Energy & Environmental Research Center

BIOMASS IMPACTS ON SCR PERFORMANCE

EERC Proposal No. 2002-0017

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ABSTRACT

Objectives: The goals of this Energy & Environmental Research Center (EERC) project are to determine the fundamental mechanisms of NO_x reduction and potential blinding or masking of selective catalytic reduction (SCR) catalysts due to flue gas constituents released from biomass fuels or from reactions of biomass and low-rank coal constituents. Specific objectives include 1) conducting biomass resource assessments and identifying candidate biomass types and coals for testing; 2) conducting specially devised long-term bench- or pilot-scale and field testing to determine the mechanisms of NO_x reduction and to determine whether SCR catalyst blinding/poisoning can occur over relatively short periods for biomass cofiring; 3) identifying SCR blinding mechanisms, rates, and cleaning methods for use in cofiring biomass; and 4) developing a database to allow utility operators to determine blinding/poisoning rates for select coals and biomass.

Expected Results: Utilities that are contemplating the installation of SCR in their coal-fired units will gain scientific and engineering information related to potential fouling of SCR catalyst material and will be able to negotiate guarantees and performance criteria for SCR systems and materials, and SCR manufacturers and distributors will gain an appreciation for potential challenges facing utilities using low-rank coals. A database of coal–biomass combustion characteristics will be developed to allow utility operators to determine blinding/poisoning rates for select coals and biomass.

Duration and Total Project Cost: The project is 24 months in duration with a total cost of \$400,000: \$120,000 from the North Dakota Industrial Commission (NDIC), \$160,000 from the U.S. Department of Energy (DOE), \$60,000 from each of two utility consortium sponsors, and possible in-kind support from a catalyst vendor.

Participants: Participants will be the EERC, DOE, NDIC, and utility consortium sponsors.

BIOMASS IMPACTS ON SCR PERFORMANCE

PROJECT SUMMARY

The work will be accomplished in four tasks. Task 1 will conduct biomass resource assessments and identify candidate biomass types and coals for testing. In Task 2, specially devised long-term bench- or pilot-scale and field tests will be performed to determine the mechanisms of NO_x (nitrogen oxide) reduction and to determine whether selective catalytic reduction (SCR) catalyst blinding can occur over relatively short periods for biomass cofiring. Task 3 will identify SCR blinding mechanisms, rates, and potential cleaning methods when biomass is cofired. Task 4 will focus on development of a database to allow utility operators to determine blinding/poisoning rates for select coals and biomass.

PROJECT DESCRIPTION

Goal

The primary goal is to determine both the effects of biomass cofiring on NO_x emissions and the mechanistic or fundamental causes of potential blinding or masking of SCR catalysts due to flue gas constituents in biomass.

Objectives

Specific project objectives include:

- Identifying candidate biomass feedstocks and coals and determining blend ratios.
- Conducting long-term bench- or pilot-scale testing, coupled with sophisticated scanning electron microscopy (SEM) of catalyst surface to determine blinding mechanisms and to assess selective noncatalytic effects of certain biomass types to actually reduce NO_x.

- Conducting testing at full-scale facilities.
- Interpreting data, preparing a report, and hosting sponsor meetings to develop recommendations related to improved catalyst design and properties, blinding elimination, and potential enhanced NO_x conversion by optimizing biomass types and blend ratios.

Methodology and Scope of Work

The scope of work includes four tasks. Task 1 will conduct biomass resource assessments and identifying candidate biomass types and coals for testing. In Task 2, specially devised long-term bench- or pilot-scale and field tests using unique SCR test reactors that were designed and built for a different project and would be available for use on this project will be performed to determine the mechanisms of NO_x reduction and to determine whether SCR catalyst blinding can occur over relatively short periods for biomass cofiring. Task 3 will identify SCR blinding mechanisms, rates, and potential cleaning methods when biomass is cofired. Task 4 will focus on development of a database to allow utility operators to determine blinding/poisoning rates for select coals and biomass.

A detailed description of the scope of work for each of the four tasks is given here.

Task 1 – Fuels Assessment and Characterization

The first task of this project will be to have a kickoff meeting between the multiclient consortium members to determine potential biomass feedstocks and coals that will be tested. Also, potential utilities and boiler units that could be tested in the field using the Energy & Environmental Research Center (EERC) SCR slipstream test chamber will be discussed; the number of field tests will depend upon the number of consortium members involved and available funding. Attempts will be made to select all sponsor coals for testing. All test coals and biomass types will be analyzed for proximate, ultimate, heating value, and bulk inorganic composition using standard American Society for Testing and Materials (ASTM) procedures. Advanced analytical techniques including chemical fractionation and SEM will be used to quantify total mineral matter. Biomass feedstocks that are rich in ammonium phosphates, such as poultry or turkey manure, may be evaluated for use as an NO_x-reducing biomass blend feedstock.

Task 2 – Bench-Scale Screening and Field Testing

SCR blinding is a slow process that occurs over a period of 500 to 2000 hours in full-scale utility boilers. In order to evaluate coal–biomass blends experimentally in the laboratory, an existing 4-lb/hr pilot-scale pulverized coal combustion system will be modified to accommodate longer-term combustion testing. Baseline coals, coal–biomass blends, and baseline biomass fuels will be fired to observe any blinding and NO_x reduction effects. NO_x reduction may be especially induced using poultry or turkey manure as biomass blend fuels. Combustion tests will be run on a minimum of two baseline coals and biomass feedstocks and on at least six different blends. Ash from the combustion test will also be sampled.

Two skid-mounted test rigs have been constructed to conduct full-scale evaluation of SCR blinding. These systems consist of a catalyst section, an ammonia injection system, and sampling ports for NO_x at the inlet and exit. The portable systems can be installed in the region ahead of the air heater in a full-scale utility boiler and will isokinetically extract a slipstream from the flue gas duct using an induced-draft fan. The test reactors are fully instrumented with a complete suite of gas analyzers and remote operation equipment. Testing will be done on at least one full-scale boiler that is burning 100% biomass or a coal–biomass blend. The SCR test chamber will be installed in a slipstream arrangement in the region ahead of the air heater for a period of 1–12 months. Upon installation of the test chamber at each boiler unit, measurements of flue gas temperatures, gas composition, and gas velocity will be taken using portable equipment. Periodic checks of the chamber by a trained boiler technician will be made to ensure experimental quality. The test chamber will be constructed so that periodic samples of the catalyst can be removed to assess reactivity as a function of time. After testing is completed at the first utility boiler site, the SCR slipstream test chamber will be moved to a second utility boiler site contingent upon funding.

