EERC®
Energy & Environmental Research Center

UNIVERSITY OF NORTH DAKOTA

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Web Site: www.undeerc.org

December 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. 2011-0140

The Energy & Environmental Research Center (EERC) of the University of North Dakota is pleased to submit the subject proposal to the North Dakota Industrial Commission Renewable Energy Program. The EERC 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 "Biomass Gasification in Entrained-Flow Systems." Also enclosed is the $100 application fee. The EERC, a research organization within the University of North Dakota, an institution of higher education within the state of North Dakota, is not a taxable entity; therefore, it has no tax liability.

Initiation of the proposed work is contingent upon the execution of mutually negotiated agreements or modifications to existing agreements between all participating sponsors.

If you have any questions, please contact me by telephone at (701) 777-5114 or by e-mail at jlaumb@undeerc.org.

Sincerely,

FOR Jason D. Laumb
Senior Research Manager

Approved by:

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

JDL/cs

Enclosures

Renewable Energy Program

North Dakota Industrial Commission

Application

Project Title: Biomass Gasification in Entrained-Flow Systems

Applicant: Energy & Environmental Research Center

Principal Investigator: Jason D. Laumb

Date of Application: December 30, 2010

Amount of Request: $325,000

Total Amount of Proposed Project: $693,100

Duration of Project: 10 months

Point of Contact (POC): Jason D. Laumb

POC Telephone: (701) 777-5114

POC Email: jlaumb@undeerc.org

POC Address: 15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

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ABSTRACT

Objective:

As the U.S. power industry prepares to comply with pending regulations for greenhouse gas 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 project developers may also help reduce the overall emissions of hazardous air pollutants from facilities. This renewed interest in biomass as a fuel source has led to a large increase in the need for multiple conversion platforms that can utilize biomass as a feedstock. The objectives of the proposed effort are to completely characterize the raw syngas composition from entrained-flow gasification of a variety of coal–biomass combinations and define the requirements for the appropriate cleanup system(s) and operating parameters.

Expected Results:

At the completion of the proposed effort, a final report will be provided containing entrained-flow gasification product compositions under appropriate conditions close to commercial coal gasification systems. Recommendations on cleanup systems, optimal gasifier operating parameters, and future work will also be provided based on the experimental database and the fundamental predictions under ongoing programs at General Electric Global Research (GE-GR) and the Energy & Environmental Research Center (EERC).

Duration:

10 months

Total Project Cost:

$325,000 Requested from NDIC REP

$34,000 Provided from GE-GR

$334,100 Provided from the Center for Biomass Utilization®

$693,100 Total Project Cost

Participants:

EERC, U.S. Department of Energy through the Center for Biomass Utilization®, GE-GR

PROJECT DESCRIPTION

Gasification of biomass in entrained-flow systems has had limited success in part because of the energy needed to reduce the size of the feed material or for the torrefaction process (1). Approximately 0.08 kW_e/kW_{th} is needed to reduce woody biomasses to a top size of 100 µm. Further challenges have also been discovered while handling biomass ash at gasifier temperatures (2). Recent economic studies by the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) have shown that thermochemical conversion of cellulosic material to ethanol can be cost-competitive with current corn ethanol processes; however, the large-scale gasification of numerous biomass feedstocks warrants further study (3). In order to ensure abundant economic and ecologically sound supply of biomass, numerous potential feedstocks will need to be studied. This proposed project will help to overcome obstacles associated with the use of biomass in entrained-flow gasifiers (EFGs) so that the advantages of high carbon conversion and limited tar production of the technology can be realized.

Objectives:

The objectives of the proposed effort are to completely characterize the raw syngas composition from entrained-flow gasification of a variety of coal–biomass combinations and define the requirements for the appropriate cleanup system(s) and operating parameters. In order to meet the objectives of this project the following task structure has been developed:

- Task 1 – System Modifications to Feed Biomass
- Task 2 – Gasification of Coal–Biomass Blends
- Task 3 – Analysis of Gasification Products
- Task 4 – Management and Reporting

Methodology:

The coal–biomass gasification product composition depends not only on the feed materials, but also on the gasification conditions, such as gasification temperature, pressure, and downstream conditions before exiting to the cleanup and subsequent liquid fuel-processing systems. It is crucial to characterize the gas products (including trace components), liquid products (if any), and solid products resulting from gasification under conditions that are similar to those found in commercial units. While the bench-scale experiments at GE Global Research (GE-GR) can enable quick preliminary characterization; the representativeness of such characterization will be limited because of its operational condition constraints and the lack of realistic pressure and downstream configurations.

The experimental part of the proposed effort will be conducted using a high-temperature, high-pressure EFG. The EFG can provide both representative commercial gasification conditions and system configurations, except for pressure. The EFG can operate at temperatures up to 1500°C and pressures up to 20 bar. The representative testing conditions of the EFG in conjunction with the state-of-the-art analytical tools are well-suited to the complete characterization of products from coal–biomass cogasification.

Task 1 – System Modifications to Feed Biomass. The high-temperature, high-pressure EFG will be configured to allow cofeeding of coal and biomass fuels at variable coal/biomass ratios. Both coal and biomass feeders will be located inside a pressure vessel to avoid issues associated with coal and biomass feeding across the pressure gradient. A reaction-quenching system will also be added to the EFG. This will allow for sample at various residence times within the gasifier. The amounts of coal and biomass fuels required for testing will be prepared based on feed requirement and the final test matrix.

