EERC
Energy & Environmental Research Center

UNIVERSITY OF NORTH DAKOTA
15 North 23rd Street — Stop 9018 / Grand Forks, ND 58202-9018 / Phone: (701) 777-5000 Fax: 777-5181
Web Site: www.undeerc.org

April 30, 2010

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

Dear Ms. Fine:

Subject: EERC Proposal No. 2010-0247

The Energy & Environmental Research Center (EERC) of the University of North Dakota is pleased to submit the subject proposal and is committed to completing the project as described in this proposal if the Commission makes the requested grant.

Enclosed please find an original and one copy of the proposal entitled "Promoting Standardization of Combustion Characteristics for Biofuels." Also enclosed is the $100 application fee.

If you have any questions, please contact me by telephone at (701) 777-5057 or by e-mail at cnyberg@undeerc.org.

Sincerely,

Carolyn M. Nyberg
Manager, Analytical Research Laboratory

Approved by:

Dr. Gerald H. Groenewold, Director
Energy & Environmental Research Center

CMN/kmd

Enclosures

EERC
Energy & Environmental Research Center

PROMOTING STANDARDIZATION OF COMBUSTION CHARACTERISTICS FOR BIOFUELS

EERC Proposal No. 2010-0247

Submitted to:

Karlene Fine

North Dakota Industrial Commission
State Capitol – 14th Floor
600 East Boulevard Avenue, Department 405
Bismarck, ND 58505-0840

Amount of Request: $50,000
Total Amount of Proposed Project: $110,000
Duration of Project: 15 months

Submitted by:

Carolyn M. Nyberg
Bruce C. Folkedahl

Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Carolyn M. Nyberg, Project Manager

for Dr. Gerald H. Groenewold, Director
Energy & Environmental Research Center

April 2010

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PROMOTING STANDARDIZATION OF COMBUSTION CHARACTERISTICS FOR BIOFUELS

ABSTRACT

As the U.S. power industry prepares to comply with pending regulations for greenhouse gas (GHG) emissions, many are considering biomass fuels as an option to reduce CO_2 or to meet renewable fuel mandates. Incorporating biomass as a fuel source for electric utilities will also help reduce the overall emissions of hazardous air pollutants (HAPs) from power plants. This renewed interest in biomass as a fuel source has led to a large increase in the need for characterization of suitable biofuels for energy production. However, the United States lacks consistency regarding the use of testing methods for biofuels when evaluating combustion and fuel quality parameters. Many European countries have been utilizing biomass as a fuel for energy production for decades and have established suitable methods for biomass chemical characterization (1). The European Committee for Standardization (CEN) works with the International Organization for Standardization (ISO) to ensure consistency among European countries utilizing biomass fuels. As the United States moves forward with its use of alternative fuels, it must work with ISO and other standards committees to ensure the use of appropriate test methods for biofuels (2). By establishing a list of consistent, reliable methods for biofuel characterization, the industry will be able to easily compare fuel quality results among different fuels analyzed by different laboratories and have confidence that the results can be traced back to common reference methods.

Objective: This project will establish appropriate test methods and Standard Reference Methods (SRMs) for the chemical characterization of biofuels to assess combustion and fuel quality parameters and promote their use to ensure a level playing field among all sectors of the industry.

Expected Results: Results include 1) a widely accepted list and/or book of standard test methods for the detailed chemical and combustion characterization of biofuels; 2) detailed chemical characterization information, including slagging behavior, for select biofuels that have been agreed upon by project participants, but at a minimum will include five dominant North Dakota biomass materials; 3) dissemination of information and promotion of standardized testing methods for biofuels to ensure consistency among the industry (at least one committee meeting and two conferences will be attended during the project); and 4) initial development of biomass SRMs.

Participants: EERC, U.S. Department of Energy (DOE) through the Center for Biomass Utilization® (CBU®), the Electric Power Research Institute, Metso Power, North Dakota State University, and Great River Energy.

Duration: 15 months **NDIC Cost:** $50,000 **Total Project Cost:** $110,000

PROJECT DESCRIPTION

Objectives

The overall goal of this project is to establish appropriate test methods and SRMs for biomass characterization that are acceptable and reproducible and promote their use to ensure a level playing field among all sectors of the industry. The objectives include:

- Evaluation of current standards and test methods and determination of the most appropriate for biomass.
- Selection of common biofuels and characterization using the accepted standards determined in the first objective, along with additional information regarding slagging behavior through modeling.
- Promotion of appropriate and reliable test methods among industry through involvement in standards committees and dissemination of information at conferences.
- Evaluation of suitable biomass candidates for the development of standard reference materials.

Methodology

The proposed scope of work for this project will be divided into the following tasks.

Task 1 – Assessment of Current Biomass Standards. Many standard methods and SRMs are available for fossil fuels; however, the methods and materials that many laboratories are utilizing for fossil fuels are not always applicable to biofuels. Currently, there are efforts by several standards organizations and committees to evaluate existing biomass standards and develop new standards where needed. To follow the progress of these efforts, the Energy & Environmental Research Center (EERC) will take an active role in these committees. Currently, two EERC researchers are members of the American Society of Agricultural and Biological Engineers (ASABE) FPE-709 committee, Biomass Energy and Industrial Products, which is working diligently to compile appropriate standards for the characterization of biofuels in the United States. This committee has established a working group, X564, to gather information and standards from several reputable organizations such as the ISO, the CEN, and ASTM International. The combined objective of this task and goal of the X564 working group is to develop a list and/or book of reliable chemical and fuel quality testing methods that are suitable for biofuels and accepted by industry.