Two different types of catalyst will be used in the test sections. Any blinding deposits that form will be analyzed using advanced techniques, such as scanning electron microscopy point count or computer-controlled scanning electron microscopy, at the EERC to determine the root causes of blinding and to propose predictive mitigation measures. SCR catalyst materials will be analyzed to obtain fundamental information on the formation of phases and components that comprise SCR blinding deposits. Some studies have observed phosphate-rich ash deposits comprising SCR deposits. Calcium, phosphorus, potassium, sulfur, silica, and chlorine elements and their compounds may contribute to low-temperature ash deposition in SCR systems. Information on how these blinding ash deposits develop and form will be invaluable for predicting SCR deposition and for formulating ash deposit mitigation measures when biomass is cofired with coal. Catalyst blinding will be assessed by extracting the catalyst section after long-duration tests and assessing catalyst reactivity and ash–catalyst surface reactions and ash deposition using advanced SEM techniques. SEM techniques have been perfected at the EERC for determining intimate deposit–substrate interface interactions and fine-particle compositions. Upon completion of the SCR chamber experiments at each plant, the SCR catalyst section in the test chamber will be analyzed to determine any degradation in catalyst reactivity. Reactivity will be measured at the EERC and by an outside laboratory.

The nature of any ash deposition or ash–catalyst reactions will be investigated by the EERC using proven methods that include SEM, x-ray diffraction, and other analytical techniques. These same techniques and other fine-particle SEM analytical techniques will be used to analyze the entrained ash samples collected at the field sites. Correlations between the physical and chemical characteristics of any ash deposits on the SCR test section and entrained ash sample collected at the chamber inlet and the coal inorganic composition will be tested for to discern mechanisms of SCR blinding. Minor and trace element analyses of deposits and SCR catalyst material will be performed in order to evaluate the effects of As, Sr, and Ba, which may act as poisoning agents.

Task 3 – NO_x Reduction and Alleviation of Catalyst Blinding

Task 3 focuses on devising ways to blend biomass to help reduce NO_x through noncatalytic reduction and devise cleaning methods or suggest catalyst design that will alleviate blinding. Blend ratios of biomass fuels will be evaluated for optimum NO_x reduction. Gas analyzers on the pilot-scale combustion system will provide recorded NO_x data, which will be compared with fuel characteristics and firing modes to determine whether NO_x reduction occurred with any of the biomass–coal blends. Based on the mechanisms of ash deposition or blinding, methods to alleviate or at least minimize ash deposition on the catalyst material will be proposed, such as sootblowing and specially prescribed coal–biomass blends.

Task 4 – Database Development and Reporting

Task 4 will focus on development of a database of all of the information gathered during this project to aid boiler operators in selecting appropriate biomass fuels to cofire with specific coals. Project reporting, periodic meetings with all consortium members, and efficient transfer of information will be facilitated in this task. Quarterly interim reports will be submitted to all sponsors and consortium members that bullet the progress and forecast of the project and highlight any key findings. A final report will be submitted to the North Dakota Industrial Commission (NDIC) and all sponsors at the end of the project. Any special reports requested by NDIC will be provided in a timely manner.

Expected Results

Several deliverables and benefits will result for active participating agencies in this project. Listed below are the most important of these:

1. Utilities that are contemplating the installation of SCR in their coal-fired units will gain scientific and engineering information related to potential fouling of SCR catalyst material and will be able to negotiate guarantees and performance criteria for SCR systems and materials.
2. SCR manufacturers and distributors will gain an appreciation for potential challenges facing utilities using low-rank coals that could cause SCR masking and will be able to adjust future systems.
3. Specific information on potential NO_x reduction by cofiring biomass with their coals.
4. A database of biomass properties and combustion characteristics.

Facilities, Resources, and Techniques

The EERC has well-equipped and instrumented bench-scale coal combustion demonstration facilities for performing these experiments. Either a drop-tube furnace (DTF) assembly that burns coal at a g/min rate or a downfired combustion system that burns 2–4 lb/hr of fuel, called the conversion and environmental process simulator (CEPS), will be adapted for these tests. The SCR reaction chamber will be assembled and attached in the postcombustion heat-exchange section of either the CEPS or DTF system, where combustion flue gas can be passed across the catalyst material. The combined combustor and SCR reaction chamber offer easy installation and removal of catalyst sections, hot synthetic flue gas injection, good control of gas composition, and full instrumentation for monitoring the system.

Environmental and Economic Impacts

In its 1990 Clean Air Act Amendments, Congress specifically directed the U.S. Environmental Protection Agency (EPA) to establish new NO_x emission standards that incorporate improvements in methods for the reduction of NO_x. As a result, coal-fired utility boilers which are considered a new source will be forced to lower NO_x emissions to levels of 0.2 lb/MMBtu. Since SCR technology is about the only choice that will be effective for lowering NO_x in a majority of boilers, especially cyclone boilers, this project may aid in improving SCR technologies for effective NO_x control and improved environmental air quality.

Rationale for the Project

Energy production from biomass combustion is currently about 1% of the total U.S. output, whereas worldwide use of biomass is between 10%–20%. An ongoing worldwide agenda to reduce greenhouse gas emissions is providing the impetus for increasing the use of biomass fuels in the United States, Europe, and the world. A new wave of "green" thinking is infiltrating utilities and causing conventional coal-fired utilities to examine the feasibility of burning renewable fuels such as biomass.

Two biomass types that are available for cofiring with coal are biomass wastes or residues and energy crops. Wastes or residues include wooden pallets, telephone poles, sawdust, manufacturing scraps, municipal solid wastes or sludges, peach pits, rice hulls, lignin, and straws of wheat, rice, alfalfa, rape, timothy, and barley. Energy crops include fast-growing switchgrass and hybrid trees such as poplar and willow.

Cofiring biomass wastes and energy crops with coals in power plants is an attractive option for establishing a "green power" sector of the utility power repertoire. Attention to mitigation of greenhouse gas emissions has led to the use of biomass as a cofiring fuel. Potential attractions include lower fuel costs, lower air toxic emissions such as from sulfur compounds and trace metal emissions, and higher efficiency with respect to convective heat transfer. Issues that need to be addressed before more utilities implement cofiring strategies include the ash behavior of biomass-derived by-products with respect to boiler operational efficiency and air toxics control such as NO_x.

NO_x is a term used for the oxides of nitrogen (NO, NO_2, and N_2O). They are formed in combustion processes by the reaction of N_2 and O_2. NO_x has received attention lately because of its global warming effects, its participation in acid rain by formation of nitric acid, and photochemical ozone (smog) generation (1). The 1990 Clean Air Act Amendments specifically directed EPA to exercise its delegated authority and establish new NO_x emissions standards that incorporate improvements in methods for the reduction of NO_x. As a result, EPA promulgated a rule lowering its NO_x New Source Performance Standards to 0.15 lb/MMBtu for utility boilers and 0.20 lb/MMBtu for industrial boilers. Currently, 392 power plants in 22 states have been ordered to curtail NO_x emissions by 50% by March 2003. SCR technology is the only proven method that will be effective for lowering NO_x in a majority of boilers. Little is known, however, of the effects of biomass cofiring on SCR catalyst deactivation.

Recent studies conducted by Hartenstein et al. (2) showed an impact of sodium, calcium, sulfur, and phosphorus on the performance of SCR catalysts when German coals were fired. Over a period of time, blinding of the SCR catalyst occurred, resulting in decreased conversion efficiency. Extrapolation of the German experience to U.S. applications reveals that catalyst deactivation may occur because of the high alkaline metals, sulfur, and SO_3 contents in some U.S. coals and the large amount of water-soluble alkaline metals in biomass. SCR systems operate in flue gas ducts downstream of the economizer and just prior to the air heater where entrained ash or dust can deposit. The high alkali and alkaline-earth element content (sodium, potassium, and calcium) of entrained fly ash generated from combustion of biomass can react with gaseous SO_2 to form low-temperature sulfate-based ash deposits on catalyst surfaces.

