston Basin. His forecasts and recent research have been widely used to better understand the socio-economic effects of shale oil development in North Dakota.

Nancy Hodur has over 25 years of professional experience in applied outreach, public policy, and extension education. Hodur is Assistant Research Professor in the Department of Agribusiness and Applied Economic at NDSU. Primary areas of research include socio-economic impact assessment, community and economic development, and natural resource management. Hodur has done research on numerous projects related to rural economic development, community development, natural resources, nature-based and heritage and cultural tourism, and biofuels and materials. Recent efforts have focused on issues related to the rapid expansion of the oil and gas industry, including population projections for the cities of Dickinson and Williston; school enrollment projections for the Association of Oil and Gas Production Counties; and an assessment of the characteristics, perceptions, and intentions of the oil and gas industry workforce.

Title: Contribution of the Petroleum Industry to the North Dakota Economy

Sponsor: **North Dakota Petroleum Council**

Description: Five studies have been conducted that survey firms in the petroleum industry in North Dakota to collect primary data on industry expenditures and returns. The ND I-O Model was used to provide estimates of the economic size of the petroleum industry in the state. Each study has created departmental reports, and several professional presentations of the study results have been made to in-state clientele and local and regional media.

Citations: Bangsund, Dean A. and Nancy M. Hodur. 2015. *Petroleum Industry's Economic Contribution to North Dakota in 2013*. Agribusiness and Applied Economics Report No. 736. Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Bangsund, Dean A. and Nancy M. Hodur. 2013. *Petroleum Industry's Economic Contribution to North Dakota in 2011*. Agribusiness and Applied Economics

Report No. 710. Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Bangsund, Dean A. and F. Larry Leistritz. 2010. *Petroleum Industry's Economic Contribution to North Dakota in 2009*. Agribusiness and Applied Economics Report No. 676 & 676-S. Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Bangsund, Dean A. and F. Larry Leistritz. 2009. *Petroleum Industry's Economic Contribution to North Dakota in 2007*. Agribusiness and Applied Economics Report No. 639 & 639-S. Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Bangsund, Dean A. and F. Larry Leistritz. 2007. *Economic Contribution of the Petroleum Industry to North Dakota*. Agribusiness and Applied Economics Report No. 559 & 559-S. Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Title: Participation in the Preparation of Strategic Plan for the City of Dickinson

Sponsor: **Kadrmas, Lee & Jackson**
Description: Provided projections of regional employment and population for the greater Dickinson trade area. In addition to the long-term employment and population projections, a housing infrastructure model estimated service population based on build out rates and nontraditional lodging in the city. Findings were presented to the Dickinson City Council and also used as inputs to a comprehensive planning process examining future growth and need for public services and infrastructures as a result of rapid expansion of the petroleum sector in North Dakota. Study results also were published as a departmental report.
Citation: Bangsund, Dean A., Nancy M. Hodur, Rich Rathge, and Karen Olson. 2012. *Modeling Employment, Housing, and Population in Western North Dakota: The Case of Dickinson*. Agribusiness and Applied Economics Report No. 695, Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Title: Economic and Social Impacts of a US Highway 85 Bypass on the City of Alexander

Sponsor: **Kadrmas, Lee & Jackson**
Description: An economic impact assessment of various Highway 85 bypass alternatives on the city of Alexander, North Dakota, was conducted. This study was part of a larger environmental assessment conducted by the study sponsor. Because of a lack of secondary data, personal interviews with area stakeholders were conducted to obtain local perceptions on how various routes might impact business activity, planned or potential development, and growth in the city.
Citation: Hodur, Nancy M. and Dean A. Bangsund. 2012. *Economic impacts of a US Highway 85 Bypass on the City of Alexander*, Final Contract Report prepared for

N.D. Department of Transportation under Contract NH-7-085-(064)146. Department of Agribusiness and Applied Economics, North Dakota State University, Fargo, www.legis.nd.gov/files/committees/63-2013nma/appendices/15_5156_03000appendixc.pdf?20150821111454

Title: Williston Basin Oil and Gas Electrical Load Growth Forecast

Sponsor: **North Dakota Transmission Authority, Primary Investigator Kadrmas, Lee and Jackson**

Description: A comprehensive assessment of the potential growth in electricity demand in the Williston Basin was sponsored by the North Dakota Transmission Authority. Models were developed to provide scenario-driven projections of future employment, housing, and population for seven regions within the Williston Basin. Three scenarios were used to illustrate the potential basinwide effects of alternative rates and sizes of oil field development on employment, housing, and population in the Basin. County-level assessments of future housing demand and population potential were used by the primary investigator (Kadrmas, Lee and Jackson) as one component of the estimate for future electrical load growth in the Basin. Comprehensive modeling developed for the study has been detailed in departmental reports and is available for use by planners, stakeholders, and policy makers in the Williston Basin. This work represents the only comprehensive effort to model employment, housing, and population for the entire Williston Basin.

Citation: Bangsund, Dean A. and Nancy M. Hodur. 2013. *Williston Basin 2012: Projections of Future Employment and Population North Dakota*. Agribusiness and Applied Economics Report No. 704, Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Title: Population Projections for the City of Williston

Sponsor: **City of Williston**

Description: The City of Williston requested an analysis similar to the study conducted for the City of Dickinson. An assessment of the current service population of Williston and Williams County and a 5-year population projection were made using two models. Employment, housing, and population projections were made using an employment model and a housing build-out model. The study results were presented to the Williston City Council. Findings received substantial media attention and requests for information. A follow-up study was conducted in 2015, which assessed the current service population of Williston and Williams County and made a 5-year population projection building upon the findings reported in 2013.

Citations: Nancy M. Hodur, and Dean A. Bangsund. 2015. *Service Population Estimates for the City of Williston*. Agribusiness and Applied Economics Report No. 742. Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Nancy M. Hodur, and Dean A. Bangsund. 2013. *Population Estimates for City of Williston*. Agribusiness and Applied Economics Report No. 707. Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Title: Estimated Future Student Enrollments in Selected Public School Districts in Western North Dakota

Sponsor: **North Dakota Association of Oil and Gas Producing Counties**

Description: Study objectives were to make 5-year projections of student enrollments in five case study public school districts acutely affected by oil development in western North Dakota. Three models were developed to estimate potential future student enrollments. Findings are being used by school administrators and public policy makers to plan for future growth and develop strategies to mitigate the effects of rapid growth in the petroleum sector on public school districts. Findings were presented to the Association's Executive Committee.

Citations: Nancy M. Hodur, Dean A. Bangsund, Rich Rathge, and Karen Olson. 2013. *Estimates of Enrollment Projections: Ray, Stanley, Watford City, Williston, and Dickinson*. Agribusiness and Applied Economics Report No. 708. Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Title: Oil and Gas Impacts Study

Sponsor: **ND Legislative Management, Primary Investigator KLJ**

Description: This study was part of a larger effort led by KLJ, Inc., and partnering with UND EERC. The larger study identified changes to oil industry practices, production and infrastructure, and environment impacts for the study period 2014–2019. This study identified and examined potential social-economic impacts based on the current understanding of those effects and the current understanding of the rate and extent of oil field development over the study period.

Citations: Bangsund Dean A., and Nancy M. Hodur. 2014 "Socio-Economic Effects of Oil and Gas Industry in Western North Dakota 2014 to 2019," report to KLJ for inclusion in contract report to ND Legislative Management, August 2014, www.legis.nd.gov/files/committees/63-2013nma/appendices/15_5156_03000 appendixc.pdf?20150821111454

Title: Employment, Housing, and Population Projections for the Williston Basin

Sponsor: **Center for Rural Entrepreneurship, University of Nebraska, Lincoln**

Description: In 2012, the research team developed a model to project employment, housing, and population. The purpose of this effort was to update employment, population, and housing projections based on factors that have changed since the 2012 projections were developed. Findings will be used to support development and outreach efforts to develop a series of sponsor-supported Webinars.

Citations: Western North Dakota Energy Project: *Shale Projection Webinar Series 2014 Regional Updates*: Dickinson Region. April 2014. Strom Center, Dickinson State University and Visionwest Consortium.

Western North Dakota Energy Project: *Shale Projection Webinar Series 2014 Regional Updates*: Williston Region. April 2014. Strom Center, Dickinson State University and Visionwest Consortium.

Western North Dakota Energy Project: *Shale Projection Webinar Series 2014 Regional Updates*: Minot Region. April 2014. Strom Center, Dickinson State University and Visionwest Consortium.

Title: An Assessment of the Oil and Gas Industries Workforce Characteristics

Sponsor: **North Dakota Industrial Commission**

Description: Study objectives are to make a comprehensive assessment of the demographic makeup of the current and expected oil and gas industry workforce in the Williston Basin. The study will entail a comprehensive primary data collection effort to elicit demographic and other pertinent information from workers in the oil and gas industry. Findings will facilitate planning and development activities to address current and future demand for infrastructure, housing, and public services. Study is ongoing, with results expected to be delivered in fall 2015.

Citations: Forthcoming.

APPENDIX A-4

ODNEY PROJECT TEAM AND TAX AND POLICY PROJECT EXAMPLES

ODNEY PROJECT TEAM AND TAX AND POLICY PROJECT EXAMPLES

While Odney's Public Affairs Division is relatively young, the team's collective experience in working on complicated projects is not. The following are examples of the kinds of diverse projects that Odney's team has led as a part of its professional experience.

ODNEY PROJECT TEAM

Cory Fong will lead Odney activities and brings nearly 20 years of experience in state and local government, most recently during his 8 years as North Dakota Tax Commissioner. As Tax Commissioner, Cory oversaw the implementation of nearly $2.2 billion in broad-based tax relief delivering savings to hardworking North Dakota families, farmers and ranchers, and small business owners. Under Cory's leadership, the tax agency became a valued and trusted partner with the state's economic development community. Cory has also served as the Deputy Commissioner of the North Dakota Department of Commerce and Deputy Secretary of State.

