EERC®
Energy & Environmental Research Center
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March 30, 2007

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

Dear Ms. Fine:

Subject: EERC Proposal No. 2007-0218, "Activated Carbon Production from North Dakota Lignite – Phase IIA"

Enclosed are the original and seven copies of the subject proposal. The goal of this project is to determine the feasibility of a commercial process for carbon production from North Dakota lignite. Research by the Energy & Environmental Research Center has shown that activated carbon prepared from North Dakota lignite could perform as well as commercially available carbon-based sorbent for mercury control. Also enclosed is the $100 application fee.

If you have any questions or comments, please contact me by phone at (701) 777-5177 or by e-mail at sbenson@undeerc.org.

Sincerely,

Steven A. Benson, Ph.D.
Senior Research Manager

SAB/kal

Enclosures

c/enc: Jeff Burgess, Lignite Energy Council

ACTIVATED CARBON PRODUCTION FROM NORTH DAKOTA LIGNITE – PHASE IIA

EERC Proposal No. 2007-0218

Submitted to:

Karlene Fine

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

Proposal Amount: $290,348

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March 30, 2007

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ACTIVATED CARBON PRODUCTION FROM NORTH DAKOTA LIGNITE – PHASE IIA

ABSTRACT

The goal of this Energy & Environmental Research Center (EERC) program is to develop information to determine the feasibility of a commercial process for activated carbon mercury sorbent production from North Dakota lignite. The objectives of the project include the following: 1) establish the technical feasibility of manufacturing high-quality mercury sorbents from North Dakota lignite using a pilot multiple-hearth furnace (MHF) for producing activated carbon and 2) examine the effectiveness of pretreatment of the produced activated carbon to generate the enhanced carbons for mercury control in a variety of coal-derived flue gas environments. Anticipated results include a method for making activated carbon from North Dakota lignite coals in a pilot-scale MHF, including a preliminary set of optimized parameters with recommendations and implications for the commercial plant; 100–200-lb batches of activated carbon (granular) from each test condition, which can be used for further enhancement and tested for mercury capture performance in flue gas at a pilot-scale coal-fired combustion facility; 25–100-lb batches of enhanced powdered activated carbon (PAC) (eSorb-Hg™) using carbons from selected pilot-scale MHF tests in Task 1, to be used for further testing of mercury capture performance; and an evaluation of mercury control performance of base and enhanced activated carbon in a pilot-scale combustion unit firing a variety of coal types.

The project is scheduled for 9 months with a total cost of $858,517, of which $277,821 is requested from the U.S. Department of Energy. Industry partners will provide $290,348 in cash; $290,348 is requested from the North Dakota Industrial Commission.

ACTIVATED CARBON PRODUCTION FROM NORTH DAKOTA LIGNITE – PHASE IIA

PROJECT SUMMARY

Since 2001, there has been growth in the use of carbon for gas- and liquid-phase cleanup such as flue gas desulfurization and water and waste remediation treatment. Carbon derived from lignite is being used in novel ways to clean dioxins from scrap metal smelters in Europe. In the United States, the imports of carbon from China have doubled from 1996 to 2001 to 57 million pounds. Activated carbon use has grown steadily and was projected to total 450 million pounds in 2006. Significant additional growth in the demand for carbon is anticipated as a result of the need to control the emission of mercury from coal-fired power plants. Activated carbon injection (ACI) upstream of a particulate control device such as fabric filter (FF) (baghouse) or electrostatic precipitator (ESP) is showing significant promise for controlling mercury emissions (1). For activated carbons to be successful, they must effectively sorb Hg^0 and Hg^{2+}. Testing at the EERC compared activated carbon sorbents prepared from Fort Union lignites to the commercial sorbent NORIT America's DARCO® FGD (2). The DARCO FGD is derived from Texas lignites. Typically, Texas lignites have higher ash contents than North Dakota lignites. The North Dakota lignites have high levels of alkali and alkaline-earth elements that are organically associated. During carbonization and activation, these elements catalyze gasification, resulting in improved pore structure in the resulting activated carbon.

In bench-scale evaluations of mercury control capabilities in a low-acid flue gas stream, the North Dakota lignite-derived activated carbon performed as well as the DARCO FGD, both as a long-term sorbent and as an elemental mercury oxidant. This means that sorbents from North Dakota lignite could compete in the market for carbon sorbent injection technology, the

most mature technology for mercury control from coal-fired power plants, from which the U.S. Environmental Protection Agency (EPA) has mandated a reduction of mercury emissions. On March 15, 2005, EPA issued a federal rule to cap and reduce mercury emissions from coal-fired power plants permanently (3). The rule is a market-based cap-and-trade program (Section 111 of the Clean Air Act) and is similar to the program in place for SO_2. The rule is to be administered in two phases. The first phase places a cap of 38 tons of mercury beginning in 2010. The second phase sets a final cap of 15 tons by 2018. Currently, the estimate of total mercury emitted from coal-fired power plants is 48 tons; therefore, the reduction is 21% and 69%, respectively. With the implementation of the Clean Air Interstate Rule (CAIR) (4) to reduce emissions of SO_2 and NO_x in the eastern 28 states, it is expected that the initial phase of the Clean Air Mercury Rule (CAMR) will partially meet the mercury emission reductions required via cobenefit expected from the additional wet scrubbers and selective catalytic reduction (SCR) systems that will be installed. However, a cap of 15 tons will require additional mercury-specific controls at many power plants. Also, states are moving forward separately and, in several cases, with more stringent mercury emission reductions and earlier timetables than federal standards. For trading purposes, EPA has established allocations for the states, the District of Columbia, and Indian reservations based on their respective shares of the total heat input from coal. These were then adjusted to reflect coal rank and existing air pollution control equipment. For allocation purposes, coals were subcategorized as bituminous, subbituminous, lignite, integrated gasification combined cycle (IGCC), and coal refuse. The total 2010–2017 state allocation is 38 tons and, for 2018 and thereafter, 15 tons. Each state will be free to decide if it wishes to participate in the trading program.

In addition to the cap-and-trade program, new coal-fired sources will have additional mercury requirements as part of the New Source Performance Standard (5). The requirements have been subcategorized as follows:

- Bituminous units – 21×10^{-6} lb/MWh
- Subbituminous units
  - Wet flue gas desulfurization (FGD) – 42×10^{-6} lb/MWh
  - Dry FGD – 78×10^{-6} lb/MWh
- Lignite units – 145×10^{-6} lb/MWh
- IGCC units – 20×10^{-6} lb/MWh
- Coal refuse units – 1.4×10^{-6} lb/MWh

The projected annual cost for activated carbon sorption of mercury in a duct injection system is significant. For an untreated activated carbon, the carbon-to-mercury weight ratios of 3000–18,000 (gram of carbon injected per gram of mercury in flue gas) have been estimated to achieve 90% mercury removal from a coal combustion flue gas containing 10 $\mu g/Nm^3$ of mercury (6). More efficient carbon-based sorbents enhanced for mercury control could enable lower carbon-to-mercury weight ratios to be used, thus reducing the operating costs of carbon injection. The United States has about 320 GW_e of coal-fired capacity. It is estimated that with the more efficient carbons, carbon injection-to-mercury removal rates of 500:1–1000:1 can be achieved. The potential sorbent cost is estimated to be $0.30–$0.50/lb for the untreated sorbent and $0.5 to $0.8/lb for the enhanced sorbent. Based on these estimates, the potential market for carbon-based sorbents for mercury control is expected to be upwards of $100 million annually. Calgone Carbon estimates the U.S. market at $100–$500 million.

The goal of this EERC program is to develop information to determine the feasibility of a commercial process for activated carbon mercury sorbent production from North Dakota lignite. The objectives of the project include the following: 1) establish the technical feasibility of manufacturing high-quality mercury sorbents from North Dakota lignite using a pilot MHF for producing activated carbon and 2) examine the effectiveness of pretreatment of the produced activated carbon to generate the enhanced carbons for mercury control in a variety of coal-derived flue gas environments.

In order to meet these objectives, the research plan will include a method for making activated carbon from North Dakota lignite coals in a pilot-scale multiple-hearth furnace (MHF), including a preliminary set of optimized parameters with recommendations and implications for the commercial plant; 100–200-lb batches of activated carbon (granular) from each test condition, which can be used for further enhancement and tested for mercury capture performance in flue gas at a pilot-scale coal-fired combustion facility; 25–100-lb batches of enhanced powdered activated carbon (PAC) (eSorb-Hg™) using carbons from selected pilot-scale MHF tests in Task 1, to be used for further testing of mercury capture performance; and an evaluation of mercury control performance of base and enhanced activated carbon in a pilot-scale combustion unit firing a variety of coal types.

PROJECT DESCRIPTION

Goals and Objectives

The goal of this EERC program is to develop information to determine the feasibility of a commercial process for activated carbon mercury sorbent production from North Dakota lignite. The objectives of the project include the following: 1) establish the technical feasibility of manufacturing high-quality mercury sorbents from North Dakota lignite using a pilot MHF for

producing activated carbon and 2) examine the effectiveness of pretreatment of the produced activated carbon to generate the enhanced carbons for mercury control in a variety of coal-derived flue gas environments.

Work Plan

The research will be carried out in four tasks.

Task 1 – Production of Activated Carbon in a Pilot-Scale Multiple-Hearth Furnace

Activated carbon derived from Center Mine lignite will be produced in a pilot-scale MHF that is ideally suited for this project in terms of production rates and the ability to make required quantities of material in a representative manner. The activated carbon produced from the pilot MHF unit, located in Rochester, New York, will be made available for the subsequent enhancement step and then for pilot-scale mercury capture testing to evaluate quality. The pilot MHF, presented in Figure 1, is a 66-in.-o.d., 39-in.-i.d. five-hearth furnace described in detail in Appendix A.

Testing in the pilot MHF with the North Dakota coal as feedstock will provide relevant and scalable design and operation and performance data. Based on the results of pilot testing, a reliable estimate of the full-scale plant size and its operating characteristics can be obtained, which will allow an accurate determination of commercial plant capital and operating costs.

The proposed pilot-scale MHF testing will be performed in two distinct phases (weeks of testing). In the first week of testing, the objective will be to determine the feasibility of producing quality activated carbon that is best suited (as a base material) for mercury control with the first sample of BNI-provided North Dakota lignite. The second week of pilot MHF testing will follow the first week by 4 to 6 weeks. In the second week of testing, additional tests may be performed based on the mercury capture performance of the first-week carbon/enhanced carbon samples. Larger quantities of product from a particular operating condition may also be generated. Finally, we would also consider using a different coal (having a high sodium content, for example) to see the effect of feedstock quality on product quality.