Task 2 – Gasification of Coal–Biomass Blends. A focused series of test matrices will be designed based on the test results from the bench-scale reactor at GE-GR and validated analytical methods. A test plan will be generated and reviewed before the tests are conducted. The required tests will be performed in the EFG to characterize gasifier operation and complete product stream compositions at high temperatures and pressures relevant to commercial-scale units. Approximately 4 weeks of testing will be conducted on the EERC's EFG. The tests will be conducted with blends of coal and corn stover, straw, wood, and switchgrass. Blends from 30% to 100% biomass will be considered. An example of a test matrix for a blend of lignite and straw is found below. Additional test matrices will be developed for the other biomass fuels upon completion of the matrix below. This will allow for GE-GR and EERC engineers to determine which parameters will require more study.

Table 1. Example Test Matrix for 70% Lignite and 30% Straw Blend

Run Order	Temperature, °C	Pressure, bar	Oxygen/Carbon Ratio
1	1300	20	0.75
2	1500	20	1
3	1500	10	0.75
4	1300	10	1

Relevant gasifier operating parameters (temperatures, pressures, etc.) will be measured to assess the impacts associated with coal–biomass mixture operation.

The raw syngas formed in the EFG will likely contain a number of impurities:

- Particulates: ash/slag and residual carbon
- Nitrogen compounds
- Sulfur compounds
- Alkali compounds
- Chloride compounds
- Volatile trace metal compounds
- Tar (if any)

Task 3 – Analysis of Gasification Products. The characterization of the main syngas components, such as H_2, CO, CO_2, and steam, can provide a syngas quality assessment for liquid fuel production. The characterization of ash and slag can assess the fate of inorganic species in coal–biomass mixtures and provide guidance needed to define the proper operating parameters for each specific coal–biomass feedstock blend. A comprehensive characterization of the syngas impurities will provide the guidance for the development of appropriate syngas cleanup system(s).

The syngas composition and the impurities makeup and concentrations depend on gasification conditions and downstream processing temperature and pressure. Thermodynamic estimations will be conducted with software such as FactSage and MTDATA to evaluate the possible partitioning and behavior of the elements and compounds through the EFG and guide the optimization of the sample collection and characterization.

In a typical EFG operation, most of the inorganic matter will exit the gasifier through ash and slag. The fly ash and the low-melting compounds, including some of the inorganic minerals such as Na and K, can be collected using the ash deposition probe located in the test section. The morphology and microstructure of the ash deposit and slag/ash will be characterized with scanning electron microscopy (SEM). This analysis will indicate whether the gasification temperature is appropriate for the operation of the slagging EFG. The compositional analysis of the deposition probe samples may also be conducted with SEM and inductively coupled plasma–mass spectroscopy (ICP–MS). These analyses will be compared with samples collected from the hot-gas filter system.

The most important nitrogen compounds of interest that must be analyzed downstream of the gasifier include NH_3 and HCN, while the major sulfur compounds include H_2S and COS**.** Drager tubes and gas chromatographs will be used to measure nitrogen and sulfur compounds. Mass balance calculations will be performed to verify mass balance closures for elemental nitrogen and sulfur. The analysis of minor (Na, K, Ca, Mg) and trace (such as As, Ba, Be, Cd, Co, Cr, Cu, Ga, Ni, Mn, Mo, Pb, Sb, V, Zn, etc.) metals will be performed separately for each ash, char, soot, and condensable tar if any. The formation of tar is unlikely under the typical high-temperature operation of the EFG. However, the condensable tar will be analyzed separately if it is formed.

The experimental data obtained will be used to provide a comprehensive description of the solid, liquid, and gaseous product compositions from the entrained-flow gasification of various coal–biomass combinations. Response mapping and statistical analysis of data will be performed to identify trends, correlations, data uncertainties, and confidence intervals.

Task 4 – Management and Reporting. This task will ensure the overall success of the project. Quarterly progress reports will be provided a month after the end of each calendar quarter. A draft final report will be submitted to DOE, GE-GR, and the North Dakota Industrial Commission (NDIC) for comments by November 30, 2011. A final report incorporating DOE, GE-GR, and NDIC comments will be submitted by December 31, 2011.

Anticipated Results:

At the completion of the proposed effort, a final report will be provided containing EFG gasification product compositions under appropriate conditions close to commercial coal gasification systems. Recommendations on cleanup systems, optimal gasifier operating parameters, and future work will also be provided based on the experimental database under ongoing programs at GE-GR, and the EERC.

Facilities and Resources:

The EERC has extensive analytical laboratories that will carry out the chemical analyses. The gasification tests will be completed in the EERC's pilot-scale EFG system. A conceptual drawing of the EFG is shown in Figure 1. The EFG is downfired and housed in an existing high-pressure vessel approximately 24 in. in diameter and 7 ft in length. It fires nominally 8–10 lb/hr of fuel and produces up to 20 scfm of fuel gas. The heating system is capable of reaching a nominal temperature of 1500°C and can provide a consistent temperature throughout the length of the furnace.

Infrared thermocouples are used to monitor the temperature of the combustion zone, and the heat input is automatically controlled to stay within a tight operating range. The pressure inside the alumina furnace tube is 300 psi and is balanced with a 300-psi nitrogen atmosphere outside the alumina tube. The reactor has the capability to run in oxygen- or air-blown mode.

Pulverized coal at a nominal rate of 8–10 lb/hr is fed to the furnace via a twin screw feed motor contained in a pressurized vessel. The design allows for 8 hours of continuous use at 4 lb/hr before the coal hopper needs to be refilled. The feed system is situated on a scale so that actual feed rates can be calculated. Combustion gases consisting of air or oxygen and steam are used to carry the solid pulverized fuel into the combustion zone.

A novel heating system is used to reach the 1500°C temperature required of a slagging gasifier. Past testing on the pressurized drop-tube furnace indicated that high temperature could not be maintained when operating above 100 psig. The novel system is able to reach and maintain the flue gas at that temperature by utilizing uniform heat input throughout the length of the furnace. Refractory used as insulation helps maintain the required temperature in the furnace. Refractory has the ability to withstand both high temperature and high pressure. A water-cooled jacket surrounds the outside of the vessel and is used to remove excess heat from the system.