Shane Goettle has an extensive background in state and federal government and the private sector as both an attorney and small business owner. As the North Dakota State Commerce Commissioner, Shane oversaw the agency that is responsible for economic development, tourism, community services, and workforce programs. During his tenure at the Department of Commerce, Shane chaired the Governor's State Energy Policy Commission and led an initiative to develop a $1 billion infrastructure investment in the state's oil and gas counties. Before joining Odney, Shane was a candidate for U.S. Congress. Prior to that, he also was the State Director for U.S. Senator John Hoeven and Chief of Staff to an Under Secretary at the U.S. Department of Agriculture in Washington, D.C.

Lacee Bjork Anderson has spent over 10 years of honing her persuasive skills as an attorney and recruiter. She has a passion for politics and spent the 2015 legislative session as the Assistant to Senate Majority Leader Rich Wardner. She previously worked on local and national campaigns and served as a volunteer election law attorney for the 2006 St. Paul mayoral race. She practiced law for 3 years at a highly respected Twin Cities firm before entering the recruiting field. As a recruiter, she worked with a wide variety of industries, including Fortune 500 companies, large national law firms, and midsized to large engineering firms throughout Minnesota and North Dakota. Her clients are her top priority, and she knows what it takes to get the job done.

EMPOWER NORTH DAKOTA

Shane led North Dakota's Energy Policy Commission while serving as the state's Commerce Commissioner from 2005 to 2010. The Commission gathered input from every segment of the energy industry, from wind to coal, biofuels to oil/gas, and the major utilities, to develop a comprehensive energy policy for North Dakota with specific recommendations for the executive and legislative branches. These complex issues also required a series of meetings

rotated throughout the state in which he gathered extensive public input. Here, Shane demonstrated his ability to drive for consensus and fashion workable proposals for public officials to consider and act on.

Reference:
Sandi Tabor
KLJ
Cell: 701.391.1175
E-mail: sandi.tabor@kljeng.com

WESTERN NORTH DAKOTA INFRASTRUCTURE DEVELOPMENT INITIATIVE

In 2010, at the request of Governor John Hoeven, Shane lead a group of state agencies through 14 meetings in western North Dakota to gather input from local political subdivisions and the general public concerning infrastructure gaps and state funding needs. Shane's efforts resulted in Governor Jack Dalrymple's proposal for a then-unprecedented funding level of $1.2 billion to address roads, water, and local infrastructure needs. The initiative also included managing a contracted study with the Great Plains Transportation Institute to understand the impact and funding gaps for county and township roads.

Reference:
James Arthaud (2010 Chair of Association of Oil and Gas Counties)
Cell: 701.290.9015
E-mail: jima@midstate.net

PROPERTY TAX VALUATION AND ASSESSMENT REFORM

Beginning in 2009, Cory Fong and the Tax Department began work toward property tax valuation and assessment reform. Passage and implementation of reforms required building coalitions with North Dakota's assessment community; local assessors; county, city and township officials; and taxpayers. After gathering input from the assessment community, the Tax Department developed a comprehensive legislative package aimed at modernizing assessment practices and record keeping, providing new and expanded authority to the State Board of Equalization to ensure fairness and equity in assessments across the state and classes of property, and putting new accountability provisions in place to ensure assessment officials follow the law and directives of the State Supervisor of Assessments and perform their responsibilities. The comprehensive package was approved by the 2009 Legislative Assembly, and the reforms are still being implemented.

References:
Dwight Cook, Senator, District 34 (Mandan)
State of North Dakota
Phone: 701.663.9446
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City of Minot
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NORTH DAKOTA DEPARTMENT OF COMMERCE AND ECONOMIC DEVELOPMENT FOUNDATION STRATEGIC PLANNING

As the Commissioner of the North Dakota Department of Commerce, Shane led an agency-wide strategic planning effort resulting in updated mission, vision, and value statements for the organization, along with targeted goals and projects with time lines, benchmarks, and measurement tools in support of the overall strategic plan. These objectives were also translated into annualized individual employee performance measures. Separate from the department's strategic planning effort, Shane also guided the strategic planning discussions of the Economic Development Foundation, which he chaired. The Economic Development Foundation comprises members representing North Dakota's key private sector partners. Its mission is to support North Dakota's economic development efforts through goal setting and establishing benchmarks and measurements. The current "Economic Development Strategic Plan: 2010–2020" is the fruit of that effort (see www.commerce.nd.gov/uploads/4/edstrategicplan10_20. pdf).

Reference:
Mark Nisbet
Xcel Energy
Cell: 701.371.5255
E-mail: mark.nisbet@xcelenergy.com

MULTISTATE TAX COMMISSION (MTC) STRATEGIC PLANNING

During Cory's time as the Chair of the MTC (2011–2013), the group took on an incremental, organization-wide strategic planning effort aimed at better defining and responding to their organizational strengths, weaknesses, opportunities, and threats (SWOT). The effort required gathering input from MTC staff, member states and their representatives, and stakeholder, including the business and industry associations that work with and monitor the activities of the MTC. The MTC gathered input by conducting an organizational scan, or SWOT analysis of the organization, which took the form of multiple focus group discussion and surveys of the MTC staff, members, and stakeholder partners.

The effort resulted in the complete overhaul of the organization's mission statement, development of new value and vision statements for the organization, creation of targeted goal areas supported by measurable work projects with timelines, and a strategic planning communications plan. Given the size of the MTC and its limited resources, they continue to take an incremental approach to the strategic planning effort. However, the effort has shown specific results with work projects being launched and completed in both the outreach and compliance

goal areas. The MTC is currently institutionalizing the strategic planning process as an ongoing and continuous process to be maintained and updated by the organizational leaders.

References:

Joe Huddleston, Executive Director
Multistate Tax Commission (MTC)
Phone: 202.660.1983
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APPENDIX A-5

CETER OIL AND GAS PROJECTS AND LCA MODEL

CETER OIL AND GAS PROJECTS AND LCA MODEL

Over the past 5 years, the EERC and The CETER Group, Inc. (CETER) have worked together on the following oil and gas projects:

- Analyzed oil production data from 13 counties in North Dakota for wells producing from the Bakken and Three Forks Formations to quantify uncertainty and forecast cumulative oil production and production decline.

- Developed a Monte Carlo-based simulation model to quantify the additional financial liability associated with burial of stabilized drill cuttings in on-site cuttings pits as well as off-site disposal of stabilized drill cuttings in special waste landfills.

- Conducted statistical analyses of a proprietary industry data set of oil reservoir performance data from 31 different CO_2 EOR sites in Colorado, Oklahoma, Texas, and Utah, resulting in a novel approach for describing key metrics that significantly influence the long-term performance and economic viability of CO_2 EOR projects.

- Assessed the life-cycle greenhouse gas (GHG) emissions associated with CO_2 EOR projects as compared to conventional and unconventional oil and gas development.

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*, 37:384–397.

Peck, W.D.; Azzolina, N.A.; Ge, J.; Gorecki, C.D.; Gorz, A.J.; and Melzer, L.S. 2015. Quantifying CO_2 storage efficiency factors in hydrocarbon reservoirs: A detailed look at CO_2 enhanced oil recovery. *Manuscript in preparation*.

CO_2 EOR LIFE CYCLE SUMMARY

As part of their research through the Plains CO_2 Reduction (PCOR) Partnership, the EERC and their subcontractor, CETER, have conducted a detailed examination of the life cycle GHG emissions for oil development with the application of CO_2 EOR. These studies show that the life-cycle GHG emissions for CO_2 EOR fields are significantly lower than the life cycle GHG emissions associated with conventional and unconventional oil production because of the significant volume of CO_2 that is permanently stored in the reservoir. Therefore, incentives that encourage CO_2 EOR development both increase domestic oil production and simultaneously reduce the GHG intensity of that energy resource. For example:

- Life cycle GHG emissions from “unconventional” oil production such as synthetic crude oil (SCO) derived from shale mining and oil sands range from approximately

530 to 800 kilograms of CO_2-equivalents per barrel of oil produced [kg CO_2e/bbl][1] (Mangmeechai, 2009).[2]

- Life cycle GHG emissions from "conventional" oil production from U.S. domestic production and other common imports to North America range from approximately 475 to 530 kg CO_2e/bbl (Mangmeechai, 2009).

- Life cycle GHG emissions from oil production via CO_2 EOR range from approximately 200 to 300 kg CO_2e/bbl (EERC and CETER, unpublished data) (Figure A-5-1).