Task 2 – Fuel Selection and Characterization. This task will include the selection of eight to ten biomass candidates that are predominantly being using in the United States for energy production. Fuel selection for this project will be based on a joint decision among project participants; however, it is expected that the candidates will include wood chips, corn stover, switchgrass, and wheat straw. NDSU will play a key role in identifying the dominant North Dakota varieties of biomass, which will also be some of the same samples that will be processed under its North Dakota Industrial Commission (NDIC) project (R008-G) entitled Biomass Testing Laboratory for Physical and Thermal Characteristics of Feedstock of North Dakota. Great River Energy will also advise on the selection of suitable North Dakota biomass samples. The final selection of biomass samples will be fully characterized to evaluate fuel quality and combustion characteristics. Analytical parameters will include proximate analysis (moisture, ash, volatile matter, and fixed carbon), ultimate analysis (carbon, hydrogen, nitrogen, sulfur, and oxygen), halogens (bromine, chlorine, and fluorine), ash chemistry (major and minor oxides), trace elements (arsenic, lead, mercury, selenium, etc.), ash fusibility, and bulk density. Methods used to analyze for these parameters will be determined based on the information obtained in Task 1. Initial characterization will be done in EERC laboratories, and splits will be sent to at least one other outside laboratory to help determine reproducibility of the methods among different laboratories.

Task 3 – Technology Transfer and Standards Promotion. Through the CBU Program, the EERC has an excellent opportunity to promote biomass standards throughout the United States by presenting important information at biomass conferences and workshops and networking with industry through involvement in standards committees as discussed in Task 1. It is anticipated that two conferences and one committee meeting will be attended during this project. All of the travel will be covered by the overall management activity of the CBU Program. With the publication of widely accepted biomass standards, industry can be assured that analytical results of different biofuels from different laboratories can be compared with confidence knowing that results can be traced back to a common reference method.

Task 4 – Predicting Slagging Behavior of Biofuels. In addition to the fuel characteristics obtained in Task 2, other important fuel information, such as slagging behavior, will be obtained through equilibrium thermodynamic modeling which is used to predict the amount and composition of gases, liquids, liquid solutions, solids, and aqueous liquids present in a system over a range of temperatures and pressures. This composition is

then used to calculate the slag viscosity. The modeling program is called FactSage, which is a commercial integrated thermodynamic database coupled to programs developed to calculate multicomponent, multiphase equilibria based on a minimization of Gibbs' free energy. At least 700 elements and compounds are considered in the calculations. Each of the biomass samples selected for this project will be analyzed with the FactSage modeling program. It is also possible to calculate biomass–coal blends by using a weighted average of the analytical results of the coal and biomass.

Task 5 – Setting the Stage for the Development of Biomass Standard Reference Materials. SRMs supplied by the National Institute of Standards and Technology (NIST) and other agencies are a vital part of methods development and validation for analytical laboratories when various materials are tested. Although many SRMs are available for fossil fuels such as coal, petroleum coke, and oil, the availability of biomass SRMs is extremely limited. Through the completion of the tasks listed above, valuable information will be obtained regarding the suitability of several biomass materials to be used as biofuels. This, along with complete characterization of select fuels using appropriate standardized methods, several biomass candidates will be available for the development of SRMs. Large quantities of these materials will be generated and sent to NIST for additional analysis, packaging, and distribution.

Anticipated Results

The anticipated results are appropriate, reliable, and reproducible standard test methods for the detailed chemical and combustion characterization of biofuels. The use of these methods for the chemical characterization of several biomass fuels will result in valuable information regarding fuel quality for the use of biomass fuels as an alternative to fossil fuels to help reduce GHG emission and potential HAPs. The final deliverable is to give those involved in the biomass and energy industries confidence in the test methods available for biofuels characterization.

Facilities and Resources

The majority of work for this project will be conducted at the EERC in Grand Forks, North Dakota. Since its founding in 1949, the EERC has conducted research, testing, and evaluation of fuels, combustion and gasification technologies, emission control technologies, ash use and disposal, analytical methods, groundwater, waste-to-energy systems, and advanced environmental control systems. The main EERC facilities, with 245,000 square

feet of technology demonstration facilities, fuel prep facilities, analytical laboratories, and office space, are located on the southeast corner of the University of North Dakota campus. State of the art laboratory- and pilot-scale equipment is available for evaluating various fuels, including coal, biomass, and refuse-derived fuel. The following fuel preparation facilities and laboratories within the EERC will be utilized in this project.

Fuel Preparation Facility. The EERC has conducted numerous resource assessments on a variety of biomass types, including wheat straw, rice straw, alfalfa, flax straw, animal manures or litter, corn stover, switchgrass, beet tailings, potato residues, hybrid poplar, sunflower hulls, municipal solid waste, sewage sludge, paper mill sludge, lignin from cellulosic ethanol processing, and many types of wood residue. The Fuel Preparation Facility includes a walk-in trailer for biomass hauling and temporary storage; a batch autoclave that operates up to 2200 psi; a 7.5-ton/day coal or biomass continuous process development unit; and complete fuel-handling, crushing, shredding, and chipping preparation facilities for developing and testing process methods for fuel preparation.

Analytical Research Laboratory. The Analytical Research Laboratory (ARL) is equipped for routine and specialized analyses of inorganic and organic constituents, which are performed using state-of-the-art instrumental procedures as well as classical wet chemistry. Established analytical techniques allow for the chemical characterization of a variety of environmental and biological sample types, including fossil fuels, biomass, combustion by-products, geologic materials, fine particulate matter, groundwater, wastewater, fish tissue, and plant materials. Particular attention is directed toward major, minor, and trace element chemical analysis. Major instrumentation includes VG PQ ExCell inductively coupled plasma–mass spectrometer (ICP–MS) with collision cell technology, Perkin Elmer Optima 2100 inductively coupled plasma–atomic emission spectrometer (ICP–AES), CETAC M6000A cold-vapor atomic absorption spectrometer (CVAAS) mercury analyzer, PS Analytical Millennium Merlin cold-vapor atomic fluorescence spectrometer (CVAFS), PS Analytical Millennium Excalibur hydride generation atomic fluorescence spectrometer (HGAFS), Varian Spectra AA-880Z graphite furnace atomic absorption spectrometer (GFAAS), Mitsubishi TOX-100 chlorine analyzer with oxidative hydrolysis microcoulometry, and Dionex ISC3000 ion chromatograph (IC) with conductivity detection.