Gas exits the bottom of the furnace and passes through a 90° turn where it is then tested in subsequent pollution control devices. A provision for a water quench has been added to the bottom of the furnace. Slag also exits the bottom of the furnace and is collected in a refractory-lined slag trap.

Techniques to Be Used, Their Availability and Capability:

Table 2 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.

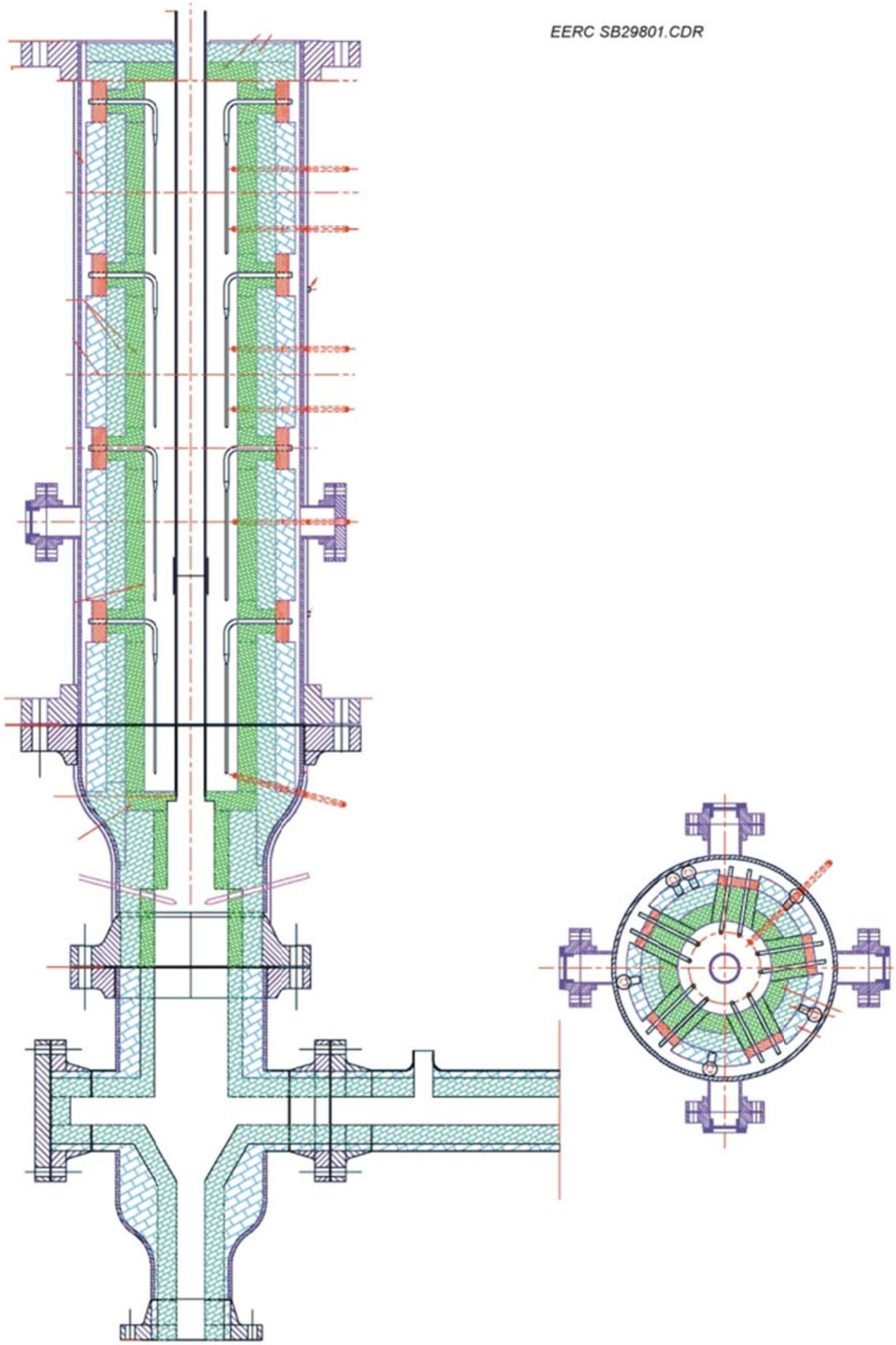

Figure 1. Schematic of the EFG.

Table 2. 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[4] and/or GFAAS[5]
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.
4 ICP–atomic emission spectroscopy.
5 Graphite furnace atomic absorption spectroscopy.

Environmental and Economic Impacts While Project Is under Way:

The benefits/impacts of this project will be realized upon completion. Because of the small scale of the tests, no environmental impacts are expected while the project is under way. The environmental and economic benefits will be realized by future energy developers.

Ultimate Technological and Economic Impacts:

The information collected from this project will provide confidence to the energy sector in North Dakota as well as the United States regarding the use of biomass fuels for the production of electricity, hydrogen, chemicals, fertilizers, and transportation fuels. In the effort to reduce greenhouse gas (GHG) emissions, this will ultimately promote the use of biomass fuels as an alternative to fossil fuels, which will promote rural economic health and growth in the state of North Dakota.

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 technology vendors (such as GE-GR) are exploring ways to increase the use of biomass in current and future energy conversion systems. The EFG process can offer efficiency gains over other technologies and is used worldwide; however, success with biomass has been limited. This project will address several key issues for the utilization of the EFG process with biomass fuels.

STANDARDS OF SUCCESS

The deliverables of this project include vital information for project developers considering the use of EFGs with biomass. Detailed characterization information, including slagging behavior, ash partitioning, carbon conversion, trace element behavior, and syngas composition, will be determined for several biomass fuels.