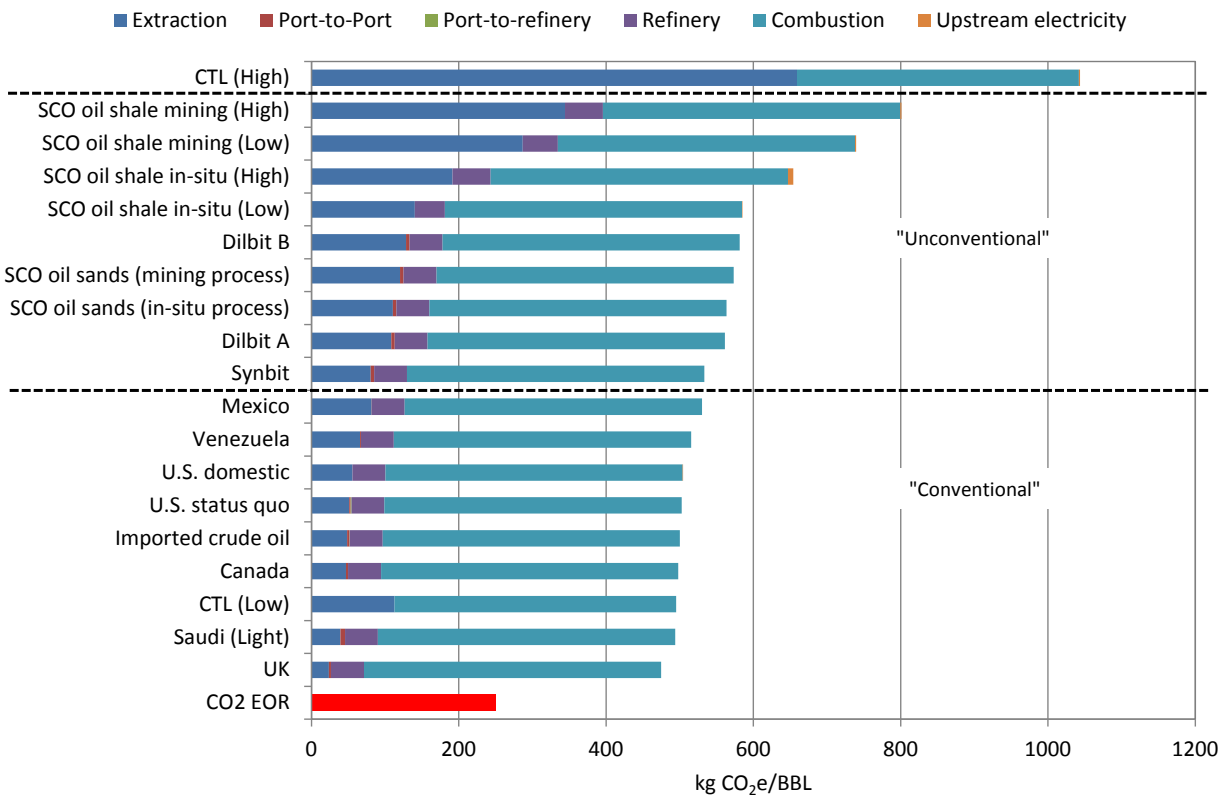


Figure CETER-1. Comparison of life cycle GHG emissions expressed as kilograms of CO_2 equivalents per barrel of oil produced (kg CO_2e/bbl) for "unconventional" and "conventional" oil as compared to CO_2 EOR (red bar, bottom). "CTL" = "coal-to-liquid," "SCO" = "synthetic crude oil" (source: adapted from Mangmeechai, 2009).

[1] CO_2 "equivalents" use standard CO_2 equivalency factors published by the Intergovernmental Panel on Climate Change (IPCC) to convert the mass amount of CO_2 emissions that would have the same impact on global climate for other emissions besides CO_2, such as methane (CH_4) and nitrous oxide (N_2O) (IPCC, 2013). Using this approach, multiple gases may be compared on a single scale, expressed in units of CO_2 "equivalents" or "CO_2e."

[2] Mangmeechai, A. (2009) *Life Cycle Greenhouse Gas Emissions, Consumptive Water Use and Levelized Costs of Unconventional Oil in N. America*. Dissertation, Carnegie Mellon University: Pittsburgh, PA.

APPENDIX B

PROJECT TEAM RESUMES

APPENDIX B-1
EERC RESUMES OF KEY PERSONNEL

APPENDIX B-2
UW COLLEGE OF BUSINESS, DEPARTMENT OF ECONOMICS & FINANCE

APPENDIX B-3
NDSU DEPARTMENT OF AGRIBUSINESS AND APPLIED ECONOMICS

APPENDIX B-4
ODNEY, PUBLIC AFFAIRS & GOVERNMENT RELATIONS

APPENDIX B-5
THE CETER GROUP, INC.

APPENDIX B-1

EERC RESUMES OF KEY PERSONNEL

JAMES A. SORENSEN
Senior Research Manager
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) 777-5287, Fax: (701) 777-5181, E-Mail: jsorensen@undeerc.org

Principal Areas of Expertise
Mr. Sorensen's principal areas of interest and expertise include tight oil resource assessment and development, carbon dioxide utilization and storage in geologic formations, and environmental issues associated with the oil and gas industry.

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

Professional Experience
1999–Present: Senior Research Manager, EERC, UND. Mr. Sorensen currently serves as manager and co-principal investigator for several research programs, including the Plains CO_2 Reduction (PCOR) Partnership, a multiyear program focused on developing strategies for reducing carbon dioxide emissions in nine states and four Canadian provinces. He has also conducted projects to develop an improved understanding of the Bakken petroleum system, including efforts to examine the potential to use carbon dioxide for enhanced oil recovery in the Bakken. Responsibilities include supervision of research personnel, preparing and executing work plans, budget preparation and management, writing technical reports and papers, presentation of work plans and results at conferences and client meetings, and proposal writing and presentation.

1997–1999: Program Manager, EERC, UND. Mr. Sorensen managed projects on topics that included produced water management, environmental fate of natural gas-processing chemicals, coalbed methane, and gas methane hydrates.

1993–1997: Geologist, EERC, UND. Mr. Sorensen conducted a variety of field-based hydrogeologic investigations throughout the United States and Canada. Activities were primarily focused on the subsurface mobility of constituents associated with natural gas production sites.

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

Professional Memberships
Society of Petroleum Engineers

Publications and Presentations
Has coauthored nearly 200 publications.

WESLEY D. PECK
Senior Research Manager
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) 777-5195, Fax: (701) 777-5181, E-Mail: wpeck@undeerc.org

Principal Areas of Expertise

Mr. Peck's principal areas of interest and expertise include geographic information systems (GIS), cartography, information graphics, geology, and digital asset management. Mr. Peck currently oversees GIS activities for the Plains CO_2 Reduction (PCOR) Partnership. He is also the task leader for two regional characterization efforts within the PCOR Partnership.

Qualifications

M.S., Geology, University of North Dakota, 1992. Thesis: The Stratigraphy and Sedimentology of the Sentinel Butte Formation (Paleocene) in South-Central Williams County, North Dakota.

B.S., Earth Science, North Dakota State University, 1987.

Professional Experience

2015–Present: Senior Research Manager, EERC, UND.

2011–2015: Research Manager, EERC, UND. Mr. Peck's responsibilities include overseeing a staff of geologists and GIS specialists involved with oil and gas research activities in the Williston Basin as well as regional geologic characterization activities associated with the PCOR Partnership.

1991–2011: Research Scientist, EERC, UND. Mr. Peck's responsibilities included overseeing major GIS activities at the EERC, serving as task leader for the regional characterization component of the PCOR Partnership, as well as report and proposal writing.

1989–1991: Graduate Research Assistant, EERC, UND. Mr. Peck's responsibilities included acquisition and management of geologic data related to Cretaceous and Tertiary geology of the Williston Basin. Mr. Peck also assisted in the collection of Cretaceous and Tertiary fossils and stratigraphic information in western North Dakota and eastern Montana.

Publications and Presentations

Has authored and coauthored several professional publications.

LONNY L. JACOBSON
Research Specialist, Oilfield Management
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) 777-5331, Fax: (701) 777-5181, E-Mail: ljacobson@undeerc.org

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, and site management.

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: Research Specialist, Oilfield Management, EERC, UND. Mr. Jacobson's responsibilities include 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.

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

Mr. Jacobson took projects from concept through to production. He worked as a site manager for over 100 workover operations and has experience working in multiple formations, including the Bakken/Three Forks, Midale, Spearfish, Dakota, Red River, and Mission Canyon. He also has experience in the completion of produced-water disposal wells in the state of North Dakota. Mr. Jacobson typically managed health, safety, and environment (HSE) during all operations, except in extreme sour/H_2S environments.

Specific site management projects included the following:

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

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

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

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

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

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

Publications and Presentations
Has coauthored several technical publications.

APPENDIX B-2

UW COLLEGE OF BUSINESS, DEPARTMENT OF ECONOMICS & FINANCE

DR. BENJAMIN R. COOK

University of Wyoming
Department of Economics & Finance
Dept. 3985, 1000 E. University Ave.
Laramie, WY 82071
Email: bencook@uwyo.edu
http://www.uwyo.edu/bencook

Office: BU #379W
Phone: (307) 766-2858
Mobile: (307) 399-7477

Permanent Address:
1817 Forest St
Laramie, WY 82070

Primary Fields: Energy Economics & Finance, Industrial Organization, Decision Making
Secondary Fields: Experimental, Regulatory, Financial Project Evaluation, Natural Resources

EDUCATION

PhD, Economics, University of Wyoming, Laramie, WY — 2011
Dissertation: *Essays on Carbon Policy and Enhanced Oil Recovery*
(Defended, December 2010)

BS, Economics, University of Wyoming, Laramie, WY — 2003
Graduation Honors, Phi Beta Kappa

Certificate in Business Strategy, Cornell University — 2014

ACADEMIC POSITIONS

Visiting Assistant Professor, University of Wyoming, Laramie, WY — July 2012 – Present
Econ & Finance/ Energy MBA / Enhanced Oil Recovery Institute

Postdoctoral Research Associate, University of Wyoming, Laramie, WY — Jan. 2011-Jun. 2012
Dept. of Economics & Finance / Enhanced Oil Recovery Institute

OTHER EXPERIENCE

Consultant & Project Advisor — 2013 – Present
North Shore Energy, True Oil, Black Hills Corporation, Arizona Clean Fuels Yuma LLC, Snowy Range Energy Consultants, SPIGOT/BetaNoire Capital, Devon Energy, Marathon Oil, Citation Oil & Gas, Merit Energy, Legacy Reserves, ESal (Engineered Salingity) LLC

Consultant/Litigation Support — 2011/2012
Plaintiff Attorneys: Hagens-Berman-Sobol-Shapiro, LLP.

Intern Analyst, Cheyenne Capital Fund LP, Private Equity, Denver, CO — Summer 2006
Due Diligence, Pro Forma Financial Model for De Novo Bank

Registered Assistant, Wealth Planning & Investments, Cheyenne, WY — 2000 - 2002
Investment Research, Client Support, NASD Series 6 & 63

COURSES TAUGHT

Principles of Macroeconomics (ECON 1010), Corporate Finance (FIN 3250), Decision Making & Ethics (MBAM 5107), Energy Finance & Project Evaluation (MBAM 5502), Summer Experiential Business Projects (MBAM 5301) , Managerial Economics (ECON 5890)

RESEARCH

Cook, Benjamin R. and Mason, Charles F. (Fall 2012), "Enhanced Oil Recovery: Going Beyond Conventional Extraction," *IAEE Energy Forum*, Fall 2012, 21-23.