The mechanisms for this type of low-temperature deposition have been examined and modeled in detail at the EERC in work termed Project Sodium and Project Calcium in the early 1990s; however, the focus of those projects was specific to primary superheater and economizer regions of boilers and not SCR systems (3, 4). Deposit buildup of this type can effectively blind or mask the catalyst, diminishing its reactivity for converting NO_2 to N_2 and water and potentially creating increased ammonia slip (4). Arsenic and phosphates, which are not uncommon in low-rank coals and biomass, may also play a role in catalyst degeneration. Arsenic is a known catalyst poison (5) in applications such as catalytic oxidation for pollution control. Phosphates can occur in low-temperature ash deposits to create blinding effects, and they also occur with arsenic and can cause catalyst poisoning (6).

It is imperative that utilities, state agencies, regulators, and SCR catalyst vendors understand fully the potential for SCR masking and poisoning for cofiring biomass with low-rank coals such as North Dakota lignites or Powder River Basin coals, which can generate very fine particulate fly ash and vapor components that may deteriorate the reactivity of a catalyst surface over time. Other options that may surface as result of this research include providing technological and fundamental science and engineering knowledge for manufacturing SCR catalysts that resist blinding from low-rank-coal-type ash material or designing SCR systems that can be cleaned on-line.

STANDARDS OF SUCCESS

The project has a determined milestone plan that will be adhered to by the EERC project manager. Milestones cover major work efforts and accomplishments within specific tasks of the project that are completed at specific times. A project schedule can be seen on page 20.

Determination of the effectiveness of the end results will occur during open communication between the researchers, executive and advisory staff, and project sponsors at meetings. It is expected that the results of this work will be published in major biomass utilization venues where results will be challenged and validated by knowledgeable peers.

BACKGROUND

SCR technologies have been successfully demonstrated to a large degree in Europe and other countries and to a smaller degree in U.S. utilities. Most of this work has been performed on higher-rank coals that do not possess significant organically associated alkali–alkaline-earth elemental constituents, which can cause severe blinding of catalyst material. The degree to which blinding occurs in biomass–coal-cofiring scenarios will be studied in this project. The EERC has years of experience studying low-temperature ash deposition, which is the likely mechanism by which SCR blinding may occur with chlorine-, potassium-, phosphorus-, and calcium-rich biomass being blended and burned in combination with sulfur-laden coal. In the past 5 years, several publications related to biomass ash interactions during combustion and cofiring with coal have been published (7–17).

The EERC has worked on recent projects including SCR blinding for low-rank coals (six-member consortium of utilities, vendors, EPRI, the U.S. Department of Energy [DOE], and the

NDIC) and a study of coal quality impacts on boiler performance at the Coyote Power Station near Beulah, North Dakota.

The EERC has established a Center for Biomass Utilization which grew out of industry-backed efforts to utilize an array of biomass resources for fuel and energy and now comprises over $4 million of activities funded through industry investment; local, state, and federal government contracts; and industry–government joint ventures. This successful program will provide additional backbone for the proposed project on biomass effects on SCR performance and NO_x emissions and has some limited bench-scale biomass cofiring testing information related to SCR which will be shared with this proposed project.

QUALIFICATIONS

The project's overall management responsibility belongs to Dr. Bruce Folkedahl and Mr. Chris Zygarlicke. They will comanage the project to ensure proper project milestone achievements, report generation and distribution, project budget control, and effective informational meetings. Dr. Folkedahl has years of experience and has proven himself an effective project manager. He has over 7 years in technical project management and research at the EERC, 3 years of Ph.D. research at Penn State University, and 3 years of program and departmental management at 3M. Dr. Folkedahl will coordinate all project activities, including production of quarterly, semiannual, and final reports; implementing technology transfer by disseminating project results to local and national communities and other interested federal entities and academia; and scheduling internal project review meetings with task leaders and program managers.

Mr. Zygarlicke has over 15 years of experience managing coal and biomass combustion-related projects. Mr. Zygarlicke has managed numerous federal and commercial projects in coal and biomass combustion over the past 13 years at the EERC and has exhaustive experience in ash behavior and air toxic emissions associated with various fuels including biomass. He has also served as the project manager for a similarly arranged $1.2 million consortium project called Coal Ash Behavior in Reducing Environments, which involved EPRI, four international sponsoring companies/agencies, and Netherlands Energy Research Foundation as a subcontractor/research collaborator. Mr. Zygarlicke's primary duties will be to oversee all activities within the project as a whole and ensure that all project objectives and milestones are being delivered.

Principal investigators are Mr. Jay Gunderson and Mr. Jim Tibbetts, who will oversee the bench-scale and full-scale SCR catalyst blinding experimental activities. Dr. Donald McCollor will oversee the analytical work performed on all fuels and catalyst materials. Mr. Lingbu Kong will provide the computer-coding expertise to develop a computer model of SCR blinding/poisoning rates for select coals and biomass. These researchers will also be responsible for cataloging and reporting all experimental results in their respective areas of focus. Resumes can be found in the Appendix.

The EERC of the University of North Dakota 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; emissions control technologies; ash use and disposal; analytical methods; groundwater; waste-to-energy systems; and advanced environmental control systems. Today's energy and environmental research needs typically require the expertise of a total-systems team that can focus on technical details while retaining a broad perspective. The EERC team has more than four decades of basic and applied research experience producing energy from all ranks of coal, with particular emphasis on low-rank coals. As a result, the EERC has become the world's leading low-rank coal research center. EERC research programs are designed to embrace all aspects of energy-from-coal technologies from cradle to grave, beginning with fundamental resource characterization and ending with waste utilization or disposal in mine land reclamation settings.

The future of North Dakota energy production depends upon developing interconnections between energy and environment that will allow the extraction of sufficient energy and other resources from the environment in a manner that does not jeopardize its integrity and stability. The EERC fulfills a valuable part of this future challenge by developing an SCR-blinding research project that will effectively develop partnerships between industry, researchers, and state agencies.

With respect to NO_x emissions, the EERC has been performing studies in low-NO_x burner technologies, catalytic effects on NO_x conversion, fly ash quality from low-NO_x burner or overfired air technology installation, and fuel impacts on NO_x emissions for over 25 years. Over a thousand pilot-scale combustion tests have been logged on two nearly identical fuel combustion rigs in the last 20 years, whereby ash issues and air toxic emissions have been studied. Several successful projects, including well over 50 field tests just in the last 5 years, have been conducted at various utilities throughout the United States to perform flue gas sampling, air toxic emissions monitoring, fly ash collection, and fouling and slagging deposit sampling. Several of those field tests involved working with plant slipstreams or direct sampling using custom-designed and -manufactured sampling equipment.