The key industries in North Dakota that will benefit from the results of this project are the agricultural and energy industries. The data collected as a result of this project will provide current and future energy developers vital information regarding the use of biomass in EFG systems. This project will 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 Center for Biomass Utilization® (CBU®), the EERC offers the most comprehensive approach to biomass conversion research.

GE-GR, which is financially supporting this project, is a worldwide vendor of gasification systems that utilize coal, biomass, and other fuels. GE-GR's in-depth commercial gasification know-how and comprehensive understanding of the many conversion technologies that can be used with a gasification systems will bring valuable expertise to this project.

The project will be managed by Mr. Jason Laumb, a Senior Research Manager at the EERC. 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 and liquid fuels production, 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. Mr. Laumb has a B.S. degree in Chemistry and an M.S. degree in Chemical Engineering, both from the University of North Dakota (UND).

Mr. Josh Stanislowski will be a principal investigator and will lead tasks for the EERC. Mr. Stanislowski's principal areas of expertise include energy conversion systems with emphasis on trace element control, gasification systems analysis, combustion and gasification pollution control, and process modeling. He has extensive experience with process engineering, process controls, and project management. He has a strong background in gauge studies, experimental design, and data analysis. Mr. Stanislowski has a B.S. degree in Chemical Engineering from UND.

Ms. Carolyn Nyberg, EERC Analytical Research Laboratory Manager, will serve as the analytical task manager for this project. Ms. Nyberg's principal areas of interest and expertise include AAS (flame, graphite furnace, and hydride generation), cold-vapor atomic absorption spectroscopy (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. degree in Biology and B.S.Ed. degree from UND.

Dr. Rama Subramanian will serve as the project advisor and principal investigator from GE-GR. Dr. Subramanian is a Chemical Engineer at the General Electric Global Research Center (GE GRC). He has a Ph.D. degree from the University of Minnesota's Department of Chemical Engineering and Materials Science, one of the top chemical engineering doctoral programs in the world, and a B. Tech in Chemical Engineering from the Indian Institute of Technology, Kharagpur. He has over 6 years of R&D experience in coal and biomass gasification, catalytic fuel conversion, and catalytic reforming. Dr. Subramanian has extensive experience in the design, operation, and optimization of various bench-scale test facilities and in experimental data collection and analysis. He is currently a team lead in a GE-GR internal R&D project focused on the development of detailed kinetic models for coal gasification and the project lead for a DOE project focused on coal biomass gasification. He is the author of more than 15 peer-reviewed and GE-GR internal technical publications and one patent and six patent applications. Additionally, Dr. Subramanian is a certified GE Green Belt in Design for Six Sigma.

MANAGEMENT

Mr. Jason Laumb will be responsible for overall project management. Other task leaders have been assigned for each of the tasks discussed above. Josh Stanislowski will lead Tasks 1 and 2 and Carolyn Nyberg will lead Task 3. Figure 2 provides an overview of the project management structure. In order for the project to be effectively managed, the following milestones with the accompanying dates are shown in Table 3. This table will be updated in quarterly reports during the project. Any delays from the schedule will also be noted, along with corrective action to ensure timely completion of the project. Resumes for key personnel can be found in Appendix A.

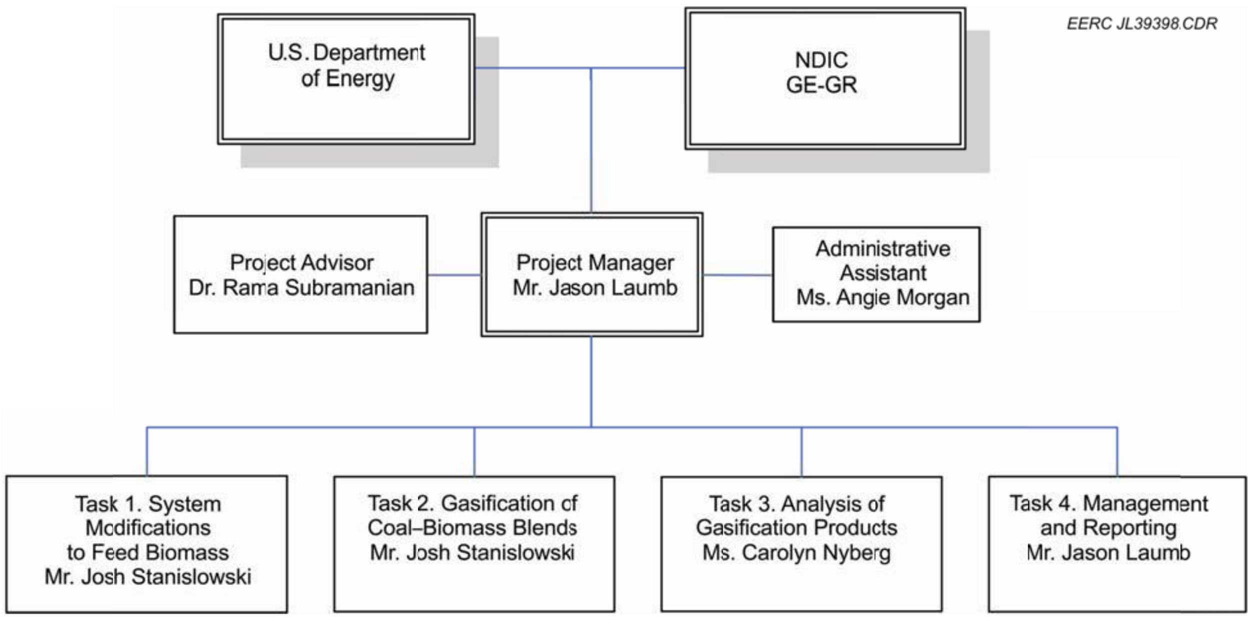

Figure 2. Management structure.