*Phillips, Owen R., Cook, Benjamin R., Strandholm, John C. Bastian, Christopher T., Menkhaus, Dale J., and Gao, Shen (Summer 2015), "Tax and Subsidy Incidence in Negotiations," (In submission).

Phillips, Owen R., Cook, Benjamin R., Bastian, Christopher T., Menkhaus, Dale J., and Gao, Shen (Summer 2015), "Diluting Institutional Favoritism: Linking Negotiations with Auctions and Vice Versa," (In submission).

*Cook, Benjamin R. (January 2014), "The Future Economic Contribution of Wyoming's CO_2-EOR Potential," University of Wyoming, Enhanced Oil Recovery Institute (EORI)

*Bastian, Christopher T., Nagler, Amy M., Menkhaus, Dale J., Ehmke, Mariah D., Phillips, Owen R., and Cook, Benjamin R. (January 2014, under submission), "Subsidy Framing, Information, and Payment Incidence in Agricultural and Bioenergy Input Markets: Laboratory Market Evidence."

*Cook, Benjamin R. (September 2013, under submission), "Wyoming's Miscible CO_2 Enhanced Oil Recovery Potential from Main Pay Zones," University of Wyoming, Enhanced Oil Recovery Institute (EORI) Working Papers & Reports.

Cook, Benjamin R. (July 2013), "The Economic Contribution of CO_2 Enhanced Oil Recovery in Wyoming: 2010-2012," University of Wyoming, Enhanced Oil Recovery Institute (EORI) Working Papers & Reports.

Cook, Benjamin R., Phillips, Owen R., Menkhaus, Dale J. and Bastian, Christopher T., (December 2012), "Impacts of Subsidies and Taxes on Private Bargaining: Experimental Insights on Carbon Sequestration Markets.

SELECTED PRESENTATIONS

Oil & Gas Project Evaluation and the Capital Budgeting Process Guest Lecture, Energy Resource Management Capstone, Laramie, WY	Mar. 2015
Thoughts on EPA CO_2 Rules & Overview of CO_2Scope^{TM}, 8th Annual Wyoming CO_2 Conference, Enhanced Oil Recovery Institute, Casper, WY	Jul. 2014
Economic Evaluations and Wyoming's Economy EORI Technical Advisory & Commission Meeting, Denver, CO.	Jan. 2014
CO_2Scope^{TM} : A New CO_2-EOR Scoping Tool from the EORI 2013 CO_2 Conference, Midland, TX	Dec. 2013
Wyoming's CO_2-EOR Potential, Economic Impact, and Looking to Nitrogen, EORI Technical Advisory & Commission Meeting, Denver, CO.	Jan. 2013

SELECTED TRAININGS & WORKSHOPS

Business Strategy: Achieving Competitive Advantage Certificate, Cornell University	Sept. 2014
2014 CO_2-EOR Training School (Steamboat, CO) Applied Petroleum Technology Academy (APTA)	Aug. 2014
Fundamentals of Petroleum Economics IBC Academy Distance Learning	Oct. 2013
CO_2 Contracting Seminar & Carbon Management Workshop, 2012 CO_2 Conference Week, Midland, TX	Dec. 2012
IMPLAN Introductory Training (using IMPLAN for Economic Impact Studies), MIG, Inc., Minneapolis, MN.	Nov. 2011

OTHER ACTIVITIES & ACCOMPLISHMENTS

Consultant/Faculty Advisor (Summer 2015), "Black Hills Corporation Project Portfolio Management & Prioritization," MBA Project (with Tyler Gibbs, Muna Oweidat, and Craig Hibberd).

Consultant/Faculty Advisor (Summer 2015), "Arizona Clean Fuels Yuma Financial Modeling," MBA Project (with Prof. Suman Banerjee, Drayson Bratt, Scott Lamb, and Patrick Flaherty).

Consultant/Faculty Advisor (Summer 2014), "Black Hills Corporation CO2 Market and Pricing Study", MBA Project (with Laurel Winkenwerder, Colin Herold, Kyle Komata, and Uffe Janus).

Consultant/Faculty Advisor (Summer 2013), "Big Horn Basin Oil Production Benchmarking Study 2011-12," MBA Project (with Christina Irion, Austin Mivshek, and Rabin Gautam).

Software. Cook, Benjamin R. and van 't Veld, Klaas (December 2013), CO_2Scope™ (An Economic Scoping Tool for CO_2-EOR), Wyoming Research Products Center, University of Wyoming, Laramie, WY. Available online at http://www.uwyo.edu/eori/co2scopetm

PROFESSIONAL AFFILIATIONS

American Economic Association (AEA), United States Association for Energy Economists (USAEE)

APPENDIX B-3

NDSU DEPARTMENT OF AGRIBUSINESS AND APPLIED ECONOMICS

Vita

Dean A. Bangsund

Business Address: Department of Agribusiness and Applied Economics
P.O. Box 6050, Dept 7610
North Dakota State University
Fargo, ND, 58105
701-231-7471
E-mail: d.bangsund@ndsu.edu

Home Address: 224 Chestnut Drive
Horace, ND, 58047

Current Position:

Research Scientist: July 1996 - present, Department of Agribusiness and Applied Economics, North Dakota State University, Fargo

Economic Research Experience (1987 to 2014):

Grant and Contract Academic Research

Professional activities at North Dakota State University have been an integral part of over 78 grant/contract funded research projects involving nearly $5.6 million.

Economic Consulting

Professional activities include direct working relationships with numerous government entities, trade groups, and associations in the northern Great Plains.

Subject Matter

◆ socio-economic assessments of community development, population change, and local infrastructure.

◆ economic and fiscal impact assessment of agriculture, energy, public service, and tourism-based industries.

◆ economic performance of regional business ventures, government programs, and land management/use alternatives.

◆ natural resource issues in areas of soil and water conservation, noxious weed management, flood impacts, and wildlife-related recreational activities.

Honors/Awards:

2008 Leslie Hewes Award for Best Social Science Article published in *Great Plains Research* "Producer Responses to Carbon Sequestration Incentives in the Northern Great Plains"

Professional Staff Award for Excellence nominee, North Dakota Agricultural Experiment Station, North Dakota State University, 2002, 2001, 1996, 1995, 1994, 1993

Publications (synopsis)**:**

Principal author and co-author of 18 Referred Journal Articles, 1 Book Chapter, 10 Published Abstracts, 12 Published Papers of Professional Meetings, 5 North Dakota Farm Research Articles, 92 Departmental Research Reports, 23 Miscellaneous Research Reports, 3 Software Analysis Tools, and 5 Newsletters.

Presentations/News Releases (synopsis)**:**

Professional presentations have been made at numerous State, National, and International Symposiums and numerous extension and outreach presentations have been made in support of grant and contract research to regional clientele groups and the general public.

Nancy M. Hodur, PhD
VITA

Relevant Experience:

Assistant Research Professor, Department of Agribusiness and Applied Economics, North Dakota State University, Fargo (March 2001-present).

Education:

PhD, Natural Resources Management: North Dakota State University, Fargo, 2010
MS, Natural Resource Management: North Dakota State University, Fargo, 1991
BA, Business Administration: Jamestown College, Jamestown, ND, 1983

Research:

Conduct research activities on a wide variety of subjects related to economic development, economic impacts, natural resources, and biomaterials. Research findings have been published in refereed academic journals, presented at national professional meetings and conferences, and delivered to numerous constituent groups in North Dakota. Special expertise in primary data collection (both quantitative and qualitative), survey design and data analysis (both quantitative and qualitative). Develop unique methods to address research questions. Recent efforts have focused on data collection efforts to address issues related to rapid expansion in the oil and gas industry in western North Dakota

Selected Recent Publications:

Bangsund, Dean A. and Nancy M. Hodur. 2015. *Petroleum Industry's Economic Contribution to North Dakota in 2013*. Agribusiness and Applied Economics Report No. 736. Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Nancy M. Hodur, and Dean A. Bangsund. 2015. *Service Population Estimates for the City of Williston*. Agribusiness and Applied Economics Report No. 742. Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Bangsund Dean A., and Nancy M. Hodur. 2014 "Socio-Economic Effects of Oil and Gas Industry in Western North Dakota 2014 to 2019", report to KLJ for inclusion in contract report to ND Legislative Management, August, 2014, http://www.legis.nd.gov/files/committees/63-2013nma/appendices/15_5156_03000 appendixc.pdf?20150821111454

Bangsund, Dean A. and Nancy M. Hodur. 2013. *Petroleum Industry's Economic Contribution to North Dakota in 2011*. Agribusiness and Applied Economics Report No. 710. Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Nancy M. Hodur, Dean A. Bangsund, Rich Rathge, and Karen Olson. 2013. *Estimates of Enrollment Projections: Ray, Stanley, Watford City, Williston, and Dickinson*. Agribusiness and Applied Economics Report No. 708. Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Nancy M. Hodur, and Dean A. Bangsund. 2013. *Population Estimates for City of Williston*. Agribusiness and Applied Economics Report No. 707. Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Nancy M. Hodur, and Dean A. Bangsund. 2013. *Population Estimates for City of Williston*. Agribusiness and Applied Economics Report No. 707-S (Summary). Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Hodur, Nancy M. and Dean A. Bangsund. 2012. *Economic impacts of a US Highway 85 Bypass on the City of Alexander*, Final Contract Report prepared for N.D. Department of Transportation under contract NH-7-085-(064)146. Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Bangsund, Dean A. and Nancy M. Hodur. 2013. *Williston Basin 2012: Projections of Future Employment and Population North Dakota*. Agribusiness and Applied Economics Report No. 704, Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Bangsund, Dean A., Nancy M. Hodur, Rich Rathge, and Karen Olson. 2012. *Modeling Employment, Housing, and Population in Western North Dakota: The Case of Dickinson*. Agribusiness and Applied Economics Report No. 695, Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Bangsund, Dean A. and Nancy M. Hodur. 2012. *Modeling Direct and Secondary Employment in the Petroleum Sector in North Dakota*. Agribusiness and Applied Economics Report No. 694. Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Bangsund, Dean A. and Nancy. M. Hodur. 2012. *The Economic Contribution of the Petroleum Industry to the State of North Dakota*. Department of Agribusiness and Applied Economics Report pending publication. North Dakota State University, Fargo.