EERC SB28475.CDR

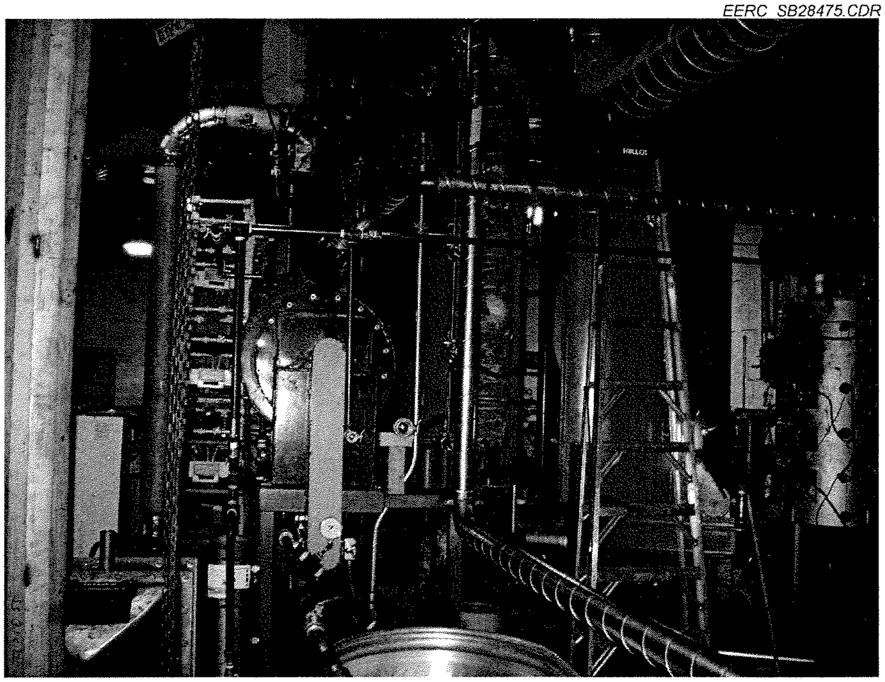

Figure 1. The IFCO pilot-scale MHF for production of activated carbon.

Prior to the pilot MHF testing, the furnace system will be reconfigured for the intended application. This includes the design, purchase, and construction of the postcombustion chamber and the water-cooled product screw, the installation of air lines and steam ports, and the supply and installation of required instrumentation.

Feedstock coal for all test runs will need to be received in 55-gallon drums already sized to ⅛-in. × ¼-in. dimensions.

The EERC will provide on-site product quality assessments during the MHF testing. Elements of product quality will include product iodine numbers, bulk density, and ash content to determine product yield during the two test weeks. It will be particularly important to obtain these data as soon as samples are generated to provide guidance with respect to operating conditions and to steer the overall test program.

The primary objective of the first week of testing is to determine the optimum conditions to make a product appropriate for mercury adsorption. Three gasification rates will be tested to see the effect on the quality. The rate of gasification is related to the temperature of the carbon, residence time, and steam concentration. An ideal experimental design would be three feed rates, three steam levels, and three activation zone temperatures. Unfortunately, this would be 3^3, or 27, steady-state experiments and would be far too time consuming and costly. In order to reduce the test matrix, the steam flow will be held constant at around 40%. The 40% value was selected as a middle range for typical commercial operation. The actual value is not critical as long as we have over 30%. This will reduce the number of operating periods to 3^2, or nine, runs, as presented in Table 1.

The experimental program is set up to generate three yield/activity curves, one for each activation zone temperature. The activities to be used are iodine number and some form of Hg adsorption value to be generated by the EERC. Based on these three curves, we should be able to interpolate the best conditions to produce a quality product at the most economical rate. While it would be ideal to perform these experiments in random order, it adds to the transition time between runs, adding to the cost. A preliminary schedule is proposed in Table 2.

The draft schedule is aggressive, with 24-hr days, and has little contingency built into it. If the proposed tests are not completed because of slippage or operational delays, the runs will be shortened and some may be dropped. The runs are ordered so that the earlier ones are most likely

Table 1. Experimental Matrix

Run No.	Wet Feed Rate, lb/h	Activation Zone, °F
1	150	1700
2	130	1700
3	110	1700
4	110	1600
5	130	1600
6	150	1600
7	150	1500
8	130	1500
9	110	1500

Table 2. Proposed Pilot Plant Schedule

Day	Time	Run	Task	Duration, h	Feed Required, lb
Monday	12:00 midnight		Fire up the MHF and heat to 1700°F	8:00	0
	8:00 a.m.	1	Start feed at 150 lb/h, 1700°F	6:00	
	2:00 p.m.		Collect first meaningful product sample	3:00	1350
	5:00 p.m.	2	Change feed rate to 130 lb/h, 1700°F	6:00	
	11:00 p.m.		Collect product samples	3:00	1170
Tuesday	2:00 a.m.	3	Change feed rate to 110 lb/h, 1700°F	6:00	
	8:00 a.m.		Collect product samples	3:00	990
	11:00 a.m.	4	Change temperature to 1600°F, 110 lb/h	6:00	
	5:00 p.m.		Collect product samples	3:00	990
Wednesday	8:00 p.m.	5	Change feed rate to 130 lb/h, 1600°F	6:00	
	2:00 a.m.		Collect product samples	3:00	1170
	5:00 a.m.	6	Change feed rate to 150 lb/h, 1600°F	6:00	
	11:00 a.m.		Collect product samples	3:00	1350
Thursday	2:00 p.m.	7	Change temperature to 1500°F, 150 lb/h	6:00	
	8:00 p.m.		Collect product samples	3:00	1350
	11:00 p.m.	8	Change feed rate to 130 lb/h, 1500°F	6:00	
Friday	5:00 a.m.		Collect product samples	3:00	1170
	8:00 a.m.	9	Change feed rate to 110 lb/h, 1500°F	6:00	
	2:00 p.m.		Collect product samples	3:00	990
	5:00 p.m.		Complete sample collection	0:00	
				Total	10,530

to generate high-quality products. For example, Run 3 has the lowest feed rate and the highest activation conditions. This may even overactivate the product and show a downturn in the yield/activity curve. The last column calculates the minimum feed required. Since we are planning for the second week, it is recommended that an equivalent amount be allocated for that week as well.

The second week of pilot MHF testing will follow the first week by 4 to 6 weeks. In the second week of testing, additional tests may be performed based on the mercury capture performance of the first-week carbon samples.

Larger quantities of product from a particular operating condition may also be generated. Finally, we would also consider using a different coal (one having a high sodium content, for example) to see the effect of the feedstock quality on product quality. The budget will allow for a full week of "second iteration" runs to cover several possible conditions.

Task 2 – Enhanced Sorbent Formulation and Pilot-Scale Testing for Mercury Capture Performance

Sorbent Enhancement. In the first part of this task, proprietary methods will be applied to the base carbon generated from North Dakota lignite in the pilot MHF furnace to enhance these carbons for mercury capture. Quantities of proprietary sorbent formulations will be produced for the following applications: low-halogen-containing flue gas, high-sulfur-containing flue gas, and for the use of fly ash in concrete.

Two campaigns of product formulation are scheduled, one for each week of the pilot MHF tests after the base material from the pilot MHF is sized to 90% smaller than 325 mesh. Powdered samples will be enhanced at the EERC and made available to Envergex for the enhancement step.

Pilot-Scale Evaluation for Mercury Control. Under this subtask, the base and enhanced sorbent products prepared from North Dakota lignite in the pilot-scale MHF will be evaluated at the EERC for mercury capture performance in the pilot-scale combustion test facility (CTF). Two test campaigns, approximately a week each, are proposed in this program by the EERC for sorbent evaluation testing for mercury capture. As part of this task, the performance of North Dakota lignite-derived activated carbon will be compared to industry benchmarks (NORIT Hg-LH, NORIT Hg).

The test conditions and coals that will be fired during these sorbent evaluation/mercury capture test campaigns will be chosen to match potential customers of the North Dakota lignite-derived activated carbon. For example, choices for the coals to be fired during the pilot tests could include low-halogen–moderate-sulfur lignite, low-halogen–low-sulfur Powder River Basin subbituminous, and high-sulfur bituminous coals being fired at potential customer utility plants.

All test periods will include real-time mercury monitoring using mercury continuous emission monitors (CEMs). Coal and ash samples will undergo proximate, ultimate, mercury, and chlorine analysis for determining furnace parameters and mercury control environments. Additional testing for suitability for concrete applications of the sorbent and ash samples, such as the foam index testing, will be performed by the EERC.

Task 3 – Carbon Resource Assessment

Industry Overview. The industry overview will include a description of the activated carbon industry, the major participants, and industry trends.

Market Assessment. Both sources of raw material and end uses will be covered in this section. The techniques used for gathering market information will include both personal interviews and literature reviews. The literature review will include database and literature searches. Interviews will be conducted with industry experts in all areas of the particular market, including both technical experts and business leads. Once key industry experts are identified, the next steps will be taken to gather information for the market assessment. Attendance at relevant meetings or conferences is an efficient way to interview numerous industry experts in one location.

Supply and Demand. The current supply and demand of activated carbon by end use will be identified. Alternative products to activated carbon also used for the same end uses will be discussed. Future projections of supply and demand will be based upon analyst summaries from external third-party reports and summaries of phone and personal interviews with industry experts.

Regulation/Legislation. One area of particular interest in this section is the outcome of the antidumping suit related to activated carbon from China. The suit was filed in March 2006. Tariffs resulting from that petition will be identified.

Regulation that enables opportunities in the mercury control market is a key driver in pursuing the development of the activated carbon product. Hence, developments in that regulatory environment will be closely monitored. The timing of those developments related to the product and business development processes is critical.

Competitive Analysis. The competition will be profiled in terms of product line, location, supply chain, sales volume, management, mode of operation, and other factors. This will also include the global perspective, especially related to China. The competitive section will include a discussion on market share along with expectations of who will make gains in the market.

Market Barriers and Opportunities. High start-up costs or other obstacles for new entrants to this industry will be identified. New market opportunities will be discussed. Any niche markets will be identified.

Task 4 – Reporting

Quarterly reports will be prepared during the course of the project. A final report will be prepared 1 month prior to the end of the project to be reviewed by project sponsors. In addition, conference calls and meetings will be held as needed.

DELIVERABLES

Information for determining the feasibility of a commercial process for carbon production from North Dakota lignite will result from the proposed research. Specific anticipated results include:

- A method for making activated carbon from North Dakota lignite coals in a pilot-scale MHF, including a preliminary set of optimized parameters with recommendations and implications for the commercial plant.
- 100–200-lb batches of activated carbon (granular) from each test condition, which can be used for further enhancement and tested for mercury capture performance in flue gas at a pilot-scale coal-fired combustion facility.
- 25–100-lb batches of enhanced PAC (eSorb-Hg™) using carbons from selected pilot-scale MHF tests in Task 1 to be used for further testing of mercury capture performance.
- An evaluation of mercury control performance of base and enhanced activated carbon in a pilot-scale combustion unit firing a variety of coal types.

- Presentation of the results to project sponsors and the U.S. Department of Energy (DOE) at a technical conference.
- Quarterly and final reports detailing the progress and results of the research.

The proposed research will be carried out using the pilot-scale MHF facility at Industrial Furnace Company (IFCO) in Rochester, New York, and using several laboratories at the EERC.

IFCO will provide equipment, labor, utilities, and supplies for a testing program for production of activated carbon from a lignite coal feed source. The work will include setup, preliminary operations, and 2 weeks of testing to produce activated carbon. The equipment to be provided will include a 5-ft 6-in.-o.d. five-hearth furnace, a postcombustion chamber, instrumentation, and exhaust gas emissions-monitoring equipment. Air and low-pressure steam will be available as process inputs. During test and production runs, the furnace will be operated 24 hours per day. The details of the system equipment and gas analyzers are presented in Appendix A.

Sorbent enhancement activities will take place at the EERC using the Process Chemistry and Development Laboratory (PCDL) and a pilot-scale rotary kiln system. Activated carbon performance can be screened in the Mercury Research Laboratory (MRL). Coal characteristics analysis will be performed in the EERC Fuels, Natural Materials, and Analytical Research Laboratories.

Product quality in terms of mercury capture performance will be evaluated using commercially available sorbents as benchmarks. This evaluation will be performed at the EERC in the CTF.

The pilot-scale CTF equipped with ESP or FF particulate control devices and K-tron feeders for the introduction of activated carbon in the flue gas will be used to evaluate and compare produced and commercial sorbents. A detailed description of the CTF is in Appendix A.

