October 3, 2005

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

Dear Ms. Fine:

Subject: EERC Proposal No. 2006-0052

Enclosed please find an original and seven copies of the subject proposal. The Energy & Environmental Research Center (EERC) is pleased to submit this proposal entitled "Controlling Mercury Emissions for Utilities Firing Lignites from North America Summary Report." The project will provide an overview and summary of research conducted on controlling mercury in lignite-fired electric generating power plants. Much of the work included in the report is based on past projects funded through the North Dakota Industrial Commission. The product of the work will be aimed at providing North Dakota uilities and coal companies easy access to information on mercury control. Also enclosed is the $100 application fee.

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

Sincerely,

Steven A. Benson
Senior Research Manager

SAB/krg

Enclosures

c/enc: Harvey Ness, Lignite Research Council

CONTROLLING MERCURY EMISSIONS FOR UTILITIES FIRING LIGNITES FROM NORTH AMERICA SUMMARY REPORT

EERC Proposal No. 2006-0062

Submitted to:

Ms. Karlene Fine

North Dakota Industrial Commission
State Capitol – Fourteenth Floor
600 East Boulevard Avenue
Bismarck, ND 58505

Proposal Amount: $25,000

Submitted by:

Steven A. Benson

Energy & Environmental Research Center
University of North Dakota
PO Box 9018
Grand Forks, ND 58202-9018

Dr. Steven A. Benson, Project Manager

Dr. Barry I. Milavetz, Associate VP for Research
Research Development and Compliance

October 2005

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ABSTRACT

The goal of this Energy & Environmental Research Center (EERC) project is to prepare a report that will summarize the findings and conclusions of research, development, and demonstration projects on controlling mercury from lignite coals. A significant amount of work has been conducted since 1994 on mercury in lignite; mercury measurement in flue gases; sorbent, sorbent enhancement additives, and oxidation agent development; and full-scale demonstration of mercury control technologies. Currently, all the information is scattered among numerous project reports, and the information is not readily accessible for use by the lignite industry. The project will develop a report that will compile all the key findings and conclusions that can be used as a guide for the lignite industry in managing mercury control in coal-fired power plants. The components of the project will include identifying and compiling the key literature and background information for use in the report, developing a detailed outline, preparing a draft report for review, finalizing the report, and printing and binding copies.

The key deliverable of the project will be will be a bound report. A minimum of 100 bound copies will be prepared. The total project cost is $45,315, with the costs of the proposed project to be shared between the North Dakota Industrial Commission for $25,000, the U.S. Department of Energy (DOE) through the EERC–DOE Jointly Sponsored Research Program for $15,315, and five lignite industry sponsors for $1000 each for a total of $5000. The project will be completed by June 30, 2006, if initiated by December 1, 2005.

CONTROLLING MERCURY EMISSIONS FOR UTILITIES FIRING LIGNITES FROM NORTH AMERICA SUMMARY REPORT

PROJECT SUMMARY

The goal of this Energy & Environmental Research Center (EERC) project is to provide a report that will summarize the findings and conclusions of research, development, and demonstration projects on controlling mercury from lignite coals. A significant amount of work has been conducted since 1994 on mercury in lignite; mercury measurement in flue gases; sorbent, sorbent enhancement additives (SEA), and oxidation agent development; and full-scale demonstration of mercury control technologies. Currently, all the information is scattered among numerous project reports, and the information is not readily accessible for use by the lignite industry. The project will develop a report that will compile all the key findings and conclusions that can be used as a guide for the lignite industry in managing mercury control in coal-fired power plants. The components of the project will include identifying and compiling the key literature and background information for use in the report, developing a detailed outline, preparing a draft report for review, finalizing the report, and printing and binding copies.

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PROJECT DESCRIPTION

Objectives

The goal of this project is to provide a report that will summarize the findings and conclusions of research, development, and demonstration projects on controlling mercury from lignite coals. The specific objectives of the project will include:

- Identification and compilation of key literature and background information relevant to mercury control for lignites.
- Development of a detailed outline for the report that is reviewed and approved by project sponsors.
- Preparation of a report that will include a draft version for review by project sponsors, and incorporation of comments and changes made by reviewers in the final version.
- Printing and distribution of the report.