Fuels and Materials Research Laboratory. The Fuels and Materials Research Laboratory (FMRL) is an integrated and fully equipped laboratory designed for testing of fuel quality parameters. The laboratory provides support for many EERC research programs. In addition to performing standard ASTM fuel testing such as proximate, ultimate analyses, and heating value, the FMRL provides a wide variety of other testing: surface area determination, laser particle sizing, dry and wet sieve analysis, and ash fusion. Major and minor equipment includes Leco TGA-701 analyzer – for the determination of moisture, volatile matter, and ash analysis; Leco TruSpec CHN analyzer, for the determination of carbon, hydrogen, and nitrogen which is part of the ultimate analysis for fuels; Leco TruSpec Sulfur analyzer; Leco AC-350 isoperibol calorimeter to determine heating values in fuels; Malvern 2600 particle-size analyzer, to detect particles in the range of 0.5 to 564 μm; fusibility of coal and coke ash furnace to predict the deformation properties of the ash; facilities for sieving, grinding, and sample preparation. The lab utilizes a variety of equipment to prep sample for analysis, iIncluding several types of grinders, pulverizers, and a Micron Powder system for typical combustion prep. Physical tests are also performed, including wet-sieve analysis, dry-sieve analysis, and bulk density.

Techniques to Be Used, Their Availability, and Capability

Table 1 lists all the chemical and fuel quality parameters that will be tested in this project. Although specific methods and test conditions are yet to be determined as a result of the methods assessment in Task 1, general analytical techniques can be listed. All equipment required for this testing is available in the laboratories at the EERC along with experienced and proficient staff to conduct the analyses.

Environmental and Economic Impacts While Project Is under Way

Sample collection for this project will have no environmental impact. Samples for this project will have already been generated and collected for use in other operations or generated from different projects. No additional samples will be generated under this project. The use of reagents and chemicals needed for the characterization of the biomass samples will be properly handled and disposed of according to the University of North Dakota's (UND's) Waste Disposal Management System.

Table 1. Chemical and Fuel Quality Parameters to Be Determined

Parameter	Technique
Proximate (moisture, ash, volatile matter, fixed carbon)	Automated TGA[1]
Carbon, Hydrogen, Nitrogen	High-temperature combustion followed by IR[2] detection for carbon and hydrogen, and TC[3] detection for nitrogen
Sulfur	High-temperature combustion followed by IR detection
Halogens (bromine, chlorine, and fluorine)	Pyrohydrolysis followed by ion chromatography
Heating value	Isoperibol calorimeter
Ash Chemistry (major and minor oxides)	X-ray fluorescence spectrometry
Trace Elements (arsenic, lead, mercury, selenium, etc.)	Digestion followed by ICP-AES and/or GFAAS
Ash Fusibility	Observation of melting behavior in a controlled furnace
Bulk Density	Mass/volume using a standardized measuring container
Thermodynamic Modeling	FactSage

[1] Thermogravimetric analysis.
[2] Infrared.
[3] Thermal conductivity.

Ultimate Technological and Economic Impacts

The information collected from this project, along with the promotion of quality test methods for biofuels, will provide confidence to the energy sector in North Dakota as well as the United States regarding the overall quality of fuels used for electricity production. In the efforts to reduce GHG and HAP emissions, this will ultimately promote the use of biomass fuels as an alternative to fossil fuels, which will promote rural economic health and growth

Why the Project Is Needed

As the United States prepares to regulate GHG emissions, such as CO_2, the energy sector is looking toward the use of alternative fuels, such as biomass, to reduce these emissions. With this increased interest in biomass as a fuel, more and more laboratories will be asked to analyze both biofuels *and* fossil fuels for combustion characteristics and fuel quality parameters. By evaluating the most appropriate methods for biomass and establishing a list of consistent, reliable methods for their characterization, the energy industry will be able to easily compare fuel quality results among different fuels analyzed by different laboratories and have confidence that the results can be traced back to common reference methods.

STANDARDS OF SUCCESS

The deliverables of this project include a widely accepted list and/or book of standard test methods for the detailed chemical characterization of biofuels, detailed characterization information, including slagging behavior,

for select biofuels that have been chosen by sponsors, promotion and dissemination of information regarding standardized testing methods for biofuels to ensure consistency among the industry, initial development of biomass SRMs, and timely project reports.

The key industries in North Dakota that will benefit from the results of this project are the agricultural and energy industries. The development and implementation of reliable test methods for biomass will instill confidence in those generating and using biomass materials. An important part of this project is the promotion of standardized test methods through presentations at conferences and discussions within standards committees. These venues provide an excellent opportunity to reach members of the private and commercial sectors as well as general interest groups. As more and more quality information is made available regarding the fuel characteristics of North Dakota's renewable energy resources (e.g., biomass), research and marketing of these materials will be enhanced. Ultimately, the increased use of renewable fuels in North Dakota will result in newly created jobs by expanding the industry.

BACKGROUND/QUALIFICATIONS

The EERC is one of the world's major energy and environmental research organizations. Since its founding in 1949, the EERC has conducted research, testing, and evaluation of fuels, combustion and gasification technologies, emission control technologies, ash use and disposal, analytical methods, groundwater, waste-to-energy systems, and advanced environmental control systems. The EERC has established working relationships with nearly 1100 clients in 51 countries and all 50 states, including federal and state agencies, universities, coal companies, utilities, research and development firms, equipment vendors, architecture and engineering firms, chemical companies, and agricultural products companies. The EERC emphasizes true working partnerships among private industry, government agencies, academic institutions, and the research community. Thus the EERC is committed to a partnership team approach for energy and environmental technologies.

The Centers for Renewable Energy and Biomass Utilization are a designated Center of Excellence located at the EERC. The Centers conduct critical research, development, demonstration, and commercial deployment of technologies utilizing biomass, wind, solar, geothermal, and hydroelectric energy sources. Under the CBU, the EERC offers the most comprehensive approach to biomass conversion research.

Metso Power, which is financially supporting this project, is the forerunner in fluidized-bed combustion technology to power plants combusting coal, biomass, and other fuels. Metso's in-depth combustion know-how and comprehensive understanding of the many fuel properties, such as bed behavior, corrosion, plugging, and fouling, bring valuable expertise to this project. Metso is committed to combating climate change by providing advanced emission management solutions in the development and production of greener energy.