The PCDL has facilities for the development and analysis of different types of product and by-product streams. These analyses provide the data necessary for the calculation of material balance, conversion, and product quality for engineering projects at the EERC. Equipment is in place for ashing, solubility testing, numerous ASTM International standard tests, coal cleaning, and a variety of general and specialized analytical testing, including wet-chemistry testing.

The EERC pilot-scale rotary kiln system includes a sealed, indirectly electrically heated rotary kiln with a nominal heated zone 6 in. in diameter and 5 feet long; three-zone temperature control to 1000°C; inert-atmosphere operating conditions; rotation from 1 to 5 rpm; internal screw-fed auger; and variable inclination to 5°. The kiln has produced char from –¼-inch North Dakota lignite at feed rates of 4.5 kg/hr (10 lb/hr).

The MRL specializes in bench-scale systems studying mercury, SO_x/NO_x, catalysts, sorbents, and related work. Two bench-scale systems capable of simulating flue gas conditions such as temperature, particulate loading, air-to-cloth ratio, and various gas concentrations (e.g., SO_2, O_2, CO, CO_2) are used. The MRL has mercury CEMs to perform bench-scale mercury-screening activities. The PCDL and MRL have over 10 years of experience developing and screening potential sorbents and filter materials, evaluating catalyst materials, and performing research on SO_x/NO_x in flue gas.

Environmental impacts of the research while under way will be minimal. Technological and economic impacts of the ultimate product could be substantial in terms of elemental mercury control from lignite-fired combustion systems. The EPA determined that mercury emissions from power plants pose significant hazards to public health and must be reduced. EPA has announced new mercury control regulations that mandate coal-fired power plants to reduce mercury emissions by 21% by 2010 and 69% by 2018 based on the current estimate of 48 tons. Activated carbon injection is the most mature technology available for mercury control. Development of a process to make sorbent capable of effective elemental mercury control will be extremely beneficial to lignite production facilities in providing sorbent and to combustion facilities in meeting the imminent regulations.

STANDARDS OF SUCCESS

The success of the project will be based on the ability to provide information to determine the feasibility of a commercial process for carbon production from North Dakota lignite. One tangible measure will be the ability of the MHF to produce an effective mercury control sorbent derived from North Dakota lignite. At a minimum, effective mercury control is defined as providing mercury capture and oxidation as well as DARCO Hg in the EERC pilot-scale CTF firing North Dakota lignite coal. An enhanced mercury control sorbent produced from North Dakota lignite in the multihearth furnace should provide good mercury control in the pilot-scale unit, that is, providing the same or better mercury capture as the DARCO Hg-LH.

The ability to assess the success of the project is based primarily on the EERC's quality management system (QMS). To ensure successful projects, the EERC adheres to an organizationwide QMS. It is authorized and supported by EERC management to define the requirements and the organizational responsibilities necessary to fulfill governmental and client requirements relating to quality assurance/quality control (QA/QC), applicable regulations, codes, and protocols. Table 3 outlines the project QC. Specific to the measurement and control of mercury emissions, the following quality parameters have been defined.

Table 3. Project Quality Measures

QA/QC Control Measure	Purpose/Clarification
EERC QMS, including *Quality Manual* and Quality Policy and Procedures	Ensure organizationwide compliance with QMS and applicable regulations, codes, and protocols based on ISO9000 standards. Authorized and supported by EERC management.
Project-Independent QA Manager at the EERC (David Brekke)	Assist research managers with planning QA for projects, does reviews and random audits for compliance assurance.
Perform Hg Mass Balance with Values 100% ± 20%	Determine total amount of Hg to be accounted for and determine removal rates.
EERC Expertise in Analytical Methods and CEM Sampling for Hg	Understand potential problems that can occur, troubleshoot, get valid data under difficult conditions.
Hg CEM Calibrations Daily, at least; if target not met, may require that additional calibration or maintenance be done and repeat QA/QC check	PS Analytical: sample clean air drawn through carbon trap followed by injecting known Hg standard. This procedure is done four times to determine scatter (internal QA/QC EERC standard is that $R^2 = 0.999$).
Chain-of-Custody Procedures	Ensure integrity of samples at all steps, including sample identification, analysis, and storage.
Interim Team Audit	Use expertise of team members to ensure consistent quality, double-check analytical systems.
Team direction by Sponsors and U.S. Department of Energy (DOE)	Ensure that communication issues and problems are addressed to ensure objectives of project are attained.
Quarterly Conference Calls (or as needed)	Ensure effective communications between all team members, address developing issues, resolve problems.
Information Transfer via FTP Site	Allows efficient transfer of data between team members.

The most important aspect of QA/QC is the expertise of the team conducting sorbent testing and spectroscopic measurements. EERC research personnel are highly trained and experienced, having conducted hundreds of sampling tests. In addition, EERC team members are considered experts in the operation of Hg CEMs, which are still considered to be in the developmental phase. The EERC has successfully demonstrated these instruments for 2 weeks or longer at 60 different power plants over the past 8 years. The EERC has actively used these instruments in bench-, pilot-, and full-scale tests for over 12 years.

BACKGROUND

Since 2001, there has been growth in the use of carbon for gas- and liquid-phase cleanup such as flue gas desulfurization, water and waste remediation treatments. Carbon derived from lignite is being used in novel ways to clean dioxins from scrap-metal smelters in Europe. In the United States, the imports of carbon from China have doubled from 1996 to 2001 to 57 million pounds. Activated carbon use has grown steadily and is projected to total 450 million pounds in 2006.

Significant additional growth in the demand for carbon is anticipated as a result of the need to control the emission of mercury from coal fired power plants. Activated carbon injection upstream of a particulate control device such as an FF (baghouse) or ESP is showing significant promise for controlling mercury emissions (4). For activated carbons to be successful, they must effectively sorb Hg^0 and Hg^{2+}. Testing at the EERC compared activated carbon sorbents prepared from Fort Union lignites to the commercial sorbent NORIT America's DARCO FGD (1). The DARCO FGD is derived from Texas lignites. Typically, Texas lignites have higher ash contents than North Dakota lignites. The North Dakota lignites have high levels of alkali and alkaline-earth elements that are organically associated. During carbonization and activation, these elements catalyze gasification resulting in improved pore structure in the resulting activated carbon. In bench-scale evaluations of mercury control capabilities in a low-acid flue gas stream, the North Dakota lignite-derived activated carbon performed as well as the DARCO FGD both as a long-term sorbent and as an elemental mercury oxidant. This means that sorbents from North Dakota lignite could compete in the market for carbon sorbent injection technology, the most mature technology for mercury control from coal-fired power plants, from which EPA has mandated a reduction of mercury emissions.

On March 15, 2005, the EPA issued a federal rule to cap and reduce mercury emissions from coal-fired power plants permanently (2). The rule is a market-based cap-and-trade program (Section 111 of the Clean Air Act) and is similar to the program in place for SO_2. The rule is to be administered in two phases. The first phase places a cap of 38 tons of mercury beginning in 2010. The second phase sets a final cap of 15 tons by 2018. Currently, the estimate of total mercury emitted from coal-fired power plants is 48 tons; therefore, the reduction is 21% and 69%, respectively.

With the implementation of CAIR (5), to reduce emissions of SO_2 and NO_x in the eastern 28 states, it is expected that the initial phase of the CAMR will partially meet the mercury emission reductions required via cobenefit expected from the additional wet scrubbers and SCR systems that will be installed. However, a cap of 15 tons will require additional mercury-specific controls at many power plants. Also, states are moving forward separately and, in several cases, with more stringent mercury emission reductions and earlier timetables than federal standards.

For trading purposes, the EPA has established allocations for the states, the District of Columbia, and Indian reservations based on their respective shares of the total heat input from coal. These were then adjusted to reflect coal rank and existing air pollution control equipment. For allocation purposes, coals were subcategorized as bituminous, subbituminous, lignite, IGCC, and coal refuse. The total 2010–2017 state allocation is 38 tons and, for 2018 and thereafter, 15 tons. Each state will be free to decide if it wishes to participate in the trading program.

In addition to the cap-and-trade program, new coal-fired sources will have additional mercury requirements as part of the New Source Performance standard (6). The requirements have been subcategorized as follows:

- Bituminous units – 21×10^{-6} lb/MWh

- Subbituminous units
  - Wet FGD – 42 x 10^{-6} lb/MWh
  - Dry FGD – 78 x 10^{-6} lb/MWh

- Lignite units – 145 x 10^{-6} lb/MWh

- IGCC units – 20 x 10^{-6} lb/MWh

- Coal refuse units – 1.4 x 10^{-6} lb/MWh

Specific to North Dakota, the 2010 cap will be 1.564 tons and 0.617 tons beginning in 2018 (7). These caps include the current coal-fired utilities as well as any new units that may be installed during this time frame. The North Dakota lignite industry has been proactive in helping to developing new mercury control technologies in preparation for these regulations. Tests are currently under way at several North Dakota power plants by the EERC, Babcock & Wilcox, and URS, with support from industry, the North Dakota Industrial Commission, Electric Power Research Institute (EPRI), and DOE.

The projected annual cost for activated carbon sorption of mercury in a duct injection system is significant. For an untreated activated carbon, the carbon-to-mercury weight ratios of 3000–18,000 (gram of carbon injected per gram of mercury in flue gas) have been estimated to achieve 90% mercury removal from a coal combustion flue gas containing 10 $\mu g/Nm^3$ of mercury (3). More efficient carbon-based sorbents enhanced for mercury control could enable lower carbon-to-mercury weight ratios to be used, thus reducing the operating costs of carbon injection. The United States has about 320 GWe of coal-fired capacity. It is estimated that with the more efficient carbons, carbon injection-to-mercury removal rates of 500:1–1000:1 can be achieved. The potential sorbent cost is estimated to be \$0.30–\$0.50/lb for the untreated sorbent and \$0.5 to \$0.8/lb for the enhanced sorbent. Based on these estimates, the potential market for carbon-based sorbents for mercury control is expected to be upwards of \$100 million annually.

Current production and use of activated carbon is illustrated in Figure 2. Activated carbon can be produced from a wide range of raw materials that includes coal, wood, and biomass materials. These materials are heat-treated with steam to produce activated carbon. The carbons that are currently used include powdered and granular carbons. These components are used to remove contaminants from liquid- and gas-phase streams. The spent carbons are either disposed of or regenerated.

The growth in the demand for activated carbon is shown in Figure 3. A significant increase is projected for 2006, not including any of the carbon used for mercury control. The market opportunity for the use of activated carbon for mercury control is the 315 GW_e of coal-fired power plant capacity in the United States. The mercury emissions reduction anticipated as a result of the EPA rule is a reduction from 48 tons to 38 tons by 2010. We estimate that 30% of

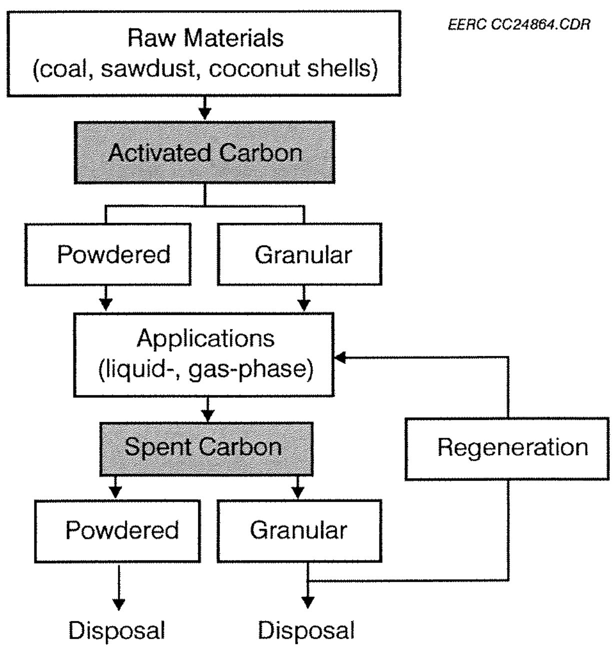

Figure 2. Flow diagram of the current production and use of activated carbon.