Table 3. Management Milestones

ID	Milestone Description	Planned Completion Date	Actual Completion Date
M1	Complete gasification tests	6/30/2011	
M2	Complete analysis of samples	8/31/2011	
M3	Draft final report	11/30/2011	
M4	Final report	12/31/2011	

TIMETABLE

The project time line can be found in Figure 3. The project is proposed with a start date of March 1, 2011, and an end date of December 31, 2011. Reports will be submitted quarterly, with a draft final on November 30, 2011, and the final report due December 31, 2011.

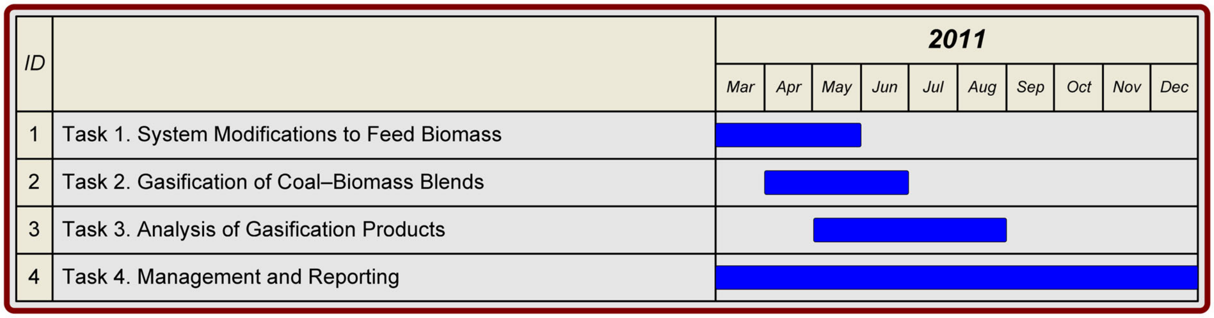

Figure 3. Project time line.

BUDGET

The total project cost is $693,100. The EERC is requesting $325,000 from the NDIC Renewable Energy Program. The EERC CBU will be providing $334,100 and GE-GR will be providing $34,000. This budget is necessary to adequately address the tasks proposed in this project. Initiation of the proposed work is contingent upon the execution of a mutually negotiated agreement or modification to an existing agreement between EERC and each of the project sponsors. A detailed budget and accompanying budget notes are enclosed in Appendix B. Letters of support from GE and the CBU can be found in Appendix C.

Project Associated Expense	NDIC Share	GE Share (Cash)	CBU Share (Cash)
Total Direct Salaries	$75,922	$13,610	$85,336
Total Fringe	$40,998	$7,349	$44,923
Total Labor	$116,920	$20,959	$130,259
Travel	$343	–	–
Equipment > $5000	–	–	$90,000
Supplies	$4,247	$216	$3,537
Communication	$63	$50	$137
Printing & Duplicating	$50	$25	$125
Food	–	–	$200
Operating Fees and Services	$81,502	–	$29,568
Total Direct Costs	$203,125	$21,250	$253,826
Total Indirect Costs (F&A)	$121,875	$12,750	$80,274
Total Project Cost	$325,000	$34,000	$334,100

CONFIDENTIAL INFORMATION

No confidential information is contained in this application.

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. Moorhead, H. Siemens IGCC and Gasification Update. Presented at the Gasification Technologies Conference 2010, Washington, DC, Nov 1, 2010.
2. Drift, A.V.; Boerrigter, H.; Coda, B.; Cieplik, M.K.; K. Hemmes. *Entrained-Flow Gasification of Biomass. Ash Behaviour, Feeding Issues, and System Analyses*; Report ECN-C-04-039. April 2004.
3. Phillips, S.; Aden, A.; Jechura, J.; Dayton, D.; Eggeman, T. *Thermochemical Ethanol Via Indirect Gasification and Mixed Alcohol Synthesis of Lignocellulosic Biomass*; Technical Report NREL/TP-510-41168 for U.S. Department of Energy Contract DE-AC36-99-GO10337; April 2007.

APPENDIX A

RESUMES OF KEY PERSONNEL

JASON D. LAUMB
Senior Research Manager
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: Senior Research Manager, 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 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.

JOSHUA J. STANISLOWSKI
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) 777-5087, Fax: (701) 777-5181, E-Mail: jstanislowski@undeerc.org

Principal Areas of Expertise
Mr. Stanislowski's principal areas of interest and expertise include fossil fuel combustion for energy conversion with emphasis on trace element control, gasification systems analysis, combustion and gasification pollution control, and process modeling. He has extensive experience with process engineering, process controls, and project management. He has a strong background in gauge studies, experimental design, and data analysis.

Qualifications
B.S., Chemical Engineering, University of North Dakota, 2000.
Six Sigma Green Belt Certified, August 2004.

Professional Experience:
2008–Present: Research Manager, EERC, UND, Grand Forks, North Dakota. Mr. Stanislowski manages projects in the areas of gasification, gas cleanup, hydrogen production, liquid fuel production, and systems engineering.

2005–2008: Research Engineer, EERC, UND, Grand Forks, North Dakota. Mr. Stanislowski's areas of focus included mercury control technologies and coal gasification. His responsibilities involved project management and aiding in the completion of projects. His duties included design and construction of bench- and pilot-scale equipment, performing experimental design, data collection, data analysis, and report preparation. He also worked in the areas of low-rank coal gasification, warm-gas cleanup, and liquid fuels production modeling using Aspen Plus software.

2001–2005: Process Engineer, Innovex, Inc., Litchfield, Minnesota.

– Mr. Stanislowski was responsible for various process lines including copper plating, nickel plating, tin–lead plating, gold plating, polyimide etching, copper etching, chrome etching, and resist strip and lamination. His responsibilities included all aspects of the process line including quality control, documentation, final product yields, continuous process improvement, and operator training. He gained extensive knowledge of statistical process control and statistical start-up methodology. Mr. Stanislowski was proficient with MiniTab statistical software and utilized statistical analysis and experimental design as part of his daily work.

