Resource Recovery from a Coal Fired Power Plant to Enhance Agricultural Production in Open Field and Greenhouse Facilities

Applicants:

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Amount Requested: $149,557.00

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Abstract

The North American Coal Corporation, Great River Energy, and Knorr Farms (collectively referred to as "Research Group") are collaborating to create a research project designed to prove and demonstrate the effectiveness of greenhouse agriculture and open field carbon utilization in North Dakota using residual heat from Coal Creek Station, CO_2 from Blue Flint Ethanol, and flue gas from Coal Creek Station. Currently the Research Group is working with North Dakota State University Plant Science Department, North Dakota State University Carrington Research Extension Center, and University of North Dakota Energy & Environmental Research Center for a collaborative engagement on working with residual carbon and resource recovery from Blue Flint Ethanol and Coal Creek Station

The project is expected to commence in June 2017 and be completed by December 2018.

The total estimated cost of the project is $299,557 with $150,000 in cash and in-kind services coming from the Research Group. The remaining $149,557 is being sought as grant funds from the North Dakota Industrial Commission.

Project Summary

Collaboration between top research facilities (NDSU and EERC) and Industry Partners has created tremendous potential to deliver a valuable project to the State through research projects in increased agricultural production by recovering resources from lignite-fired power plants. The availability of excess heat and CO_2 at a common location presents a unique opportunity for a link between agriculture and the energy industry. Resources that are not currently being utilized at a lignite power plant could be used to benefit agriculture and will decrease the carbon footprint of the plant.

There is a lack of conclusive literature on the positive impacts of CO_2 on horticulture, especially specific to North Dakota agricultural crops. Research is needed to fully understand the response high-value greenhouse crops and agricultural cash crops, typically grown in North Dakota, have to varying levels of CO_2. In addition, the project will focus on finding the most economical and feasible way to clean-up, process and deliver CO_2 from Blue Flint Ethanol (BFE) and flue gas from GRE to open field and greenhouse applications at this and, possibly, other power plant locations. Upon successful completion of this research, a follow-up project may be proposed to build and operate a pilot scale greenhouse and to expand in-field testing to a larger, more commercial scale.

The project matches the Lignite Research Council goals of promoting economic, efficient, and clean uses of lignite and products derived from North Dakota lignite. A successful conclusion to this project will show that it is economically feasible to utilize available resources generated by the North Dakota lignite industry to benefit the North Dakota agricultural industry and make energy generation from lignite more efficient, thereby providing a value-added boost to the North Dakota economy.

Project Description

The North American Coal Corporation (NACoal), Great River Energy (GRE), and Knorr Farms (Knorr) , collectively referred to as the “Research Group”, have strategically aligned to explore research projects in increased agricultural production, carbon capture and sequestration, and resource recovery in the form of residual heat. The Research Group has been working on a design for a proof of concept commercial greenhouse facility, open field application of carbon dioxide (CO_2), and resource recovery concepts for Coal Creek Station (CCS) and Blue Flint Ethanol (BFE). This concept was initiated due to identified benefits of a hot water heat source and a nearly pure stream of CO_2 at a common location. This research will allow for the development and execution of projects that could enhance both carbon capture and agricultural production.

Currently the Research Group has proposed to engage in several research projects with the North Dakota State University Plant Science Department (NDSU), North Dakota State University Carrington Research Extension Center (CREC) and the Environmental Energy Research Center (EERC). All supporting the overall project titled: “Resource Recovery from a Coal Fired Power Plant to Enhance Agricultural Production in Open Field and Greenhouse Facilities”.

NDSU has a long and established history of agricultural research. They have existing greenhouse and test chamber facilities that can be used to measure plant responses to various CO_2 enriched environmental conditions, with control of all the other environmental conditions to minimize outside variables.

The EERC is an internationally recognized research and development organization with extensive experience in the energy industry. The EERC will be supporting the project by assisting in the design and optimization of CO_2 and heat transportation and delivery systems from CCS and BFE. EERC will also research the characterization and potential use of the flue gas from CCS.

The Research Group is pursuing a two phase approach to the research. Phase I will consist of the preliminary research to determine optimal levels of environmental CO_2

enrichment for increased biomass production with potential high value crops. Phase II will utilize the findings of Phase I to design, construct, and operate a year-round pilot scale commercial greenhouse facility. Phase I, including parts A, B, C, D, and E described below, will constitute the project's initial research, which is the subject of this grant application. Also during Phase I, the Research Group will provide in-kind services to continue the evaluation of greenhouse use and the utilization of resources available through CCS and BFE.

Once Phase I is completed and deemed a success, plans to move Phase II forward will begin. The current grant request is for Phase I.

Preliminary Research

The goal of the project is to determine the feasibility of recovering resources derived from a coal-fired power plant to increase agricultural production. Phase I of the project is broken into five parts, each with independent results so the project can move forward on parallel paths and complete objectives within a time constrained schedule limited by the growing season. Each of the steps is summarized below, with further detail in the proposals included as appendices:

Part A: NDSU – Department of Plant Science, Fargo, ND

> **Objective**: To evaluate the increase in leaf growth and production of baby greens from enriched CO_2 concentrations and to determine an optimum CO_2 concentration with the shortest production phase for the baby green industry.
>
> **Methodology:** The different varieties of lettuce and greens used by Duncan Family Farms in the organic baby leaf item (red and green oak Salanova lettuce, red and green romaine lettuce, red and green leaf Salanova lettuce, lolla rosa, tango, and mizuna lettuce, red chard, green chard, tatsoi, baby kale, arugula and spinach) will be evaluated in this study. Four CO_2 concentrations will be evaluated (ambient air ~ 400 µmol/mol, 800 µmol/mol, 1200 µmol/mol, and 1600 µmol/mol). The research will be conducted at NDSU's on-campus facility.

Anticipated Results: Research will result in an identified matrix for leafy green plant response to differing levels of ambient CO_2, determining the optimum level for maximum productivity and, thereby, maximum absorption of CO_2. Scientific literature will be produced to confirm and validate CO_2 response as a beneficial way to improve leafy green Greenhouse Production. This will allow for levels to be set in a Proof of Concept Green House (POCG) for maximum production in Phase II. Economic impact will be shown in POCG with increased production allowing for a greater economic return.

Part B: NDSU – Carrington Research Extension Center

Objective: Evaluate corn and wheat response, in a greenhouse setting, to CO_2 delivery at varying concentrations, supplied once or twice a week, and with or without mulch, which could slow down CO_2 loss from the soil.

Methodology: The trial will consist of plantings of corn and wheat. Each test group will utilize CO_2 enhanced water with three different CO_2 concentrations (0.0%, 0.3%, and 0.5%).

Anticipated Results: Results will show whether there is an increase in dry matter accumulation at the end of the trial period between differing treatments using CO_2 delivered by a concept developed by the research team.

Part C: NDSU – Carrington Research Extension Center

Objective: To evaluate the response of corn and wheat to identified CO_2 delivery methods in an open field environment. Further, this study will measure soil CO_2 flux from those delivery systems, to estimate their efficiency in retaining CO_2 in the soil and evaluate changes in soil pH due to irrigation with CO_2 enhanced water and gaseous CO_2.

Methodology: The study will consist of four differing treatments of CO_2 identified in Confidential Appendix.

Anticipated Results: Results will show the feasibility of applying CO_2 to corn and wheat fields. It will also show effects on soil pH and CO_2 retention by measuring the CO_2 flux.

Part D: EERC, Grand Forks, ND

Objective: To define processes and economics needed to prepare CO_2 from BFE and CCS for use in conjunction with a commercial agricultural greenhouse facility. Work will also be done to further characterize flue gas from CCS and determine safe operating concentrations. Future studies may examine plant growth with the introduction of flue gas, or modified flue gas.

Methodology: Characterize the CO_2 produced at BFE and determine what processing, if any, are needed to provide a product that can be fed directly to the greenhouse or used in open field situations. Examine the removal of sulfur and nitrogen oxides in flue gas to a level that green plants can tolerate and that could enhance crop yields.

Anticipated Results: A determination of how CO_2 from BFE and flue gas from CCS would need to be processed to be utilized in a greenhouse or open field setting.

Part E: In-House Research on the Requirements for Building a Pilot Greenhouse

Objective: Determine the best fit greenhouse technology for location at CCS. This will include selecting a greenhouse building system, determining how to best utilize the "waste" water heat available from the power plant, and how to obtain CO_2 from BFE and CCS flue gas.

Methodology: Research greenhouse operations that are currently in operation in the US and Canada, utilizing site visits, meetings with manufacturers, and other contacts. When a general design has been determined, a consultant may be engaged to assist in working out the details.

Perform engineering studies to determine how to best utilize the 115 degree plant cooling water to provide heat for the pilot greenhouse. It will be necessary to investigate different heat exchange technologies to determine which will provide the most cost efficient approach. Upon choosing a technology, a system will be designed and preliminary costs produced.

After the CO_2 from BFE and flue gas from CCS is characterized, determine what will need to be done to condition the gas for greenhouse use. Also, establish a methodology and preliminary costs for transporting CO_2/flue gas to the greenhouse site.

Anticipated Results: The results of this work will be to provide a well-reasoned jumping off point for a potential Phase II, construction of a pilot greenhouse.

Benefits of the Project:

The benefits of the project ultimately take excess resources from CCS and BFE and recycle them to increase agricultural production. Each of the steps in Phase I have independent benefits that will be broken down in detail as described below:

- **Part A:** Research will allow the POCG in Phase II to maximize performance by creating identified levels of ambient CO_2 that will increase production (yield) in baby leaf greens. The greatest value of this research will be to show benefits of carbon enhanced green leaf material (biomass). Future research may be proposed to examine the effect of varying CO_2 levels on different crops.

- **Part B**: Research will show how CO_2 enhanced water simulating ground water and surface water temperatures affect plant dry matter accumulation between C3 (cool season crops) and C4 (warm season crops). This will identify what effect water carbonation levels and temperatures have on crop species. Note:

Groundwater irrigation is substantially cooler than surface water irrigation and may affect carbonation and plant responses.

- **Part C:** Research will show how crops respond to project developed delivery methods of CO_2 in open field applications. Increased yields will demonstrate the feasibility of applying CO_2 in an open field application.

- **Part D:** Research will show how to process flue gas, both from a safety and economic standpoint, to levels optimized for crop production, as well as how best to utilize the CO_2 from BFE.

- **Part E:** Research, engineering and economic studies will provide the basis for the Research Group to approach Phase II, the construction of a pilot greenhouse, with the successful completion of the other Parts of Phase I.

In summation, Phase I: Parts A, B, C, D, and E will allow for the creation of products, pathways, and potential productivity increases in Greenhouse and Open Field Applications that could reduce carbon footprint and increase crop biomass. According to the World Food Bank Organization, the world needs to produce at least 50% more food to feed 9 billion people by 2050. Currently one-third of all child deaths globally are attributed to under–nutrition (World Food Program, USA). Food shortages are one of the biggest issues facing our world today. If our Research and Development project can bring a fraction of agronomic impact we will be bringing a model of both improvements on global food production as well a reduction in the carbon footprint.

Standards of Success

As previously described, this initial part of the project (Phase I) is composed of five different sub-projects, identified as Parts A, B, C, D and E. Each of these Parts is designed to investigate a different aspect of how CO_2 and flue gas from an integrated lignite-fired energy generation facility can be optimized to improve agricultural crop production.

Based on final economics, the Phase I deliverables will be used as the basis for design, construction, and operation of a pilot-scale greenhouse and open field testing that will constitute Phase II of the project. It is envisioned that the successful completion of Phase II could lead to the implementation of the concepts developed here on a commercial basis.