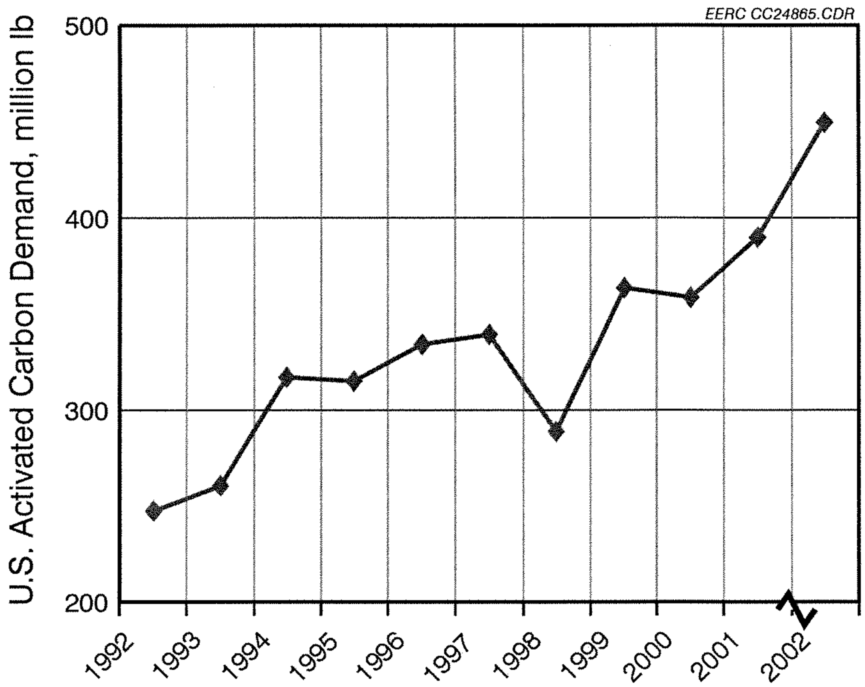

Figure 3. Demand for activated carbon in the United States.

coal-fired power plants will use ACI for mercury. Based on the expected amounts of activated carbon required for mercury reduction, we estimate the market size for activated carbon for mercury control to be about 150,000 tpy. This is compared with the current U.S. consumption of activated carbon for other applications at 225,000 tpy, suggesting a significant increase in the demand for activated carbon.

Previous investigations examined the ability to produce activated carbons from four Fort Union lignites for use as mercury sorbents (1). Activated carbons were prepared from relatively high-sodium (4–9 wt% Na_2O on an ash basis) lignites because the high sodium contents catalyze the gasification reactions producing a highly porous activated carbon. The activated carbons were produced by carbonization at 400°C (752°F) in nitrogen followed by steam activation at 750°C (1382°F) and 800°C (1472°F) in nitrogen. Iodine numbers (mg I_2/g sorbent) for the lignite-based activated carbons ranged from 320 to 440 as compared to 524 for the DARCO FGD.

The lignite-based activated carbons, were tested in a thin-film, fixed-bed, bench-scale reactor using a simulated lignitic flue gas consisting of nominally 10 $\mu g/Nm^3$ Hg^0, 6% O_2, 12% CO_2, 15% H_2O, 580 ppm SO_2, 120 ppm NO, 6 ppm NO_2, and 1 ppm HCl in N_2. All of the lignite-based activated (750°C, 1382°F) carbons required a 30- to 45-minute conditioning period in the simulated lignite flue gas before they exhibited good mercury sorption capacities and Hg^0 oxidation potentials (>90% Hg^{2+}).

The Fort Union Lignite Activated Carbon (800°C, 1472°F) and DARCO FGD were selected for additional testing in a 580-MJ/hr (550,000-Btu/hr) pulverized coal-fired unit based on the sorbent screening results (reactivity and capacity), physical properties (particle size and surface area), and cost (1). The Fort Union Lignite Activated Carbon, activated at 800°C (1472°F), and DARCO FGD were effective in capturing Hg.

QUALIFICATIONS

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 as the U.S. Bureau of Mines Robertson Lignite Research Laboratory, 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. 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 connections between energy and the environment that will allow the extraction of sufficient energy and other resources from our environment in a manner that does not jeopardize its integrity and stability.

The EERC has been a leader in mercury research for several years and is viewed as an expert in the field. In recent years, EERC researchers have been in the forefront of advancing the understanding of mercury chemistry, measurement, transformations, solid–gas interactions, and the development of control technologies.

VALUE TO NORTH DAKOTA

A major challenge facing North Dakota lignite-fired power plants is the control of mercury emissions. The mercury species in combustion flue gases produced from North Dakota lignite plants is primarily elemental and much more difficult to control than oxidized mercury forms. Preliminary testing at the EERC showed that activated carbon sorbents prepared from North Dakota lignites performed as well as the commercial sorbent NORIT America DARCO FGD in bench-scale evaluations of mercury control capabilities in a low-acid flue gas stream, both as a long-term sorbent and an elemental mercury oxidant. This means that sorbents from North Dakota lignite could compete in the market for carbon sorbent injection technology, the most mature technology for mercury control from coal-fired power plants. This project aims to develop a mercury sorbent production facility in North Dakota which could provide an additional market for North Dakota lignite, effectively control the emissions of mercury during the combustion of North Dakota lignites, and aid in maintaining and potentially increasing the use of lignite for power generation in the future.

MANAGEMENT

Dr. Steven A. Benson will be the EERC Project Manager responsible for oversight of the project. Ms. Crocker will act as liaison between the activities of project tasks and subcontractors. She will assist with product analysis activities during the pilotscale activated carbon production runs and organize and manage the CTF test runs to evaluate base and enhanced sorbents. Ms. Crocker will assist Dr. Benson with the preparation of the progress and final reports and Dr. Olson with sorbent enhancement activities. Dr. Olson will have primary responsibility for sorbent enhancement activities at the EERC. Dr. Hanson will have primary responsibility for the market research component of Task 3. Principal Investigators Ms. Charlene Crocker, Dr. Sheila Hanson, and Ms. Constance Wixo will assist with project tasks. Dr. Benson has more than 30 years in coal utilization and environmental control technologies and has managed numerous projects involving government and industry participants. Ms. Crocker has 12 years of experience in mercury and chlorine analysis and measurement in coal combustion and sorbent development. Dr. Ed Olson has more than 40 years of experience in carbon and coal structure and reactivity, mercury analysis, emission, adsorption chemistry, coal liquefaction, and gasification catalysis. Dr. Hanson has 14 years of experience in market research. Ms. Wixo has 30 years of experience in various capacities in the energy and environmental field.

Resumes of key personnel are included in Appendix B.

PROJECT TIMETABLE

The project will be initiated upon receipt of DOE funding and approval of the project by the NDIC. It is anticipated that the proposed work will be carried out over 9 months. Project milestones can be seen in Figure 4.

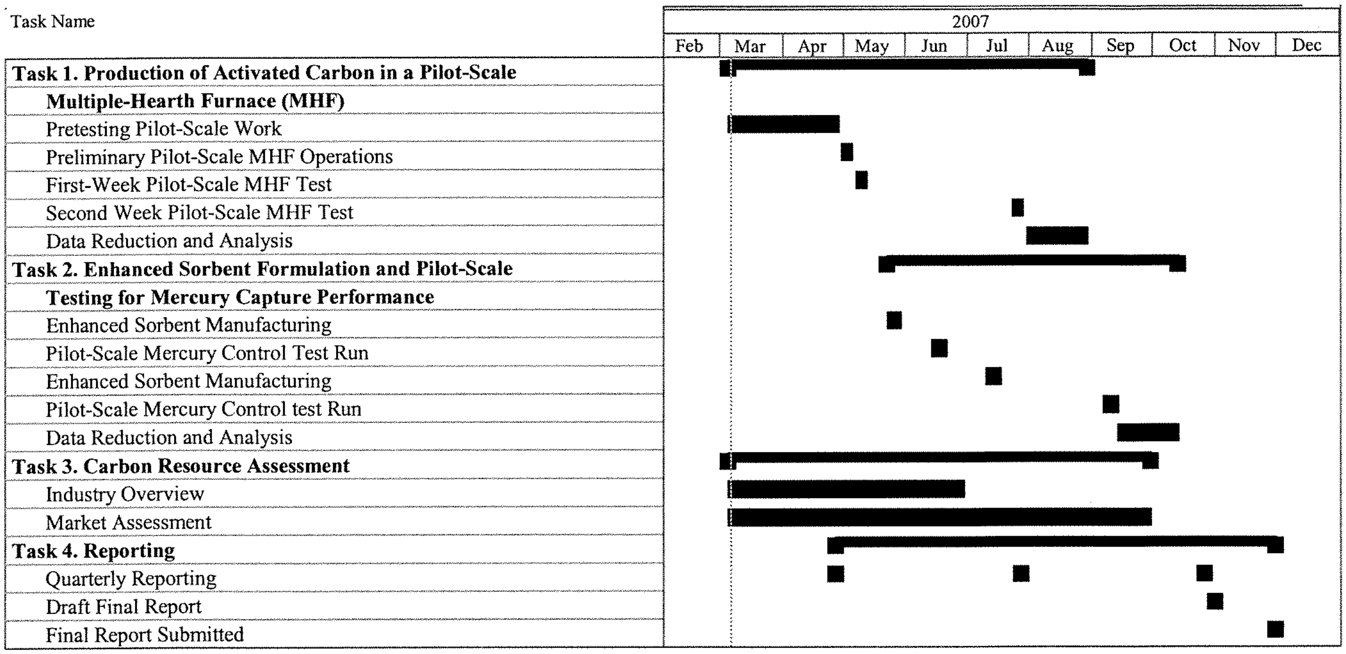

Figure 4. Project milestones.

BUDGET

The budget outlining the costs for the project is enclosed. The total cost of the project is $858,517.

The EERC is requesting that NDIC commit $290,348 of funding to this project. Once NDIC has given its commitment, the EERC 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's project manager and/or key technical contributor.
- A short description of NDIC.

MATCHING FUNDS

The total cost of the project is $858,517. Cost-share funding to be requested from the EERC–DOE Jointly Sponsored Research Program is $277,821. Funding requested from NDIC is $290,348. Cash funding from BNI Coal, Ltd., is anticipated to total $290,348.

TAX LIABILITY

None of the participants in this research proposal have outstanding tax liabilities to the state of North Dakota.

CONFIDENTIAL INFORMATION

No confidential information is included in the proposal.

REFERENCES

1. Benson, S.A.; Crocker, C.R.; Galbreath, K.C.; Gunderson, J.R.; Holmes, M.J.; Laumb, J.D.; Mackenzie, J.M.; Olderbak, M.R.; Pavlish, J.H.; Yan, L.; Zhuang, Y. *Pilot- and Full-Scale Demonstration of Advanced Mercury Control Technologies for Lignite-Fired Power Plants*; Final Report for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-03NT41897 and Multiclients; EERC Publication 2005-EERC-02-05; Energy & Environmental Research Center: Grand Forks, ND, Feb 2005.