APPENDIX B-4

ODNEY, PUBLIC AFFAIRS & GOVERNMENT RELATIONS

Cory Fong

Public Affairs Senior Specialist
2014 - present

- Uses vast network of state and national connections to help our clients achieve their public affairs and government relations goals

Experience

Tax Commissioner
2005 – 2013
Office of North Dakota State Tax Commissioner
Bismarck, ND

- Developed, coordinated and carried out the office's legislative agenda relating to the agency's $40 million budget
- Drafted legislation and amendments
- Led 134 full-time employees
- Worked with division directors and supervisors to manage the workloads of agency employees
- Led the agency-wide implementation of a $12 million integrated tax system
- Assisted in promoting the agency and its services to customers, the public and the media

Deputy Commissioner
2004 – 2005
North Dakota Department of Commerce
Bismarck, ND

- Assisted with the development and implementation of economic initiatives to improve North Dakota's economy
- Oversaw agency employees

Campaign Director
2003 – 2004
Hoeven Committee, Governor John Hoeven
Bismarck, ND

- Crafted overall campaign messsages in partnership with Gov. Hoeven, campaign staff and campaign consultants
- Oversaw the campaign fundraising effort
- Served as the official spokesperson and media contact for the 2004 Hoeven Committee
- Cultivated relationships with and support for Gov. Hoeven from statewide coalitions and interest groups

Deputy Secretary of State
2001 – 2003
Office of the North Dakota Secretary of State
Bismarck, ND

- Promoted the agency and its services
- Spearheaded the Green Book project
- Organized the completion of the 1995-97 North Dakota Blue Book
- Facilitated inter-agency projects and initiatives
- Developed and maintained the initial web site for the Secretary of State's office

Education

Coursework toward Master's in Public Administration

- University of North Dakota – Grand Forks, ND

B.A. in Political Science and Speech Communications

- Gonzaga University – Spokane, WA

Shane Goettle

Director of Public Affairs
2012 – present

- Provides clients with results-oriented government relations and lobby services, as well as political and business consulting

Experience

Owner
2011 – 2012
Goettle Consulting
Mandan, ND

- Consulted for APEX Engineering re: Bismarck's 2012 flood plan
- Consulted for Annabelle Homes projects throughout western North Dakota
- Consulted for Greg Bamford (equity investing in North Dakota)

State Director
2011
U.S. Senator John Hoeven
Bismarck, ND

- Established, hired and managed statewide offices and personnel
- Acted as the Senator's lead representative and spokesperson in dealing with federal and state agencies to coordinate response to unprecedented state-wide flood challenges
- Engaged groups, business leaders and constituents on energy and agricultural policy

Commissioner
2005 – 2011
North Dakota Department of Commerce
Bismarck, ND

- Led state agency responsible for economic development, tourism, community services and workforce programs
- Chaired Governor's State Energy Policy Commission and secured input from private sector energy industries concerning legal, regulatory and tax policy ("EmPowerND")
- Led initiative to develop $1 Billion infrastructure investment in oil and gas counties
- Managed state's contract with North Dakota Trade Office and led trade missions
- Promoted development of angel and venture capital within state
- Developed and launched "InnovateND," an innovation competition
- Aggressively marketed North Dakota for investment, tourists and workforce
- Developed and implemented a performance management system throughout agency

Chief of Staff to Under Secretary
2004 – 2005
USDA-Rural Development
Washington, D.C.

- Implemented Under Secretary's policy directives and assisted in management and day-to-day operations of $87 billion, 7200 employee, rural capital investment organization

Education

Juris Doctor

- Hamline University School of Law – St. Paul, Minn.

B.S. in Agricultural Economics

- North Dakota State University – Fargo, ND

Lacee Anderson

Public Affairs Specialist
2015 - present

- Provides full-service public affairs and lobbying services to assist clients with their governmental and political goals

Experience

Assistant to Senate Majority Leader
2015
State of North Dakota
Bismarck, ND

- Assisted Senate Majority Leader and Senate Republican Caucus with a wide variety of legislative issues, including tracking legislation, drafting memorandum, handling public relations and media, conducting legislative research and summarizing important bills
- Networked with key political players and built relationships with lawmakers

Consultant
2014 – present
The Quaero Group
Minneapolis, MN and
Denver, CO

- Partners with local and national law firms to assist in recruiting top talent for attorney permanent direct hire positions
- Consults with law firm partners regarding client needs, hiring strategies and growth goals
- Recruits partner level candidates, groups and law firms for placements and mergers
- Develops marketing strategies and materials

Senior Recruiter
2012 – 2014
George Konik Associates
Edina, MN

- Oversaw business development and provided specialized recruiting and headhunting for entry- to senior-level professionals
- Built a network of candidates and clients through cold calls, referrals and networking
- Developed marketing strategies

Senior Attorney Search Director
2007 – 2012
Special Counsel
Minneapolis, MN

- Partnered with local and national law firms to assist in recruiting top talent for attorney permanent direct hire positions
- Worked directly with CEOs, General Counsels and high-level HR professionals to assess and articulate hiring needs
- Developed marketing strategies

Associate
2003 – 2006
Larson • King, LLP
St. Paul, MN

- Conducted legal research
- Drafted motions, research memos and court documents
- Prepared for and attended court hearings, trials and depositions

Education

Juris Doctor

- William Mitchell College Law – St. Paul, MN

B.A. in International Relations, Business and Spanish

- Concordia College – Moorhead, MN

APPENDIX B-5

THE CETER GROUP, INC.

The CETER Group, Inc.

NICHOLAS A. AZZOLINA, PH.D.
Principal / Co-Founder
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's principal areas of interest and expertise include statistical analysis and modeling of industrial and environmental data. He has extensively studied carbon dioxide (CO_2) storage associated with enhanced oil recovery (EOR); life-cycle analysis (LCA) of greenhouse gas (GHG) emissions associated with oil and gas development; and project risk analysis for large-scale geologic storage of CO_2.

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

Professional Experience
2010–Present: *Principal and Co-Founder of The CETER Group, Inc. (CETER).*
Dr. Azzolina is currently principal and co-founder of CETER, where he supports various industry and environmental projects. His project experience related to the oil and gas sector includes: oil production decline-curve analysis; novel modeling approaches for describing key metrics that significantly influence the long-term performance and economic viability CO_2 EOR; Monte Carlo simulation modeling to quantify uncertainty; project risk analysis; and LCA of GHG emissions associated with oil and gas development.

2008–2010: *Scientist / Project Manager, Foth Infrastructure & Environment, LLC.*
Mr. Azzolina managed projects on topics that included non-ferrous mine permit applications, contaminated sediments, environmental forensics, and statistical data analysis.

2005–2008: *Scientist / Project Manager, The RETEC Group, Inc.*
Mr. Azzolina managed projects on topics that included contaminated sediments, environmental toxicology, environmental forensics, and groundwater contamination.

2000–2003: *Supervisor, McMaster-Carr Supply Company.*
Mr. Azzolina supervised the assembly and receiving operations of McMaster-Carr's 250,000-item warehouse located in Dayton, New Jersey, and was responsible for logistics, supply-chain management, and staff training and development.

1997–2000: *Senior Field Engineer, Schlumberger Oilfield Services.*
Mr. Azzolina managed field teams of 3 to 5 personnel and was responsible for the collection of down-hole geologic and geophysical data used to evaluate oil and gas wells in Texas and Louisiana.

Publications and Presentations

Dr. Azzolina has co-authored numerous industry and peer-reviewed publications. Relevant publications specific to the oil and gas industry and geologic CO_2 storage include:

- Peck, W.D.; **Azzolina, N.A.**; Ge, J.; Gorecki, C.D.; Gorz, A.J.; and Melzer, L.S. 2015. Quantifying CO_2 storage efficiency factors in hydrocarbon reservoirs: A detailed look at CO_2 enhanced oil recovery. *Manuscript in preparation*.
- **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*, 37:384-397.
- 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*, 49(7):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*, 49(2):1215–1224.
- **Azzolina, N.A.**; Small, M.J.; Nakles, D.V., 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*, 28:895-909.

APPENDIX C

ADVISORY BOARD COMMITMENT LETTERS

Department of Mineral Resources

Lynn D. Helms – Director

North Dakota Industrial Commission
www.dmr.nd.gov

August 17, 2015

Mr. James Sorensen
Senior Research Manager
Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear Mr. Sorensen:

If the Energy & Environmental Research Center is awarded the North Dakota Legislative Management Committee study pertaining to Section 42 of 2015 Senate Bill No. 2015, I would be happy to represent the interests of North Dakota's Department of Mineral Resources, the state's primary oil and gas regulator, through participation on a technical advisory board. Specifically, I will help the project team to better understand varying implications of potential tax scenarios on enhanced oil recovery development in North Dakota.

Sincerely,

Lynn D Helms

Lynn Helms
Director

600 E Boulevard Ave - Dept 405, Bismarck, North Dakota 58505-0840 Phone (701)328-8020 Fax (701)328-8022

Lignite Energy Council
1016 E. Owens Avenue
P.O. Box 2277
Bismarck, ND 58502
Tel (701) 258-7117
Fax (701) 258-2755

August 17, 2015

Mr. James Sorensen
Senior Research Manager
Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear Mr. Sorensen:

The Lignite Energy Council is pleased to support the Energy & Environmental Research Center's proposed effort related to the North Dakota Legislative Management Committee study pertaining to Section 42 of 2015 Senate Bill No. 2015. If the study is awarded, I am prepared to represent the collective interests of the North Dakota lignite energy industry through participation on a technical advisory board. Specifically, I will help the project team to better understand varying implications of potential tax scenarios on enhanced oil recovery development in North Dakota.