– Mr. Stanislowski designed and oversaw experiments as a principal investigator; wrote technical reports and papers, including standard operating procedures and process control plans; presented project and experimental results to suppliers, customers, clients, and managers; created engineering designs and calculations; and performed hands-on mechanical work when troubleshooting process issues. He demonstrated the ability to coordinate activities with varied entities through extensive project management and leadership experience.

1998–2000: Student Research Assistant, EERC, UND. Mr. Stanislowski worked on a wide variety of projects, including data entry and programming for the Center for Air Toxic Metals® (CATM®) database, contamination cleanup program development, using aerogels for emission control, and the development of a nationwide mercury emission model.

Publications and Presentations
Has coauthored several publications.

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.

Rama Subramanian, Ph.D.

Lead Engineer, GE Global Research

Dr. Rama Subramanian is a Chemical Engineer at the General Electric Global Research Center (GE GRC). He has a Ph.D. from the University of Minnesota's Department of Chemical Engineering and Materials Science, one of the top chemical engineering doctoral programs in the world, and a B. Tech in Chemical Engineering from the Indian Institute of Technology, Kharagpur. He has over 6 years of R&D experience in coal and biomass gasification, catalytic fuel conversion and catalytic reforming. Dr. Subramanian has extensive experience in the design, operation, and optimization of various bench-scale test facilities and in experimental data collection and analysis. He is currently a team lead in a GE internal R&D project focused on the development of detailed kinetic models for coal gasification and the project lead for a DOE project focused on coal biomass gasification. He is the author of more than 15 peer-reviewed and GE internal technical publications and one patent and 6 patent applications. Additionally, Dr. Subramanian is a certified GE Green Belt in Design for Six Sigma.

Education and Training

- Ph.D., Chemical Engineering, University of Minnesota, Minneapolis, Minnesota, 2005.
- B.Tech, Chemical Engineering, Indian Institute of Technology, Kharagpur, India, 2001.

Professional Experiences

2009-Current	Lead Engineer, GE Global Research, Irvine, CA Project Lead for DOE project on 'Product Characterization for Coal/Biomass Gasification'. Team lead in a GE internal R&D project focused on the development of detailed kinetic models for coal gasification. Involved in several other coal and biomass gasification programs. EHS Site Lead responsible for ensuring work-place safety of employees in an industrial environment, characterized by highly toxic and poisonous species.
2007-2009	Research Engineer, GE Global Research, Irvine, CA Task lead in DARPA Bio-Oil to Jet Fuel program, Alternative Fuels Advanced Technology program and DOE program on Catalytic Partial Oxidation for selective tar conversion. Conducted experiments and performed modeling of various gasification systems.
2006-2007	Senior Process Engineer, Intel Corporation, Portland, Oregon Primary owner of lithographic exposure tools ($20M). Involved in the development of 65nm, 45nm & 32nm lithographic processes for next generation microprocessor fabrication. Determined optimal operating conditions for the patterning tools required to achieve the desired critical dimensions for the microprocessors.

2001-2005 Graduate Research Assistant, University of Minnesota, Minneapolis MN
Doctoral research focused on the design, development and optimization of high-temperature short-contact time reactors for the conversion of heavy hydrocarbons into chemicals such as hydrogen or olefins. Developed catalytic processes to convert high boiling renewable fuels such as biodiesel (methyl esters derived from soy oil) and vegetable oils into syngas, olefins and olefinic esters.

Selected Publications

1. Eiteneer, B., Subramanian, R., Maghzi, S., Zeng, C., Guo, X., Long, Y., Chen, L., Ravichandra, JS., Raman, A., Jain, J., Fletcher, T., Shurtz, R. "Gasification Kinetics: Modeling Tools Development and Validation", 26th Annual International Pittsburgh Coal Conference, Pittsburgh, PA, September 20-23, 2009
2. Subramanian, R., Guan, J., Deluga, G. "Entrained flow gasification of biomass: kinetics, gas clean-up & slag behavior", GE Internal Report, 2008
3. Ma, F., Tiwari, P., Subramanian, R. "Coal and Biomass Gasification Study Using Multiphase CFD Model", GE Internal Report, 2008
4. Eiteneer, B., Subramanian, R., Maghzi, S., Wark, D., Arnason, J. "Product Characterization for Entrained Flow Coal/Biomass Co-Gasification", 8 Quarterly Progress Reports to DOE-NETL, 2009-2010
5. Subramanian, R. and Schmidt, L. D. "Renewable Olefins from Biodiesel by Autothermal Reforming," Angewandte Chemie 44, 302-305 (2005). ***Featured as the "The News of the Week" in Chemical & Engineering News***
6. Subramanian, R., Panuccio, G. J., Krummenacher, J. J., Lee, I. C., Schmidt, L. D. "Catalytic Partial Oxidation of Higher Hydrocarbons: Reactivities and Selectivities of Mixtures", Chemical Engineering Science 59, 5501-5507 (2004).
7. Schmidt, L. D., Subramanian, R., Salge, J. R., Deluga, G. A. "Hydrogen and Chemicals from Renewable Fuels by Autothermal Reforming", Indian Chemical Engineer 47, 100 – 105 (2005).
8. Degenstein, N.J., R. Subramanian, Schmidt, L.D. "Partial Oxidation of n-Hexadecane at Short Contact Times: Catalyst & Washcoat Loading and Catalyst Morphology," Applied Catalysis, A: General 305, 146-159 (2006).
9. Ramanathan, S. P., Mukherjee, S., Dahule, R. K., Ghosh, S., Rahman, I., Tambe, S. S., Ravetkar, D. D., Kulkarni, B. D. "Optimization of continuous distillation columns using stochastic optimization approaches", Chemical Engineering Research and Design, 79, 3, 310 – 322 (2001).