Background

EERC completed a study in 2012 identifying the most promising technologies for the utilization of CO_2 from coal-fired power plants in North Dakota. It concluded that photosynthesis-based technologies, more specifically greenhouse agriculture, appears to be the only promising technology in which CO_2 benefits are obvious and can be assessed for potential markets. The production of marketable products is clearly defined for the direct use of CO_2 and photosynthesis technologies because industries based on these technologies already exist and currently purchase externally sourced CO_2 (EERC, 2012).

Greenhouse agriculture has potential in North Dakota because of the high market value of its products. Productivity of such greenhouses is several times higher than traditional farming, so the extra cost could be recovered through the sale of the additional product. Transport of fresh produce to North Dakota from other locales is expensive, and the market study confirmed that consumers and food distributors prefer locally sourced, high-quality vegetables to the imports (EERC, 2012). Michael Miller owner of a local high end restaurant in Minot ND stated “there is a social movement for restaurants to provide their customers with fresh, farm to fork products (Elevation Letter, 2017).

Appendix G contains letters from local companies expressing their support for the idea of increased greenhouse agriculture in North Dakota.

Greenhouse agriculture in North Dakota would require supplemental heat and lighting for many months each year. Co-locating a greenhouse with a coal-fired power plant would provide access to low-grade heat and, possibly, lower priced energy to operate a greenhouse in a northern region, all while lowering the carbon footprint through CO2 use.

Greenhouse agriculture is an emerging market. In Canada, greenhouses have gross sales of 1.3 billion dollars ($1,300,000,000). Supporting this Canadian market means that Canada has sixty percent (60%) more greenhouse space than the USA, with only eleven percent (11%) of the population. Energy for heat is an issue for some Canadian greenhouses and thereby has caused some movement of the industry to the USA.

There is a lack of conclusive literature on the positive impacts of CO_2 on horticulture and it was surprising to the Research Group that NDSU has not done any significant previous work on enriched CO_2 growing environments. There also appears to be a very limited amount of past work between NDSU and EERC and the team believes these projects could have great benefits for the collaboration between energy and agriculture research and development.

There are examples of existing greenhouses associated with power plants and/or using CO_2 to enhance crop production. Some examples that have been visited by the Research Group include:

Minnesota Power – Boswell Station,
<u>Cohasset, Minnesota</u>

Since the mid-1980s, Itasca Tree Greenhouse has been using warm water from the plant's cooling tower basin to heat greenhouses that are growing pine trees. The process is very simple and operates on a tight budget.

Figure 1: Trees growing in Itasca Tree Greenhouse

<u>Houwelings, Inc., Mona, Utah</u>

Houwelings has greenhouses in California, Utah, and British Columbia. In Utah, they have 30 acres of hydroponically grown tomatoes under glass, co-located with a 500 MW PacifiCorp combined cycle natural gas power plant. The power plant supplies CO_2 enriched flue gas to Houwelings, who use a patented process to mix ambient air with the flue gas to supply the greenhouse with heat and CO_2.

Figure 2: Inside a Houwelings Tomato Greenhouse

They are selling their crops to Walmart, Albertsons and other major retailers. Current plans are to build an additional 30 acres of greenhouses in 2017; doubling their size.

Figure 3: Houwelings Marketing Photo for Their Utah Greenhouse

Duncan Family Farms

Figure 4: Duncan Family Farms Logo

In 1994 Duncan Family Farms expanded into organic production, growing organic baby leaf items including several different varieties of lettuce and greens (red and green oaks, red and green romaine, red and green leaf, lolla rosa, tango, mizuna, red chard, green chard, tatsoi, baby kale, arugula and spinach). These greens are delivered to some of the largest value-added processors in North America, Canada and the United Kingdom who provide bagged salads to the retail and food service industries. Duncan Family Farms has won numerous awards and is nationally recognized as a ‘showcase’ of progressive and environmentally-sensitive farming techniques, due to their innovative programs. Today their multi-regional operations are located in the Imperial Valley and on the Central Coast of California and in Central Arizona. The geographic diversity of these organically-certified growing locations positions Duncan Family Farms as one of the leading organic growers in the United States. Their products are shipped across North America, into Canada and over to the United Kingdom. Duncan Family Farms is looking for opportunity in Green House Production and is excited about the opportunity at Coal Creek Station. They currently are not in Greenhouse production. Hence the need for proof of concept Greenhouse that will be part of Phase II of this project.

Qualifications: Key Personnel

Project Managers:

Mr. Gerard Goven is Senior Geologist at The Falkirk Mining Company's Falkirk Mine in Underwood, North Dakota. The Falkirk Mining Company is a subsidiary of The North American Coal Corporation. Mr. Goven will serve as Co-Project Manager for the project. As Senior Geologist, Mr. Goven manages and supervises a wide variety of projects ranging from research to exploration to mine operations. He has 20 years of professional geologist experience and 30 years of experience operating a farm and ranch in North Dakota. Mr. Goven has a Bachelor of Science degree in Geology from the University of North Dakota.

Mr. Steve Knorr is Owner and Production Manager of Knorr Farms ND. Knorr Farms is a fourth generation Farm located in central North Dakota. Mr. Knorr will serve as Co-project Manager for the project. Mr. Knorr operates a 4,000 (+) acre irrigation farm that grows, corn, soybeans, pinto beans and potatoes. Along with traditional commodities, Mr. Knorr has worked with high-value specialty crops such as cabbage, onions, carrots and other vegetable crops in North Dakota. Mr. Knorr has a degree in Plant Sciences from North Dakota State University.

Principal Investigators:

Dr. Harlene Hatterman-Valenti - Professor, High - Value Crops Specialist, NDSU

Dr. Paulo Flores - Precision Agriculture Specialist, NDSU-CREC

Dr. Mike Ostlie - Research Agronomist, NDSU-CREC

John Kay - Principal Engineer, EERC, UND

Jason Laumb - Principal Engineer, EERC, UND

Melanie Jensen – Senior Chemical Engineer, EERC, UND

Resumes for key personnel can be found in Appendix A.

Value to North Dakota

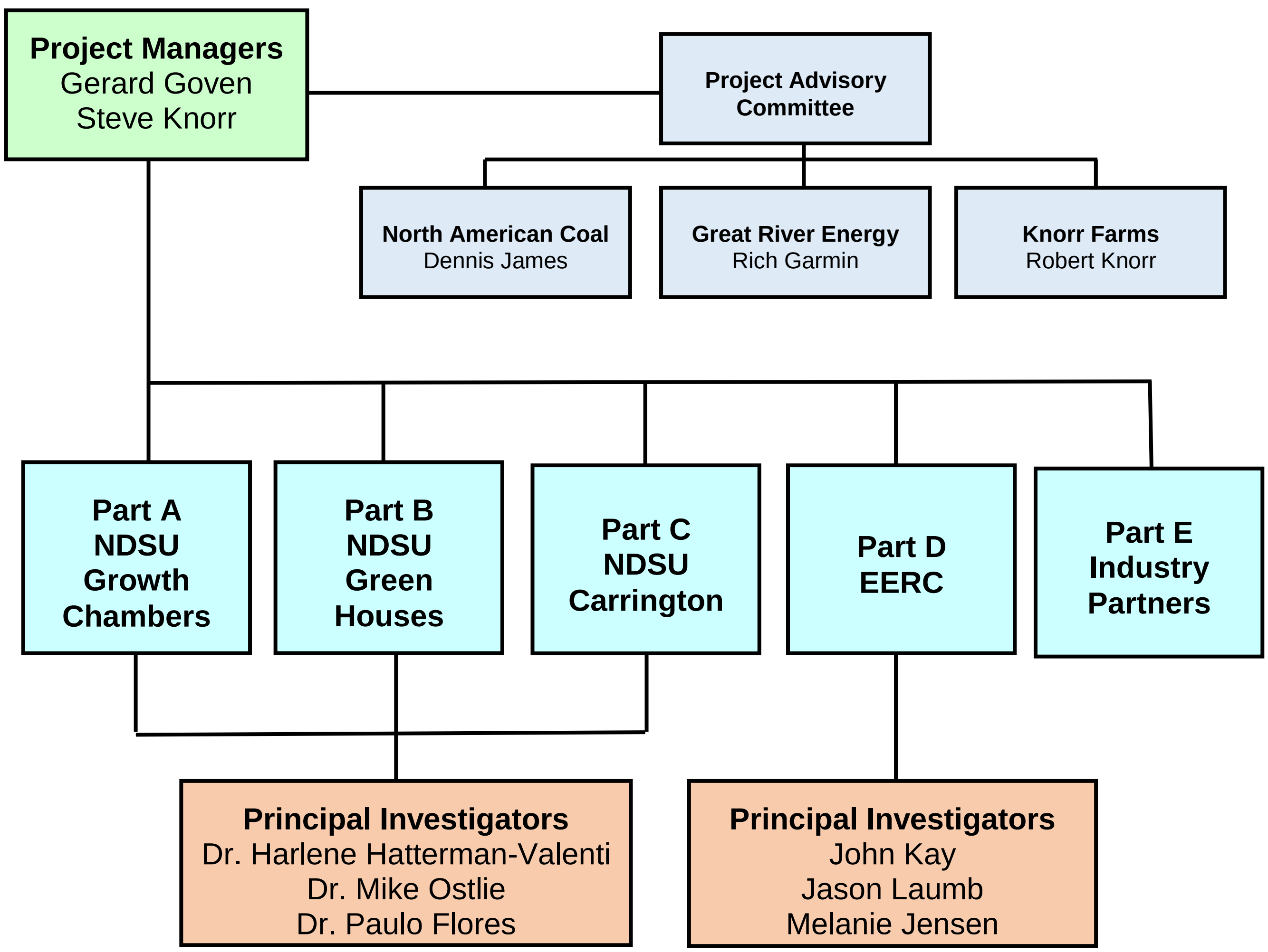
This project can bring significant benefits to North Dakota on multiple levels. The project to-date has brought two industries together (Ag and Energy) to evaluate areas through which they can jointly benefit. Collaboration between top research facilities (NDSU and EERC) and Industry Partners has created tremendous potential to deliver a valuable project to the State. The Research Group has used the term "thinking outside the box" to potentially deliver a social and economically positive project to, not only the people of North Dakota, but to the world. Here are a few of the potential positives for North Dakota:

- Positive light on the Coal Industry (Providing fuel in the form of carbon for Agriculture)
- Commercial-scale Greenhouses to create the availability of locally grown, fresh produce year-round. (Economically viable and scalable due to the availability of low grade heat, CO_2, and flue gas)
- Creation of marketable CO_2 or flue gas products to the Ag sector, increasing crop yields
- Job creation for commercial-scale greenhouses and related agricultural industries
- Job creation for the manufacturing, storage, and distribution of CO_2 or flue gas products to Ag sector
- Reduction in carbon footprint for GRE's Coal Creek Station
- Increase in power plant efficiency by lowering the temperature of cooling tower water
- Creates a model that can be duplicated at other lignite power plants in the state

The successful conclusion of this project will allow the utilization of existing and available resources generated by the North Dakota lignite industry to benefit the North Dakota agricultural industry, thereby providing a value-added boost to the North Dakota economy.