Methodology

Task 1. Literature and Background Information

This task will focus on compiling all relevant information for the preparation of the report. A listing of key NDIC projects that involved mercury issues is included in Appendix A. This is a relatively small task since most of the information is already available at the EERC. A literature search will be conducted in order to ensure all publications are available for review.

Task 2. Report Outline

A detailed outline of the report will be prepared. The detailed outline will be reviewed and approved by project sponsors before preparation of the report is initiated. The components of the report will likely include:

- Composition of lignite and the forms of mercury.

- Transformations and speciation of mercury in flue gas derived from lignite combustion.
- Measurement and speciation of mercury in combustion flue gases.
- Challenges and options for mercury control – sorbents, oxidation agents, SEAs, and regenerable sorbents.
- Testing of mercury control technologies in bench- and pilot-scale systems.
- Testing of mercury control options in full-scale plants including those equipped with electrostatic precipitators (ESPs), ESP wet scrubbers, and spray dryer fabric filters (SDA–FFs). In addition, slipstream studies including selective catalytic reduction (SCR) for NO_x reduction, ESP–FF, and other technologies will be included.
- Compilation and summary of results and costs of control.
- Status of commercial mercury control technologies.

Task 3. Report Preparation and Distribution

This task will involve the preparation of the report. The report will include detailed text as well as graphs and tables that summarize data. The report will be written in sections so review and input from sponsors can be obtained for each section of the report. In addition, the complete report will be available for review a minimum of 6 weeks prior to the end of the project. A review of a final version of the report will also be made available prior to printing. The review will be conducted at a meeting that will include project sponsors. Once the final version of the report has been reviewed and approved by the project sponsors, the report will be submitted for printing and binding at the University of North Dakota Printing Center. A minimum of 100 copies of the report will be made available to project sponsors.

Anticipated Results

This project will provide a detailed report on controlling mercury from power plants firing lignites from North America over the past 11 years. The majority of the work has been conducted on North Dakota lignite and will be the focus of much of the report. However, information available from testing other lignite coals will be included for comparison with North Dakota lignite results.

STANDARDS OF SUCCESS

The EERC is committed to delivering consistent and high-quality research that meets client needs and expectations. In order to ensure that the goals of specific projects or programs are realized, an organizationwide quality management system (QMS), authorized and supported by EERC managers, is in effect and governs all programs within the organization. A Quality Manual defines the requirements and the organizational responsibilities for each major element of the QMS and references the supporting documents needed to provide a comprehensive program. Compliance with this manual and its supporting documents ensures that the EERC adequately fulfills governmental and private client requirements relating to quality and compliance with applicable regulations, codes, and protocols. Each project is required to follow the Quality Manual, all revisions, and project-specific quality assurance procedures. The EERC Quality Assurance Manager oversees all aspects of quality assurance/quality control (QA/QC) for all research, development, and demonstration projects and will review the QA/QC components of this project. The project manager is responsible for implementing project-specific QA/QC components.

The EERC maintains a wide range of laboratories and equipment for solid, liquid, and gaseous characterization of the physical, chemical, mineralogical, biological, hydrological, and

geological properties of natural and synthetic materials and processes. Laboratory procedures and instrument calibrations follow nationally recognized or approved standards and methods put forth by the U.S. Environmental Protection Agency (EPA), ASTM International, the National Institute of Standards and Technology, and other agencies. Each laboratory manager is responsible for ensuring that the applicable QA/QC procedures in this project are implemented.