2. Pavlish, J.H.; Holmes, M.J.; Benson, S.A.; Crocker, C.R.; Olson, E.S.; Galbreath, K.C.; Zhuang, Y.; Pavlish, B.M. *Mercury Control Technologies for Electric Utilities Burning Lignite Coal, Phase I Bench- and Pilot-Scale Testing*; Final Report for U.S. Department of Energy Environmental Management Contract No. DE-FC26-98FT40321; Energy & Environmental Research Center: Grand Forks, ND, Oct 2003.

3. Standards of Performance for New and Existing Stationary Sources: Electric Utility Steam Generating Units, amended. *Code of Federal Regulations*, Part 60, 63, 72, and 75, Title 40, 2005.

4. Rule to Reduce Interstate Transport of Fine Particulate Matter and Ozone (Clean Air Interstate Rule); Revisions to Acid Rain Program; Revisions to the NO_x SIP Call. *Code of Federal Regulations*, Parts 51, 72, 73, 77, 78, and 96, Title 40, 2005.

5. Standards of Performance for New and Existing Stationary Sources: Electric Utility Steam Generating Units. *Code of Federal Regulations*, Part 60 subpart Da, 63, 72, and 75, Title 40, 2005, Page 23.

6. Pavlish, J.H.; Sondreal, E.A.; Mann, M.D.; Olson, E.S.; Galbreath, K.C.; Laudal, D.L.; Benson, S.A. Status Review of Mercury Control Options for Coal-Fired Power Plants. *Fuel Process. Technol.* **2003**, *82* (2–3), 89–165.

7. Holmes, M.J.; Wocken, C.A.; Pavlish, J.H.; Hill Brandt, K.L.; Ericksen, R.; Brickett, L. Field Testing of Mercury Control for Lignite-Fired Systems with Activated Carbon and Sorbent Enhancement Additives: Field Test Results from Antelope Valley Station. In *Proceedings of the International Conference on Air Quality V: Mercury, Trace Elements, SO_3, and Particulate Matter*; Arlington, VA, Sept 19–21, 2005.

ACTIVATED CARBON PRODUCTION FROM NORTH DAKOTA LIGNITE - PHASE IIA - JV90 ADD-ON
BNI/ALLETE/DEPARTMENT OF ENERGY
PROPOSED START DATE: 3/1/2007
EERC NDIC PROPOSAL #2007-0218 (BNI Proposal 2007-0139, DOE Proposal 2007-0158)

SUMMARY BUDGET

	TOTAL		BNI SHARE		NDIC SHARE		EERC JSRP SHARE	
CATEGORY	**HRS**	**$COST**	**HRS**	**$COST**	**HRS**	**$COST**	**HRS**	**$COST**
TOTAL DIRECT LABOR	4,503	$ 151,365	40	$ 1,354	2,235	$ 72,148	2,228	$ 77,863
TOTAL FRINGE BENEFITS		$ 76,762		$ 691		$ 36,795		$ 39,276
TOTAL LABOR		$ 228,127		$ 2,045		$ 108,943		$ 117,139
OTHER DIRECT COSTS								
TRAVEL		$ 28,687		$ -		$ 15,500		$ 13,187
EQUIPMENT > $5000		$ 24,000		$ -		$ -		$ 24,000
SUPPLIES		$ 28,500		$ 112		$ 18,637		$ 9,751
FEES						$ 33,613		
SUBCONTRACT - ENVERGEX		$ 286,951		$ 286,951				$ -
ANALYTICAL, GRAPHICS		$ 54,997		$ -				$ 21,384
COMMUNICATION - PHONES & POSTAGE		$ 3,214		$ 20		$ 898		$ 2,296
OFFICE (PROJECT SPECIFIC SUPPLIES)		$ 6,122		$ -		$ 1,530		$ 4,592
GENERAL (FREIGHT, FOOD)		$ 10,500		$ -		$ 7,000		$ 3,500
TOTAL OTHER DIRECT COST		$ 442,971		$ 287,083		$ 77,178		$ 78,710
TOTAL DIRECT COST		$ 671,098		$ 289,128		$ 186,121		$ 195,849
FACILITIES & ADMIN. RATE - % OF MTDC	VAR	$ 187,419	56%	$ 1,220	56%	$ 104,227	47.7%	$ 81,972
TOTAL PROJECT COST		$ 858,517		$ 290,348		$ 290,348		$ 277,821

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.

ACTIVATED CARBON PRODUCTION FROM NORTH DAKOTA LIGNITE - PHASE IIA - JV90 ADD-ON
BNI/ALLETE/DEPARTMENT OF ENERGY
PROPOSED START DATE: 3/1/2007
EERC NDIC PROPOSAL #2007-0218 (BNI Proposal 2007-0139, DOE Proposal 2007-0158)

DETAILED BUDGET

			TOTAL		BNI SHARE		NDIC SHARE		EERC JSRP SHARE	
LABOR	**LABOR CATEGORY**	**HOURLY RATE**	**HRS**	**$COST**	**HRS**	**$COST**	**HRS**	**$COST**	**HRS**	**$COST**
BENSON, S.	PROJECT MANAGER	$ 61.48	240	$ 14,754	-	$ -	120	$ 7,378	120	$ 7,376
CROCKER, C.	PRINCIPAL INVESTIGATOR	$ 33.17	800	$ 26,535	40	$ 1,327	360	$ 11,941	400	$ 13,267
OLSON, E.	PRINCIPAL INVESTIGATOR	$ 51.86	120	$ 6,223	-	$ -	60	$ 3,112	60	$ 3,111
HANSON, S.	PRINCIPAL INVESTIGATOR	$ 33.61	440	$ 14,788	-	$ -	170	$ 5,714	270	$ 9,074
RESEARCH ENGINEER	RESEARCH SCIENTIST/ENGINEER	$ 28.55	300	$ 8,565	-	$ -	150	$ 4,283	150	$ 4,282
--------------	SENIOR MANAGEMENT	$ 59.15	281	$ 16,621	-	$ -	31	$ 1,834	250	$ 14,787
--------------	RESEARCH SCIENTIST/ENGINEER	$ 32.92	774	$ 25,479	-	$ -	359	$ 11,818	415	$ 13,661
--------------	RESEARCH TECHNICIAN	$ 21.80	504	$ 10,987	-	$ -	81	$ 1,766	423	$ 9,221
--------------	TECHNOLOGY DEV. MECH.	$ 25.67	864	$ 22,179	-	$ -	864	$ 22,179	-	$ -
--------------	UNDERGRAD-RES.	$ 8.51	100	$ 851	-	$ -	-	$ -	100	$ 851
--------------	TECHNICAL SUPPORT SERVICES	$ 17.70	80	$ 1,416	-	$ -	40	$ 708	40	$ 708
			4,503	$ 148,398	40	$ 1,327	2,235	$ 70,733	2,228	$ 76,338
ESCALATION ABOVE CURRENT BASE		2%		$ 2,967		$ 27		$ 1,415		$ 1,525
TOTAL DIRECT LABOR				$ 151,365		$ 1,354		$ 72,148		$ 77,863
FRINGE BENEFITS - % OF DIRECT LABOR - STAFF		51%		$ 76,753		$ 691		$ 36,795		$ 39,267
FRINGE BENEFITS - % OF DIRECT LABOR - UNDERGRAD-RES		1%		$ 9		$ -		$ -		$ 9
TOTAL FRINGE BENEFITS				$ 76,762		$ 691		$ 36,795		$ 39,276
TOTAL LABOR				$ 228,127		$ 2,045		$ 108,943		$ 117,139
OTHER DIRECT COSTS										
TRAVEL				$ 28,687		$ -		$ 15,500		$ 13,187
EQUIPMENT > $5000				$ 24,000		$ -		$ -		$ 24,000
SUPPLIES				$ 28,500		$ 112		$ 18,637		$ 9,751
SUBCONTRACT - ENVERGEX				$ 286,951		$ 286,951		$ -		$ -
COMMUNICATION - PHONES & POSTAGE				$ 3,214		$ 20		$ 898		$ 2,296
OFFICE (PROJECT SPECIFIC SUPPLIES)				$ 6,122		$ -		$ 1,530		$ 4,592
GENERAL (FREIGHT, FOOD)				$ 10,500		$ -		$ 7,000		$ 3,500
NATURAL MATERIALS ANALYTICAL RES. LAB.				$ 3,195		$ -		$ 1,600		$ 1,595
FUELS & MATERIALS RESEARCH LAB.				$ 1,512		$ -		$ 750		$ 762
ANALYTICAL RESEARCH LAB.				$ 2,203		$ -		$ 1,100		$ 1,103
COMBUSTION TEST SERVICES				$ 30,274		$ -		$ 20,600		$ 9,674
PARTICULATE ANALYSIS				$ 5,834		$ -		$ 2,917		$ 2,917
PROCESS CHEM. & DEV. LAB.				$ 947		$ -		$ 474		$ 473
FUEL PREP. AND MAINTENANCE				$ 5,508		$ -		$ 2,754		$ 2,754
GRAPHICS SUPPORT				$ 3,849		$ -		$ 1,743		$ 2,106
SHOP & OPERATIONS SUPPORT				$ 1,675		$ -		$ 1,675		$ -
TOTAL OTHER DIRECT COST				$ 442,971		$ 287,083		$ 77,178		$ 78,710
TOTAL DIRECT COST				$ 671,098		$ 289,128		$ 186,121		$ 195,849
FACILITIES & ADMIN. RATE - % OF MTDC			VAR	$ 187,419	56.0%	$ 1,220	56.0%	$ 104,227	47.7%	$ 81,972
TOTAL PROJECT COST				$ 858,517		$ 290,348		$ 290,348		$ 277,821

ACTIVATED CARBON PRODUCTION FROM NORTH DAKOTA LIGNITE - PHASE IIA - JV90 ADD-ON
EERC NDIC PROPOSAL #2007-0218 (BNI Proposal 2007-0139, DOE Proposal 2007-0158)

DETAILED BUDGET - FEES

NATURAL MATERIALS ANALYTICAL RES. LAB.	RATE	#	TOTAL $COST
XRFA	$174	18	$ 3,132
SUBTOTAL			$ 3,132
ESCALATION		2%	$ 63
TOTAL NATURAL MATERIALS ANALYTICAL RES. LAB.			$ 3,195

FUELS & MATERIALS RESEARCH LAB.	RATE	#	$COST
BTU	$52	8	$ 416
MISCELLANEOUS	$85	2	$ 170
PROXIMATE ANALYSIS	$60	8	$ 480
SULFUR	$52	8	$ 416
SUBTOTAL			$ 1,482
ESCALATION		2%	$ 30
TOTAL FUELS & MATERIALS RESEARCH LAB.			$ 1,512

ANALYTICAL RESEARCH LAB.	RATE	#	$COST
ACID EXTRACTABLE MERC	$36	18	$ 648
CHLORINE	$52	18	$ 936
CVAA	$32	18	$ 576
SUBTOTAL			$ 2,160
ESCALATION		2%	$ 43
TOTAL ANALYTICAL RESEARCH LAB.			$ 2,203

COMBUSTION TEST SERVICES	RATE	#	$COST
COMB TEST FACILITY BASE RATE/HOUR	$141	80	$ 11,280
INSTRUMENTATION & PROBES/HOUR	$230	80	$ 18,400
SUBTOTAL			$ 29,680
ESCALATION		2%	$ 594
TOTAL COMBUSTION TEST SERVICES			$ 30,274