Management

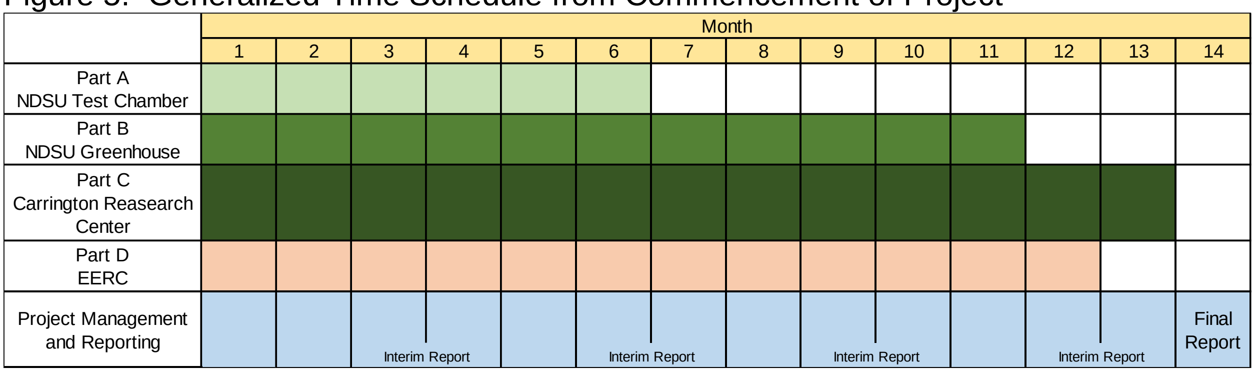
The project will be managed and coordinated by Mr. Gerard Goven and Mr. Steve Knorr, who will serve as the contact point for the Industrial Commission and the industry sponsors. NACoal will act as the primary applicant and contract coordinator. The following organizational chart summarizes the management structure that will be used for the project:



The Project Managers will hold regular meetings and/or conference calls that will include the leads of each part of the project and the Project Advisory Committee representatives. These meetings and communications will serve as the basis for the quarterly interim reports. The final project report will be created as a joint effort of the group. The Key Personnel listed in Qualifications are responsible for the work being proposed under each module of the project. The organizational chart lists the personnel that are specifically involved with each part.

Timeline

Figure 5: Generalized Time Schedule from Commencement of Project



This timeline is a month based schedule; however, weekly schedules and plans will be created as the tasks move ahead.

After the initial week of organization and planning, work on each task will commence. The key personnel will meet and communicate on a regular basis. About every 6 weeks, the Project Advisory Committee will meet for progress updates and future plans and directions. The Project Manager and key personnel will prepare interim reports on quarterly basis; reporting on the findings and progress to date.

Upon completion of the final report, the Research group will evaluate the feasibility of progressing on to Phase II.

Budget

The budget for the Project is $299,557, which includes $46,500 of direct cash funding and $103,500 of in-kind service divided between the member companies of the Research Group. The remainder $149,557 cash portion of the Project is being requested from the NDIC. Table 1 provides a breakdown of costs.

Table 1. Proposed Project Budget for Phase 1

Project Budget						
Description	**Part A**	**Part B**	**Part C**		**Part D**	**Part E**
	Year 1	**Year 1**	**Year 1**	**Year 2**	**Year 1**	**Year 1**
Salaries	5,000					73,500
Faculty		1,250				
Technical Support		5,000	8,374	6,340		
Student Assistant		600				
PT Support Staff/Hourly Worker			3,200	3,200		
Total salaries and wages	**5,000**	**6,850**	**11,574**	**9,540**	**-**	**73,500**
Fringe Benefits	2,250	3,135	4,842	3,744		
EERC Management and Reporting Fees					20,000	
Total Salaries, Wages & fringe benefits	**7,250**	**9,985**	**16,416**	**13,284**	**20,000**	**73,500**
Consultant fees	4,896					15,000
Equipment purchases over $5,000			24,000			
Equipment purchases under $5,000	11,542					
Equipment rental			792	792		
Utilities			1,635	1,635		
Fees			180	180		
Printing			100	100		
Repairs			1,500	1,500		
Research supplies		2,300	7,538	6,388		
Seed, feed & fertilizer			800	800		
Software			870			
Travel	315	150	1,724	907		10,000
EERC Consulting Fees					30,000	
Total Operating Costs	**16,753**	**2,450**	**39,139**	**12,302**	**30,000**	**25,000**
Total Direct Costs	**24,003**	**12,435**	**55,555**	**25,586**	**50,000**	**98,500**
Facilities & Administrative/Indirect Costs	10,801	3,233	7,998	6,446	-	5,000
Proposal Totals (USD)	**34,804**	**15,668**	**63,553**	**32,032**	**50,000**	**103,500**
Total Cost of Project					**$**	**299,557**

Matching Funds

Commitment for matching cash funds for this project totaling $46,500, or 16 percent of the total project budget have been secured from the industry partners identified in this application. The in-kind services in the amount of $103,500, or 34 percent of the total project will be completed by the partners as follows:

Industry Partner	Direct Cash	In-Kind Services
NAC	$17,000	$33,000
GRE	$17,000	$33,000
Knorr Farms	$12,500	$37,500

The grant funds requested for this project total $149,557 or 50 percent of the total project budget. Letters of commitment by the industry sponsors are contained in appendix F.

Tax Liability

Appendix B contains letter affidavits stating that the following business entities owe no outstanding taxes to the State of North Dakota:

The North American Coal Corporation

Great River Energy

Knorr Farms

Confidential Information

Part C proposal listed in Appendix D

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Appendix A – Resumes for Key Personnel

JOHN P. KAY
Principal Engineer, Emissions and Carbon Capture Group Lead
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-4580, Fax: (701) 777-5181, E-Mail: jkay@undeerc.org

Principal Areas of Expertise
Mr. Kay's principal areas of interest and expertise include applications of solvents for removing CO_2 from gas streams to advance technology and look toward transformational concepts and techno-economic assessments. He has 6 years of experience in field testing site management and sampling techniques for hazardous air pollutants and mercury control in combustion systems along with10 years of experience utilizing scanning electron microscopy (SEM), x-ray diffraction (XRD), and x-ray fluorescence (XRF) techniques to analyze coal, fly ash, biomass, ceramics, and high-temperature specialty alloys. He is also interested in computer modeling systems, high-temperature testing systems, and gas separation processes and is a FLIR Systems, Inc.-certified infrared thermographer.

Qualifications
B.S., Geological Engineering, University of North Dakota, 1994.
Associate Degree, Engineering Studies, Minot State University, 1989.

Professional Experience
2011–Present: Principal Engineer, Emissions and Carbon Capture Group Lead, EERC, UND. Mr. Kay's responsibilities include management of CO_2 separation research related to bench-, pilot-, and demonstration-scale equipment for the advancement of the technology. This also includes the development of cleanup systems to remove SO_x, NO_x, particulate, and trace elements to render flue gas clean enough for separation.

2005–2011: Research Manager, EERC, UND. Mr. Kay's responsibilities included the management and supervision of research involving the design and operation of bench-, pilot-, and demonstration-scale equipment for development of clean coal technologies. The work also involved the testing and development of fuel conversion (combustion and gasification) and gas cleanup systems for the removal of sulfur, nitrogen, particulate, and trace elements.

1994–2005: Research Specialist, EERC, UND. Mr. Kay's responsibilities included conducting SEM, XRD, and XRF analysis and maintenance; creating innovative techniques for the analysis and interpretation of coal, fly ash, biomass, ceramics, alloys, high-temperature specialty alloys, and biological tissue; managing the day-to-day operations of the Natural Materials Analytical Research Laboratory; supervising student workers; developing and performing infrared analysis methods in high-temperature environments; and performing field work related to mercury control in combustion systems.

1993–1994: Research Technician, Agvise Laboratories, Northwood, North Dakota. Mr. Kay's responsibilities included receiving and processing frozen soil samples for laboratory testing of chemical penetration, maintaining equipment and inventory, and training others in processing techniques utilizing proper laboratory procedures.

1991–1993: Teaching Assistant, Department of Geology and Geological Engineering, UND. Mr. Kay taught Introduction to Geology Recitation, Introduction to Geology Laboratory, and Structural Geology. Responsibilities included preparation and grading of assignments and administering and grading class examinations.

1990–1992: Research Assistant, Natural Materials Analytical Laboratory, EERC, UND. Mr. Kay's responsibilities included operating an x-ray diffractometer and interpreting and manipulating XRD data, performing software manipulation for analysis of XRD data, performing maintenance and repair of the XRD machine and sample carbon coating machine, preparing samples for XRD and SEM analysis, and performing point count analysis on the SEM.

Professional Memberships
ASM International
American Ceramic Society
Microscopy Society of America

Publications and Presentations
Has authored or coauthored numerous publications.

JASON D. LAUMB
Principal Engineer, Coal Utilization Group Lead
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, ND 58202-9018 USA
Phone: (701) 777-5114, Fax: (701) 777-5181, E-Mail: jlaumb@undeerc.org

Principal Areas of Expertise
Mr. Laumb's principal areas of interest and expertise include biomass and fossil fuel conversion for energy production, with an emphasis on ash effects on system performance. He has experience with trace element emissions and control for fossil fuel combustion systems, with a particular emphasis on air pollution issues related to mercury and fine particulates. He also has experience in the design and fabrication of bench- and pilot-scale combustion and gasification equipment.

Qualifications
M.S., Chemical Engineering, University of North Dakota, 2000.
B.S., Chemistry, University of North Dakota, 1998.

Professional Experience
2008–Present: Principal Engineer, Coal Utilization Group Lead, EERC, UND. Mr. Laumb's responsibilities include leading a multidisciplinary team of 30 scientists and engineers whose aim is to develop and conduct projects and programs on power plant performance, environmental control systems, the fate of pollutants, computer modeling, and health issues for clients worldwide. Efforts are focused on the development of multiclient jointly sponsored centers or consortia that are funded by government and industry sources. Current research activities include computer modeling of combustion/gasification and environmental control systems, performance of selective catalytic reduction technologies for NO_x control, mercury control technologies, hydrogen production from coal, CO_2 capture technologies, particulate matter analysis and source apportionment, the fate of mercury in the environment, toxicology of particulate matter, and in vivo studies of mercury–selenium interactions. Computer-based modeling efforts utilize various kinetic, systems engineering, thermodynamic, artificial neural network, statistical, computation fluid dynamics, and atmospheric dispersion models. These models are used in combination with models developed at the EERC to predict the impacts of fuel properties and system operating conditions on system efficiency, economics, and emissions.

2001–2008: Research Manager, EERC, UND. Mr. Laumb's responsibilities included supervising projects involving bench-scale combustion testing of various fuels and wastes; supervising a laboratory that performs bench-scale combustion and gasification testing; managerial and principal investigator duties for projects related to the inorganic composition of coal, coal ash formation, deposition of ash in conventional and advanced power systems, and mechanisms of trace metal transformations during coal or waste conversion; and writing proposals and reports applicable to energy and environmental research.

2000–2001: Research Engineer, EERC, UND. Mr. Laumb's responsibilities included aiding in the design of pilot-scale combustion equipment and writing computer programs that aid in the reduction of data, combustion calculations, and prediction of boiler performance. He was also involved in the analysis of current combustion control technology's ability to remove mercury and studying in the suitability of biomass as boiler fuel.

1998–2000: SEM Applications Specialist, Microbeam Technologies, Inc., Grand Forks, North Dakota. Mr. Laumb's responsibilities included gaining experience in power system performance including conventional combustion and gasification systems; a knowledge of environmental control systems and energy conversion technologies; interpreting data to predict ash behavior and fuel performance; assisting in proposal writing to clients and government agencies such as the National Science Foundation and the U.S. Department of Energy; preparing and analyzing coal, coal ash, corrosion products, and soil samples using SEM/EDS; and modifying and writing FORTRAN, C+, and Excel computer programs.

Professional Memberships
American Chemical Society

Publications and Presentations
Has coauthored numerous professional publications.