The EERC has extensive experience working in biomass utilization including these specific opportunities, which are described separately here:

1. Biomass District Energy Consortium
2. Center for Biomass Utilization
3. Small, Modular Biopower Projects
4. Cofiring Projects

5. New Technology Development

6. Biomass Utilization Project

7. Larger-Scale Gasification

Biomass District Energy Consortium

Biomass can be expensive, difficult to handle, and available in limited quantity when compared to coal. Even when a biomass resource is available in a sufficient amount, the low specific volumetric energy density and resulting high transport volume renders biomass unattractive for incorporation in the fuel diet of a large coal-fired utility boiler. The smaller size and versatility of stoker-type furnaces is much better suited for matching the characteristics of biomass resources. The market for the small biomass user can be tremendous; however, technology has been slow to progress into the marketplace, inhibiting manufacturers from offering substantial equipment guarantees which would enable the successful use of biomass fuels.

For small communities, district energy is a more efficient use of energy and enables fuel flexibility that provides for more stable energy costs. The EERC, in cooperation with DOE, has obtained funding to initiate a biomass district energy consortium. The consortium will primarily focus on two activities: 1) marketing through presentations to end users encouraging the use of biomass and the implementation of district energy and 2) conducting research and development on fuel storage and handling, resource assessments, feasibility studies, combustion, ash deposition, fouling and slagging issues, and cofiring effects on ash and emissions.

The Forest Products Laboratory of the United States Department of Agriculture (USDA) Forest Service, through membership of the biomass district energy consortium, will promote the use of woody residues for energy using conventional district energy infrastructure and advanced small power system technologies.

Center for Biomass Utilization

The EERC's Center for Biomass Utilization grew out of industry-backed efforts to utilize an array of biomass resources for fuel and energy and now comprises over $4 million of activities funded through industry investment; local, state, and federal government contracts; and industry–government joint ventures. Federal funding has been awarded through the DOE, USDA, and EPA. The technical goals of the EERC Center for Biomass Utilization include:

- Developing biomass fuels for utility- and industrial-scale conventional power systems.
- Establishing biomass as a viable option in small-scale distributed energy systems.
- Developing advanced power systems that utilize biomass which may involve:
  - Designing and demonstrating small gasification systems.
  - Hydrogen and other fuel production for fuel cells.
  - Gas separation and reforming technologies.
- Researching the new bioproducts from agricultural residues, energy crops, and forest residues, such as ethanol, ethanol-derived oxygenates, biodiesel, lactic acid, foods, fiber, and chemicals.
- Improving public awareness of the great potential of biomass as a resource for energy and products.

Small, Modular Biopower Projects

The EERC is currently working with two developers under this DOE program, which includes Flex-Energy and King Coal Furnace Corporation. Flex-Energy is developing a trailer-mounted biomass gasifier coupled to a Capstone microturbine for power generation. King Coal is developing a more conventional boiler-type modular power system. In both cases, the EERC will be involved in the demonstration of these technologies expected to take place over the next 2 years.

Cofiring Projects

The EERC has been investigating the opportunity for biomass use in utility- and stoker-scale systems. Two feasibility studies looking at low-rank coal and biomass are currently under way. One project in particular will result in a full-scale cogeneration stoker-fired demonstration using municipal wood and lignite coal. The project will have an attractive return on investment and multiple benefits to the local community. Combustion testing of lignin, a by-product from ethanol production using lignocellulosic biomass feedstocks such as wood, rice straw, and municipal solid waste, is being evaluated by the EERC for the two largest lignin-producing projects in the United States. Pilot-scale combustion testing to evaluate ash behavior and air toxic emissions is being done for BCI International for rice straw lignin and for the Tennessee Valley Authority and the Masada Corporation for municipal solid waste lignin. Both of these projects have plans for constructing commercial-scale ethanol plants near energy-producing boilers to utilize the lignin by-product, either as a 100% biomass fuel or in a cofiring scenario with coal.

New Technology Development

The EERC is developing a small power system fueled with biomass to overcome the hurdles of capital cost typically associated with conventional power systems. The technology is known as a boundary layer turbine. In partnership with the California Energy Commission the EERC has a project to prove the thermodynamic performance of the turbine and its potential use for burning biomass fuels directly without the need for expensive gas cleanup devices. This technology could be applied to the small, modular biomass program, but requires further fundamental development.

Biomass Utilization Project

Part of a $1 million DOE Biomass Utilization project awarded in 2001 will focus on using a DTF approach to producing fine particulate and other flue gas components from biomass cofiring.

The materials will be analyzed for propensity to form SCR-blinding deposits. The information from this project will be used in conjunction with the DOE Biomass Utilization project. Although the proposed project involves more realistic pilot-scale combustion testing, this DOE Biomass Utilization project will produce bench-scale results to aid in the understanding of blinding mechanisms and perhaps formulate a method for predicting NO_x emissions and blinding propensity based on fuel composition and biomass–coal blend ratios.

Larger-Scale Gasification

The EERC has worked with various large gasification companies and more recently in the area of black liquor gasification. Biomass gasification research for larger systems has involved developing a pressurized biomass feed system for Global Energy in a DOE joint venture project, running biomass feedstocks in a transport reactor development unit, and designing a new high-efficiency biomass gasification–gas turbine combined-cycle-type of system for power, resin products, and clean heated air for wood product plants.

VALUE TO NORTH DAKOTA

North Dakota's economy is driven by the energy and agriculture industries. The benefits to the State of North Dakota from this study have great impacts on energy and agriculture. First of all, the promotion of biomass which is a renewable fuel is an attractive option for mitigation of greenhouse gas emissions from power plants. Power plants in North Dakota need to continue to utilize the large indigenous lignite resources, and the incorporation of biomass, a renewable fuel, at a low level is one way to add green power capacity. More and more utility customers are even willing to pay higher electrical rates for green power. Biomass for power helps to give consumers another choice and yet preserves the use of a valuable lignite resource.

Secondly, air toxic emissions such as NO_x and sulfur oxide (SO_x) emissions and mercury from coal-fired power plants can be lowered by cofiring biomass, which is also a means of preserving a valuable lignite resource without the threat of being shutdown by regulations on air toxic emissions. The U.S. Forest Service has designated national parks, national wilderness areas, and national monuments as Class I areas which are entitled to special environmental protection. The Clean Air Act requires that EPA and federal land managers be notified and involved in the permitting process for any new major stationary air emissions source or major modification to a source located within 100 kilometers of a Class I area. North Dakota has two Class I areas that include the Lost Woods Wildlife preserve and the Theodore Roosevelt National Grasslands. NO_x and SO_x emissions from coal-fired power plants are considered secondary fine particulate precursors that can cause or be a part of regional haze in Class I areas. The proposed project works toward utilizing lower-sulfur biomass fuels that also may be fired as reburn fuels to lower NO_x emissions. Lowering SO_x and NO_x will reduce regional haze air pollution.

Third, the possibility of utilizing low-cost biomass residue such as flax straw or turkey manure, the production of short rotation woody crops, and the conversion of low-value agriculture products to diversified, value-added agriculture products will expand economic opportunities in rural communities. This program also seeks to enhance sustainable rural economic growth, develop new crop uses, and conserve natural resources through renewable energy. Job creation in biomass supply and trucking is a direct economic impact of biomass cofiring.

Finally, by diverting biomass residues that are typically landfilled to energy uses, this project will enhance terrestrial land quality by adding life to landfills, or in the case of energy crops, short rotation woody crops or grasses could be grown as mine reclamation projects, thereby enhancing their value (18).