Personnel

Ms. Carolyn Nyberg, EERC Analytical Research Laboratory Manager, will serve as Project Manager for this project. Ms. Nyberg's principal areas of interest and expertise include AAS (flame, graphite furnace, and hydride generation), CVAAS, ICP–AES, Ontario Hydro (OH) method and U.S. Environmental Protection Agency (EPA) Method 29 sampling and analysis, microwave digestion methods, and trace element analysis of various fuels and by-products, including coal, biomass, fly ash, and flue gas desulfurization materials. A member of two committees dedicated to the development and maintenance of standardized test methods for fuels: the ASTM D05 committee on Coal and Coke and the ASABE FEP-709 committee on Biomass Energy and Industrial Products, she has been with the EERC for 20 years. She received her B.S. in Biology and B.S.Ed. from UND.

Dr. Donald McCollor, a Technical Manager at the EERC, will serve a principal investigator for this project and will be responsible for the modeling effort proposed in Task 4. His areas of expertise and principal areas of interest include coal combustion kinetics and inorganic transformation and deposition processes. He has extensive experience in the collection, analysis, and interpretation of data from bench-, pilot-, and full-scale combustion systems and in the development of predictive models to assess combustion and slagging behavior as a result of inorganic constituents. Dr. McCollor has been with the EERC for 27 years. He received his B.A. in Chemistry from the University of Minnesota, Morris, and his Ph.D. in Physical Chemistry from UND.

Dr. Bruce Folkedahl, a Senior Research Manager at the EERC, will serve as a research advisor for this project and will be responsible for the overall project management for the EERC CBU, which is cofunding this project. His principal areas of expertise include coal inorganic transformation and disposition, biomass conversion to energy, biomass to fuels and chemicals, and development of methodologies to mitigate the effects of inorganic components of the performance of combustions, gasification, and air pollution control systems. He

has been with the EERC for 17 years and has a B.S in Computer Science from the University of North Dakota and a Ph.D. in Materials Science and Engineering from the Pennsylvania State University.

Dr. Igathinathane Cannayen and Dr. Cole Gustafson from North Dakota State University will offer biomass selection advice regarding the most appropriate North Dakota biomass types for fuel candidates. They have recently received funding from the NDIC REP to establish a Biomass Testing Laboratory, which will focus on physical and thermal characteristics of North Dakota feedstock and densified biomass. These properties along with the chemical characteristics and slagging properties proposed in this project will provide a thorough and full evaluation of select North Dakota biofuels.

MANAGEMENT

Ms. Carolyn Nyberg, EERC Analytical Research Laboratory Manager, will serve as Project Manager for this project. She will have the overall responsibility for the contract and will communicate regularly will all project sponsors and participants. She will be responsible for contractual reporting to the NDIC REP, DOE, and other industry partners. Other members of the project management team will include Donald McCollor and Bruce Folkedahl. Resumes of key personnel are enclosed in Appendix A.

Internal project review meetings will be scheduled to ensure that all analytical activities in this project are completed in a timely manner according the project schedule. Quarterly reports will be prepared for project sponsors with updated results, as well as final a report at project completion. Information will also be disseminated through presentations at two biomass conferences.

TIMETABLE

Figure 1 outlines the schedule of project activities. All of the travel will be covered by the overall management activity of the CBU Program.

BUDGET

The EERC is requesting $50,000 from the NDIC Renewable Energy Program. Additional funding details can be found in Appendices B and C. Total expected project cost is $110,000. This budget is necessary to adequately address the tasks proposed in this project. The scope of work developed for the overall project funding assumes funding is received from the NDIC, DOE, and two commercial sponsors. Initiation of the proposed work is

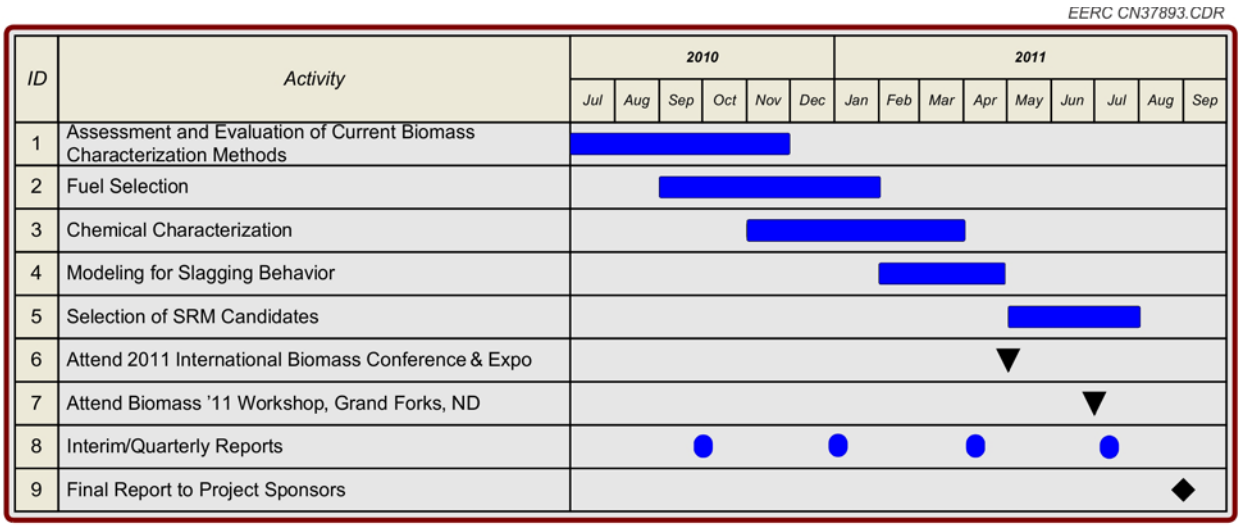

Figure 1. Time line of project activities.

contingent upon the execution of a mutuallkiy negotiated agreement or modification to an existing agreement between our organizations. A detailed budget and accompanying budget notes are enclosed in Appendix B.

TAX LIABILITY

The EERC—a research organization within UND, which is an institution of higher education with the state of North Dakota—is not a taxable entity.

CONFIDENTIAL INFORMATION

No confidential information is included in this proposal.

PATENTS/RIGHTS TO TECHNICAL DATA

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

REFERENCES

1. European Committee of Standardization. www.cen.eu (accessed Oct 2009).
2. Gibson, L. Industry News, ISO Looks for Help to Develop International Solid Biofuels Standards. *Biomass Magazine* **2009**, *11*, 21.