MELANIE D. JENSEN
Senior Chemical Engineer, CO_2 Capture and Infrastructure Team Lead
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5115, Fax: (701) 777-5181, E-Mail: mjensen@undeerc.org

Principal Areas of Expertise

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

Education and Training

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

Professional Experience

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

1985–2011: Research Engineer, EERC, UND. Ms. Jensen performed research in the areas of CO_2 capture and storage, reaction engineering, coal combustion, reburning, hazardous waste treatment, gas-phase particulate and mercury collection, photocatalytic processes, fuel production from biomass, contaminated water cleanup, and phytoremediation. She designed, developed, operated, and/or evaluated complex processes and equipment, including column CO_2 capture systems, high-pressure/high-temperature coal conversion systems, low-temperature plasma systems, and multicolumn sorption systems. She identified promising carbon sequestration opportunities by matching CO_2 capture technologies with point sources, pairing those combinations with nearby geologic sinks, and performing the preliminary compressor and pipeline specifications. She evaluated and compared characterization, remediation, and decontamination technologies for application to waste treatment/cleanup programs. Ms. Jensen developed statistically designed experimental matrices; tracked, reduced, and interpreted data generated during research projects; and derived empirical models describing system behavior. Ms. Jensen also developed integrated, multiproject programs to meet both the immediate and long-term needs of clients; prepared or assisted with the preparation of proposals and supporting documentation; developed comprehensive QA/QC plans; and prepared patent applications. Her project management activities included detailed program planning; scheduling of equipment and personnel; budget monitoring; maintenance of project schedules, dissemination of research results through reports, papers, and presentations; and communicating with clients.

Patents

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

Publications

Has authored or coauthored numerous publications.

Michael H. Ostlie

Research Agronomist – NDSU-CREC

PO Box 219 C:218-791-8912
Carrington ND 58421 mike.ostlie@ndsu.edu

EDUCATION

Ph.D. Bioagricultural Science and Pest Management – 2008-2012
"Development and characterization of acetyl CoA carboxylase inhibitor resistant wheat"
-Colorado State University
M.S. Plant Science; Weed Science Specialty – 2006-2008
"Downy brome competition and evaluation of herbicidal control for no-till hard red spring wheat"
-North Dakota State University
B.S. Crop and Weed Science; Minor in Extension Education – 2002-2006
-North Dakota State University

EXPERIENCE

North Dakota State University – Carrington Research Extension Center 2012 - present
Research Agronomist

Key details:

- Coordinate day-to-day activities of seven technicians and the student labor at the CREC
- Acted as the PI for numerous studies, ranging from pathology, weed science, soil health, and general agronomy and including co-PI on a new four year NIFA project
- Initiated an effort to enhance the dissemination of research trial data through a new position tasked with enhancing the website functionality/organization and the creation of numerous videos
- Management of the agronomy program at the CREC
- Maintenance of $200,000 annually in research funding

Colorado State University
PhD student - GRA 2008 - 2011

Key details:

- Coordinated a restricted field study evaluating drought tolerance genes in corn
- Performed herbicide absorption and translocation studies on feral rye to test cold effects and synergism effects of imidazolinone herbicides for Clearfield wheat systems
- Performed in-vitro and in-vivo enzyme assays on feral rye, downy brome, and wheat measuring acetolactate synthase (ALS) accumulation in the presence of imazamox
- Administered a mutagenic compound to wheat to obtain altered gene function
- Coordinated and established a long-term Targeting Induced Local Legions IN Genomes (TILLING) wheat population and DNA library for novel gene discovery
- Discovered a novel mutation resulting in herbicide resistant wheat (patent filed)
- Coordinated the establishment of a new molecular biology lab for the Weed Research building
- Wrote research proposals to public and private groups to fund side projects
- Presented research information to extension and commodity groups in Colorado and Wyoming
- Presented research to multiple Western Society of Weed Science and Weed Science Society of America annual meetings
- Taught 3 weekly sections of a Plants and Civilizations course

North Dakota State University 5/2006 – 11/2008
Masters Student - GRA

Key details:

- Established, planted, applied pesticides, and harvested research plots
- Conducted greenhouse studies evaluating spray adjuvant systems for enhanced downy brome control
- Designed field experiments evaluating downy brome control at different growth stages and temperatures, and phenotypic characterization of downy brome after herbicide treatment
- Presented research to multiple extension groups and at North Central Society of Weed Science and Western Society of Weed Science meetings
- Taught a Principles of Weed Science Lab course for one semester

SKILLS

- Work with various molecular biology techniques including DNA/RNA and enzyme and protein extractions, PCR, restriction enzyme digestion, and cloning
- Familiarity with many lab techniques such as ^{14}C tracing, enzyme purification, spectrophotometry, equipment purchasing, and experiment-appropriate cleanliness
- Farm implement operation, general farm operation experience, exposure to grower practices in multiple areas of the country
- Experience with multiple teaching and presentation settings; for students, industry, growers and university faculty
- Involvement in many collaborative projects/experiments

ACTIVITIES

North Dakota 4-H Ambassadors (2002-2007)

- State Extension Youth Conference Coordinator (2005-2006)

Grand Forks County 4-H

- County crops judging team head coach (2002-2005)

North Dakota State University Student Government

- Founder of NDSU's only television studio (2007-2008)
  -garnered over $200,000 in start-up funds plus established a new faculty position

MANUSCRIPTS

- Ostlie, M.H., and K.A. Howatt. 2013. Downy Brome (*Bromus tectorum*) Competition and Control in No-Till Spring Wheat. Weed Technol. 27:502-508.
- Shaner, D.L., R.B. Lindenmeyer, M.H. Ostlie. 2012. What have the mechanisms of resistance to glyphosate taught us? Pest Manag. Sci. 68:3-9
- Ostlie, M., M., Bridges, P. Westra, and D. Shaner. Imazamox Tolerance and Translocation in Feral Rye (*Secale cereal*) as affected by temperature. *In preparation*
- Ostlie, M., S. Haley, V. Anderson. D. Shaner, H. Manmathan. C. Beil, and P. Westra. 2015. Development and Characterization of Mutant Winter Wheat Accessions Resistant to the Herbicide Quizalofop. Theoret. Appl. Genet. 128:343-351.
- Ostlie, M., S. Haley, P. Westra, V.A. Valdez. 2017. Acetyl Co-Enzyme A Carboxylase Herbicide Resistant Plants. US Patent 9578880. Feb 28 2017.

RECENT PROFESSIONAL PRESENTATIONS GIVEN

- Ostlie, M., K. Howatt, and C. Dalley. 2017. Cover Crop Safety Following Wheat Herbicide Application. Western Society of Weed Science annual meeting. Coeur d'Alene, Idaho, March 2017.
- Ostlie, M., G. Endres, and J. Nielson. 2017. Soybean PRE Herbicide Effectiveness with Limited Water. Western Society of Weed Science annual meeting. Coeur d'Alene, Idaho. March 2017.

- Ostlie, M., B. Jenks, and G. Endres. 2016. Evaluating the Effectiveness of Fall-Applied Herbicides for Kochia Management in the Upper Great Plains. Western Society of Weed Science. Albuquerque, NM. March 2016.
- Ostlie, M., J. Teboh, E. Aberle, and B. Schatz. 2016. Energy Beet Utilization for Saline Soil Bioremediation in Non-Traditional Sugar Beet Growing Regions. American Society of Agronomy. Minneapolis, MN. Nov. 2016.
- Ostlie, M., J.P. Flores, B. Schatz, and S. Zilahi-Sebess. 2016. Novel Applications for Unmanned Aerial Systems (UAS) in Cropland. American Society of Agronomy. Minneapolis, MN. Nov 2016.
- Ostlie, M., and J.P. Flores. 2015. Early observations from unmanned aerial systems (UAS) operations in cropland. Western Society of Weed Science. Portland OR. March 2015.
- Ostlie, M., and S. Zwinger. 2015. Utilizing winter rye for weed suppression in soybeans. Western Society of Weed Science. Portland OR. March 2015.
- Ostlie, M,. P. Stahlman, P. Westra. 2013. Spread of glyphosate resistant kochia in the Great Plains. Precision Ag Conference. Keynote speaker.
- Ostlie, M., P. Westra, S. Haley, D. Shaner. 2012. Development of a new herbicide resistance trait in wheat. Western Society of Weed Science.
- Ostlie, M., D Shaner, P. Westra. 2011. Feral rye stage of growth effects on imidazolinone translocation and efficacy. Weed Science Society of America.

Paulo Flores
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Phone: 701-652-2951, FAX: 701-652-2055
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I. Education

Ph.D., Soil Science, 2008, Federal University of Rio Grande do Sul, Brazil. Research topic: soil physical and chemical attributes and soybean yield under livestock-crop integration in different management systems.

M.S., Soil Science), 2004, Federal University of Rio Grande do Sul, Brazil. Research topic: Soil attributes and soybean yield in an animal-crop integration system with different pasture heights in no-tillage with surface lime application.

B.S., **Agronomy**, 2002, Federal University of Santa Maria, Brazil.

Other

Exchange Ph.D Program, 08/2006-07/2007, Department of Crop Science, University of Illinois at Urbana-Champaign.

II. Research Experience

12/2016-present	**Precision Agriculture Specialist** – NDSU Carrington Research Extension Center.
01/2014-11/2016	**Nutrient Management Specialist** – NDSU Carrington Research Extension Center.
1/2013-9/2013	**Project Researcher/Lab and Field Assistant** - Crop & Soil, Environmental Science Department. Virginia Tech University.
01/2009-01/2013	**Postdoctoral Associate** - Crop & Soil, Environmental Science Department. Virginia Tech University.
03/2004-03/2008	**Graduate (PhD) Student Researcher** – Department of Soils, Federal University of Rio Grande do Sul, RS, Brazil.
03/2002-03/2004	**Graduate (M.S.) Student Researcher** - Department of Soils, Federal University of Rio Grande do Sul, RS, Brazil
03/1997-02/2002	**Undergraduate Student Researcher** – Department of Soils, Federal University of Santa Maria, RS, Brazil.

VI. Selected Publications

<u>Peer reviewed papers</u>

1. TRACY, B. F., K. ALBRECHT, **J. FLORES**, M. HALL, A. ISLAM, G. JONES, W. LAMP, J. W. MACADAM, H. SKINNER, AND C. TEUTSCH. 2016. Evaluation of Alfalfa–Tall Fescue Mixtures across Multiple Environments. Crop Sci. 56:2026-2034. doi:10.2135/cropsci2015.09.0553
2. TRACY, B. F., SCHLUETER, D. H. and **FLORES, J. P.** (2015), Conditions that favor clover establishment in permanent grass swards. Grassland Science, 61: 34 -40. doi: 10.1111/grs.12075.
3. BONIN, C., **FLORES, J.;** LAL, R., TRACY, B. Root Characteristics of Perennial Warm-Season Grasslands Managed for Grazing and Biomass Production. *Agronomy*, v.3, p.508-

523, 2013.

4. **FLORES, J.P.C**, TRACY, B. Impacts of winter hay feeding on pasture soils and plants. Agriculture, Ecosystems & Environment, v.149, p.30 - 36, 2012.

5. CONTE, O., **FLORES, J.P.C**., CASSOL, L.C., ANGHINONI, I., CARVALHO, P.C.F., LEVIEN, R., WESP, C.L. Evolution of soil physical attributes in an integrated crop‑livestock system. *Pesquisa Agropecuária Brasileira*, v.46, p.1301 - 1309, 2011. (In Portuguese with Abstract in English)

6. CARVALHO, P.C.F., ANGHINONI, I., MORAES, A., SOUZA, E.D., SULC, R.M., LANG, C.R., **FLORES, J.P.C**., TERRA LOPES, M.L., SILVA, J.L.S., CONTE, O., WESP, C. L., LEVIEN, R., FONTANELI, R.S., BAYER, C. Managing grazing animals to achieve nutrient cycling and soil improvement in no-till integrated systems. *Nutrient Cycling in Agroecosystems*, v.88, p. 259 – 273, 2010.