PARTICULATE ANALYSIS	RATE	#	$COST
MERCURY CEM (PER DAY)	$286	20	$ 5,720
SUBTOTAL			$ 5,720
ESCALATION		2%	$ 114
TOTAL PARTICULATE ANALYSIS			$ 5,834

PROCESS CHEM. & DEV. LAB.	RATE	#	$COST
PREP/GC/CHN	$58	16	$ 928
SUBTOTAL			$ 928
ESCALATION		2%	$ 19
TOTAL PROCESS CHEM. & DEV. LAB.			$ 947

FUEL PREP. & MAINTENANCE	RATE/HR.	#	$COST
FUEL PREP. AND MAINTENANCE (PER EQUIP)	$30	180	$ 5,400
SUBTOTAL			$ 5,400
ESCALATION		2%	$ 108
TOTAL FUEL PREP. & MAINTENANCE			$ 5,508

GRAPHICS SUPPORT	RATE	#	$COST
GRAPHICS (HOURLY)	$51	74	$ 3,774
SUBTOTAL			$ 3,774
ESCALATION		2%	$ 75
TOTAL GRAPHICS SUPPORT			$ 3,849

SHOP & OPERATIONS SUPPORT	RATE	#	$COST
TECHNICAL DEVELOPMENT HOURS	$1.90	864	$ 1,642
SUBTOTAL			$ 1,642
ESCALATION		2%	$ 33
TOTAL SHOP & OPERATIONS SUPPORT			$ 1,675

DETAILED BUDGET - TRAVEL

RATES USED TO CALCULATE ESTIMATED TRAVEL EXPENSES

DESTINATION	NO SAT. AIRFARE	PER MILE	LODGING	PER DIEM	CAR RENTAL	REGIST.
Unspecified Destination (USA)	$ 1,500	$ -	$ 150	$ 64	$ 75	$ 525
Duluth, MN	$ 700	$ 0.33	$ 125	$ 49	$ -	$ -
Bismarck, ND	$ -	$ 0.33	$ 60	$ 25	$ -	$ 525
Rochester, NY	$ 927	$ -	$ 150	$ 44	$ 60	$ -
Pittsburgh, PA	$ 1,200	$ -	$ 150	$ 54	$ 60	$ -

PURPOSE/DESTINATION	NUMBER OF TRIPS	NUMBER OF PEOPLE	NUMBER OF MILES	NUMBER OF DAYS	AIRFARE	MILEAGE	LODGING	PER DIEM	CAR RENTAL	MISC.	REGIST.	TOTAL
Nat'l Conference/Unspecified Dest. (USA)	2	2	-	5	$ 6,000	$ -	$ 2,400	$ 1,280	$ 750	$ 400	$ 2,100	$ 12,930
Wastewater Conf./Bismarck, ND	1	2	700	3	$ -	$ 231	$ 240	$ 150	$ -	$ 60	$ 1,050	$ 1,731
ALLETE Sponsor Mtg/Duluth, MN	4	1	-	2	$ 2,800	$ -	$ 500	$ 392	$ -	$ 160	$ -	$ 3,852
Oversight/Analytical/Rochester, NY	2	2	-	5	$ 3,708	$ -	$ 2,400	$ 880	$ 600	$ 400	$ -	$ 7,988
Contractor Rvw Mtg/Pittsburgh, PA	1	1	-	4	$ 1,200	$ -	$ 450	$ 216	$ 240	$ 80	$ -	$ 2,186
TOTAL ESTIMATED TRAVEL												$ 28,687

DETAILED BUDGET - EQUIPMENT

Other Equipment	
Gas Analyzer	$ 24,000
	$ 24,000
Total Equipment	$ 24,000

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. Escalation of labor and EERC fee rates is incorporated in 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 current escalation rate of 5% is based on historical averages. 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.

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.

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 contracts and intellectual property, accounting, personnel, and purchasing and receiving, as well as clerical support of these functions, are included in the EERC facilities and administrative cost rate.

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 can be found at www.und.edu/dept/accounts/employeetravel.html. Estimates include 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, 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 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, 2006. 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 and subcontracts/subgrants in excess of the first $25,000 for each award.

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APPENDIX A

DESCRIPTION OF PILOT-SCALE TEST FACILITIES

DESCRIPTION OF PILOT-SCALE TEST FACILITIES

IFCO MULTIPLE-HEARTH FURNACE SYSTEM EQUIPMENT AND INSTRUMENTATION

Equipment

- Multiple-hearth furnace – 5-ft 6-in. OD, 39-in. i.d., with five hearths
- Feed system
  - Feed hopper – ~ 1 yd^3
  - Hopper bottom screw conveyor, with variable frequency drives (VFD) speed control
  - Inclined-belt conveyor, constant speed
  - Furnace inlet feed screw conveyor, with VFD speed control
- Postcombustion chamber – 3 ft i.d. × 6 ft long
- Cyclone (three sizes available)
- Water-cooled product screw conveyor
- Laboratory equipment
  - Small muffle furnace
  - Mettler balance

Instrumentation

The following list describes those instruments which are particularly required for this process application. It does not include all of the standard instruments installed with the furnace for safety or other operations.

- Temperature measurement (thermocouple with 4–20-ma transmitter)
  - At all hearths
  - Postcombustion chamber inlet
  - Postcombustion chamber outlet
  - Steam inlet
  - Product outlet
- Flowmetering (manual read)
  - Steam inlet (rotameter)
  - Furnace air inlets (3) (orifice plate)
  - Postcombustion air inlet (orifice plate)
- Pressure (DP sensor with 4–20-ma transmitter)
  - Draft at furnace outlet
- Fuel gas volume (gas meter with 4–20-ma transmitter)
  - Total furnace fuel usage

Emission Testing Equipment

- "Testo" Model 330-2 – CO, O_2, NO
- "ECOM" Model AC+ – CO, O_2, NO, NO_2, NO_x, SO_x

A photo and schematic of the MHF is presented in Figure A-1.

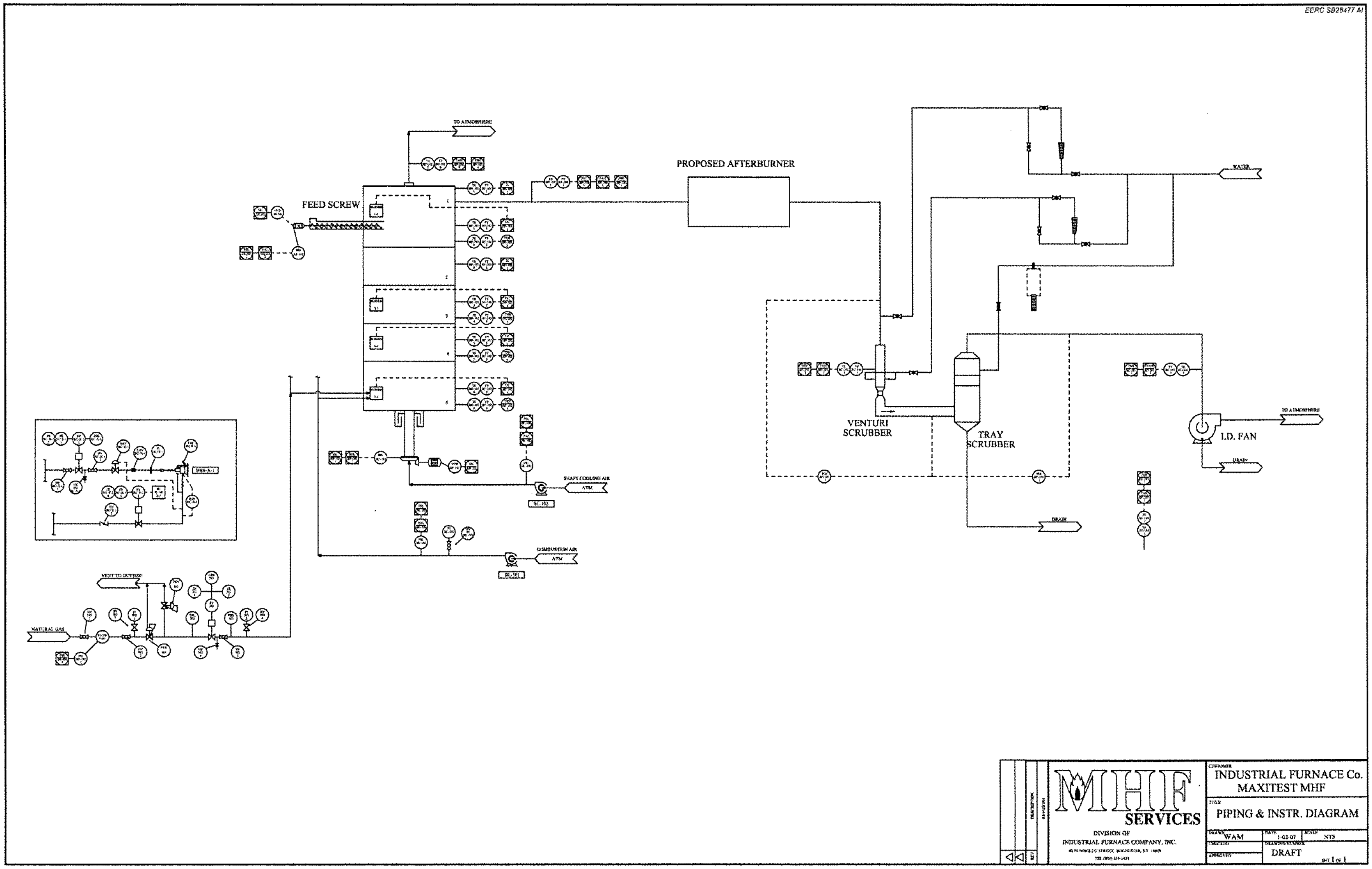

Figure A-1. IFCO MHF furnace system.

EERC COMBUSTION TEST FACILITY (CTF)

The CTF unit (Figure A-2) is designed to generate fly ash and flue gas representative of that produced in a full-scale utility boiler. The combustor is oriented vertically to minimize wall deposits. A refractory lining helps to ensure adequate flame temperature for complete combustion and prevents rapid quenching of the coalescing or condensing fly ash. The mean residence time of a particle in the combustor is approximately 3 seconds, based on the superficial gas velocity. The coal nozzle of the CTF fires axially upward from the bottom of the combustor, and secondary air is introduced concentrically to the primary air with turbulent mixing. In addition, tertiary air is supplied above the base of the combustor. Coal is introduced to the primary airstream via a screw feeder controlled by an Acrison automatic feed system ejector. The feed rate is nominally 50 lb/hr. An electric air preheater is used for precise control of the combustion air temperature.

The CTF instrumentation permits system temperatures, pressures, flow rates, flue gas constituent concentrations, and operating data to be monitored continuously and downloaded to a data acquisition system.