APPENDIX A

RESUMES OF KEY PERSONNEL

CAROLYN M. NYBERG
Laboratory Manager/Research Chemist
Analytical Research Laboratory (ARL)
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) 777-5057, Fax: (701) 777-5181, E-Mail: cnyberg@undeerc.org

Principal Areas of Expertise

Ms. Nyberg's principal areas of interest and expertise include atomic absorption spectroscopy (AAS) (flame, graphite furnace, and hydride generation), cold-vapor atomic absorption spectroscopy (CVAAS), inductively coupled plasma–atomic emission spectroscopy (ICP–AES), Ontario Hydro (OH) and U.S. Environmental Protection Agency (EPA) Method 29 sampling and analysis, microwave digestion methods, trace element analysis of various fuels and by-products including coal, biomass, fly ash, and FGD materials, as well as leaching characterization of coal fly ash for environmental impacts.

Qualifications

B.S.Ed., Education and Science, University of North Dakota, 1986.
B.S., Biology with Chemistry minor, University of North Dakota, 1984.
Specialized training courses include graphite furnace AAS (1995), x-ray fluorescence spectrometry (1999), inductively coupled plasma mass spectrometry (2001), CVAAS (2003), and bloodborne pathogens (2007).

Professional Experience

1990–Present: Laboratory Manager/Research Chemist, ARL, EERC, UND. Ms. Nyberg manages the day-to-day operation of the ARL, including scheduling samples and laboratory staff workloads and preparing research proposals, reports, and scientific publications. Additional duties include coordinating the financial aspects and contractual obligations of the ARL.

1988–1990: Laboratory Technician IV, Department of Biology, UND. Ms. Nyberg's responsibilities included assisting professors by conducting radioimmunoassays to understand the reproductive cycles of sandpipers and salmon.

1987–1988: Soil Technician, Minnesota Valley Testing Laboratories, Grand Forks, North Dakota. Ms. Nyberg's responsibilities included testing for a variety of soil parameters including pH, texture, organic matter, and numerous soil nutrients.

Research Experience

- Emission sampling and analysis of hazardous air pollutants using EPA Method 29
- Nickel speciation of residual oil fly ash
- Verification and implementation of the OH method for Hg speciation for various emission-testing programs
- Leaching characterization of coal combustion by-products (CCBs) for environmental impact
- ICP–AES methods development for fly ash and related CCBs
- Selenium mobility as it relates to overburden in post-coal-mining environments
- Determination of trace metals in biological tissues

Professional Memberships
Member, ASTM International Committee D05 Coal and Coke, 1996–Present
Member, American Society of Agricultural and Biological Engineers (ASABE) Committee FPE-709, Biomass Energy and Industrial Products, 2009–Present

Publications and Presentations
Has authored or coauthored numerous publications.

DR. BRUCE C. FOLKEDAHL
Senior Research Manager
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5243, Fax: (701) 777-5181, E-Mail: bfolkedahl@undeerc.org

Principal Areas of Expertise

Dr. Folkedahl's principal areas of interest and expertise include biomass conversion to energy; biomass to fuels and chemicals; and development of methodologies to mitigate the effects of inorganic components on the performance of combustion, gasification, and air pollution control systems; fuel inorganic transformations and deposition and development of predictive models to assess these processes. He is also interested in the study and development of high-temperature materials for aggressive environments and the kinetics of mercury speciation in combustion systems.

Qualifications

Ph.D., Materials Science and Engineering, Pennsylvania State University, 1997.
B.S., Computer Science, University of North Dakota, 1990.

Professional Experience

2001–Present: Senior Research Manager, EERC, UND. Dr. Folkedahl's responsibilities include studies of biomass combustion in conjunction with conventional combustion for electricity generation; research on the fundamental mechanisms of ash deposition and fouling during cofiring of biomass fuels with coal; process development for the conversion of biomass feedstocks to fuels, chemicals, and value-added products; and studies of corrosion and development of high-temperature materials to withstand aggressive combustion environments.

2000–2001: Product Manager, 3M Industrial Mineral Products Division, Little Rock, Arkansas. Dr. Folkedahl's responsibilities included managing a crushing and screening business unit 24-hr/day, 7-day/week manufacturing operation, including hiring, training, and directing 40 employees; managing a $12,000,000 annual budget; forecasting budgets; developing and implementing cost reduction plans; and developing automated labor-reducing equipment and routines.

1999–2000: Senior Product Engineer, 3M Industrial Mineral Products Division, St. Paul, Minnesota. Dr. Folkedahl's responsibilities included developing ceramer-coated roofing granules, developing automated dry powder-handling system for slurry-making process, investigating the mechanism of fluorine alkalinity reduction and coating enhancement in roofing granules, and investigating mechanisms of rust formation in mild steel storage tanks for roofing granules.

1994–1998: Graduate Assistant, Pennsylvania State University, University Park, Pennsylvania. Dr. Folkedahl's responsibilities included proctoring and grading exams and teaching lab classes. Thesis work consisted of development of a neural network model of inorganic ash viscosity in high-temperature systems; development of an image analysis program to identify graphitizability of cokes; and statistical cluster analysis of the chemical composition of ash deposits in electrical generation boilers.

1989–1999: Research Scientist, EERC, UND. Dr. Folkedahl's projects and responsibilities included corrosion studies of high-temperature alloys, modeling of slag and silicate material viscosities, and crystallization studies of coal. Other responsibilities included design, development, and maintenance of

analytical software; development and implementation of new analysis techniques; and operation and performance analysis with x-ray diffraction, x-ray fluorescence, scanning electron microscopy, and processing and manipulation of raw data.

Publications and Presentations
Has authored or coauthored over 40 publications, including technical contract reports, symposium papers, and journal articles.

DR. DONALD P. MCCOLLOR
Technical Manager
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5121, Fax: (701) 777-5181, E-Mail: dmccollor@undeerc.org

Principal Areas of Expertise

Dr. McCollor's principal areas of interest and expertise include coal transformation kinetics and inorganic transformation and deposition processes. He has extensive experience in the collection, analysis, and interpretation of data from bench-, pilot-, and full-scale combustion and gasification systems and in the development of predictive models to assess combustion gasification and ash deposition behavior.