The Lignite Energy Council conducts programs to help maintain a strong lignite industry that currently employs more than 17,000 people, has an annual economic impact of $3.5 billion in North Dakota, and generates more than $100 million in state tax revenue each year. Members of the Lignite Energy Council include mining companies; major users that use lignite to generate electricity, synthetic natural gas, and other valuable by-products; and businesses that provide goods and services to the lignite industry.

I can assure you my membership has a profound interest in this effort and is prepared to facilitate participation on this technical advisory board.

Best regards,

Mike Jones
Vice President of Research and Development,
Lignite Energy Council

NORTH DAKOTA
PETROLEUM
COUNCIL

100 West Broadway, Ste. 200 | P.O. Box 1395 | Bismarck, ND 58502-1395
701.223.6380 | ndpc@ndoil.org | www.NDOil.org

August 18, 2015

Mr. James Sorensen
Senior Research Manager
Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear Mr. Sorensen:

The North Dakota Petroleum Council (NDPC) is pleased to support the Energy & Environmental Research Center's proposed effort related to the North Dakota Legislative Management Committee study pertaining to Section 42 of 2015 Senate Bill No. 2015. If the study is awarded, I am prepared to represent the collective interests of the North Dakota oil and gas industry through participation on a technical advisory board. Specifically, I will help the project team to better understand varying implications of potential tax scenarios on enhanced oil recovery development in North Dakota.

The North Dakota Petroleum Council (NDPC) is a trade association that represents more than 500 companies involved in all aspects of the oil and gas industry, including oil and gas production, refining, pipeline, mineral leasing, consulting, legal work, and oilfield service activities in North Dakota, South Dakota, and the Rocky Mountain region. Council members produced 98% of the 243 million barrels of oil produced in North Dakota in 2012.

I can assure you my membership has a profound interest in this effort and is prepared to facilitate participation on this technical advisory board.

Sincerely,

Ron Ness
President
North Dakota Petroleum Council

NORTH DAKOTA oil can!
www.NorthDakotaOilCan.com

August 17, 2015

Mr. James Sorensen
Senior Research Manager
Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear Mr. Sorensen:

If the Energy & Environmental Research Center is awarded the North Dakota Legislative Management Committee study pertaining to Section 42 of 2015 Senate Bill No. 2015, I would be happy to represent the interests of the North Dakota fossil fuel industry through participation on a technical advisory board. Specifically, I will help the project team to better understand varying implications of potential tax scenarios from North Dakota's Oil and Gas Producing Counties' perspective on enhanced oil recovery development in North Dakota.

Best regards,

Vicky Steiner

Vicky Steiner
Executive Director, North Dakota Association of
Oil and Gas Producing Counties

APPENDIX D

PROJECT TEAM COMMITMENT LETTERS

APPENDIX D-1
UW COLLEGE OF BUSINESS, DEPARTMENT OF ECONOMICS & FINANCE

APPENDIX D-2
NDSU DEPARTMENT OF AGRIBUSINESS AND APPLIED ECONOMICS

APPENDIX D-3
ODNEY, PUBLIC AFFAIRS & GOVERNMENT RELATIONS

APPENDIX D-4
THE CETER GROUP, INC.

APPENDIX D-1

UW COLLEGE OF BUSINESS, DEPARTMENT OF ECONOMICS & FINANCE

UNIVERSITY OF WYOMING

ENHANCED OIL RECOVERY INSTITUTE

www.uwyo.edu/eori

Casper Office (Main)
2435 King Boulevard
Room 302
Casper, WY 82604

tel (307) 315-6441
fax (307) 315-6440

Laramie Office
Dept. 4068
1000 E. University Ave.
Laramie, WY 82071-2000

tel (307) 766-2791
fax (307) 766-2737

August 26, 2015

James Sorenson, Senior Research Manager
Energy & Environmental Research Center (EERC)
15 North 23rd Street Stop 9018
Grand Forks, ND 58202-9018
P: (701) 777-5013 | F: (701) 777-5181

Reference: Response to solicitation/RFP regarding the **North Dakota Carbon Capture and EOR Economic Impact Study**

Dear Mr. Sorenson**:**

This letter confirms that Dr. Benjamin R. Cook, and the appropriate program and administrative personnel at the Enhanced Oil Recovery Institute (EORI) at the University of Wyoming have reviewed the above referenced Solicitation/RFP and are committed to enter into a subcontract with the Energy & Environmental Research Center (EERC) for the performance period of October 1st, 2015 to August 31st, 2016. The EORI Principal Investigator on this proposal is Dr. Benjamin R. Cook. The work to be performed by Dr. Cook and EORI does not include animal and/or human research subjects. While no conflicts of interest have been identified at this time, EORI and Dr. Cook will continue to monitor and vet any future projects undertaken by EORI for such conflicts.

Dr. Cook's budget, budget justification and scope of work are provided as separate enclosures to this letter. The estimated cost of the proposed subcontract will not exceed $28,868 and includes appropriate direct and indirect costs.

Furthermore, by submission of this commitment letter EORI and its Principal Investigator (PI), EORI certifies (1) that the information submitted within the application is true, complete and accurate to the best of the EORI's and PI's knowledge; (2) that any false, fictitious, or fraudulent statements or claims may subject the EORI and PI to criminal, civil, or administrative penalties; and (3) that the PI agrees to accept responsibility for the scientific conduct of the project and to provide the required progress reports if an award is made as a result of the EERC application.

Sincerely,

Steven M. Carpenter

Steven Carpenter, Director

Benjamin R. Cook, Principal Investigator

Attached:
Scope of Work
Timeline
Budget
Budget Justification

Enhanced Oil Recovery Institute

Scope of Work

Task 2 – A comprehensive economic study of oil and gas recovery and EOR in North Dakota.

2.1. The estimated annual economic impacts, near- and long-term, from implementation of conventional CO2 EOR

The CO_2SCOPE model will be utilized to estimate economical oil production, CO_2 demand, and cash flows for application to the North Dakota Oil & Gas Industry. [Required inputs from IMPAN data, as well as estimated original oil, well locations for the study region, and estimated injection flow rates will be provided by EERC]. Where input values specific to North Dakota are not available, information from known EOR projects (e.g., MT, WY, TX) will be garnered and adjusted to approximate costs for North Dakota's industry. A reference oil price as forecasted by the U.S. Energy Information Administration (EIA) will be implemented as the base-case price point for determining economic viability. Annual economic impacts will be estimated for near- and long-term (up to 2035) projections.

A sensitivity analysis will be conducted to consider the effect of oil price on the estimated annual economic impacts. Two scenarios for oil price will be investigated using EIA-forecasted high and low oil prices above and below the reference oil price, respectively. The magnitude of the effect from these changes in estimated economic annual oil production, and the associated CO2 demand will be evaluated.

2.2. Investigation of current and potential tax incentives to encourage implementation of conventional CO2 EOR

Impacts for previous findings in Task 2.1 related to identified potential tax incentives (up to 4 options): Identified tax incentives will be incorporated into the CO2 SCOPE model. Previously investigated scenarios for varying oil price points will be considered. Comparisons will then be made to the initial economic results to determine the potential effects the identified tax incentives may have on the estimated annual economics for implementation of EOR in North Dakota.

Preliminary/Anticipated Schedule

Date	Work
October 1st – December 31st 2015	• Identification and assembly of data needed from EERC on ND oil properties. • Identification of policy incentive scenarios. • Modification of the CO2Scope model to accommodate ND data, operating realties, oil pricing scenarios, and policy incentives.
December 31st 2015	Quarterly Progress Update
January 1st – March 31st 2016	• Begin running scenario analysis of the assembled data. • Compile analysis and collaborate with EERC on any necessary modification and presentation of results. • Begin drafting report sections for the defined scope of work. • Collect and compile relevant data from the scenarios for analysis in the IMPLAN economic impact model.
March 31st 2016	Quarterly Progress Update
April 1st – June 30th 2016	• Work with EERC to complete the economic impact analysis, including any necessary changes or modifications. • Finalize analysis write-up for the report sections related to the scope of work. • Accommodation of any other issues or additional scenarios identified during the execution of the envisioned research.
June 30th 2016	Quarterly Progress Update
July 1st – August 19th 2016	• Iterative drafting of overall project deliverables and/or other activities such as presentations related to the reporting of the research outcomes
August 19th 2016	Finalization of Project

Budget

Budget Items	3 Weeks Faculty + 320 Hrs EnergyMBA
Benjamin Cook, Supplemental Salary	$7,942
Associated Fringe (33.72%)	$2,678
Hourly Research Support (Energy MBA)	$8,000
Student Employment Fringe (0.45%)	$36
Travel to ND (if necessary)+Incidentals	$2,000
Subtotal	***$20,656***
University Overhead (44%)	$9,089
Total Budget Request	**$29,745**

Budget Justification

A. Salaries and Wages

(PI) Economist/Visiting Assistant Professor – Benjamin R. Cook, PhD

The PI researcher will be responsible for developing and implementing the project deliverables, including oversight of a graduate research assistant from the UW Energy Management MBA program. This position will facilitate the identification and collection of appropriate data, underlying scenario assumptions, consultation with other project participants, primary authorship of deliverables, any work regarding the use, customization, and implementation of IMPLAN economic impact modeling, and any presentation responsibilities. The proposed supplemental pay equivalent to 3 weeks of salary represents the estimated time commitment of the PI above and beyond that which will be supported under the PI's existing EORI contract for EOR research benefiting WY.