Flue gas samples can be taken at multiple sample points: the furnace exit, the PCD inlet, and the PCD outlet. After passing through sample conditioners to remove the moisture, the flue gas is typically analyzed for O_2, CO_2, SO_2, and NO_x. Except for the NO_x, each constituent is normally analyzed at both the furnace exit and outlet of the ESP simultaneously, using two analyzers. The concentration values from all of the instruments are recorded continuously using

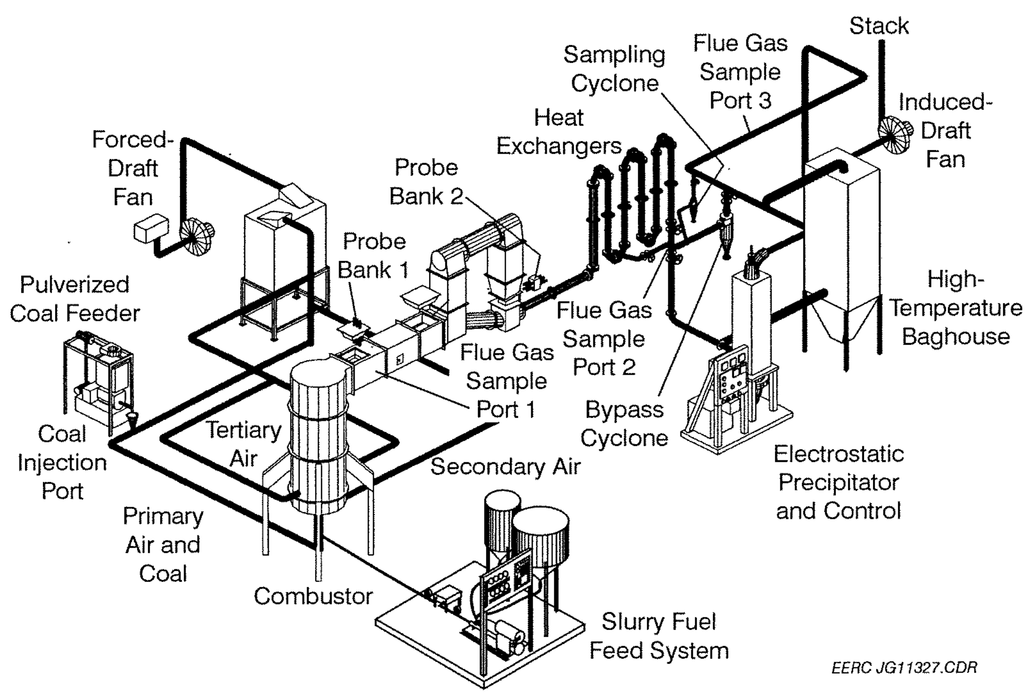

Figure A-2. CTF and auxiliary systems.

circle charts. In addition, all data are manually recorded at set time intervals. NO_x is determined using two thermoelectron chemiluminescent NO_x analyzers. The O_2 and CO_2 analyzers are made by Beckman, and the SO_2 analyzers are manufactured by DuPont. Each of these analyzers is regularly calibrated and maintained to provide accurate flue gas concentration measurements.

The CTF is designed to operate in conjunction with either a baghouse or an ESP. The baghouse vessel is a 20-in.-i.d. chamber that is heat-traced and insulated, with the flue gas introduced near the bottom. Since the combustor produces about 200 acfm of flue gas at 300°F, three 13-ft by 5-in. bags provide an air-to-cloth ratio of 4 ft/min. Each bag is cleaned separately with its own diaphragm pulse valve. In order to quantify differences in pressure drop for different test conditions, the bags are cleaned on a time basis, rather than with the cleaning cycle initiated by pressure drop. Once bag cleaning is initiated, all three bags are pulsed in rapid succession online.

The CTF is also equipped with a new, single-wire, tubular ESP. The ESP has an electrically isolated plate that is grounded through an ammeter, allowing continual monitoring of the actual plate current. This will help to ensure consistent operation of the ESP from test to test. The tubular plate is suspended by a load cell which will help to monitor rapping efficiency. In addition, sight ports are located at the top of the ESP to allow for online inspection of electrode alignment, sparking, rapping, and dust buildup on the plate. The ESP was fabricated to facilitate thorough cleaning between tests. Removal of both the top of the ESP and the bottom hopper will allow access to the ESP interior for complete cleaning of the wire and plate so that all tests can begin on the same basis.

Fly ash samples are obtained by various means at the inlet and outlet of the pilot-scale ESP or baghouse (agglomeration tower). U.S. Environmental Protection Agency Method 5 is normally used to establish particulate concentrations in the flue gas. Collection hoppers located at the bottom of each control device can provide large samples for investigation.

APPENDIX B

RESUMES OF KEY PERSONNEL

DR. STEVEN A. BENSON
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Principal Areas of Expertise

Dr. Benson's principal areas of interest and expertise include development and management of complex multidisciplinary programs that are focused on solving environmental and energy problems, including 1) technologies to improve the performance of combustion/gasification and associated air pollution control systems; 2) transformations and control of air toxic substances in combustion and gasification systems; 3) advanced analytical techniques to measure the chemical and physical transformations of inorganic species in gases; 4) computer-based models to predict the emissions and fate of pollutants from combustion and gasification systems; 5) advanced materials for power systems; 6) impacts of power system emissions on the environment; 7) national and international conferences and training programs; and 8) state and national environmental policy.

Qualifications

Ph.D., Fuel Science, Materials Science and Engineering, The Pennsylvania State University, 1987.
B.S., Chemistry, Moorhead State University (Minnesota), 1977.

Professional Experience

1999 – Senior Research Manager/Advisor, EERC, UND. Dr. Benson is responsible for leading a group of about 30 highly specialized 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 have focused on the development of multiclient jointly sponsored centers or consortia that are funded by a combination of government and industry sources. Current research activities include computer modeling of combustion and environmental control systems, performance of selective catalytic reduction technologies for NO_x control, carbon-based NO_x reduction technologies, mercury control 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. The computer-based modeling efforts utilize various kinetic, 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 and emissions. Dr. Benson is Program Area Manager for Modeling and Database Development for the U.S. Environmental Protection Agency (EPA) Center for Air Toxic Metals® (CATM®)

at the EERC. He is responsible for identifying research opportunities and preparing proposals and reports for clients.

1994 – 1999 Associate Director for Research, EERC, UND. Dr. Benson was responsible for the direction and management of programs related to integrated energy and environmental systems development. Dr. Benson led a team of over 45 scientists, engineers, and technicians. In addition, faculty members and graduate students from Chemical Engineering, Chemistry, Geology, and Atmospheric Sciences have been involved in conducting research projects. The research, development, and demonstration programs involve fuel quality effects on power system performance, advanced power systems development/demonstration, computational modeling, advanced materials for power systems, and analytical methods for the characterization of materials. Specific areas of focus included the development and direction of EPA CATM at the EERC (CATM, a peer-reviewed, EPA-designated Center of Excellence, is currently in its 12th year of operation and has received funding of over $12,000,000 from government and industry sources), ash behavior in combustion and gasification systems, hot-gas cleanup, and analytical methods of analysis. He was responsible for the identification of research opportunities and the preparation of proposals and reports for clients. Dr. Benson left this position to focus efforts on Microbeam Technologies' Small Business Innovation Research (SBIR).

1986 – 1994 Senior Research Manager, Fuels and Materials Science, EERC, UND. Dr. Benson was responsible for management and supervision of research on the behavior of inorganic constituents, including air toxic metals during combustion and gasification, hot-gas cleanup (particulate gas-phase species control), fundamental combustion, and analytical methods of inorganic analysis, including SEM and microprobe analysis, Auger, XPS, SIMS, XRD, and XRF. Responsible for identification of research opportunities, preparation of proposals and reports for clients, and publication.

1989 – 1991 Assistant Professor (part-time), Department of Geology and Geological Engineering, UND. Dr. Benson was responsible for teaching courses on coal geochemistry, coal ash behavior in combustion and gasification systems, and analytical methods of materials analysis. Taught courses on SEM/microprobe analysis and mineral transformations during coal combustion.

1984 – 1986 Graduate Research Assistant, Fuel Science Program, Department of Materials Science and Engineering, The Pennsylvania State University.

1983 – 1984 Research Supervisor, Distribution of Inorganics and Geochemistry, Coal Science Division, UND Energy Research Center. Dr. Benson was responsible for management and supervision of research on the distribution of major, minor, and trace inorganic constituents and geochemistry of coals and ash chemistry related to inorganic constituents and mineral interactions and transformations during coal combustion and environmental control systems.

1980 – 1983 Research Chemist, U.S. Department of Energy (DOE) Grand Forks Energy Technology Center. Dr. Benson performed research on surface and/or chemical analysis and characterization of coal-derived materials by SEM, XRF, and thermal analysis in support of projects involving SO_x, NO_x, and particulate control; ash deposition; heavy metals in combustion systems; coal gasification; and fluidized-bed combustion.

1979 – 1980 Research Chemist, DOE Grand Forks Energy Technology Center. Dr. Benson performed research on the application of such techniques as differential thermal analysis, differential scanning calorimetry, thermogravimetric analysis, and energy-dispersive XRF analysis with application to low-rank coals and coal process-related material. In addition, research was performed on the use of x-ray analysis to measure trace elements in fuels and conversion products.

1977 – 1979 Chemist, DOE Grand Forks Energy Technology Center. Dr. Benson performed analysis on coal and coal derivatives by techniques such as wavelength-dispersive x-ray analysis, argon plasma spectrometry, atomic absorption spectrometry, thermal analysis, and elemental analysis (CHN).

1976 – 1977 Teaching Assistant, Department of Chemistry, Moorhead State University.

Awards

- Lignite Energy Council, Distinguished Service Award, Research & Development, 1997
- GEMS Award, College of Earth and Mineral Sciences, Pennsylvania State University, 2002
- Lignite Energy Council, Distinguished Service Award, Research & Development, 2003

Professional Memberships and Activities

- United States Senate Committee on the Environment and Public Works
  - One of three technical panelists invited to provide testimony on mercury control for the coal-fired power industry.
- American Chemical Society (ACS)
  - Member, Executive Committee, Fuel Division – 2005–present – Participates on the Executive Committee involved in the coordination and direction of division activities, including outreach, programming, finances, and publications.
  - Chair, Fuel Division – 2004–2005 – Duties comprised coordinating all aspects of the division, including publications and national conferences.
  - Fuel Division – Participates on the Executive Committee involved in the coordination and direction of division activities, including outreach, programming, finances, and publications.
  - Councilor, Fuel Division – Represents the Fuel Division at the National ACS Council meeting.
  - Chair Elect, Fuel Division – August 2002 – Elected to be Chair of the Fuel Division.
  - Member, Committee on Environmental Improvement (CEI) – The committee provides advice and direction to the ACS governance on policies and programs related to the environment. Since becoming a member of the committee, we have developed policy statements on Global Climate Change, Reformulated Gasoline and MtBE, and Energy

Policy. These policy statements are used to assist legislators in developing national environmental policy. Members of CEI also provide testimony on a variety of environmental issues.

- American Society for Mechanical Engineers (ASME)
  - Advisory Member, ASME Committee on Corrosion and Deposition Resulting from Impurities in Gas Streams. Developed several conferences through the International Engineering Foundation.
- Mercury Reduction Initiative – Minnesota Pollution Control Agency (MPCA)
  - Participated in meetings for the mercury reduction initiative and provided advice regarding mercury control technologies for electric utilities and MPCA for voluntary mercury reduction strategies.
- Elsevier Science, *Fuel Processing Technology*
  - Editorial board member whose role is to provide advice and direction for the journal.

Publications and Presentations

- Has authored/coauthored over 210 publications and is the editor of eight books and *Fuel Processing Technology* special issues.

CHARLENE R. CROCKER
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Principal Areas of Expertise

Ms. Crocker's principal areas of interest and expertise include trace element emissions and control for fossil fuel combustion systems, with a particular emphasis on air pollution issues related to mercury and fine particulates. This includes developing carbon-based mercury control sorbents, mercury and halogens in coal combustion, and airborne particulate matter instrumentation. Ms. Crocker has experience in water quality-monitoring and analytical methods, development and implementation of fish consumption surveys, general public and K–12 education, laser-induced breakdown spectroscopy (LIBS), atomic absorption spectroscopy (AAS) (flame, graphite furnace, and hydride generation), inductively coupled plasma (ICP) spectroscopy, trace element analysis of water, coal and coal by-products, and atomic fluorescence spectroscopy (AFS).