Qualifications

Ph.D., Physical Chemistry, University of North Dakota, 1981.
B.A., Chemistry, University of Minnesota, Morris, 1974.

Professional Experience

1983–Present: Technical Manager, EERC, UND. Dr. McCollor's responsibilities include design, construction, and operation of equipment and instrumentation for combustion and gasification research; analysis and interpretation of results from bench-, pilot-, and full-scale testing; and development of models to predict ash transformations and deposition.

1981–1983: AWU Postdoctoral Fellow and Research Chemist, Grand Forks Energy Technology Center, U.S. Department of Energy, Grand Forks, North Dakota. Dr. McCollor's responsibilities included conducting research to characterize inorganic species in coal and products from coal combustion. Computer-based statistical and data reduction methods were extensively used to interpret data from a variety of analytical instruments. Position included research to develop and modify sampling techniques and analytical methods.

Professional Memberships

American Chemical Society
American Crystallographic Association
North Dakota Academy of Science

Publications and Presentations

Has authored or coauthored numerous publications.

APPENDIX B

BUDGET AND BUDGET NOTES

PROMOTING STANDARDIZATION OF COMBUSTION CHARACTERISTICS FOR BIOFUELS
NDIC
PROPOSED PROJECT START DATE: 7/1/10
EERC PROPOSAL #2010-0247

BUDGET

CATEGORY			TOTAL		NDIC SHARE		INDUSTRY SHARE		DOE-CBU SHARE	
LABOR		Rate	Hrs	Cost	Hrs	Cost	Hrs	Cost	Hrs	Cost
Nyberg, C.	Project Manager	$ 37.33	242	$ 9,034	55	$ 2,053	175	$ 6,533	12	$ 448
McCollor, D.	Principal Investigator	$ 42.53	90	$ 3,828	30	$ 1,276	20	$ 851	40	$ 1,701
Folkedahl, B.	Project Advisor	$ 55.79	10	$ 558	-	$ -	-	$ -	10	$ 558
----------	Senior Management	$ 70.17	29	$ 2,035	1	$ 70	-	$ -	28	$ 1,965
----------	Research Technicians	$ 25.08	50	$ 1,254	-	$ -	-	$ -	50	$ 1,254
----------	Technology Dev. Mechanics	$ 29.23	30	$ 877	30	$ 877	-	$ -	-	$ -
----------	Technical Support Services	$ 20.02	25	$ 501	10	$ 200	9	$ 180	6	$ 121
				$ 18,087		$ 4,476		$ 7,564		$ 6,047
Escalation Above Base		6%		$ 1,085		$ 269		$ 454		$ 362
TOTAL DIRECT HRS/SALARIES			476	$ 19,172	126	$ 4,745	204	$ 8,018	146	$ 6,409
Fringe Benefits - % of Direct Labor - Staff		54.0%		$ 10,353		$ 2,562		$ 4,330		$ 3,461
TOTAL FRINGE BENEFITS				$ 10,353		$ 2,562		$ 4,330		$ 3,461
TOTAL LABOR				$ 29,525		$ 7,307		$ 12,348		$ 9,870
OTHER DIRECT COSTS										
SUPPLIES				$ 915		$ 330		$ 100		$ 485
COMMUNICATION - LONG DISTANCE & POSTAGE				$ 100		$ 20		$ 27		$ 53
PRINTING & DUPLICATING				$ 78		$ 33		$ 25		$ 20
OPERATING FEES & SVCS										
Natural Materials Analytical Res. Lab.				$ 12,775		$ -		$ -		$ 12,775
Fuels & Materials Research Lab.				$ 11,620		$ 8,300		$ -		$ 3,320
Analytical Research Lab.				$ 9,932		$ 9,932		$ -		$ -
Fuel Prep. and Maintenance				$ 1,081		$ 1,081		$ -		$ -
Graphics Support				$ 323		$ -		$ -		$ 323
Shop & Operations Support				$ 47		$ 47		$ -		$ -
Outside Lab.				$ 4,200		$ 4,200		$ -		$ -
TOTAL DIRECT COST				$ 70,596		$ 31,250		$ 12,500		$ 26,846
FACILITIES & ADMIN. RATE - % OF MTDC			VAR	$ 39,404	60%	$ 18,750	60%	$ 7,500	49%	$ 13,154
TOTAL PROJECT COST - US DOLLARS				$ 110,000		$ 50,000		$ 20,000		$ 40,000

Due to limitations within the University's accounting system, bolded budget line items represent how the University proposes, reports and accounts for expenses. Supplementary budget information, if provided, is for proposal evaluation.

PROMOTING STANDARDIZATION OF COMBUSTION CHARACTERISTICS FOR BIOFUELS
EERC PROPOSAL #2010-0247

DETAILED BUDGET - EERC RECHARGE CENTERS

Natural Materials Analytical Res. Lab.	Rate	#	TOTAL $Cost
Miscellaneous (Hourly)	$179	44	$ 7,876
XRFA	$174	24	$ 4,176
Subtotal			$ 12,052
Escalation		6%	$ 723
Total Natural Materials Analytical Res. Lab.			$ 12,775

Fuels & Materials Research Lab.	Rate	#	$Cost
Ash Determination	$49	14	$ 686
Ash Fusion	$283	14	$ 3,962
BTU	$74	14	$ 1,036
Miscellaneous	$102	14	$ 1,428
Moisture %	$66	14	$ 924
Proximate Ultimate	$209	14	$ 2,926
Subtotal			$ 10,962
Escalation		6%	$ 658
Total Fuels & Materials Research Lab.			$ 11,620

Analytical Research Lab.	Rate	#	$Cost
Coal Digestion	$172	10	$ 1,720
CVAA	$33	10	$ 330
ICP	$34	100	$ 3,400
ICP - MS	$49	60	$ 2,940
Miscellaneous (Sample)	$49	20	$ 980
Subtotal			$ 9,370
Escalation		6%	$ 562
Total Analytical Research Lab.			$ 9,932

Fuel Preparation & Maintenance	Rate	#	$Cost
Fuel Preparation & Maintenance (Hourly per piece of equip)	$34	30	$ 1,020
Subtotal			$ 1,020
Escalation		6%	$ 61
Total Fuel Prep. & Maintenance			$ 1,081

Graphics Support	Rate	#	$Cost
Graphics (hourly)	$61	5	$ 305
Subtotal			$ 305
Escalation		6%	$ 18
Total Graphics Support			$ 323

Shop & Operations Support	Rate	#	$Cost
Technical Development Hours	$1.46	30	$ 44
Subtotal			$ 44
Escalation		6%	$ 3
Total Shop & Operations Support			$ 47

BUDGET NOTES

ENERGY & ENVIRONMENTAL RESEARCH CENTER (EERC)

BACKGROUND

The EERC is an independently organized multidisciplinary research center within the University of North Dakota (UND). The EERC receives no appropriated funding from the state of North Dakota and is funded through federal and nonfederal grants, contracts, and other agreements. Although the EERC is not affiliated with any one academic department, university faculty may participate in a project, depending on the scope of work and expertise required to perform the project.