BACKGROUND

Introduction

Research on trace elements including mercury in lignites of North America has been ongoing for over 30 years (Schobert, 1995). Research, development, and demonstration projects specifically on mercury control for lignites of North America have been ongoing for over 10 years. The majority of the work has been on lignites from North Dakota, with some work conducted on lignites in Texas and Canada. The Clean Air Act was amended in 1990 to include Title III, which is focused on hazardous air pollutants (HAPs). Title III identified 189 HAPs that were to be regulated by EPA. As a result of this amendment, a significant amount of research was conducted by many organizations to assess the emission levels, potential health impacts, and control technologies.

In 1993, a workshop was coordinated by the EERC, the Electric Power Research Institute (EPRI), and DOE focused on determining the state of the art and identifying the challenges facing the coal-fired utility industry in dealing trace element transformations and control in coal fired power systems. The workshop provided information on the status of measurement, fate and speciation during combustion, and application of control technologies. A detailed special issue of *Fuel Processing Technology* was published entitled “Trace Element Transformations in Coal-Fired Power Systems” (Benson et al., 1994). Mercury forms in flue gas were identified as a key

to identifying and developing control technologies for mercury. However, sufficient information on the emissions of mercury and HAPs from coal-fired power plants did not exist. As a result, DOE conducted an assessment of toxic emissions from coal-fired power plants in the mid-1990s. The EERC conducted a comprehensive assessment of the data collected by DOE contractors from all of the sites (Miller et al., 1996) that included sampling at Great River Energy's Coal Creek Station near Underwood, North Dakota. These studies indicated that mercury in flue gas derived from North Dakota lignite was primarily in the vapor phase in the combustion and environmental control system and was not removed.

In 1997, EPA submitted the Mercury Report to Congress (EPA, 1997) that provided an assessment of the magnitude of U.S. mercury emissions by source, the health and environmental implications of those emissions, and the availability and cost of control technologies. The report indicated that 87% of the anthropogenic emissions of mercury in the United States were from combustion sources including waste incinerators and fossil fuel-fired systems. EPA indicated in the report that coal-fired utility combustion systems are the largest source of mercury emissions. Because the chemical species of mercury emitted from boilers varies from plant to plant, there is no single control technology that removes all forms of mercury. In the health section of the report, EPA indicated that fish consumption is the primary way humans are exposed to methylmercury. In addition, the report supports the relationship between anthropogenic emissions of mercury combustion sources and methylmercury in fish. The reference dose (RfD) of methylmercury ingested daily was also discussed in the report. EPA determined that the RfD for methylmercury must be at or below 0.1 µg/kg bw/day (microgram per kilogram of body weight per day) to be safe exposures. Exposures to methylmercury above the RfD are uncertain, and health risks are increased. The National Research Council (2000) reviewed the RfD and

found the value obtained by EPA adequate to protect humans. A fish consumption survey of residents in Minnesota and North Dakota was conducted, and the results showed that the level of exposure was similar to the national average and, when validated with hair analysis for mercury, the exposure to mercury was potentially much lower (Benson et al., 2001).

Lignite Composition and Mercury Speciation

Mercury control technologies for lignite-fired combustion system must focus on technologies that readily capture elemental forms of mercury in the flue and must not be impacted by the changes in lignite characteristics. Lignite coals are unique because of highly variable ash content, ash that is rich in alkali and alkaline-earth elements, high oxygen levels, high moisture levels, and low chlorine content. Lignite coals typically contain comparable levels of Hg but significantly lower levels of chlorine compared to bituminous coals. Lignites have chlorine concentrations well below 200 ppm in the coal, whereas Appalachian and Illinois Basin bituminous coals can have chlorine levels in excess of 1000 ppm. These differences in composition have been shown to have important effects on the form of Hg emitted from a boiler and the capabilities of different control technologies to remove Hg from flue gas. Coals containing chlorine levels greater than 200 ppm typically produce flue gas dominated by more easily removable mercuric compounds (Hg^{2+}), most likely mercuric chloride ($HgCl_2$). Conversely, experimental results indicate that low-chlorine (<50-ppm) coal combustion flue gases (typical of lignite) contain predominantly Hg^0, which is substantially more difficult to remove than Hg^{2+} (Laudal et al., 1999). Additionally, the generally high alkali and alkaline-earth contents of lignite coals may reduce the oxidizing effect of the already-low chlorine content by reactively scavenging chlorine species (Cl, HCl, and Cl_2) from the combustion flue gas. The level of chlorine in flue gases of recently tested lignites from North Dakota and Saskatchewan

ranged from 2.6 to 3.4 ppmv, with chlorine contents ranging from 11 to 18 ppmw in the coal on a dry basis, respectively.