7. COSTA, S.E.V.G.A., SOUZA, E.D., ANGHINONI, I., **FLORES, J.P.C.**, VIEIRA, F.C.B., MARTINS, A.P., FERREIRA, E.V.O. Patterns in phosphorus and corn root distribution and yield in long-term tillage systems with fertilizer application. *Soil & Tillage Research*, v.109, p.41 – 49, 2010.

8. COSTA, S.E.V.G.A., SOUZA, E.D., ANGHINONI, I., **FLORES, J.P.C.**, ANDRIGUETTI, M.H. Potassium and root distribution in soil and corn growth in long-term soil management and fertilization systems. *Revista Brasileira de Ciência do Solo*, v.33, p.1291 – 1301, 2009. (In Portuguese with Abstract in English)

9. COSTA, S.E.V.G.A., SOUZA, E.D., ANGHINONI, I., **FLORES, J.P.C.**, CAO, E.G., HOLZSCHUH, M.J. Phosphorus and root distribution and corn growth as related to long-term tillage systems and fertilizer placement. *Revista Brasileira de Ciência do Solo*, v.33, p.1291 – 1301, 2009. (In Portuguese with Abstract in English)

10. LOPES, M.L.T., CARVALHO, P.C.F., ANGHINONI, I., SANTOS, D.T., AGUINAGA, A.A.Q., **FLORES, J.P.C**., MORAES, A. Crop-livestock integration system: effect of oat and italian ryegrass sward height management on soybean yield. *Ciência Rural*, v.39, p.1499 – 1506, 2009. (In Portuguese with Abstract in English)

11. MAUGHAN, M. W., **FLORES, J.P.C.**, ANGHINONI, I., BOLLERO, G., FERNANDEZ, F. G., TRACY, B. F. Soil Quality and Corn Yield under Crop-Livestock Integration in Illinois. *Agronomy Journal*, v.101, p.1503 – 1510, 2009.

12. **FLORES, J.P.C.**, CASSOL, L.C., ANGHINONI, I., CARVALHO, P.C.F. Chemical attributes of an oxisol under no-tillage submitted to surface liming and distinct grazing pressures in a crop-livestock integration system. *Revista Brasileira de Ciência do Solo*, v.32, p.2385 – 2396, 2008. (In Portuguese with Abstract in English)

13. **FLORES, J.P.C.**, ANGHINONI, I., CASSOL, L.C., CARVALHO, P.C.F., LEITE, J.G.D.B., FRAGA, T.I. Soil physical attributes and soybean yield in na integrated livestock-crop system with different pasture heights in no-tillage. *Revista Brasileira de Ciência do Solo*, 31*:* 771-780, 2007. (In Portuguese with Abstract in English)

VII. Grants

11/01/2015-03/31/2017 – North Dakota Agricultural Experiment Station. Increasing UAV related research capacity at the Carrington REC. $96,689. Role: PI ($65,196).

11/01/2015-03/31/2017 – North Dakota Department of Commerce. Determining Crop Harvest Readiness Using an UAV and Thermal Infrared Sensors. $62,291. Role: PI.

07/01/2015-06/30/2017, U.S. Environmental Protection Agency / North Dakota Department of Health. North Dakota Discovery Farms. $140,000. Role: PI.

7/01/2015-06/30/2017, North Dakota Corn Council. Corn Production Optimization with Distiller's Grains as a Phosphorus Fertilizer Source. PI: Jasper Teboh $13,597. Role: Co-PI.

07/01/2010-09/30/2015, U.S. Environmental Protection Agency / North Dakota Department of Health. North Dakota Discovery Farms. $685,900. Role: PI (inherited funds)

2012-2015 USDA, Natural Resources Conservation Service (*69-33A7-12-002*). "Managed Grazing for Improved Soil Health and Environmental Protection". PI: Benjamin Tracy; $75,000. Role: Co-PI.

VIII. Professional Affiliations

American Society of Agronomy

Harlene M. Hatterman-Valenti

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Fax (701) 231-8474
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Education

Ph. D. 1993. Co-major, Agronomy-Crop Production and Physiology; Horticulture. Iowa State University. Dissertation: Herbicide spray movement during turfgrass postemergence applications.

M.S. 1985. Horticulture. University of Nebraska - Lincoln. Thesis: Production of annual statice (*Limonium sinuatum*) in Nebraska.

B.S. 1981. Biology. University of Nebraska - Kearney.

Professional Experience

2013 - present	Professor, High - Value Crops Specialist, North Dakota State University.
2012 - present	Assistant Head, Dept. Plant Sciences, North Dakota State University.
2007 - 2013	Associate Professor, High - Value Crops Specialist, North Dakota State University.
2000 - 2007	Assistant Professor, High - Value Crops Specialist, North Dakota State University.
1997 - 2000	Consultant, Instructor, Southeast Technical Institute, Sioux Falls, SD 57107.
1994 - 1997	Research Biologist, FMC Corporation, Princeton, NJ 08543.

Organizations

American Society for Enology and Viticulture
Potato Association of America
North Dakota Nursery and Greenhouse Association
Eastern Reg. Soc. for Enology & Viticulture
American Society of Horticulture Science
North Central and Western Weed Science Societies
North Dakota Grape and Wine Association
Gamma Sigma Delta - Agricultural Honorary

Awards and Honor

Chamber of Commerce NDSU Distinguished Faculty Service Award, 2017; NDSU Outstanding Academic Advising Award, 2014; North Central Weed Science Society Fellow, 2011; AAIC Best Medicinal and Nutraceutical Plants Paper Presentation of 2011; Larson/Yaggie Excellence in Research Award, 2010; Alpha Tau Omega Amazing Teacher Award, 2008; Madison's Who's Who and Marquis Who's Who in America, 2008; ECI Who's Who Among America's Teachers and Educators, 2007; Academic Keys Who's Who in Agricultural Higher Education, 2003.

Selected Publications

Köycü, N.D., J.E. Stenger, and H.M. Hatterman-Valenti. 2017. Cold climate winegrape cultivar sensitivity to sulfur in the northern Great Plains region of the United States. HortTechnology 27(2):215-219.

Debner, A. and H. Hatterman-Valenti. 2016. Establishment of primocane blackberry cultivars in a northern climate. Acta Hortic. 1133:201-206.

Gegner-Kazmierczak, G. and H. Hatterman-Valenti. 2016. Strip tillage and early-season broadleaf weed control in seeded onion (*Allium cepa*). Agriculture 6(2): 11, doi:10.3390/agriculture6020011.

Hatterman-Valenti, H.M., C.P. Auwarter, and J.E. Stenger. 2016. Evaluation of cold-hardy grape cultivars for North Dakota and the North Dakota State University germplasm enhancement project. Acta Hortic. 1115:13-22.

Mehring, G.H., J.E. Stenger, and H.M. Hatterman-Valenti. 2016. Weed control with cover crops in irrigated potatoes. Agronomy *6*(1), 3; doi:10.3390/agronomy6010003.

Mettler, D. and H. Hatterman-Valenti. (2016). Cultivar comparison and winter row covers for blackberry production in North Dakota. Acta Hortic. 1133: 217-222.

Stenger, J.E. and H. Hatterman-Valenti. 2016. Alternative weed control methods during grape establishment in the United States Upper Midwest. Agriculture Sciences. 7:357-363.

Zuk, A., Q. Zhang, T. Helms, and H. Hatterman-Valenti. 2016. Cold hardiness and the effects of a low-input regime on 15 tall, warm-season, native and ornamental grasses in the upper midwestern United States. HortTechnology 26(6): 735-741.

Ardayfio, N.K. and H. Hatterman-Valenti. 2015. Juneberry cultivar evaluation in North Dakota. HortTechnology 25:747-751.

Gegner-Kazmierczak, S., and H. M. Hatterman-Valenti. 2015. Effects of tillage and herbicides on direct-seeded onion (Allium cepa). Acta Hortic. 1105:205-212.

Hatterman-Valenti, H.M. and A.P. Robinson. 2015. Potato production near glyphosate-resistant crops – Injury potential, p. 35-56. In: A. Price, J. Kelton, and L. Sarunaite (eds.). Herbicides, Physiology of Action, and Safety. InTech, Rijeka, Croatia.

Hatterman-Valenti, H. M. 2014. Simulated glyphosate drift to potato mother plants and effect on daughter tubers used for seed production. Weed Technology 28:253-258.

Loken, J. R. and H. M. Hatterman-Valenti. 2013. Early-season weed control using herbicides with adjuvants in direct-seeded onion. Weed Technology 27:369-372.

Hatterman-Valenti, H. 2012. Managing weeds with reduced herbicide inputs: Developing a novel system for onion. Pages 121-134. *in* R. Alverez-Fernandez ed., Herbicides – Environmental Impact Studies and Management Approaches. Rijeka: InTech.

Hatterman-Valenti, H., A. Pitty, and M. Owen, 2011. Environmental effects on velvetleaf (Abutilon theophrasti) epicuticular wax deposition and herbicide absorption. Weed Sci. 59:14-21.

Paparozzi E.T., K.A. Williams, R. Geneve, H. Hatterman-Valenti, C. Haynes, H. Kraus, C. McKenney, and J. Pitts. 2011. Development of the AG*IDEA alliances's horticulture graduate certificates program and inter-institutional course share. HortTechnology 21:688-691.

Hatterman-Valenti, H. M. 2010. North Dakota State University horticulture and forestry program assessment. HortTechnology 20:678-682.

Loken, J. R. and H. M. Hatterman-Valenti. 2010. Multiple applications of reduced-rate herbicides for weed control in onion. Weed Technology 24:153-159.

Willard, D. M. and H. M. Hatterman-Valenti. 2008. Juneberry growth is affected by weed control methods. HortTechnology 18:75-79.

Thompson, A.L., B.L. Farnsworth, N.C. Gudmestad, G.A. Secor, D. Preston, J.R. Sowokinos, M. Glynn and H. Hatterman-Valenti. 2008. Dakota Diamond: An exceptionally high yielding, cold chipping potato cultivar with long-term storage potential. Amer. J. Potato Res. 85:171-182.

Schumacher, C. E. and H. M. Hatterman-Valenti. 2007. Effect of dose and spray volume on early-season broadleaved weed control in allium using herbicides. Crop Protection 26:1178-1185.

Thompson, A.L., B. L. Farnsworth, G. A. Secor, N.C. Gudmestad, D. Preston, J. R. Sowokinos, M. Glynn, and H. Hatterman-Valenti. 2007. Dakota Crisp: a new high-yielding, cold-chipping potaot cultivar with tablestock potential. Am. J. Potato Res. 84: 477-486.

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NORTH AMERICAN COAL CORPORATION
FALKIRK MINE

GERARD E. GOVEN

2801 1st St SW, PO Box 1087, Underwood, ND 58576
Phone: (701) 442-5751, Fax: (701) 442-5288, Email: gerard.goven@nacoal.com

Education:

University of North Dakota (Grand Forks, ND) –
Bachelor of Science – Geology – August 1996

Summary of Qualifications:

Mr. Gerard Goven is Senior Geologist at The Falkirk Mining Company's Falkirk Mine in Underwood, North Dakota. The Falkirk Mining Company is a subsidiary of The North American Coal Corporation. As Senior Geologist, Mr. Goven manages and supervises a wide variety of projects ranging from research to exploration to mine operations. He has 20 years of professional geologist experience and 30 years of experience operating a farm and ranch in North Dakota.