MANAGEMENT

Although all capital assets within the EERC are owned by the University of North Dakota, the EERC is basically a self-sustaining organization that procures its own research dollars, hires its own personnel, and operates all support departments including accounting, contracts, and other administrative staff. The project manager will track technical and experimental progress on a task-specific basis. He will also generate reports in accordance with requirements that are monitored by the EERC Contracts staff, who also ensure that proper work scope items are adhered to as specified in the contract. Assisting the EERC project manager is a full-time administrative staff who track personnel time and provide updates to the project manager and implement his budget changes and adjustments. Accounting staff is also on-site and enforces responsible expenditure of funds by tracking all expenditures and purchases made with respect to the project.

The EERC is committed to delivering consistent and high-quality research that meets its clients' needs and expectations. An organizationwide quality management system is in effect that governs all programs within the organization. This project is required to be in compliance with the *Quality Manual* and any project-specific quality assurance (QA) procedures, thus ensuring that any requirements relating to quality and compliance with applicable regulations, codes, and protocols are adequately fulfilled. The EERC Quality Assurance Manager implements and oversees all aspects of quality assurance/quality control (QA/QC) for all research, development, and demonstration projects and will review the QA/QC components of this project. The EERC maintains a wide range of analytical and testing laboratories that follow nationally recognized or approved standards and methods put forth by EPA, ASTM, National Institute of Standards and Technology, and other agencies.

Executive staff consisting of the EERC Director, Associate Director, and Director of Marketing will ensure that high-quality fundamental research with potential for commercialization is being implemented and managed efficiently.

Evaluation and monitoring of the project results will be done by periodic internal meetings, reports, and meetings with the project sponsors. The meetings with project sponsors will include a minimum of one face-to-face meeting each year, with the other meetings being teleconference. Progress with respect to accomplishing the milestones will be discussed in meetings and reports to ensure that the project goals are being met.

TIMETABLE

The project will be completed within 24 months (Table 1). There will be a 4-month period to select, acquire, and characterize coals and biomass; a 6-month period to conduct pilot-scale tests for NO_x emissions effects and SCR blinding due to biomass cofiring; a 10-month period to collect data at select utilities; and a 4-month period to analyze data, interpret results, and evaluate blinding mitigation and NO_x reduction strategies with biomass cofiring.

Quarterly interim reports that describe project progress, forecast, and key results will be submitted to all project sponsors. A final comprehensive report will be submitted to the same parties at the end of the 24-month project.

Table 1. Project Schedule

	2002												2003											
Task Name	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
1. Fuels Assessment and Characterization																								
2. Bench-Scale Screening and Field Testing																								
3. NOx Reduction & Alleviation of Catalyst Blinding																								
4. Database Development and Reporting																								

BUDGET

The total project cost is $400,000: $120,000 from NDIC, $160,000 from DOE, $60,000 from each of two utility consortium sponsors, and possible in-kind support from a catalyst vendor. This is a minimum project total needed to fulfill the project objectives and the work scope as outlined in the four-task structure. The project would run over a course of 2 years. It is possible that a catalyst vendor would contribute in-kind cost share for activities involving catalyst reactor design and construction. Should total contributions increase beyond the two U.S. utilities currently planned for, additional utility boiler testing or analytical work will be added to the project work scope. An itemized budget is listed following the reference section.

The EERC is requesting NDIC to commit $120,000 of funding for this project. Once we have NDIC's commitment, we will submit the proposal to DOE, requesting approval of its share of the funding.

Three items are required from NDIC for inclusion in our proposal to DOE.

- A formal commitment to the project. This can be a letter of commitment, a purchase order, or a signed contract.
- A biographical sketch or resume for NDIC project manager and/or key technical contributor.
- A short overview of NDIC.

The EERC will submit a proposal to DOE for its approval upon receipt of NDIC commitment and the information noted above.

MATCHING FUNDS

The greatest leveraging of funding and expertise for developing a fruitful project would be through a consortium project between the EERC, commercial entities, and DOE. The EERC proposes to assemble and manage a multiclient consortium consisting of the EERC as the prime contractor and administrator of the program, with consortium members consisting of utilities, catalyst vendors, and NDIC, which is active in funding research related to enhancing the utilization of North Dakota lignite. The EERC brings to this program its nearly 50 years of experience in coal and biomass combustion, ash deposition, and air toxics control to effectively guide this project toward meaningful results.

Consortium members would include a catalyst vendor that could supply catalyst material and also aid in the design and modification of the pilot-scale SCR test reactor, several utilities, EPRI, NDIC, and DOE.

The project would be funded through the EERC–DOE Jointly Sponsored Research Program, whereby the sum total of the commercial or industrial partners' contributions would be matched by a DOE contribution equaling 40% of the total project cost. A project budget has been assembled by the EERC for addressing SCR blinding potential and NO_x emissions with respect to biomass cofiring testing at both the pilot- and full-scale for a total project cost of about $400,000. This is a minimum project total needed to fulfill the project objectives and the work scope as outlined in the four-task structure. The project would run over a course of 24 months. In order to reach the total budget of $400,000, two U.S. commercial sponsors, not including NDIC, will be needed to contribute $60,000 to total $120,000. NDIC would in essence match this amount and contribute $60,000 per year to total $120,000. It is possible that a catalyst vendor would contribute in-kind cost share for activities involving catalyst reactor design and construction. Should total contributions increase beyond the two U.S. utilities currently planned for, additional testing or analytical work will be added to the project work scope. The total commercial contribution would therefore be $240,000. DOE would be solicited to contribute a total of $160,000 as a 40% match to meet the total project cost of $400,000. The EERC is confident that a minimum of two commercial sponsors will be secured and that DOE will approve the 40% cost share.

TAX LIABILITY

None.

CONFIDENTIAL INFORMATION

None.

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SUMMARY BUDGET

BIOMASS IMPACTS ON SCR PERFORMANCE
XCEL/NDIC/DOE
PROPOSED START DATE: 1/1/02
EERC PROPOSAL #2002-0017

CATEGORY		TOTAL PROJECT HRS	TOTAL PROJECT $ COST	NDIC SHARE HOURS	NDIC SHARE $ COST	OTHER COMM. SHARE HOURS	OTHER COMM. SHARE $ COST	EERC JSRP SHARE HRS	EERC JSRP SHARE $ COST
TOTAL DIRECT LABOR		4,379	$116,464	1,189	$36,098	1,117	$33,619	2,073	$46,747
FRINGE BENEFITS			$64,055		$19,854		$18,490		$25,711
TOTAL LABOR			$180,519		$55,952		$52,109		$72,458
OTHER DIRECT COSTS									
TRAVEL			$9,199		$1,523		$4,184		$3,492
SUPPLIES			$15,000		$1,202		$4,242		$9,556
COMMUNICATIONS - PHONES & POSTAGE			$1,042		$263		$331		$448
OFFICE (PROJECT SPECIFIC SUPPLIES)			$1,685		$466		$669		$550
DATA PROCESSING - SOFTWARE			$2,500		$879		$1,621		$0
GENERAL (FREIGHT, FOOD, MEMBERSHIPS, ETC.)			$465		$134		$145		$186
FEES			$55,023		$17,503		$14,621		$22,899
TOTAL OTHER DIRECT COST			$84,914		$21,970		$25,813		$37,131
TOTAL DIRECT COST			$265,433		$77,922		$77,922		$109,589
FACILITIES AND ADMIN. RATE	**VAR**		$134,567		$42,078		$42,078		$50,411
TOTAL ESTIMATED COST			$400,000		$120,000		$120,000		$160,000

NOTE: Due to limitations within the University's accounting system, the system does not provide for accumulating and reporting expenses at the Detailed Budget level. The Summary Budget is presented for the purpose of how we propose, account, and report expenses. The Detailed Budget is presented to assist in the evaluation of the proposal.