Mercury Measurement and Control Testing

The abundance and form as well as the variability of mercury in flue gas was further substantiated by testing conducted through short-term and continuous 2-month sampling and measurement time periods at power plants in North Dakota (Laudal et al., 1999; Thompson et al., 2003). The results showed that the elemental form of mercury was dominant, with 85% to 95% being elemental. The remaining portions were in the oxidized and particulate forms.

A substantial amount of research and development conducted through Center for Air Toxic Metals® (CATM®) at the EERC (Benson et al., 1995, 1998; Sondreal et al., 2000). The efforts were focused on better understanding mercury transformations, improving mercury species measurement (Ontario Hydro and continuous mercury monitors), mercury control technologies, and database development. The work conducted through CATM and other efforts identified sorbents, oxidizing agents, and SEAs that showed promise for mercury control using bench-scale equipment (Olson et al., 2005; Pavlish et al., 2004). The most promising were testing on a pilot scale using a small-scale combustion system that fired coal at 75 to 100 lb/hr equipped with various combinations of air pollution control devices, including ESP only, ESP–FF, SDA–FF, and ESP–*Advanced Hybrid*. Testing of mercury control when firing lignites using various sorbents including activated carbons, amended silicates, and other materials along with SEAs provided key data on the potential effectiveness of the technologies (Pavlish et al., 2003; Benson et al., 2004). The results of this testing provided key background information that led to the funding of a series of larger-scale tests. The EERC-led team—EPRI, URS, ADA–ES, NDIC, SaskPower, and the Mercury Task Force, which includes Basin Electric Power Cooperative,

Otter Tail Power Company, Great River Energy, Texas Utilities (TXU), Montana–Dakota Utilities Co., Minnkota Power Cooperative, BNI Coal Ltd., Dakota Westmoreland Corporation, and the North American Coal Company—obtained funding for large-scale mercury control testing through the DOE National Energy Technology Laboratory's (NETL's) Phase II Mercury Control Program. The plants that have been and are in the process of being tested are listed in Table 1. The plants include Leland Olds Station Unit 1 (LOS1), Stanton Station Unit 10 (SS10), Antelope Valley Station Unit 1(AVS1), and Milton R. Young Unit 2 (MRY2). The tests at these sites have been completed or are nearly complete. All data and reports will be available by approximately January 1, 2006. These plants have tested activated carbon injection, enhanced activated carbon injection, oxidizing agents, SEAs, oxidation catalysts, SCR catalysts, and gold amalgam for mercury control.

Table 1. North Dakota Power Plant Mercury Control Testing

Plant	Coal	Boiler Type	Boiler Size[1], MW	Particulate Control	SO_2 Control
LOS1[2]	Lignite–PRB[3] Blend	Wall fired	220 (110)	ESP SCA[4]=320	None
SS10	Freedom	Tang. fired	60	FF	Spray dryer
AVS1	Freedom	Tang. fired	440 (220)	FF	Spray dryer
SS1	Freedom	Wall fired	140 (70)	ESP SCA=470	None
MRY2	Center	Cyclone	450	ESP SCA=375	Wet FGD

[1] Total size of the boiler with the value in parenthesises being the test size.
[2] Fires mostly North Dakota lignite; however, periodically fires a 30% blend of PRB coal.
[3] Powder River Basin.
[4] Specific collection area, ft^2/1000 afm.