Professional Highlights:

2007 - Present	The Falkirk Mining Company - Underwood, ND Senior Geologist
1998 - 2007	North Dakota Department of Health - Bismarck, ND Hydrogeologist
1995 - 1998	North Dakota Geological Survey - Bismarck, ND Geologist
1994 - 1994	The Coteau Properties Company - Beulah North Dakota Geologist - Trainee
1993 - 1994	Kadermas Lee and Jackson Land Surveyor

Professional Highlights Continued:

1997 - Present — Goven Farms and Ranch - Turtle Lake, ND
Owner/Operator

1987 - 1997 — Goven Farms and Ranch - Turtle Lake, ND
Operator

Memberships and Boards:

Turtle Lake Mercer School Board - Board Member

McLean County Water Board - Board Member

North Dakota Geological Society - Member

Research and Publications:

Ellis, M.S., Gunther, G.L., Ochs, A.M., Keighin, C.W., Goven, G.E., Schuenemeyer, J.H., Strieker, G.D., and Blake, D., 1999, Coal Resources, Williston Basin, Chapter WN, *in* 1999 Resource Assessment of Selected Tertiary Coal Beds and Zones in the Northern Rocky Mountains and Great Plains Region by Fort Union Assessment Team: U.S. Geological Survey Professional Paper 1625-A, Version 1.2, p. WN1-74

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Murphy, E.C., Kruger, N.W, Vandal, Q.L, and Goven, G.E., Tudor, E.A., The Harmon lignite bed in western North Dakota: NDGS Miscellaneous Map no. 35, 1:750,000 Scale.

Murphy, E.C., Vandal, A., Kruger, N.W., Goven, G.E., in prep., Thick coals in Divide, Burke, Williams, and Mountrail counties: NDGS Open-File Report No. 02-1.

3409 21st Street Minot, ND 58701•701-720-0356•steveknorr@hotmail.com

STEVE KNORR

Experience

1995-2000 | Knorr Produce | Sawyer, ND

Owner/Manager

- Karlsruhe, ND center-pivot irrigation: cabbage, onions, pumpkins, sweet corn
- Managed and marketed vegetable production within a tri-state region

2003-2006 | Kidco Farms Inc. | Dawson, ND

Former Owner/VP Marketing and Sales/Production Manager/VP of Grower Relations

- Marketed Whole Peel onions throughout all 48 States
- Managed all production aspects: General Factory, Sanitation, Quality Control, Shipping and Receiving
- Identified Market opportunities
- Developed Strategic Selling Method
- Developed Grower Relations/Contracting

2004 -2006 | SBARE

New and Emerging Crops SBARE (State Board of Agriculture Research and Education)

Board Member

- Selecting Research Projects for New and Emerging Crops in North Dakota

2006- Present | Knorr Farms ND | Sawyer, ND

Owner/Manager

- Sawyer, ND Dry-land production: Wheat, Edible Beans, Corn, Sunflowers
- Manage all operations: Production, Marketing, and Logistics

2011- Present | K & T Farms LLP | Turtle Lake, ND

Owner/ Manager

- Turtle Lake, ND center-pivot irrigation: Corn
- Land acquisitions and development of irrigation
- Responsible for budgets, marketing and selling of farm products
- Interaction with Federal agencies (Bureau of Reclamation)

Appendix B - Tax Liability Affidavits

Appendix B contains letter affidavits stating that the following business entities owe no outstanding taxes to the State of North Dakota:

The North American Coal Corporation

Great River Energy

Knorr Farms

STACI D. SHEWMAKE, CPA
Tax Director

Direct Dial No.
972.448.5419
Staci.shewmake@nacoal.com

March 28, 2017

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

Dear Ms. Fine,

The North American Coal Corporation does not have any outstanding tax liens or liabilities and is current with all federal and state tax reporting agencies.

Please do not hesitate to let me know if you have additional questions. My contact information is provided above.

Very truly yours,

Staci D. Shewmake
Tax Director

GREAT RIVER ENERGY

12300 Elm Creek Boulevard
Maple Grove, Minnesota 55369-4718
763-445-5000
greatriverenergy.com

April 3, 2017

Ms. Karlene Fine
Executive Director
Attn: Lignite Research Program
North Dakota Industrial Commission
State Capitol, 14th Floor
Bismarck, ND 58505-0840

Ms. Fine:

This is to confirm that as of the date of this letter Great River Energy has no known tax delinquencies with respect to the State of North Dakota.

Feel free to contact me at 763-445-5435 or sleyh@grenergy.com if you have additional questions or need further clarification.

Sincerely,
Great River Energy

Steve Leyh
Leader, Property & Tax

KNORR FARMS

Knorr Farms ND
3409 21st ST SE
Minot, ND 58701
March 30, 2017

Ms. Karlene Fine
Executive Director
ATTN: Lignite Research Program
North Dakota Industrial Commission
600 East Boulevard Avenue
Bismarck, ND 58505-0840

Dear Ms. Fine,

Knorr Farms ND does not have any outstanding tax liens or liabilities and is current with all federal and state tax reporting agencies.

Please do not hesitate to call myself or our accountant Iver J. Eliason (CPA,701-839-2520) with any additional questions.

Sincerely,

Steve Knorr
Knorr Farms ND
701-720-0356
steveknorr@hotmail.com

Appendix C – NDSU Fargo Proposal

Green House Project: Research and Development; "Specific to Green and Growing Projects".

1. Steve Knorr "Knorr Farms"......................................steveknorr@hotmail.com

2. Gerard Goven "NACoal"...gerard.goven@nacoal.com

3. Rich Garmin "Great River Energy".........................rgarman@grenergy.com

Title: Evaluating CO_2 enrichment on greenhouse produced vegetables in North Dakota.

Principal Investigator: Dr. Harlene Hatterman-Valenti, Assistant Department Head/Professor, Department of Plant Science, North Dakota State University, Fargo, ND 58108, Tel: 701-231-8536, Email:H.Hatterman.Valenti@ndsu.edu

Collaborators (Name, Institution, Email address)

Dr. Mike Ostlie, Agronomist, Carrington REC, mike.ostlie@ndsu.edu

Dr. Paulo Flores, Precision Agriculture, Carrington REC, paulo.flores@ndsu.edu

Blaine Schatz, Director/Agronomist, Carrington REC, blaine.schatz@ndsu.edu.

Jasper Teboh, Research Soil Scientist, Carrington REC, jasper.teboh@ndsu.edu

Rationale:

The effects of elevated atmospheric carbon dioxide concentrations on plant growth and tissue composition has focused on C3 species as photosynthesis in these plants is unsaturated at the present atmospheric CO_2 concentrations and thus responds positively to CO_2 concentration increases (Bowes 1993; Drake et al. 1997; Long et al. 2004). If these plants are supplied with ample nutrients and water, the 'CO_2 fertilization effect' as coined by Thomson et al. (2013), leads to improved growth and production of the many plant species that humans use as food. Since carbon dioxide is the direct substrate of photosynthesis and increasing concentrations typically stimulate plant growth, increased CO_2 has been used to achieve higher yields in glasshouse production (Sanchez-Guerroro et al. 2005). Jin et al. (2009) showed that suboptimal CO_2 concentrations in greenhouses could be increased using crop-residues and animal-manure composting. This method doubled the CO_2 concentration and increased the yields of celery, leaf lettuce, stem lettuce, oily sowthistle, and Chinese cabbage by 270%, 257%, 87%, 140%, and 227%, respectively, compared to those in control greenhouses. Nitrate concentrations were decreased between 8 and 36%, while soluble sugars concentrations were increased for oily sowthistle and Chinese cabbage, and all five species had increases in ascorbic acid concentrations (13 to 72%). A review by Idso and Idso (2001) on the effects of atmospheric CO_2 enrichment on plant constituents related to animal and human health indicated that increases in the air's CO_2 content typically leads to reductions in the nitrogen and protein concentrations of animal-sustaining forage and human-sustaining cereal grains when soil nitrogen levels are sub-optimal. However, when plants are supplied with the needed nitrogen, no reductions occur. They also concluded that atmospheric CO_2 enrichment appeared to reduce oxidative stresses in plants, increased the concentration of vitamin C in certain fruits and vegetables, increased the biomass of plants grown for medicinal purposes, and increased the disease-fighting substances produced with these medicinal plants. Similarly, Perez-Lopez et al. (2013) concluded that elevated CO_2 and its combination with salinity or high light increased biomass production and the antioxidant capacity in both a green-leaf and red-leaf lettuce cultivar.

Not all studies with elevated CO_2 concentrations have resulted in only positive responses. Jain et al. (2007) evaluated the photosynthesis and nutrient composition of spinach and fenugreek grown under elevated CO2 concentration and found that the 600 ± 50μmol/mol increased net photosynthetic rate and lowered the stomatal conductance compared to planted exposed to ambient conditions. The elevated CO_2 concentration also changed the nutrient composition: lower N, Mg, and Fe contents and higher C and Ca contents in the leaves of plants exposed to elevated CO_2 concentrations. Furthermore, Fu et al. (2015) found that when CO_2 levels exceed 3000 μmol/mol, Chinese cabbage and lettuce yields were decreased along with the contents of polyphenols, flavonoids and vitamin C in both vegetables. Thus, there is a limit to the benefits of increasing the atmospheric CO_2 concentrations.

Objective: Based on the above rationale the specific objective is:

To evaluate the increase in leaf growth and production of baby greens from enriched CO_2 concentrations and to determine an optimum CO_2 concentration with the shortest production phase for the baby green industry.

Procedure:

The different varieties of lettuce and greens used by Duncan Family Farms in the organic baby leaf item (red and green oak Salanova lettuce, red and green romaine lettuce, red and green leaf Salanova lettuce, lolla rosa, tango, and mizuna lettuce, red chard, green chard, tatsoi, baby kale, arugula and spinach) will be evaluated in this study. Four CO_2 concentrations will be evaluated (ambient air ~ 400 µmol/mol, 800, 1200, and 1600). Eight chambers will be constructed with capillary watering/fertilizer capabilities. Within each chamber, pure CO_2 will be released from a cylinder and injected into the chamber, maintaining the specific desired concentration. Small fans will be place within each chamber to ensure air circulation. A ventilation hose will be used to vent each chamber to the outside. Total CO_2 flow will be controlled by mass flow controllers while gas flow into individual chambers will be regulated by rotameters with adjustable needle valves. The CO_2 concentrations will be monitored in each chamber using the LiCor 6400 photosynthetic system. Photosynthetic active radiation (PAR) will be measured at the plant canopy. Supplemental lighting will be utilized with a photoperiod of 14 h. Fertilization will mimic the Duncan production system when possible, but must be dissolvable for use in the capillary watering system. To minimize the effects of intra-chamber environmental gradients, containers will be randomly repositioned within each chamber each week.

Leaf gas-exchange parameters including photosynthetic rate, stomatal conductance, and chlorophyll fluorescence will be measured simultaneously three hours after dawn using the open gas-exchange Li-6400 system. Data will also be collected to determine growth rates by destructively sampling plants every four days after emergence. In addition, biomass production as well as leaf water content and carbon content will be collected on the final samples. Trials will be repeated at least twice in time to ensure CO_2 response accuracy. Other vegetables will be examined after optimal CO_2 level is determined for the leafy vegetables, but without carbon tissue analysis. The initial experimental design will be a randomized complete block design with two replications arranged as a 15x4 factorial (15 species/cultivars and four CO_2 concentrations). Data will be analyzed using PROC MIXED (SAS® 9.3, Statistical Analysis Software, SAS Institute Inc., Cary, NC, USA). Means will be separated where appropriate using a pairwise t-test with a $P \leq 0.05$.