DETAILED BUDGET - YEAR ONE

BIOMASS IMPACTS ON SCR PERFORMANCE
XCEL/NDIC/DOE
PROPOSED START DATE: 1/1/02
EERC PROPOSAL #2002-0017

					YEAR ONE					
		HOURLY	TOTAL		NDIC SHARE		OTHER COMM. SHARE		EERC JSRP SHARE	
LABOR	**LABOR CATEGORY**	**RATE**	**HOURS**	**$ COST**	**HOURS**	**$ COST**	**HOURS**	**$ COST**	**HOURS**	**$ COST**
B. FOLKEDAHL	PROJECT MANAGER	$32.21	320	$10,307	75	$2,416	97	$3,124	148	$4,767
C. ZYGARLICKE	PROJECT MANAGER	$39.43	150	$5,915	53	$2,090	67	$2,642	30	$1,183
J. GUNDERSON	PRINCIPAL INVESTIGATOR	$25.18	320	$8,058	133	$3,349	87	$2,191	100	$2,518
D. MCCOLLOR	PRINCIPAL INVESTIGATOR	$27.43	100	$2,743	33	$905	32	$878	35	$960
J. TIBBETTS	PRINCIPAL INVESTIGATOR	$22.24	320	$7,117	123	$2,736	86	$1,913	111	$2,468
L. KONG	PRINCIPAL INVESTIGATOR	$21.63	0	$0	0	$0	0	$0	0	$0
---------------	SENIOR MANAGEMENT	$44.82	64	$2,868	17	$762	20	$896	27	$1,210
---------------	QUALITY CONTROL MANAGER	$23.99	25	$600	7	$168	8	$192	10	$240
---------------	RESEARCH SCIENTIST/ENGINEER	$21.57	331	$7,140	41	$884	83	$1,790	207	$4,466
---------------	RESEARCH TECHNICIAN	$16.73	124	$2,075	27	$452	28	$468	69	$1,155
---------------	UNDERGRAD. RESEARCH ASSISTANT	$7.45	300	$2,235	0	$0	0	$0	300	$2,235
---------------	TECHNICAL SUPPORT SERVICES	$13.86	62	$859	20	$277	22	$305	20	$277
			2,116	$49,917	529	$14,039	530	$14,399	1057	$21,479
ESCALATION ABOVE CURRENT BASE		3%		$1,498		$421		$432		$645
TOTAL DIRECT LABOR				$51,415		$14,460		$14,831		$22,124
FRINGE BENEFITS - % OF DIRECT LABOR - STAFF		55%		$28,278		$7,953		$8,157		$12,168
TOTAL LABOR				$79,693		$22,413		$22,988		$34,292
OTHER DIRECT COSTS										
TRAVEL				$4,305		$666		$1,335		$2,304
SUPPLIES				$12,500		$667		$3,033		$8,800
COMMUNICATIONS - PHONES & POSTAGE				$600		$163		$181		$256
OFFICE (PROJECT SPECIFIC SUPPLIES)				$1,000		$333		$302		$365
DATA PROCESSING - SOFTWARE				$2,500		$879		$1,621		$0
GENERAL (FREIGHT, FOOD, MEMBERSHIPS, ETC.)				$245		$83		$70		$92
GRAPHICS				$3,278		$667		$1,333		$1,278
NATURAL MATERIALS ANALYTICAL RES. LAB.				$8,316		$4,000		$3,245		$1,071
FUELS & MATERIALS RESEARCH LAB				$1,450		$762		$688		$0
COMBUSTION TEST SERVICE				$27,656		$7,889		$3,945		$15,822
FUEL PREP. AND MAINTENANCE				$659		$439		$220		$0
TOTAL OTHER DIRECT COST				$62,509		$16,548		$15,973		$29,988
TOTAL DIRECT COST				$142,202		$38,961		$38,961		$64,280
FACILITIES AND ADMIN. RATE- % OF MTDC			VAR	$71,647	54%	$21,039	54%	$21,039	46%	$29,569
TOTAL ESTIMATED COST				$213,849		$60,000		$60,000		$93,849

DETAILED BUDGET - YEAR TWO

BIOMASS IMPACTS ON SCR PERFORMANCE
XCEL/NDIC/DOE
PROPOSED START DATE: 1/1/02
EERC PROPOSAL #2002-0017

					YEAR TWO					
		HOURLY	TOTAL		NDIC SHARE		OTHER COMM. SHARE		EERC JSRP SHARE	
LABOR	**LABOR CATEGORY**	**RATE**	**HOURS**	**$ COST**	**HOURS**	**$ COST**	**HOURS**	**$ COST**	**HOURS**	**$ COST**
B. FOLKEDAHL	PROJECT MANAGER	$32.21	580	$18,682	200	$6,442	150	$4,832	230	$7,408
C. ZYGARLICKE	PROJECT MANAGER	$39.43	350	$13,801	140	$5,520	120	$4,732	90	$3,549
J. GUNDERSON	PRINCIPAL INVESTIGATOR	$25.18	180	$4,532	67	$1,687	48	$1,209	65	$1,636
D. MCCOLLOR	PRINCIPAL INVESTIGATOR	$27.43	340	$9,326	145	$3,977	113	$3,100	82	$2,249
J. TIBBETTS	PRINCIPAL INVESTIGATOR	$22.24	0	$0	0	$0	0	$0	0	$0
L. KONG	PRINCIPAL INVESTIGATOR	$21.63	160	$3,461	53	$1,146	67	$1,449	40	$866
---------------	SENIOR MANAGEMENT	$44.82	60	$2,689	13	$583	22	$986	25	$1,120
---------------	QUALITY CONTROL MANAGER	$23.99	27	$648	6	$144	8	$192	13	$312
---------------	RESEARCH SCIENTIST/ENGINEER	$21.57	104	$2,243	0	$0	0	$0	104	$2,243
---------------	RESEARCH TECHNICIAN	$16.73	95	$1,589	13	$217	27	$452	55	$920
---------------	UNDERGRAD. RESEARCH ASSISTANT	$7.45	285	$2,123	0	$0	0	$0	285	$2,123
---------------	TECHNICAL SUPPORT SERVICES	$13.86	82	$1,137	23	$319	32	$444	27	$374
			2263	$60,231	660	$20,035	587	$17,396	1016	$22,800
ESCALATION ABOVE CURRENT BASE		8%		$4,818		$1,603		$1,392		$1,823
TOTAL DIRECT LABOR				$65,049		$21,638		$18,788		$24,623
FRINGE BENEFITS - % OF DIRECT LABOR - STAFF		55%		$35,777		$11,901		$10,333		$13,543
TOTAL LABOR				$100,826		$33,539		$29,121		$38,166
OTHER DIRECT COSTS										
TRAVEL				$4,894		$857		$2,849		$1,188
SUPPLIES				$2,500		$535		$1,209		$756
COMMUNICATIONS - PHONES & POSTAGE				$442		$100		$150		$192
OFFICE (PROJECT SPECIFIC SUPPLIES)				$685		$133		$367		$185
DATA PROCESSING - SOFTWARE				$0		$0		$0		$0
GENERAL (FREIGHT, FOOD, MEMBERSHIPS, ETC.)				$220		$51		$75		$94
GRAPHICS				$1,918		$133		$1,567		$218
NATURAL MATERIALS ANALYTICAL RES. LAB.				$11,746		$3,613		$3,623		$4,510
FUELS & MATERIALS RESEARCH LAB				$0		$0		$0		$0
COMBUSTION TEST SERVICE				$0		$0		$0		$0
FUEL PREP. AND MAINTENANCE				$0		$0		$0		$0
TOTAL OTHER DIRECT COST				$22,405		$5,422		$9,840		$7,143
TOTAL DIRECT COST				$123,231		$38,961		$38,961		$45,309
FACILITIES AND ADMIN. RATE- % OF MTDC			VAR	$62,920	54%	$21,039	54%	$21,039	46%	$20,842
TOTAL ESTIMATED COST				$186,151		$60,000		$60,000		$66,151