(RA) Research Assistant – TBD, Energy Management MBA Candidate

The graduate RA drawn from a pool of 2nd year Energy Management MBA students will be responsible for making all of the necessary modeling modifications to the CO_2Scope™ framework as well as scenario analysis. These modeling and analysis responsibilities will include accommodation for all North Dakota oil assets under consideration, incorporation of any identified policy incentives such as subsidies and taxes, and the implementation of sensitivity analysis The RA will also be responsible for drafting summaries, producing charts and tables, and other work as needed and determined by the PI. The budget allotment of $8,000 was calculated based on 320 hours of work over the commitment period, billed at $25/hour which is inline with typical stipends offered to graduate research assistants at the University of Wyoming.

B. Fringe Benefits

Fringe benefits are calculated as 33.72% of the requested supplemental salary for the principal investigator. This is amount is based on the actual fringe rate paid to Dr. Cook from Jan-May 2015. The requested fringe for student employment is calculated as 0.45% per University recommendations. These amounts are established by University of Wyoming employment policy and covers compensation related benefits such as FICA, Medicare, workers compensations, unemployment compensation, retirement and health insurance. Note: The 33.72% requested is actually below the 46.55% recommended by UW sponsored programs for funding proposals that is based on university-wide faculty fringe averages.

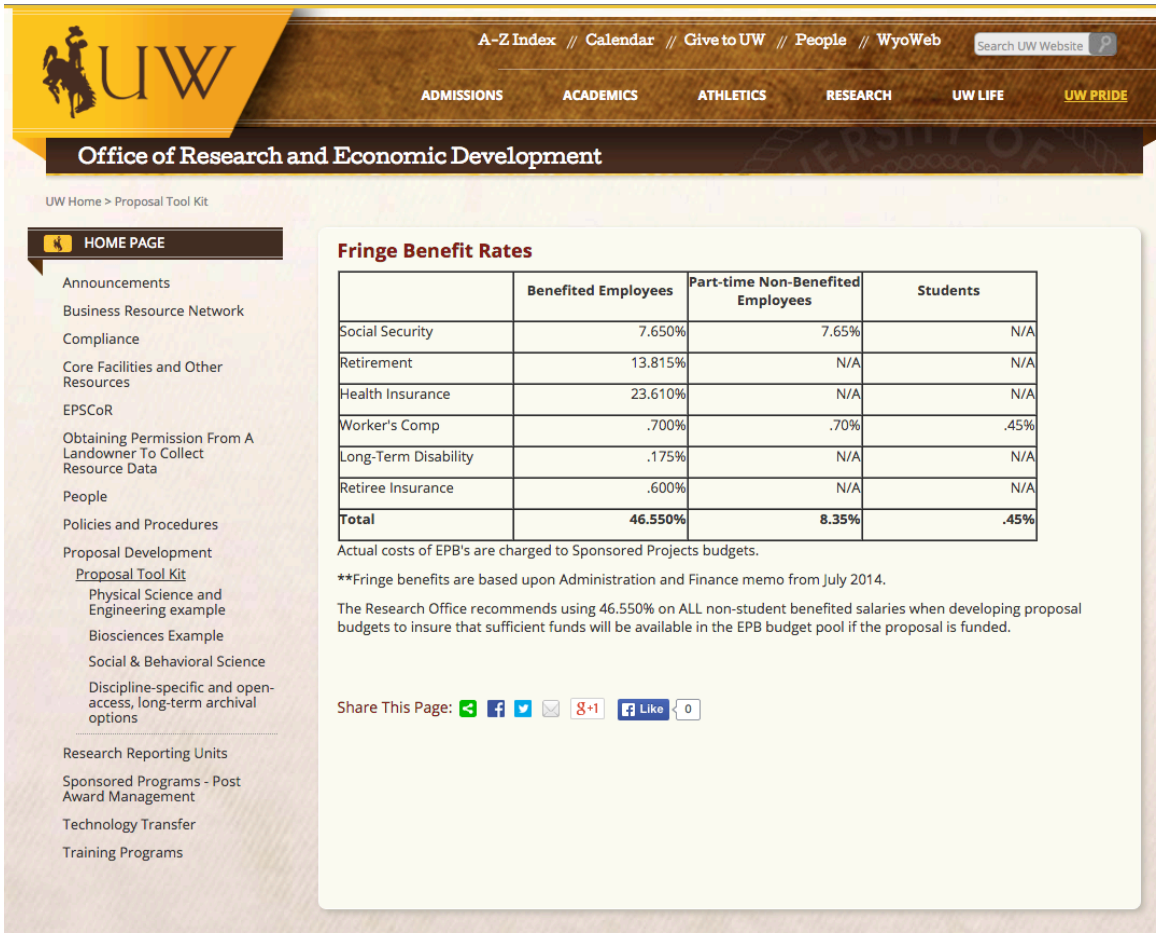
C. Travel & Incidentals

The travel and incidentals budget of $2,000 represents the approximate cost of travel for 2 persons from Denver, CO to Grand Forks, ND by airline with hotel accommodations for 2-nights, a rental car, and per diem allotment for meals. This amount also includes any incidental costs such as page fees etc.

D. University Overhead

Per University of Wyoming policy, grant awards such as the proposed project must include a 44% allotment for institutional administrative, facility and indirect overheard associated with the execution of the proposed work. The University memo documenting the indirect overhead rate is included below.

University of Wyoming Fringe Benefits Breakdown



A-Z Index // Calendar // Give to UW // People // WyoWeb

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Office of Research and Economic Development

UW Home > Proposal Tool Kit

HOME PAGE

- Announcements
- Business Resource Network
- Compliance
- Core Facilities and Other Resources
- EPSCoR
- Obtaining Permission From A Landowner To Collect Resource Data
- People
- Policies and Procedures
- Proposal Development
  - Proposal Tool Kit
    - Physical Science and Engineering example
    - Biosciences Example
    - Social & Behavioral Science
    - Discipline-specific and open-access, long-term archival options
- Research Reporting Units
- Sponsored Programs - Post Award Management
- Technology Transfer
- Training Programs

Fringe Benefit Rates

	Benefited Employees	Part-time Non-Benefited Employees	Students
Social Security	7.650%	7.65%	N/A
Retirement	13.815%	N/A	N/A
Health Insurance	23.610%	N/A	N/A
Worker's Comp	.700%	.70%	.45%
Long-Term Disability	.175%	N/A	N/A
Retiree Insurance	.600%	N/A	N/A
Total	**46.550%**	**8.35%**	**.45%**

Actual costs of EPB's are charged to Sponsored Projects budgets.

**Fringe benefits are based upon Administration and Finance memo from July 2014.

The Research Office recommends using 46.550% on ALL non-student benefited salaries when developing proposal budgets to insure that sufficient funds will be available in the EPB budget pool if the proposal is funded.

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http://www.uwyo.edu/research/Proposal%20Development/proposal-tool-kit/fringe_benefits.html

University of Wyoming Indirect Costs Rate

UNIVERSITY
OF WYOMING

Vice President for Research & Economic Development
1000 E. University Avenue, Department 3355 • Room 305/308, Old Main • Laramie, WY 82071
(307) 766-5353 • (307) 766-5320 • fax (307) 766-2608 • www.uwyo.edu/research

May 14, 2015

TO: Deans/Directors, Department Heads/Chairs, Faculty and Staff

FROM: William A. Gern, Vice President for Research & Economic Development
William H. Mai, Vice President for Administration and Finance

RE: **NEW INDIRECT COST RATES APPLICABLE THROUGH JUNE 30, 2019**

New indirect cost rates have been negotiated with the U.S. Department of Health and Human Services, UW's cognizant federal agency to determine indirect cost rates on behalf of the federal government. The new rates goes into effect July 1, 2015 and all awards received after that date will be changed to reflect the change in rate. Active awards received prior to July 1, 2010 will continue to be assessed at the awarded rate per 2 CFR 200. Proposals submitted prior to this notice will be adjusted to reflect the new indirect cost rates at time of award. These new rates will be in effect until June 30, 2019.

Federal cost principles for educational institutions dictate that the recovery of indirect costs be based on modified total direct costs (MTDC). Indirect costs are assessed against all items in the budget (salaries, fringe, benefits, materials and supplies, service, travel, contractual and other) **EXCEPT:**

1. Individual items of equipment costing in excess of $5,000
2. Graduate student tuition, fees, and health insurance
3. Subcontracts in excess of $25,000 (the initial $25,000 of each subcontract must be assessed indirect costs)
4. Rental costs of off-campus facilities

The approved rates for the period **July 1, 2015** through **June 30, 2017** are as follows:

- On-campus organized research 44.0%
- Instruction/educational services 52.0%
- Other sponsored projects 34.0%
- Off-campus research or instruction see note below

The approved rates for the period of **July 1, 2017** through **June 30, 2019** are as follows:

- On-campus organized research 44.5%
- Instruction/educational services 52.0%
- Other sponsored projects 34.0%
- Off-campus research or instruction see note below

APPENDIX D-2

NDSU DEPARTMENT OF AGRIBUSINESS AND APPLIED ECONOMICS

Economic Impact of Conventional CO_2 EOR (Enhanced Oil Recovery) in North Dakota

Concept Discussion
Submitted to
EERC
August 20, 2015

Primary Investigators:

Nancy M. Hodur
Dean A. Bangsund
Department of Agribusiness and Applied Economics
North Dakota State University

Primary Contact:
Nancy Hodur
701-231-7357
nancy.hodur@ndsu.edu

NDSU NORTH DAKOTA STATE UNIVERSITY

Rational: A number of technologies exist for the U.S. petroleum industry to augment and extend the economic viability of oil and gas wells. Of particular interest in North Dakota is the potential forCO_2-based enhanced oil recovery (EOR) to increase the recoverable reserves in conventional wells in the Williston Basin. The adoption of those technologies could have substantial impacts in the state. CO_2 EOR has been demonstrated to improve the recoverable oil in place in convention wells. In an every increasingly volatile economic environment for domestic oil production, a number of important issues associated with CO2 EOR remain largely unanswered. This proposal is limited in scope, but contributes to a larger research effort focusing on answering several key issues relating to CO_2 EOR. The University of Wyoming has developed a model to evaluate the economic feasibility of adopting CO_2 EOR, which will be used with information specific to North Dakota to assist in defining key economic questions for the state. To better manage future developments associated with oil and gas production, state agencies, legislators, business leaders, and affected citizens are interested in more fully understanding the potential timeline, scope of adoption, and physical footprint that EOR might have in western North Dakota. Those management challenges will require examining the tax implications, profitability of the technologies; economic sector and labor force impacts, as well as addressing the potential local economic development concerns of cities and communities in the region.