QUALIFICATIONS

The EERC is a research facility that operates as a business unit of the University of North Dakota (UND). The EERC currently has an annual budget of $20.4 million and has worked with over 800 clients in all 50 states and in 47 countries. The EERC has a multidisciplinary staff of

more than 270 that has expertise and partnerships in a broad spectrum of energy and environmental programs, including over 50 years of research experience on lignite properties and variability; gasification processes; ash-related impacts; the fate of pollutants including Hg, particulate, and acid gases; Hg sampling, measurement, and speciation; development, demonstration, and commercialization of combustion and environmental control systems; conducting field testing and demonstrations; and advanced analysis of materials.

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. A significant amount of research has been conducted and is distributed throughout various technical papers, project reports, and presentation slides. The project is aimed at compiling the information on mercury control for lignites of North America, making the information more accessible to the North Dakota lignite industry. The report will provide information that will aid in making decisions on effective measures to control the emissions of mercury during the combustion of North Dakota lignites.

MANAGEMENT

Dr. Steve Benson will be the project manager and will be responsible for the coordination of efforts that lead to the development of the report. Dr. Benson will work closely with the project sponsors to identify all key literature, review the report outline, review and finalize the report, and distribute the report. At the EERC, Dr. Benson and Ms. Constance Wixo will work with EERC Office, Editing, and Graphics Services in the preparation of the report. Office Services consists of a team of research information associates who coordinate word processing,

formatting, and compiling of the report. Editing Services is a team composed of technical and grammatical editors. The editors have degrees in science and English and are fluent in several languages. Graphics Services consists of a group of graphic design artists who apply their expertise to a variety of products. Their talents will be utilized in the preparation of graphs, diagrams, photographs, and other materials for the report including report cover designs. This group utilizes cutting-edge technology to produce its work. The Graphics team works closely with Editing Services, Office Services, and the authors to ensure the quality and accuracy of the graphics produced.

A brief description of Dr. Benson's qualifications is as follows: Dr. Benson is a Senior Research Manager/Advisor at the EERC. He received his Ph.D. in Fuel Science from the Pennsylvania State University and his B.S. in Chemistry from Moorhead State University. Dr. Benson has over 25 years of experience in research, development, demonstration, and commercialization projects in advanced combustion and gasification systems. His principal areas of interest and expertise include development and management of complex multidisciplinary programs 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. Dr. Benson

has authored or coauthored over 210 publications and is the editor of eight books and *Fuel Processing Technology* special issues.

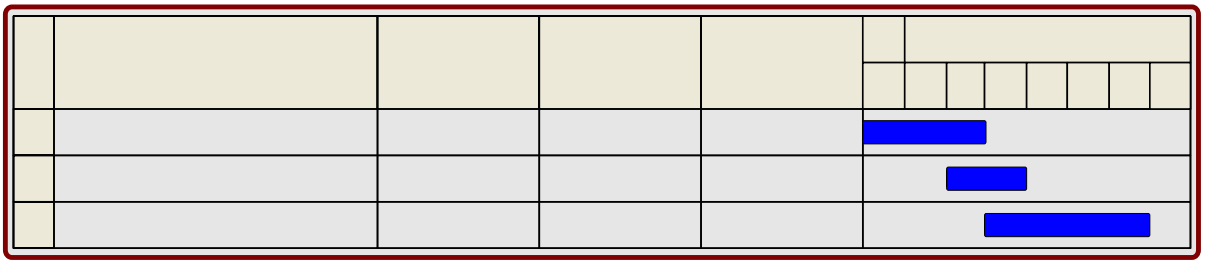
BUDGET

A budget is attached that provides an overview of the costs of the project. The total project cost to NDIC is $25,000 on a cost-reimbursable basis.

TIMETABLE

The schedule for the overall project is shown in Table 2. It is anticipated that the duration of the project will be approximately 6 months.

Table 2. Project Schedule



MATCHING FUNDS

The total project cost is $45,315, with the costs of the proposed project to be shared between NDIC for $25,000, DOE through the EERC–DOE JSRP for $15,315, and five lignite industry sponsors for $1000 each for a total of $5000.