INTELLECTUAL PROPERTY

If federal funding is proposed as part of this project, the applicable federal intellectual property (IP) regulations may govern any resulting research agreement. In addition, in the event that IP with the potential to generate revenue to which the EERC is entitled is developed under this agreement, such IP, including rights, title, interest, and obligations, may be transferred to the EERC Foundation, a separate legal entity.

BUDGET INFORMATION

The proposed work will be done on a cost-reimbursable basis. The distribution of costs between budget categories (labor, travel, supplies, equipment, etc.) is for planning purposes only. The project manager may, as dictated by the needs of the work, incur costs in accordance with Office of Management and Budget (OMB) Circular A-21 found at www.whitehouse.gov/omb/circulars. If the Scope of Work (by task, if applicable) encompasses research activities which may be funded by one or more sponsors, then allowable project costs may be allocated at the Scope of Work or task level, as appropriate, to any or all of the funding sources. Financial reporting will be at the total-agreement level.

Escalation of labor and EERC recharge center rates is incorporated into the budget when a project's duration extends beyond the current fiscal year. Escalation is calculated by prorating an average annual increase over the anticipated life of the project.

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

Salaries: The EERC employs administrative staff to provide required services for various direct and indirect support functions. Salary estimates are based on the scope of work and prior experience on projects of similar scope. The labor rate used for specifically identified personnel is the current hourly rate for that individual. The labor category rate is the current average rate of a personnel group with a similar job description. Salary costs incurred are based on direct hourly effort on the project. Faculty who work on this project will be paid an amount over their normal base salary, creating an overload which is subject to limitation in accordance with university policy. Costs for general support services such as contracts and intellectual property, accounting, human resources, purchasing, shipping/receiving, and clerical support of these functions are included in the EERC facilities and administrative cost rate.

Fringe Benefits: Fringe benefits consist of two components which are budgeted as a percentage of direct labor. The first component is a fixed percentage approved annually by the UND cognizant audit agency, the Department of Health and Human Services. This portion of the rate covers vacation, holiday, and sick leave (VSL) and is applied to direct labor for permanent staff eligible for VSL benefits. Only the actual approved rate will be charged to the project. The second component is estimated on the basis of historical data and is charged as actual expenses for items such as health, life, and unemployment insurance; social security; worker's compensation; and UND retirement contributions.

Travel: Travel is estimated on the basis of UND travel policies which can be found at www.und.edu/dept/accounts/policiesandprocedures.html. Estimates include General Services Administration (GSA) daily meal rates. Travel may include site visits, field work, meetings, and conference participation as indicated by the scope of work and/or budget.

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

Supplies – Professional, Information Technology, and Miscellaneous: Supply and material estimates are based on prior experience and may include chemicals, gases, glassware, nuts, bolts, and piping. Computer supplies may include data storage, paper, memory, software, and toner cartridges. Maps, sample containers, minor equipment, signage, and safety supplies may be necessary as well as other organizational materials such as subscriptions, books, and reference materials. General purpose office supplies (pencils, pens, paper clips, staples, Post-it notes, etc.) are included in the facilities and administrative cost.

Subcontracts/Subrecipients: Not applicable.

Professional Fees/Services (consultants): Not applicable.

Other Direct Costs

Communications and Postage: Telephone, cell phone, and fax line charges are generally included in the facilities and administrative cost. Direct project costs may include line charges at remote locations, long-distance telephone, postage, and other data or document transportation costs.

Printing and Duplicating: Photocopy estimates are based on prior experience with similar projects. Page rates for various photocopiers are established annually by the university's duplicating center.

Food: Food expenditures for project meetings, workshops, and conferences where the primary purpose is dissemination of technical information may include costs of food, some of which may exceed the institutional limit.

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

Fees and Services – EERC Recharge Centers, Outside Labs, Freight: EERC recharge center rates for laboratory, analytical, graphics, and shop/operation fees are anticipated to be approved for use beginning July 1, 2009. Only the actual approved rates will be charged to the project.

Laboratory and analytical fees are charged on a per sample, hourly, or daily rate, depending on the analytical services performed. Additionally, laboratory analyses may be performed outside the university when necessary.

Graphics fees are based on an established per hour rate for production of such items as report figures, posters, and/or PowerPoint images for presentations, maps, schematics, Web site design, professional brochures, and photographs.

Shop and operation fees are for expenses directly associated with the operation of the pilot plant facility. These fees cover such items as training, personal safety (protective eyeglasses, boots, gloves), and physicals for pilot plant and shop personnel.

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

Facilities and Administrative Cost: Facilities and administrative (F&A) cost is calculated on modified total direct costs (MTDC). MTDC is defined as total direct costs less individual items of equipment in excess of $5000 and subawards in excess of the first $25,000 for each award. The F&A rate for commercial sponsors is 60%. This rate is based on costs that are not included in the federally approved rate, such as administrative costs that exceed the 26% federal cap and depreciation/use allowance on buildings and equipment purchased with federal dollars.

APPENDIX C

LETTERS OF SUPPORT

metso

January 19, 2010

Ms. Carolyn Nyberg
Manager, Analytical Research Laboratory
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Subject: Participation in the Task Entitled "Promoting Standardization of Biomass Characterization"

Dear Ms. Nyberg:

This letter is in response to your request for participation in the Energy & Environmental Research Center (EERC) proposed project to help establish consistency throughout the biomass industry regarding standard methods for fuels characterization.