Objectives: The primary focus on this research effort will be to use existing information, and combine that information with other study collaborators, to evaluate the potential future economic impacts of EOR-based oil and gas recovery in North Dakota. Within that context, the NDSU study will focus on two research questions.

1. Estimate annual economic impacts, near- and long-term, from implementation of conventional CO_2 EOR in North Dakota

- Economic data from IMPLAN for the state of North Dakota will be garnered to estimate the relative costs for capital and operating expenses for input into the University of Wyoming CO_2 SCOPE model.

- Outputs of the CO2 SCOPE model will then be utilized to estimate the potential economic influences of EOR on the North Dakota Oil & Gas Industry. Those impacts can be defined as statewide and within sub-state regions specific to oil producing counties. Upon defining the impacts on the oil and gas industry, those effects will be used with Input-Output analysis to estimate the indirect and induced economic effects on related industries. For example, the implementation and operational requirements for EOR are likely to directly impact employment within the oil & gas industry, which in turn generate additional secondary employment. Secondary employment impacts is defined to include induced employment for goods and services supplying the oil & gas industry and indirect employment for consumption of personal goods and services of employees supported by the business activity generated

by the oil & gas industry. These findings will be evaluated to estimate how EOR implementation may affect population, potential revenue from key state-level taxes (e.g., income, sales, etc.), and community infrastructure needs (e.g., housing, roads, etc.).

- Since EOR is not yet widely adopted in the state, and considerable near-term price uncertainty exists with the overall economic environment for domestic oil production, the economic impacts will be articulated use a scenario-based analysis. Scenarios for oil price will be investigated using EIA-forecasted high and low oil prices above and below the base-case reference oil price, respectively. The magnitude of the subsequent potential effects in employment and community infrastructure needs from changes in estimated economical annual oil production, CO_2 demand will be evaluated.

2. Investigation of current and potential tax incentives to encourage implementation of conventional CO_2 EOR

- Since EOR is not currently in widespread use within the Williston Basin, the economic viability of the technology is not likely feasible given current industry parameters (e.g., efficiency, tax policy, logistical constraints). Therefore, the impacts in objective 1 are contingent upon assumptions for price, technological efficiency, profitability, and other financial constraints. While many of those constraints or economic factors are beyond the state's control or ability to influence, the state does have the capacity to address the viability of EOR adoption through tax incentives or other fiscal policies.

- A sensitivity analysis of potential tax revenue that could affect the state/regional/local government expenditures from changes in oil volume and price for various tax-incentive scenarios will be investigated.

- The potential effects of those scenarios on other fossil fuel-related industries in North Dakota will be discussed, such as oil refineries, electricity generation, carbon capture, rail or pipeline infrastructure, etc.

Timeline: Project duration will be 11 months with a projected start date of October 1 2015. Project time line is contingent upon data collection efforts done in conjunction and in cooperation with the study sponsor.

Deliverables: Findings will be detailed in a written report provided to EERC for inclusion in the final report to the ND Legislative Management Committee.

Personnel: Research activities will be completed by Dean Bangsund and Nancy Hodur, PhD. Brief resumes are attached.

NDSU NORTH DAKOTA STATE UNIVERSITY

GRANT APPLICATION TRANSMITTAL

This page indicates university endorsement of the referenced proposal and is intended to be submitted to the sponsor organization.

Sponsor Organization: ND Legislative Council/UND

Project Title: *Economic Impact of Conventional CO2 EOR (Enhanced Oil Recovery) in North Dakota*

Project Director: Nancy Hodur

Department: Agribusiness and Applied Economics

Project Budget:

Total Direct Costs		$ 34,274
F&A/In-direct Costs		$ 15,423
F&A/IDC Rate	45%	
Total Requested		$ 49,697

Authorized University Representative: Jill Mackenzie

Title: Award and Program Officer
Sponsored Programs Administration

Address: North Dakota State University
NDSU Dept. 4000, PO Box 6050
Fargo ND 58108-6050

Phone: (701) 231-8045

Signature: Amy B. Scott

Date: 8-26-15

Any future notifications regarding this proposal, including award notices, should be directed to the authorized university representative at the address listed above.

Thank you.

APPENDIX D-3

ODNEY, PUBLIC AFFAIRS & GOVERNMENT RELATIONS

odney bismarck

117 W Front Ave.
P.O. Box 2035
Bismarck, ND 58502-2035
phone: 701.222.8721
toll free: 888.500.8721

www.odney.com

August 28, 2015

James Sorensen
Senior Research Manager
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND, 58202-9018

Dear Mr. Sorensen:

I am thrilled that the Energy & Environmental Research Center (EERC) has invited Odney to participate as an independent sub-contractor to provide professional consulting services in support of the EERC's efforts to be selected by the state of North Dakota to study and provide recommendations concerning tax incentives for enhanced oil recovery by CO_2.

The study, provided in Section 42 of Senate Bill 2015 and recently approved by the 2015 Legislative Assembly and signed by Governor Dalrymple, will be managed by the Interim Taxation Committee, Chaired by Senator Jessica Unruh. The Interim Taxation Committee will also be selecting the consultant to conduct the study, subject to approval by the Chairman of Legislative Management, Senator Ray Holmberg.

Odney expects to designate Shane Goettle, Cory Fong, and Lacee Bjork Anderson to work on this project. Cory Fong will serve as the primary contact and lead contact on this project for Odney.

If the EERC is selected by the Interim Taxation Committee to provide the services and conduct the study, Odney looks forward to working with the EERC to develop and finalize a work plan, budget, and compensation plan related to Odney's responsibilities. Please find attached to this letter a proposed work plan and budget for the EERC's consideration.

Once again, Odney is very excited about the opportunity to work directly with the EERC on this project and we look forward to future communications.

Sincerely,

Pat Finken
President & CEO
Odney

Proposed Work Plan & Budget

WORK	Scope	Hours	Cost
MEETINGS	Arrange, participate, and facilitate meetings and interactions with the Office of State Tax Commissioner as needed (Tax Commissioner) and its appropriate staff, and any other relevant/appropriate agencies, stakeholders, and interested parties.	40 hours	$8,000
INFORMATION GATHERING	Gather necessary information from the Tax Commissioner concerning prior and existing tax incentives related to enhanced recovery techniques, including enhanced recovery techniques from carbon dioxide injection.	40 hours	$8,000
ANALYSIS	Analyze the effectiveness of past and existing tax incentives in helping develop the industry while providing for a stable revenue source for the state.	60 hours	$12,000
CONSIDER MODIFICAITONS	Develop, evaluate, and consider any potential modifications and/or recommendations to change tax incentives related to enhanced recovery techniques from carbon dioxide.	60 hours	$12,000
EVALUATE	Evaluate the potential impacts that any modifications and/or recommendations to tax incentives may have on the state and any of its political subdivisions.	40 hours	$8,000
STATE COMPARISON	Gather information from other oil and gas producing states concerning similar tax incentives related to oil and gas development, most notably incentives related to enhanced recovery techniques, including enhanced recovery techniques from carbon dioxide injection, and their effectiveness in helping develop the industry while providing a stable revenue source for those states.	40 hours	$8,000
REPORTS & PRESENTATIONS	Develop and deliver the final written report and necessary presentation(s) to the Interim Taxation Committee by August 16, 2016, and/or any other legislative committee(s) or organization(s), along with any required presentations, briefings, or updates throughout the study process.	110 hours	$22,000
	SUBTOTAL	390	$78,000
TRAVEL	Anticipated travel and other related incidental expenses.		$2,000
	TOTAL PROPOSED BUDGET		$80,000

APPENDIX D-4

THE CETER GROUP, INC.

The CETER Group, Inc.

4952 Oakhurst Ave
Gibsonia, PA 15044

Phone: 412.486.6242
Mobile: 412.848.1935
Email: david.nakles@gmail.com

Mr. James A. Sorensen
Senior Research Manager
Energy and Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

August 19, 2015

RE: North Dakota Legislative Management Proposal: "North Dakota Carbon Capture and EOR Economic Impact Study"

Dear Mr. Sorensen:

I am writing to confirm my commitment to provide technical support for a carbon dioxide (CO_2) life-cycle analysis (LCA) for the project described in the above-referenced proposal.

I will be providing support to Task 2.2: "Investigation of current and potential tax incentives to encourage implementation of conventional CO_2 EOR." Specifically, my scope of work includes performing a CO_2 LCA for North Dakota enhanced oil recovery (EOR) for several scenarios representing estimated economical oil production and CO_2 demand. These scenarios may include two different scenarios for oil price using U.S. Energy Information Administration (EIA)-forecasted high and low oil prices above and below the reference oil price, respectively, which will generate up to 3 estimations for economical oil production and CO_2 demand. In addition, several tax incentives options (up to 4) will be investigated for impacts on economical oil production and CO_2 demand.

Over the course of this approximately 10-month project, I anticipate working 80 hours at my standard consulting rate of $190 per hour. This represents a cost estimate of $15,200 for the entire project.

If you have any questions, please contact me by telephone at (920) 857-6032, or by e-mail at nick.azzolina@gmail.com.

Sincerely,

Nicholas A. Azzolina

Nicholas Azzolina, Ph.D.
Principal/Co-Founder