Selected Patents and Applications

1. US 7,683,232 B2: Production of olefins having a functional group
2. US 2008: Multi-zone co-gasification of coal and biomass
3. US 2008: Diesel Conversion Catalysts for NOx Reduction using Hydrocarbons
4. US 2009: Plasma assisted thermal treatment of coal

APPENDIX B

BUDGET AND BUDGET NOTES

BIOMASS GASIFICATION IN ENTRAINED-FLOW SYSTEMS
NDIC RENEWABLE PROGRAM
PROPOSED PROJECT START DATE: 3/1/11
EERC PROPOSAL #2011-0140

BUDGET

CATEGORY			**TOTAL**		**NDIC SHARE**		**GE SHARE**		**CBU SHARE**	
LABOR		Rate	Hrs	Cost	Hrs	Cost	Hrs	Cost	Hrs	Cost
Laumb, J.	Project Manager	$ 54.01	300	$ 16,203	100	$ 5,401	75	$ 4,051	125	$ 6,751
Stanislowski, J.	Principal Investigator	$ 38.99	400	$ 15,596	100	$ 3,899	50	$ 1,950	250	$ 9,747
Nyberg, C.	Research Scientist/Engineer	$ 39.03	100	$ 3,903	-	$ -	-	$ -	100	$ 3,903
--------------	Senior Management	$ 74.19	165	$ 12,241	15	$ 1,113	-	$ -	150	$ 11,128
--------------	Research Scientists/Engineers	$ 39.47	2,450	$ 96,702	1,223	$ 48,272	180	$ 7,105	1,047	$ 41,325
--------------	Research Technicians	$ 25.94	329	$ 8,534	42	$ 1,089	-	$ -	287	$ 7,445
--------------	Technology Dev. Mechanics	$ 30.94	440	$ 13,614	440	$ 13,614	-	$ -	-	$ -
--------------	Undergrad-Res.	$ 10.61	200	$ 2,122	-	$ -	-	$ -	200	$ 2,122
--------------	Technical Support Services	$ 21.50	40	$ 860	15	$ 323	5	$ 108	20	$ 429
				$ 169,775		$ 73,711		$ 13,214		$ 82,850
Escalation Above Base		3%		$ 5,093		$ 2,211		$ 396		$ 2,486
TOTAL DIRECT HRS/SALARIES			4,424	$ 174,868	1,935	$ 75,922	310	$ 13,610	2,179	$ 85,336
Fringe Benefits - % of Direct Labor - Staff		54%		$ 93,248		$ 40,998		$ 7,349		$ 44,901
Fringe Benefits - % of Direct Labor - Undergrad. Research		1%		$ 22		$ -		$ -		$ 22
TOTAL FRINGE BENEFITS				$ 93,270		$ 40,998		$ 7,349		$ 44,923
TOTAL LABOR				$ 268,138		$ 116,920		$ 20,959		$ 130,259
OTHER DIRECT COSTS										
TRAVEL				$ 343		$ 343		$ -		$ -
EQUIPMENT > $5000				$ 90,000		$ -		$ -		$ 90,000
SUPPLIES				$ 8,000		$ 4,247		$ 216		$ 3,537
COMMUNICATION - LONG DISTANCE & POSTAGE				$ 250		$ 63		$ 50		$ 137
PRINTING & DUPLICATING				$ 200		$ 50		$ 25		$ 125
FOOD				$ 200		$ -		$ -		$ 200
OPERATING FEES & SVCS										
Natural Materials Analytical Res. Lab.				$ 22,085		$ 22,085		$ -		$ -
Fuels & Materials Research Lab.				$ 4,369		$ -		$ -		$ 4,369
Analytical Research Lab.				$ 24,226		$ -		$ -		$ 24,226
Combustion Test Svcs.				$ 58,710		$ 58,710		$ -		$ -
Graphics Support				$ 973		$ -		$ -		$ 973
Shop & Operations Support				$ 707		$ 707		$ -		$ -
TOTAL DIRECT COST				$ 478,201		$ 203,125		$ 21,250		$ 253,826
FACILITIES & ADMIN. RATE - % OF MTDC			VAR	$ 214,899	60%	$ 121,875	60%	$ 12,750	49%	$ 80,274
TOTAL PROJECT COST - US DOLLARS				$ 693,100		$ 325,000		$ 34,000		$ 334,100

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.

BUDGET - TRAVEL

RATES USED TO CALCULATE ESTIMATED TRAVEL EXPENSES			
DESTINATION	PER MILE	LODGING	MEALS
Bismarck, ND	$ 0.33	$ 75	$ 25

	NUMBER OF								
PURPOSE/DESTINATION	TRIPS	PEOPLE	MILES	DAYS	MILEAGE	LODGING	MEALS	MISC.	TOTAL
NDIC Meeting/Bismarck, ND	1	1	600	2	$ 198	$ 75	$ 50	$ 20	$ 343
TOTAL ESTIMATED TRAVEL									$ 343

DETAILED BUDGET - EQUIPMENT

Fabricated Equipment	$COST
Tubing	$ 10,000
Injection Pump	$ 10,000
Fittings	$ 20,000
Flanges and gaskets	$ 5,000
Insulation	$ 15,000
Instrumentation	$ 20,000
Valves and regulators	$ 10,000
Total Estimated Cost: Quenched Probe	$ 90,000

DETAILED BUDGET - EERC RECHARGE CENTERS

		TOTAL	
Natural Materials Analytical Res. Lab.	Rate	#	$Cost
Morphology (Hourly)	$281	10	$ 2,810
XRD	$211	12	$ 2,532
XRFA	$161	100	$ 16,100
Subtotal			$ 21,442
Escalation		3%	$ 643
Total Natural Materials Analytical Res. Lab.			$ 22,085