DETAILED BUDGET - ALL YEARS

BIOMASS IMPACTS ON SCR PERFORMANCE
XCEL/NDIC/DOE
PROPOSED START DATE: 1/1/02
EERC PROPOSAL #2002-0017

					ALL YEARS					
					NDIC SHARE		OTHER COMM. SHARE		EERC JSRP SHARE	
		HOURLY	TOTAL							
LABOR	**LABOR CATEGORY**	**RATE**	**HOURS**	**$ COST**	**HOURS**	**$ COST**	**HOURS**	**$ COST**	**HOURS**	**$ COST**
B. FOLKEDAHL	PROJECT MANAGER	$32.21	900	$28,989	275	$8,858	247	$7,956	378	$12,175
C. ZYGARLICKE	PROJECT MANAGER	$39.43	500	$19,716	193	$7,610	187	$7,374	120	$4,732
J. GUNDERSON	PRINCIPAL INVESTIGATOR	$25.18	500	$12,590	200	$5,036	135	$3,400	165	$4,154
D. MCCOLLOR	PRINCIPAL INVESTIGATOR	$27.43	440	$12,069	178	$4,882	145	$3,978	117	$3,209
J. TIBBETTS	PRINCIPAL INVESTIGATOR	$22.24	320	$7,117	123	$2,736	86	$1,913	111	$2,468
L. KONG	PRINCIPAL INVESTIGATOR	$21.63	160	$3,461	53	$1,146	67	$1,449	40	$866
---------------	SENIOR MANAGEMENT	$44.82	124	$5,557	30	$1,345	42	$1,882	52	$2,330
---------------	QUALITY CONTROL MANAGER	$23.99	52	$1,248	13	$312	16	$384	23	$552
---------------	RESEARCH SCIENTIST/ENGINEER	$21.57	435	$9,383	41	$884	83	$1,790	311	$6,709
---------------	RESEARCH TECHNICIAN	$16.73	219	$3,664	40	$669	55	$920	124	$2,075
---------------	UNDERGRAD. RESEARCH ASSISTANT	$7.45	585	$4,358	0	$0	0	$0	585	$4,358
---------------	TECHNICAL SUPPORT SERVICES	$13.86	144	$1,996	43	$596	54	$749	47	$651
			4,379	$110,148	1,189	$34,074	1,117	$31,795	2,073	$44,279
ESCALATION ABOVE CURRENT BASE		VAR		$6,316		$2,024		$1,824		$2,468
TOTAL DIRECT LABOR				$116,464		$36,098		$33,619		$46,747
FRINGE BENEFITS - % OF DIRECT LABOR - STAFF		55%		$64,055		$19,854		$18,490		$25,711
TOTAL LABOR				$180,519		$55,952		$52,109		$72,458
OTHER DIRECT COSTS										
TRAVEL				$9,199		$1,523		$4,184		$3,492
SUPPLIES				$15,000		$1,202		$4,242		$9,556
COMMUNICATIONS - PHONES & POSTAGE				$1,042		$263		$331		$448
OFFICE (PROJECT SPECIFIC SUPPLIES)				$1,685		$466		$669		$550
DATA PROCESSING - SOFTWARE				$2,500		$879		$1,621		$0
GENERAL (FREIGHT, FOOD, MEMBERSHIPS, ETC.)				$465		$134		$145		$186
GRAPHICS				$5,196		$800		$2,900		$1,496
NATURAL MATERIALS ANALYTICAL RES. LAB.				$20,062		$7,613		$6,868		$5,581
FUELS & MATERIALS RESEARCH LAB				$1,450		$762		$688		$0
COMBUSTION TEST SERVICE				$27,656		$7,889		$3,945		$15,822
FUEL PREP. AND MAINTENANCE				$659		$439		$220		$0
TOTAL OTHER DIRECT COST				$84,914		$21,970		$25,813		$37,131
TOTAL DIRECT COST				$265,433		$77,922		$77,922		$109,589
FACILITIES AND ADMIN. RATE- % OF MTDC			VAR	$134,567	54%	$42,078	54%	$42,078	46%	$50,411
TOTAL ESTIMATED COST				$400,000		$120,000		$120,000		$160,000

BIOMASS IMPACTS ON SCR PERFORMANCE
EERC PROPOSAL #2002-0017

DETAILED BUDGET - TRAVEL

RATES USED TO CALCULATE ESTIMATED TRAVEL EXPENSES

DESTINATION	AIRFARE	PER MILE	LODGING	PER DIEM	CAR RENTAL	REGIST.
Unspecified Destination (USA)	$1,524	--	$125	$46	$50	$400
Minnesota Area	--	$0.405	$80	$46	--	--

PURPOSE/DESTINATION	NUMBER OF TRIPS	NUMBER OF PEOPLE	NUMBER OF MILES	NUMBER OF DAYS	AIRFARE	MILEAGE	LODGING	PER DIEM	CAR RENTAL	MISC.	REGIST.	TOTAL
YEAR ONE												
Site Visit/Minnesota Area	2	3	500	5	--	$405	$1,920	$1,380	--	$600	--	$4,305
TOTAL YEAR ONE												$4,305
YEAR TWO												
Conference/Unspecified Dest. (USA)	1	2	--	3	$3,048	--	$500	$276	$150	$120	$800	$4,894
TOTAL YEAR TWO												$4,894
TOTAL ALL YEARS												$9,199