Metso Power is pleased to offer support to the proposed task in the form of cash cost share of $10,000. It is understood that Metso Power's funding for this task will provide cost share to federal funding through the EERC's Center for Biomass Utilization® project, which is funded by the U.S. Department of Energy (DOE); therefore, our contribution of $10,000 will comprise nonfederal dollars. We understand that the total cost for this task, including industry and DOE funding, is estimated at $80,000.

Again, we express our interest and support of the proposed task and look forward to working with the EERC, DOE, and other participants in this task.

Sincerely,

Kerry Flick
General Manager of Technology, North America
Metso Power
3430 Toringdon Way, Suite 201
Charlotte, NC 28277
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Metso Power, 3430 Toringdon Way, Ste.201, Charlotte, NC 28277 USA
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701.231.7441
Fax 701.231.7400
NDSU.Agribusiness@ndsu.edu

April 28, 2010

Ms. Carolyn Nyberg
Manager, Analytical Research Laboratory
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear Ms. Nyberg:

Subject: Participation in the NDIC REP Proposed Project Entitled "Promoting Standardization of Combustion Characteristics for Biofuels"

This letter is in response to your request for nonfinancial support in the Energy & Environmental Research Center (EERC) proposed project to the North Dakota Industrial Commission Renewable Energy Program (NDIC) REP to help establish consistency throughout the biomass industry regarding standard methods for fuels chemical characterization.

I am pleased to offer support in the form of advice regarding the selection of North Dakota biomass samples to be included in the project. We also will provide samples from our NDIC project entitled "Biomass Testing Laboratory for Physical and Thermal Characteristics of Feedstock of North Dakota" in exchange for analytical data obtained in your project. We expect that data from both projects will complement each other and, ultimately, provide a thorough assessment of the fuel quality of select North Dakota biomass varieties.

Again, we express our interest and support of the proposed project and look forward to collaborating with the EERC, NDIC, and other participants on this project.

Sincerely,

Professor

NDSU Department of **Agricultural and Biosystems Engineering**
North Dakota State University, Fargo ND

April 28, 2010

Ms. Carolyn M. Nyberg
Manager, Analytical Research Laboratory
Energy & Environmental Research Center
15 North 23rd St., Stop 9018
Grand Forks, ND 58202-9018
Phone: (701) 777-5057
Email: cnyberg@undeerc.org

Igathinathane Cannayen, Ph.D.
Assistant Professor
Agricultural and Biological Engineering
PO Box 6050, North Dakota State University
1221 Albrecht Blvd
Fargo, ND 58102
Office: NGPRL, USDA-ARS, Mandan, ND
Phone: 701-667-3011; Fax: 701-667-3054
Email: Igathinathane.Cannayen@ndsu.edu

Dear Ms. Nyberg:

Sub: Letter of Support - NDIC REP proposed project entitled "Promoting Standardization for Biofuels Characterization" – Reg.

I am happy to write this letter in support of your proposed research project entitled "**Promoting Standardization for Biofuels Characterization**" to the North Dakota Industrial Commission Renewable Energy Program (NDIC–REP) through the Energy & Environmental Research Center (EERC), Grand Forks, ND that envisions to standardize testing methods to determine the chemical composition of biomass specifically to biomass co-firing with coal that aimed at achieving the environmental benefits.

We from the "NDSU - Biomass Testing Laboratory" located at USDA-ARS, Mandan, ND work towards characterizing the North Dakota biomass species for the physical, mechanical, and thermal properties can able to support your vision, as our efforts complement each other. We can offer non-financial support in the form of biomass species selection for testing, supplying the biomass samples that were tested in our laboratory, and any technical advice from the crop and engineering perspectives.

Tests data from similar biomass samples would provide a complete spectrum of properties that would be helpful both for energy- and sugar-platform pathways of biomass utilization. Such properties characterization of North Dakota biomass feedstocks will be of great value for the emerging bio-based industries and the biomass producers alike.

While we look forward to collaborating with the EERC, NDIC, and others involved in this project, I wish you the best on this grant application.

With regards,

Igathinathane Cannayen

GREAT RIVER ENERGY®

12300 Elm Creek Boulevard • Maple Grove, Minnesota 55369-4718 • 763-445-5000 • Fax 763-445-5050 • www.GreatRiverEnergy.com

April 29, 2010

Carolyn Nyberg
Energy & Environmental Research Center
15 North 23rd St., Stop 9018
Grand Forks, ND 58202-9018

RE: Letter of Support for Biomass Characterization Proposal

Dear Ms. Nyberg,

Great River Energy strongly supports EERC's proposed Biomass Characterization project to document the composition of various types of biomass as an important step in establishing a new renewable source of energy in North Dakota.

Great River Energy is particularly interested in understanding the local composition of biomass in order to further evaluate the opportunities and operational challenges of co-firing biomass.

We are excited to support this innovative project and look forward to the results on the project.

Sincerely,

GREAT RIVER ENERGY

Sandra Broekema, P.E.
Manager, Business Development
(763) 445-5304

EERC
Energy & Environmental Research Center

UNIVERSITY OF NORTH DAKOTA
15 North 23rd Street — Stop 9018 / Grand Forks, ND 58202-9018 / Phone: (701) 777-5000 Fax: 777-5181
Web Site: www.undeerc.org

April 29, 2010

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

Dear Ms. Fine:

Subject: North Dakota Industrial Commission (NDIC) Renewable Energy Program

This letter is in regard to the cost share to be provided by the Energy & Environmental Research Center (EERC) for the "Promoting Standardization of Combustion Characteristics for Biofuels" proposal submitted to the North Dakota Renewable Energy Program. The EERC will provide $40,000 toward the $110,000 project, contingent on award from the 2010 U.S. Department of Energy (DOE)-sponsored Center for Biomass Utilization® (CBU®) Program. CBU funding is expected in July 2010. The likelihood of funding is very strong, as the EERC has been receiving CBU Program awards from DOE for nine consecutive years.

If you have any further questions, please contact me by phone at (701) 777-5243 or by e-mail at bfolkedahl@undeerc.org.

Sincerely,

Bruce C. Folkedahl
Senior Research Manager

BCF/kmd