Fuels & Materials Research Lab.	Rate	#	$Cost
BTU	$75	6	$ 450
CHN	$115	12	$ 1,380
Proximate Ultimate	$260	6	$ 1,560
Sulfur	$71	12	$ 852
Subtotal			$ 4,242
Escalation		3%	$ 127
Total Fuels & Materials Research Lab.			$ 4,369

Analytical Research Lab.	Rate	#	$Cost
ICP - MS	$23	840	$ 19,320
Trace Element Digestion	$60	70	$ 4,200
Subtotal			$ 23,520
Escalation		3%	$ 706
Total Analytical Research Lab.			$ 24,226

Combustion Test Services	Rate	#	$Cost
EFG (Hourly)	$190	300	$ 57,000
Subtotal			$ 57,000
Escalation		3%	$ 1,710
Total Combustion Test Services			$ 58,710

Graphics Support	Rate	#	$Cost
Graphics (hourly)	$63	15	$ 945
Subtotal			$ 945
Escalation		3%	$ 28
Total Graphics Support			$ 973

Shop & Operations Support	Rate	#	$Cost
Technical Development Hours	$1.56	440	$ 686
Subtotal			$ 686
Escalation		3%	$ 21
Total Shop & Operations Support			$ 707

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 (value of $5000 or more) is budgeted, it is discussed in the text of the proposal and/or identified more specifically in the accompanying budget detail.

Supplies – 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 (value less than $5000), 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 established and approved at the beginning of the university's fiscal year.

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 capital expenditures, such as equipment or software costing $5000 or more with a useful life of greater than one year, as well as 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

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

December 29, 2010

Ms. Karlene Fine
Executive Director
Attn: Renewable Energy Program
North Dakota Industrial Commission
State Capitol – Fourteenth Floor
600 East Boulevard Avenue
Bismarck, ND 58505

Dear Ms. Fine:

Subject: Center for Biomass Utilization® (CBU®) Commitment for EERC Proposal No. 2011-0140 Entitled "Biomass Gasification in Entrained-Flow Systems"

This letter is in regard to the cost share to be provided by the Energy & Environmental Research Center (EERC) for the "Biomass Gasification in Entrained-Flow Systems" proposal submitted to the the North Dakota Industrial Commission Renewable Energy Program (NDIC REP). The EERC will provide $334,100 toward the total project cost of $693,100, under the 2010 U.S. Department of Energy (DOE)-sponsored CBU Program. The CBU is an ongoing program within the EERC that has been in existence for over 12 years. The funds that are committed toward this project are available now and have been reserved and allocated toward the support of this project.

The CBU has a history of funding research projects that involve the development of technologies and tools to advance electricity, heat, and fuels production from renewable resources. The approach and concepts outlined in the proposed project should provide the data and information needed to address critical questions that remain unanswered and allow biomass to play a larger role as greenhouse gas issues are addressed.

I am hopeful that the NDIC REP will view this proposal favorably and look forward to supporting and participating in this project.

If you have any questions, please feel free to contact me by phone at (701) 777-5243, by fax at (701) 777-5181, or by e-mail at bfolkedahl@undeerc.org.

Sincerely,

Bruce C. Folkedahl
Senior Research Manager

BCF/cs

Enclosures

c: John Hendrikson, EERC

GE Global Research

Gary Leonard
Global Technology Leader
Energy & Propulsion Technologies
GE Global Research
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Mr. Jason D. Laumb
Senior Research Manager
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018
Phone: +1 (701) 777-5114
Fax: +1 (701) 777-5181
E-mail: jlaumb@undeerc.org

December 29, 2010

Dear Mr. Laumb:

GE is one of the world leaders in gasification and has installed and licensed well over 100 medium- to large-scale coal gasification units. As part of our efforts in this area, we are continually evaluating the development of advanced and economical biomass conversion technologies that are more reliable and cost effective than conventional approaches and translate to economic and environmental benefits to the nation. Large-scale entrained flow (EF) gasification of biomass mixtures with coal, may offer commercial potential for conversion to electricity or liquid fuels and mitigates several risks associated with biomass-only gasifiers, including feedstock availability and variability, high specific costs, and low efficiency. Gasification data obtained using pilot-scale equipment operating at temperature, pressure and heating rate conditions that are representative of commercial EF gasifiers would enable the development of a successful coal biomass gasification technology. Therefore, GE strongly supports your proposal to the North Dakota Industrial Commission titled "Biomass Gasification in Entrained Flow Systems".

GE has on-going developmental efforts in coal biomass gasification. Commercial EF gasifiers typically operate at high temperatures ranging from 1300°C to 1500°C, pressures ranging from 40 to 80 bars, and particle heating rates on the order of 10^4-10^5°C/s. These high temperatures, pressures, and heating rates are difficult to achieve simultaneously in small-scale experimental facilities, resulting in relative scarcity of experimental data at these conditions. Your proposed work using the Entrained Flow Gasifier (EFG) to gasify mixtures of coal and biomass under conditions that are similar to those found in commercial EF units will likely play an important role in the development of a coal biomass gasification technology.

We are aware of the capabilities existing at Energy & Environmental Research Center and fully support the approaches you have proposed for this effort. We have committed $34,000 towards experimentation using the EFG, financially supporting the proposed effort. GE also plans to build on its long-term collaboration with your company by providing technical support from Dr. Rama Subramanian, and Dr. George Rizeq. This would involve aid in designing test matrices based on results

9.9.

from the bench scale reactor at GE Global Research, characterizing gasification products, and interpreting the test results.

We look forward to working with you to develop representative gasification data, and apply these valuable results to the development of new gasification technologies.

Jim Lal Inman acting GTL for Gary Leonard
12/30/2010

Gary Leonard
Global Technology Leader
Energy & Propulsion Technologies