Timetable:

1. March-Dec 2017: Initiate trials and collect data.

2. Dec 2017-Jan 2018: Analysis of data and preparation of report.

3. Mar 2018: Present project results to Great River Energy and others involved in project.

Budget & Budget Justification: ($34,804)

John Stenger, a post-doc will conduct the trials with assistance from Collin Auwarter and Harlene Hatterman-Valenti.

Postdoc Salaries: $5,000

Fringe benefits: $5,000 x .45 = $2,250

Supplies: $16,438

Travel: $ 315

2 trips to Carrington REC 290 mi rt x .42/mi = $244

1 trip to EERC, Grand Forks 170 mi rt x .42/mi = $71

Total Direct Cost: $24,003

Indirect Cost: $24,003 x 45% = $10,801

Total Cost: $34,804

Item	Price/unit	qty	subtotal
Electronics			
CO2 regulator controller	500	8	4000
CO2 datalogger	400	8	3200
Regulator/solenoid	100	8	800
CO2 Distribution			
CO2 Tank (50gal)	400	2	800
Regulator branch	100	1	100
pneumatic manifolds	40	3	120
Air Fittings	5	8	40
Air Hoses	20	1	20
inline fans	30	2	60
Circulation fans	5	16	80
wire (12V DC)	20	3	60
400 watt high pressure sodium lights	20	8	160

Enclosure Assembly			
Plastic covering	100	1	100
Lumber	10	12	120
Hardware	10	1	10
Adhesive	20	1	20
PVC	2	15	30
Capillary mat	200	1	200
Disposables			
Trays	3	144	432
Labels	20	1	20
Soil	15	10	150
Fertilizer	20	1	20
CO2	1	1000	1000
Lab work (sent to a different lab)			
Tissue analysis			
Carbon	8.5	576	4896
	TOTAL		16,438

References:

Bowes, G. 1993. Facing the inevitable: plants and increasing atmospheric CO_2. Ann. Rev. Plant Biol. 44:309-332.

Drake, B.G., M.A. Gonzalez, and S.P. Long. 1997. More efficient plants: a consequence of rising atmospheric CO2. Ann. Rev. Plant Physiol. Plant Mol. Biol. 48:609-639.

Fu, Y., L Shao, H. Liu, H. Li, Z. Zhao, P. Ye, P. Chen, and H. Liu. 2015. Unexpected decrease in yield and antioxidants in vegetable at very high CO_2 levels. Environ. Chem. Lett. 13:473-479.

Idso, S.B. and K.E. Idso. 2001. Effects of atmospheric CO2 enrichment on plant constituents related to animal and human health. Environ. Expt. Bot. 45:179-199.

Long, S.P., E.A. Ainsworth, A. Rogers, and D.R. Ort. 2004. Rising atmospheric carbon dioxide: Plants FACE the future. Ann. Rev. Plant Biol. 55:591-628.

Jain, V., M. Pal, A. Raj, and S. Khetarpal. 2007. Photosynthesis and nutrient composition of spinach and fenugreek grown under elevated carbon dioxide concentration. Biol. Plant. 51(3):559-562.

Jin, C. S. Du, Y. Wang, J. Condon, X. Lin, and Y. Zhang. 2009. Carbon dioxide enrichment by composting in greenhouses and its effect on vegetable production. J. Plant Nut. 172:418-424.

Perez-Lopez, U. J. Miranda-Apodaca, A. Munoz-Rueda, and A. Mena-Petite. 2013. Lettuce production and antioxidant capacity are differentially modified by salt stress and light intensity under ambient and elevated CO_2. J. Plant Physiol. 170:1517-1525.

Sanchez-Guerroro, M.C., P. Lorenzo, E. Medrano., N. Castilla, T. Soriano., and A. Baille. 2005. Effect of variable CO2 enrichment on greenhouse production in mild winter climates. Agric. Forest Meterol. 132:244-252.

Thomson, G. M.R. Mollah, D.L. Partington, R. Jones, R. Argall, J. Tregenza, and G.J. Fitzgerald. 2013. Effects of elevated carbon dioxide and soil nitrogen on growth of two leafy Brassica vegetables. New Zealand J. Crop and Hort. Sci. 41(2):69-77.

Appendix E – EERC Proposal

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

March 31, 2017

Mr. Gerard Goven
Geologist
North American Coal Corporation
2801 1st Street Southwest
Underwood, ND 58576

Dear Mr. Goven:

Subject: EERC Proposal No. 2017-0115 Entitled "Industrial CO_2 Use for Agriculture"

Introduction

The Energy & Environmental Research Center (EERC) is pleased to submit this proposal on behalf of sponsorship team composed of North American Coal Corporation, Great River Energy, NoDak Energy Services, and Knorr Farms for research into the feasibility of using CO_2 from the Blue Flint Ethanol plant/Coal Creek Station campus for enhancing plant growth of marketable crops.

The EERC is proposing to assist with identifying and defining processes needed to prepare CO_2 captured from either the Blue Flint Ethanol plant or the Coal Creek Station for use in agriculture. All of these activities have been organized into four tasks which consist of consulting with project sponsors and developing high-level cost estimations for the processes required to best use the CO_2 from the Blue Flint Ethanol plant and flue gas from the Coal Creek Station. Aspects of this work will be performed utilizing data collected by North Dakota State University (NDSU) agronomists and agriculture specialists.

Scope of Work

The work is divided into four tasks, with Task 1 concentrating on field application and Tasks 2 and 3 concentrating on flue gas utilization from Blue Flint Ethanol and the Coal Creek Station. Task 4 will be for management of the work and final reporting.

Task 1 – Consultation on Field Studies – Delivery of CO_2 to the Plants

Consultation will be conducted by the EERC, as needed, with project leaders and NDSU researchers in addressing challenges associated with the performance of field studies to enhanced plant growth with CO_2. The focus will be in assisting NDSU with the utilization of CO_2 tanks for field tests and delivery of CO_2 to the plants, including gaseous CO_2 delivery to the plants via drip tape without water, and delivery of carbonated water via drip tape and/or pivot irrigation sprinklers.

Task 2 – Consultation on Dehydration, Compression, Piping, and Heating

The EERC will, as needed, consult with project leaders and facility engineers in the areas of dehydration, compression, piping, and transport of the CO_2 from the Blue Flint Ethanol plant. Additionally, if needed, the EERC will also consult with project leaders and facility engineers in the area of utilizing warm water from the Coal Creek Station cooling towers to provide heating for a greenhouse facility.

Task 3 – Flue Gas Cleaning and Transport

Task 3 will investigate several aspects of CO_2 delivery to a field or greenhouse setting.

Separation of the CO_2 from the flue gas or utilization of the flue gas directly will be investigated to deliver CO_2 into a greenhouse facility. Important aspects of this process will include the removal of sulfur and nitrogen oxides along with other trace constituents to a level that is not hazardous to personnel working in the enhanced environment. Removal levels will be based on two primary factors: 1) tolerance of the plants to these components and 2) levels that are considered safe for a human environment. Technologies and/or processes will be suggested for the required reduction levels that are proper for the volume of gas that would be needed for a greenhouse scenario.

Costs will be estimated for the processes of treating, dehydrating, compressing, and delivering the CO_2/flue gas via a pipeline from the source facility to the greenhouse facility. These costs will be dependent on the level of cleaning and/or separation needed, gas flow required, and the associated equipment needs to deliver the gas.

In conjunction with the research being carried out by NDSU agronomists, the EERC will identify the associated costs of delivering CO_2 to an open-air field as opposed to a greenhouse. The NDSU research will be vital to this activity as the method of CO_2 delivery at the field must be known to identify the appropriate subsystems required.

After the delivery processes to the greenhouse and to the field are determined, the EERC will investigate any possible uses of low-grade heat from the piping of hot gas from the CO_2 source unit. The utilized gas temperature must be controlled at the end-use location, and this may allow for some use of the excess heat in the process.

Task 4 – Management and Reporting

The administrative activities required for tracking the work effort of all tasks, attendance at review meetings, and preparation of the final project report will be performed as a part of this task. Status reports will be provided as needed throughout the progress of the project.

Three meetings have been planned to conduct face-to-face meetings through the course of the project. It is assumed for this proposal that meetings will be conducted at the Carrington Research Extension Center, but the EERC would also like to offer an open invitation to host a meeting at the EERC.

Deliverable

The deliverable for this project will be a final report describing the processing needed to transport flue gas from either the Blue Flint Ethanol plant or the Coal Creek Station, the different approaches for delivery of the CO_2 to crops, and expected associated costs. The report will include conclusions based on the study results as well as recommendations of the most appropriate engineering approaches for enhancing the growth of marketable crops using CO_2 captured from an industrial or utility facility with a focus on what is needed to begin a small-scale greenhouse pilot facility.

Period of Performance

The project is anticipated to begin at approximately mid-May 2017 and will conclude 1 year after the initiation of the project.

Cost

The fixed-price cost for the work effort outlined in this proposal is $50,000. The EERC requests full payment prior to initiating work. A budget and resumes for the three key EERC personnel are attached in Appendix A. Initiation of the proposed work is contingent upon the execution of a mutually negotiated agreement between our organizations.

Thank you for the opportunity to be a part of this proposed project. If there are any questions, please feel free to contact me by phone at (701) 777-4580 or by e-mail at jkay@undeerc.org.

Sincerely,

John P. Kay
Principal Engineer
Carbon Capture Group Lead

Approved by:

Thomas A. Erickson, CEO
Energy & Environmental Research Center

JPK/bjr

Attachments

APPENDIX A

BUDGET AND KEY PERSONNEL

INDUSTRIAL CO_2 USE FOR AGRICULTURE
NORTH AMERICAN COAL CORPORATION
PROPOSED PROJECT START DATE: 5/1/17
EERC PROPOSAL #2017-0115

BUDGET

CATEGORY		TOTAL
Total Labor	$	47,328
Travel	$	701
Supplies	$	192
Other*	$	594
Laboratory Fees & Services		
Graphics Service	$	1,185
Total Project Cost – U.S. Dollars	$	50,000

Labor Categories	Labor Hours Total per Category
Research Scientists/Engineers	254
Research Technicians	21
Senior Management	7
Technical Support Services	34
Total per Task	**316**

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

JOHN P. KAY
Principal Engineer, Emissions and Carbon Capture Group Lead
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-4580, Fax: (701) 777-5181, E-Mail: jkay@undeerc.org

Principal Areas of Expertise
Mr. Kay's principal areas of interest and expertise include applications of solvents for removing CO_2 from gas streams to advance technology and look toward transformational concepts and techno-economic assessments. He has 6 years of experience in field testing site management and sampling techniques for hazardous air pollutants and mercury control in combustion systems along with10 years of experience utilizing scanning electron microscopy (SEM), x-ray diffraction (XRD), and x-ray fluorescence (XRF) techniques to analyze coal, fly ash, biomass, ceramics, and high-temperature specialty alloys. He is also interested in computer modeling systems, high-temperature testing systems, and gas separation processes and is a FLIR Systems, Inc.-certified infrared thermographer.

Qualifications
B.S., Geological Engineering, University of North Dakota, 1994.
Associate Degree, Engineering Studies, Minot State University, 1989.

Professional Experience
2011–Present: Principal Engineer, Emissions and Carbon Capture Group Lead, EERC, UND. Mr. Kay's responsibilities include management of CO_2 separation research related to bench-, pilot-, and demonstration-scale equipment for the advancement of the technology. This also includes the development of cleanup systems to remove SO_x, NO_x, particulate, and trace elements to render flue gas clean enough for separation.

2005–2011: Research Manager, EERC, UND. Mr. Kay's responsibilities included the management and supervision of research involving the design and operation of bench-, pilot-, and demonstration-scale equipment for development of clean coal technologies. The work also involved the testing and development of fuel conversion (combustion and gasification) and gas cleanup systems for the removal of sulfur, nitrogen, particulate, and trace elements.