BIOMASS IMPACTS ON SCR PERFORMANCE
EERC PROPOSAL #2002-0017

DETAILED BUDGET - FEES - YEAR ONE

		YEAR ONE		YEAR TWO		ALL YEARS	
NATURAL MAT. ANALYTICAL RES. LAB.	**RATE**	**#**	**$ COST**	**#**	**$ COST**	**#**	**$ COST**
CCSEM	$466	6	$2,796	0	$0	6	$2,796
CHEMICAL FRACT.	$1,132	4	$4,528	0	$0	4	$4,528
POINT COUNT	$471	0	$0	16	$7,536	16	$7,536
MORPHOLOGY (HOURLY)	$126	0	$0	18	$2,268	18	$2,268
XRD	$134	0	$0	8	$1,072	8	$1,072
XRFA	$150	5	$750	0	$0	5	$750
SUBTOTAL			$8,074		$10,876		$18,950
ESCALATION		3%	$242	8%	$870	VAR	$1,112
TOTAL NATURAL MATERIALS ANALYTICAL RES. LAB			$8,316		$11,746		$20,062

FUELS & MATERIALS RESEARCH LAB.	**RATE**	**#**	**$ COST**	**#**	**$ COST**	**#**	**$ COST**
BTU	$46	8	$368	0	$0	8	$368
DRY SIEVE	$44	8	$352	0	$0	8	$352
MOISTURE %	$35	8	$280	0	$0	8	$280
PROXIMATE ANALYSIS	$51	8	$408	0	$0	8	$408
SUBTOTAL			$1,408		$0		$1,408
ESCALATION		3%	$42	8%	$0	VAR	$42
TOTAL FUELS & MATERIALS RESEARCH LAB			$1,450		$0		$1,450

COMBUSTION TEST SERVICE	**RATE**	**#**	**$ COST**	**#**	**$ COST**	**#**	**$ COST**
COMB. TEST SERVICE RATES							
COMB. FACILITY BASE RATE (HOURLY)	$147	48	$7,056	0	$0	48	$7,056
INSTRUMENTATION & PROBES (HOURLY	$147	48	$7,056	0	$0	48	$7,056
FIELD TESTING-STARTUP	$3,529	2	$7,058	0	$0	2	$7,058
MISC FEE (HOURLY)	$71	80	$5,680	0	$0	80	$5,680
SUBTOTAL			$26,850		$0		$26,850
ESCALATION		3%	$806	8%	$0	VAR	$806
TOTAL COMBUSTION TEST SERVICES			$27,656		$0		$27,656

FUEL PREP AND MAINTENANCE	**ATE/HR.**	**#**	**$ COST**	**#**	**$ COST**	**#**	**$ COST**
FUEL PREP AND MAINTENANCE (PER HOUR PER PIECE OF EQUIP)	$16	40	$640	0	$0	40	$640
SUBTOTAL			$640		$0		$640
ESCALATION		3%	$19	8%	$0	VAR	$19
TOTAL FUEL PREP & MAINTENANCE			$659		$0		$659

GRAPHICS SUPPORT COST CENTER	**RATE**	**#**	**$ COST**	**#**	**$ COST**	**#**	**$ COST**
GRAPHICS (HOURLY)	$37	86	$3,182	48	$1,776	134	$4,958
SUBTOTAL			$3,182		$1,776		$4,958
ESCALATION		3%	$96	8%	$142	VAR	$238
TOTAL GRAPHICS SUPPORT COST CENTER			$3,278		$1,918		$5,196

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, or other agreements. Although the EERC is not affiliated with any one academic department, university academic faculty may participate in a project, depending on the scope of work and expertise required to perform the project.

The proposed work will be done on a cost-reimbursable basis. The distribution of costs between budget categories (labor, travel, supplies, equipment, subcontracts) is for planning purposes only. The principal investigator may, as dictated by the needs of the work, reallocate the budget among approved items or use the funds for other items directly related to the project, subject only to staying within the total dollars authorized for the overall program. The budget prepared for this proposal is based on a specific start date; this start date is indicated at the top of the EERC budget or identified in the body of the proposal. Please be aware that any delay in the start of this project may result in an increase in the budget. Financial reporting will be at the total project level.

Salaries and Fringe Benefits

As an interdisciplinary, multiprogram, and multiproject research center, the EERC employs an administrative staff to provide required services for various direct and indirect support functions. Direct project salary estimates are based on the scope of work and prior experience on projects of similar scope. Technical and administrative salary charges are based on direct hourly effort on the project. 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. For faculty, if the effort occurs during the academic year and crosses departmental lines, the salary will be in addition to the normal base salary. University policy allows faculty who perform work in addition to their academic contract to receive no more than 20% over the base salary. Costs for general support services such as grants and contracts administration, accounting, personnel, and purchasing and receiving, as well as clerical support of these functions, are included in the EERC facilities and administrative cost.

Fringe benefits are estimated on the basis of historical data. The fringe benefits actually charged consist of two components. The first component covers average vacation, holiday, and sick leave (VSL) for the EERC. This component is approved by the UND cognizant audit agency and charged as a percentage of direct labor for permanent staff employees eligible for VSL benefits. The second component covers actual expenses for items such as health, life, and unemployment insurance; social security matching; worker's compensation; and UND retirement contributions.

Travel

Travel is estimated on the basis of UND travel policies, which include estimated General Services Administration (GSA) daily meal rates. Travel includes scheduled meetings and conference participation as indicated in the scope of work.

Communications (phones and postage)

Monthly telephone services and fax telephone lines are generally included in the facilities and administrative cost. Direct project cost includes line charges at remote locations, long-distance telephone, including fax-related long-distance calls; postage for regular, air, and express mail; and other data or document transportation costs.

Office (project-specific supplies)

General purpose office supplies (pencils, pens, paper clips, staples, Post-it notes, etc.) are provided through a central storeroom at no cost to individual projects. Budgeted project office supplies include items specifically related to the project; this includes duplicating and printing.

Data Processing

Data processing includes items such as site licenses and computer software.

Supplies

Supplies in this category include scientific supply items such as chemicals, gases, glassware, and/or other project items such as nuts, bolts, and piping necessary for pilot plant operations. Other items also included are supplies such as computer disks, computer paper, memory chips, toner cartridges, maps, and other organizational materials required to complete the project.

Instructional/Research

This category includes subscriptions, books, and reference materials necessary to the project.

Fees

Laboratory and analytical fees are established and approved at the beginning of each fiscal year, and charges are based on a per sample or hourly rate depending on the analytical services performed. Additionally, laboratory analyses may be performed outside the University when necessary.

Graphics services fees are based on an established per hour rate for overall graphics production such as report figures, posters for poster sessions, standard word or table slides, simple maps, schematic slides, desktop publishing, photographs, and printing or copying.

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

General

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

Membership fees (if included) 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 as well as by the research team directly involved in project activity.

General 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), transportation, rental of facilities, and other items incidental to such meetings or conferences.

Facilities and Administrative Cost

The facilities and administrative rate (indirect cost rate) included in this proposal is the rate that became effective July 1, 1995. Facilities and administrative 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[1] and subcontracts/subgrants in excess of the first $25,000 of each award.

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[1] The equipment threshold is stated at $5000 in anticipation of the pending Facilities and Administrative Cost Rate Agreement. The proposal has been submitted to the Department of Health and Human Services with a stated effective date of July 1, 2001.