Qualifications

B.S., Chemistry, University of North Dakota, 1994
B.A., French, Colby College, Waterville, ME, 1986

Professional Experience

2004 – Research Manager, EERC, UND. Ms. Crocker's responsibilities include managerial and principal investigator duties for projects related to the development of sorbents for emission control strategies in fossil fuel-fired energy systems; writing proposals and reports applicable to energy and environmental research; providing technical support to project activities as needed; and mentoring junior scientists.

2002 – 2004 Research Scientist, Ms. Crocker's responsibilities included managing projects relating to environmental management and air quality; collaborating with other scientists on development of carbon-based flue gas sorbents, particulate matter (PM) sampling, development of water quality education and CO_2 sequestration public outreach materials, evaluation of bioassessment tools, fish consumption survey development, proposal and report writing, data analysis, presentation of results, and budget tracking; developing PM-sampling protocols; participating in development of a water-based geoscience education program and outreach activities for school children; directing activities of student assistants.

1994 – 2002 Research Chemist, EERC, UND. Ms. Crocker's responsibilities included managing projects relating to environmental management and air quality; collaborating with other scientists on fish consumption survey development, particulate matter (PM) sampling, corrosion of ceramic and alloy materials, coal ash, water purification, and surface decontamination research; proposal and report writing, data analysis, presentation of results, and budget tracking; developing PM sampling protocols; participating in development of a water-based geoscience education program and outreach activities for school children; directing activities of student assistants; developing and implementing analytical methods employing LIBS. Previous duties performed in the Analytical Research Laboratory focused on water quality and energy-related analyses. Responsibilities included preparing and analyzing ultratrace element samples in aqueous and inorganic media using AAS, ICP, and IC; recording and disseminating analytical results and quality control checks; performing research on ultratrace elemental analysis of mercury using AFS; and preparing reagents and solutions.

1993 – 1994 Research Assistant, EERC, UND. Ms. Crocker's responsibilities included preparing and analyzing ultratrace element samples in inorganic media; performing research on ultratrace element analysis of mercury in air using AFS; and preparing reagents and solutions.

1990 Naturalist, Deep Portage Conservation Reserve, Hackensack, Minnesota. Ms. Crocker's responsibilities included planning and conducting environmental education programs for children and adults; evaluating curriculum; and organizing lending of educational learning stations.

1988 – 1990 Sanctuary Manager, Wetlands, Pines & Prairie Audubon Sanctuary, Warren, Minnesota. Ms. Crocker's responsibilities included planning and conducting environmental education programs; organizing chapter meetings; publishing the Sanctuary newsletter; and performing administrative tasks.

1988 – Park Ranger/Interpreter, Boston Harbor Islands State Park, Boston, Massachusetts. Ms. Crocker's responsibilities included interpreting natural and human history; developing special programs and leading walking tours of the islands; and conducting school programs.

Presentations and Publications

- Has authored and coauthored over 50 publications

DR. EDWIN S. OLSON
Senior Research Advisor
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Principal Areas of Expertise
Dr. Olson's principal areas of interest and expertise include carbon and coal structure and reactivity, mercury sorption, water purification chemistry, catalysis of alcohol formation, production of liquid fuels from coal and biomass precursors, enzyme-catalyzed esterification and desulfurization reactions, new biorefinery concepts, chromatography, organic trace analysis, mass spectrometry, and organic spectroscopy. Dr. Olson is currently chair of the American Chemical Society Division of Fuel Chemistry.

Qualifications
Ph.D., Chemistry and Physics, California Institute of Technology, 1964.
B.A., Chemistry, magna cum laude, St. Olaf College, 1959.

Professional Experience

1994 – Senior Research Advisor, EERC, UND. Novel activated carbons for air and water treatment were designed and tested. A new model for mercury sorption in flue gas was developed. A new method for determining Hg (II) compounds in flue gas was published. A method for direct esterification of ammonium lactate was developed resulting in a substantial advancement in biorefinery technologies.

1988 – President, Universal Fuel Development Associates, Inc. Dr. Olson served as Project Manager for Phase I and II SBIR projects involving water purification, nonaqueous enzymatic solubilization of coal materials, and oxygenate synthesis from agricultural materials and for DOE projects involving geotechnical characterizations and fine-particle catalysts for coal liquefaction.

1983 – 1994 Research Supervisor, Process Chemistry & Development, EERC, UND. Dr. Olson performed hydrotreating and HDS catalyst, coal liquefaction, and gasification research and analytical methods development.

1980 – 1983 Research Chemist, Grand Forks Energy Technology Center, U.S. Department of Energy. Dr. Olson developed analytical methods for coal conversion products by GC, MS, HPLC, and NMR and trace organics in air, water, and fly ash.

1968 – 1980 Professor of Chemistry, South Dakota State University. Dr. Olson taught graduate and undergraduate courses in organic, biochemistry, and instrumental analysis. His research projects involved homogeneous carbonylation catalysts, synthesis of antimicrobial heterocyclic compounds, amino acid analogs, and fatty acids.

1977 – (summer)	Professor, University of Notre Dame.
1972 – 1976 (summers)	Visiting Staff Member, Los Alamos Scientific Laboratory. Dr. Olson performed synthesis and biosynthesis of labeled compounds.

Dr. Olson also has experience at the University of California, Los Angeles, Department of Biochemistry, and at Idaho State University, Department of Chemistry.

Publications and Presentations

- Has authored or coauthored over 200 publications

DR. SHEILA K. HANSON
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Principal Areas of Expertise
Dr. Hanson's principal areas of interest and expertise include marketing high-tech products, feasibility studies, university–industry relations, and business planning.

Qualifications
Ph.D., Research Methodologies with a cognate in Business Administration, University of North Dakota, 2000.
M.S., Research Methodologies, University of North Dakota, 1992.
B.A., Psychology and German, University of North Dakota, 1990.
B.B.A., Marketing, University of North Dakota, 1988.

Professional Experience

2001 – Marketing Research Manager, EERC, UND. Dr. Hanson's responsibilities include conducting marketing research for a variety of industry and government organizations, providing market information for interdisciplinary teams of scientists and engineers, and assisting senior management with marketing tasks.

2000 – Assistant Professor, Department of Marketing, UND. Dr. Hanson teaches Marketing Research, Advertising, and Marketing Foundations.

1998 – 1999 Lecturer, Department of Marketing, UND. Dr. Hanson taught Principles of Marketing.

1997 – 2001 Marketing Director, Center for Innovation, UND. Dr. Hanson's responsibilities included managing the research, analysis, and writing of commercial evaluations and marketing assessments of energy-related technologies for a U.S. Department of Energy grant and researching and writing economic and marketing feasibility studies, business plans, and marketing plans for clients for a variety of products and technologies.

1997 – 1998 Instructor, Department of Educational Foundations and Research, UND. Dr. Hanson taught Statistical Methods.

1996 – Consulting Services. Dr. Hanson has provided focus group, survey research, market planning, and media planning consultation for a broad range of clients, including the Grand Forks Economic Development Corporation, Grand Forks Chamber of Commerce, health care facilities, banks, and retail organizations.

1992 – 1997 Marketing Research Director, Simmons Advertising, Grand Forks, North Dakota. Dr. Hanson's responsibilities included conducting market reviews, focus groups, and survey research for a wide variety of clients, including electric utilities, fast food, banking, and health care facilities; using account planning to develop creative themes for advertising campaigns; and researching, planning, and managing marketing and communications plans and budgets for clients.

1992 – 1997 Media Buyer. Dr. Hanson's responsibilities included performing qualitative and quantitative media analysis and evaluation, evaluating media opportunities and trends, and measuring the effectiveness of media campaigns using Media Management Plus software.

Professional Memberships

- American Academy of Advertising
- Association for Consumer Research
- Academy of Management
- American Marketing Association
- American Advertising Federation

Publications and Presentations

- Has authored and coauthored numerous professional publications

CONSTANCE Y. WIXO
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Principal Areas of Expertise
Ms. Wixo's principal areas of interest and expertise include data reduction and interpretation as well as data presentation for report preparation; coordination of the publishing process for publications in journals, special issues, and books; compilation and drafting of project reports; and performing Internet and other methods of research for research engineers and managers. Ms. Wixo has worked in the energy and environmental field in various capacities for over 30 years.

Qualifications
B.B.A., Business Administration, University of North Dakota, 1991.

Professional Experience

2006 – Research Specialist, EERC, UND. Ms. Wixo compiles and prepares proposals, reports, technical and peer-reviewed papers, presentations, and posters for research projects; performs data reduction and analysis to include in tables, graphs, and slides; performs Internet research and other research methods to facilitate the timely preparation and/or availability of information for the group and others; is responsible for all publishing activities required to provide timely publication of papers, journals, books, or other technical materials; and maintains current knowledge of all updates and any other pertinent information for RFPs of interest to the group and assists project managers in compiling the requisite data/information for timely submittal of the proposal.

1993 – 2006 Administrative Manager, EERC, UND. Ms. Wixo provided oversight to administrative efforts including assisting the Associate Director for Research in the management and coordination of meetings, conferences, workshops, publications, and newsletters. Duties included supervision of a team of research information associates, assisting in the organization and coordination of meetings and conferences at EERC and elsewhere, assisting in the development of newsletters and mailing lists, coordinated the publication of special peer-reviewed special issues, and acted as a liaison between EERC clients and the Associate Director for Research.

1987 – 1993 Information Processing Operator, Office Services, EERC, UND. Ms. Wixo worked approximately 20 hours per week while attending UND and served as grammatical editor for approximately 6 months until workload necessitated the restructure of the position to full time; subsequently provided backup to the editor as required. Coordinated preparation of the EERC Annual Program Plan submittal to the U.S. Department of Energy and the EERC Annual Report (the EERC's primary marketing tool). This entailed designing format; word processing; initiating direct communication with up to 200 researchers and other personnel to obtain a wide range of pertinent information; and tracking progress through all stages of revising, editing, graphics, printing, and mailing. Provided production typing and assembly of publications, periodic reports, proposals, slides, letters, and other documents.

1980 – 1987 Administrative Assistant, Fuels & Process Chemistry Research Division, Grand Forks Energy Research Center, UND (from 1977 to 1983, was called the Grand Forks Energy Technology Center, U.S. Department of Energy). Ms. Wixo assisted project managers in preparation of program plans, proposals, topical and periodical reports, etc.; maintained suspense file on same. Produced charts, graphs, and data displays by obtaining, compiling, and presenting information in appropriate format. Performed first review of draft reports, organizing data, editing, and proofreading for format and correctness. Initiated procedures for efficient operation and work flow among research supervisors, managers, and clerical workers. Maintained current record on budget status of funded projects. Set up and maintained Division files. Interviewed, hired, supervised, and trained Administrative Secretary, Engineering Technician, and student employees.

1977 – 1980 Secretary to the Deputy Director and Project Management Division, Grand Forks Energy Technology Center, U.S. Department of Energy. Ms. Wixo prepared topical and periodic reports, letters, memoranda, etc., editing material to assure correct grammar, format, and special requirements were met. Maintained and searched files for information used in reports, analyses, and letters.

1973 – 1977 Clerk/Stenographer, Grand Forks Energy Research Laboratory, U.S. Bureau of Mines/ERDA. Ms. Wixo typed technical reports, correspondence, and personnel actions, assisted Personnel Officer, and maintained library and numerous file systems.

Publications and Presentations

- Has coauthored several publications.