1994–2005: Research Specialist, EERC, UND. Mr. Kay's responsibilities included conducting SEM, XRD, and XRF analysis and maintenance; creating innovative techniques for the analysis and interpretation of coal, fly ash, biomass, ceramics, alloys, high-temperature specialty alloys, and biological tissue; managing the day-to-day operations of the Natural Materials Analytical Research Laboratory; supervising student workers; developing and performing infrared analysis methods in high-temperature environments; and performing field work related to mercury control in combustion systems.

1993–1994: Research Technician, Agvise Laboratories, Northwood, North Dakota. Mr. Kay's responsibilities included receiving and processing frozen soil samples for laboratory testing of chemical penetration, maintaining equipment and inventory, and training others in processing techniques utilizing proper laboratory procedures.

1991–1993: Teaching Assistant, Department of Geology and Geological Engineering, UND. Mr. Kay taught Introduction to Geology Recitation, Introduction to Geology Laboratory, and Structural Geology. Responsibilities included preparation and grading of assignments and administering and grading class examinations.

1990–1992: Research Assistant, Natural Materials Analytical Laboratory, EERC, UND. Mr. Kay's responsibilities included operating an x-ray diffractometer and interpreting and manipulating XRD data, performing software manipulation for analysis of XRD data, performing maintenance and repair of the XRD machine and sample carbon coating machine, preparing samples for XRD and SEM analysis, and performing point count analysis on the SEM.

Professional Memberships
ASM International
American Ceramic Society
Microscopy Society of America

Publications and Presentations
Has authored or coauthored numerous publications.

JASON D. LAUMB
Principal Engineer, Coal Utilization Group Lead
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, ND 58202-9018 USA
Phone: (701) 777-5114, Fax: (701) 777-5181, E-Mail: jlaumb@undeerc.org

Principal Areas of Expertise
Mr. Laumb's principal areas of interest and expertise include biomass and fossil fuel conversion for energy production, with an emphasis on ash effects on system performance. He has experience with trace element emissions and control for fossil fuel combustion systems, with a particular emphasis on air pollution issues related to mercury and fine particulates. He also has experience in the design and fabrication of bench- and pilot-scale combustion and gasification equipment.

Qualifications
M.S., Chemical Engineering, University of North Dakota, 2000.
B.S., Chemistry, University of North Dakota, 1998.

Professional Experience
2008–Present: Principal Engineer, Coal Utilization Group Lead, EERC, UND. Mr. Laumb's responsibilities include leading a multidisciplinary team of 30 scientists and engineers whose aim is to develop and conduct projects and programs on power plant performance, environmental control systems, the fate of pollutants, computer modeling, and health issues for clients worldwide. Efforts are focused on the development of multiclient jointly sponsored centers or consortia that are funded by government and industry sources. Current research activities include computer modeling of combustion/gasification and environmental control systems, performance of selective catalytic reduction technologies for NO_x control, mercury control technologies, hydrogen production from coal, CO_2 capture technologies, particulate matter analysis and source apportionment, the fate of mercury in the environment, toxicology of particulate matter, and in vivo studies of mercury–selenium interactions. Computer-based modeling efforts utilize various kinetic, systems engineering, thermodynamic, artificial neural network, statistical, computation fluid dynamics, and atmospheric dispersion models. These models are used in combination with models developed at the EERC to predict the impacts of fuel properties and system operating conditions on system efficiency, economics, and emissions.

2001–2008: Research Manager, EERC, UND. Mr. Laumb's responsibilities included supervising projects involving bench-scale combustion testing of various fuels and wastes; supervising a laboratory that performs bench-scale combustion and gasification testing; managerial and principal investigator duties for projects related to the inorganic composition of coal, coal ash formation, deposition of ash in conventional and advanced power systems, and mechanisms of trace metal transformations during coal or waste conversion; and writing proposals and reports applicable to energy and environmental research.

2000–2001: Research Engineer, EERC, UND. Mr. Laumb's responsibilities included aiding in the design of pilot-scale combustion equipment and writing computer programs that aid in the reduction of data, combustion calculations, and prediction of boiler performance. He was also involved in the analysis of current combustion control technology's ability to remove mercury and studying in the suitability of biomass as boiler fuel.

1998–2000: SEM Applications Specialist, Microbeam Technologies, Inc., Grand Forks, North Dakota. Mr. Laumb's responsibilities included gaining experience in power system performance including conventional combustion and gasification systems; a knowledge of environmental control systems and energy conversion technologies; interpreting data to predict ash behavior and fuel performance; assisting in proposal writing to clients and government agencies such as the National Science Foundation and the U.S. Department of Energy; preparing and analyzing coal, coal ash, corrosion products, and soil samples using SEM/EDS; and modifying and writing FORTRAN, C+, and Excel computer programs.

Professional Memberships
American Chemical Society

Publications and Presentations
Has coauthored numerous professional publications.

MELANIE D. JENSEN

Senior Chemical Engineer, CO_2 Capture and Infrastructure Team Lead
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5115, Fax: (701) 777-5181, E-Mail: mjensen@undeerc.org

Principal Areas of Expertise

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

Education and Training

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

Professional Experience

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

1985–2011: Research Engineer, EERC, UND. Ms. Jensen performed research in the areas of CO_2 capture and storage, reaction engineering, coal combustion, reburning, hazardous waste treatment, gas-phase particulate and mercury collection, photocatalytic processes, fuel production from biomass, contaminated water cleanup, and phytoremediation. She designed, developed, operated, and/or evaluated complex processes and equipment, including column CO_2 capture systems, high-pressure/high-temperature coal conversion systems, low-temperature plasma systems, and multicolumn sorption systems. She identified promising carbon sequestration opportunities by matching CO_2 capture technologies with point sources, pairing those combinations with nearby geologic sinks, and performing the preliminary compressor and pipeline specifications. She evaluated and compared characterization, remediation, and decontamination technologies for application to waste treatment/cleanup programs. Ms. Jensen developed statistically designed experimental matrices; tracked, reduced, and interpreted data generated during research projects; and derived empirical models describing system behavior. Ms. Jensen also developed integrated, multiproject programs to meet both the immediate and long-term needs of clients; prepared or assisted with the preparation of proposals and supporting documentation; developed comprehensive QA/QC plans; and prepared patent applications. Her project management activities included detailed program planning; scheduling of equipment and personnel; budget monitoring; maintenance of project schedules, dissemination of research results through reports, papers, and presentations; and communicating with clients.

Patents

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

Publications

Has authored or coauthored numerous publications.

Appendix F – Industry Sponsors' Letters of Commitment

Carroll L. Dewing
Vice President – Operations

Direct Dial: (701) 873-7207
E-mail: carroll.dewing@nacoal.com

April 3, 2017

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

Re: Support and Commitment to Project Entitled "Resource Recovery from a Coal-Fired Power Plant to Enhance Agricultural Production in Open Field and Greenhouse Facilities."

Dear Ms. Fine:

The North American Coal Corporation ("NACoal") supports the proposed project to enhance agricultural production through the utilization of lignite-fired industry resources. We are looking forward to working with our co-sponsors, Great River Energy (Coal Creek Station) and Knorr Farms, and with North Dakota State University and University of North Dakota, on the project. We think identifying and developing mutually beneficial links between two of North Dakota's largest industries (agriculture and energy) is exciting.

NACoal is pleased to provide $17,000 cash cost-share for the project. In addition, as described in the proposal, NACoal will be providing up to $33,000 of in-kind services to the project.

If you have questions or require additional information, please contact Mr. Gerard Goven, Senior Geologist, The Falkirk Mining Company. Mr. Goven's direct office number is (701) 250-2604 and his email address is gerard.goven@nacoal.com.

Regards,

THE NORTH AMERICAN COAL CORPORATION

Carroll L. Dewing
Vice President – Operations

5340 Legacy Drive, Building 1, Suite 300, Plano, Texas 75024-3141 • 972-239-2625 • Fax 972-387-1328 • www.nacoal.com

GREAT RIVER ENERGY

12300 Elm Creek Boulevard
Maple Grove, Minnesota 55369-4718
763-445-5000
greatriverenergy.com

April 6, 2017

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

Re: Support and commitment to project entitled "Resource Recovery from a Coal Fired Power Plant to Enhance Agricultural Production in Open Field and Greenhouse Facilities"

Dear Ms. Fine:

Great River Energy (GRE) supports the proposed project to enhance agricultural production through the utilization of lignite-fired industry resources. We look forward to working with our co-sponsors (North American Coal and Knorr Farms) and the North Dakota universities on the project.

As a cost share for the project GRE will be providing $17,000 cash. In addition, as defined in the project, GRE will be providing an estimated $33,000 of in-kind services to the project.

If you have questions or require additional information, please contact Mr. Rich Garman, Senior Project Manager, Great River Energy. Mr. Garman's direct office number is (701) 250-2160 and his email address is rgarman@GREnergy.com.

Yours truly,

GREAT RIVER ENERGY

Eric J. Olsen
Vice President and General Counsel

KNORR FARMS

Knorr Farms ND
3409 21st ST SE
Minot, ND 58701
March 30, 2017

Ms. Karlene Fine
Executive Director
ATTN: Lignite Research Program
North Dakota Industrial Commission
600 East Boulevard Avenue
Bismarck, ND 58505-0840

Re: Support and Commitment to Project Entitled "Resource Recovery from a Coal-Fired Power Plant to Enhance Agricultural Production in Open Field and Greenhouse Facilities".

Dear Ms. Fine,

Knorr Farms ND is excited to support the project. As an agricultural producer seeing the potential deliverables of this project are extremely exciting. We want to bridge a gap between Ag and Energy and rely on each other strength's. We firmly believe that Agricultural and the Energy Sectors can mutually benefit from this project.

Knorr Farms ND is excited to support the project with a cash contribution of $12,500 and up to $37,500 of in-kind contribution.

Please do not hesitate to call with any additional questions.

Sincerely,

Steve Knorr
Knorr Farms ND
701-720-0356
steveknorr@hotmail.com

Appendix G – Industry Sponsors’ Letters of Support

ELEVATION

Michael R. Miller
701.240.5799
mr.miller1997@gmail.com

1912 Valley Bluffs Drive
Minot, ND 58701

3.20.17

To Whom It May Concern:

Being a native of North Dakota growing up with a hand in agriculture on the farm, I know the importance of food in society. Providing a sustainable dining experience has always been a goal of mine to accomplish in the food sector up in the Midwest region.

I started in the food and beverage industry 20 years ago. I have experience working in North Dakota, Minnesota, California and Arizona where I have garnered knowledge and experience on all parts of the restaurant industry, and have seen firsthand the global shift in society of wanting fresh food products.

With my vast knowledge and experience, I returned to Minot in 2008 to open Big Time Bistro, a successful restaurant based on fresh ingredient sandwiches in downtown Minot. After six years, I made the decision to close Big Time Bistro as I was offered the opportunity to be a part of the community in a larger way by opening an upscale casual restaurant at the new Minot Country Club. I created Elevation restaurant utilizing all of my previous skills and on the premise of providing the Minot community with a dining experience like no other.

I am a passionate Minot advocate who strives to provide my customer base with a great quality product. In today's society, there has been a social movement for restaurants to provide their customers with fresh, 'farm-to-fork' products and knowing where your food comes from. In the Midwest, one of the largest challenges we face as restaurant owners is getting fresh, local products at a cost efficient price year-round. A majority of the costs comes from shipping of products. As a retailer, I want a consistent product year-round which currently doesn't exist.

Sincerely,

Michael Miller
President, Bev Naps Inc.