TAX LIABILITY

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

CONFIDENTIAL INFORMATION

No confidential information is included in this proposal.

REFERENCES

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APPENDIX A

MERCURY-RELATED PROJECTS

LIGNITE RESEARCH AND DEVELOPMENT MERCURY-RELATED PROJECTS

Lignite Research and Development Mercury-Related Projects (www.lignite.com)

Supported by the North Dakota Industrial Commission

FY94-XIV-47: "Assessment of Toxic Emissions from a Lignite-Fired Power Plant Utilizing an ESP/Wet Flue Gas Desulfurization System": Program Funding: $55,000; Total Project Costs: $1,000,919. Objective: To provide a comprehensive assessment of toxic emission from the Great River Energy Coal Creek Station near Underwood, North Dakota. Specific objectives were to analyze solid, liquid, and gas input and output streams and to determine removal efficiencies of hazardous air pollutants in the electrostatic precipitator and a wet flue gas desulfurization units.

FY94-XV-51: "Mitigation of Air Toxics from Lignite Generation Facilities": Program Funding: $99,924; Total Project Costs: $380,000. Objective: To determine trace element concentrations of the six major lignite mines in North Dakota and to test promising trace element mitigation methods. Trace element analyses are presented. The most effective mitigation method was injection of lignite activated carbon. Additional testing is required to optimize mitigation methods.

FY94-XVII-56: "Air Toxics Removal Using the IFGT for an Upgraded Lignite Coal Blend": Program Funding: $54,534; Total Project Costs: $109,068. Objective: To assess the ability of a condensing heat exchanger to clean the flue gas resulting from the combustion of a coal blend using an upgraded lignite fuel. Specific objectives included flue gas characterization (particulates, mercury concentration, and SO_2), particulate removal efficiency by size range, total and form of mercury removal, SO_2 removal efficiency and thermal performance of the condensing heat exchanger.

FY95-XX-62: "Center for Air Toxic Metals Affiliates Program": Program Funding: $80,000; Total Project Costs: $3,580,000. Objective: To provide data and models on the behavior of potentially toxic metals. Center for Air Toxic Metals goals are to develop methods to prevent or reduce air toxic metal emissions, predict the fate of metals, determine the effectiveness of control devices, and identify new control technologies.

FY97-XXVII-79: "Mercury Formation and Fate": Program Funding: $120,000; Total Project Costs: $400,000. Objective: To determine the abundance and forms of mercury in flue gas emitted from Milton R. Young and Coal Creek Station.

FY99-XXXI-87: "Bench-Scale Tests to Evaluate Mercury Fly Ash Interactions": Program Funding: $40,000; Total Project Costs: $2,425,641. Objective: To develop an improved understanding of the mechanisms involved in the formation of toxic metals during coal combustion, to develop improved models describing the formation, and to use the improved models to predict trace toxics formation.

FY99-XXXI-88: "Fish Consumption Survey: Minnesota and North Dakota": Program Funding: $39,000; Total Project Costs: $130,000. Objective: To determine the fish-eating tendencies of people in North Dakota and Minnesota. The project will focus on the general public but will include women of childbearing age and Native Americans.

FY99-XXXII-89: "Center for Air Toxic Metals Affiliates Program": Program Funding: $75,000; Total Project Costs: $3,892,400. Objective: To evaluate factors affecting emission of air toxic metals from coal-fired facilities, and development and evaluation of control technologies. A continuation of project FY95-XX-62.

FY00-XXXIV-93: "Mercury Speciation Sampling at Great River Energy's Stanton Station": Program Funding: $44,000; Total Project Costs: $135,998. Three specific objectives: To meet mandated requirements of U.S. Environmental Protection Agency information collection request (ICR), to determine mercury mass balance across the Stanton Power Plant, and to determine forms and abundance of mercury emitted from Stanton Power Plant.

FY00-XXXVI-100: "Evaluation of Potential SCR Catalyst Blinding During Coal Combustion": Program Funding: $200,000; Total Project Costs: $733,333. Objectives: To determine the potential of low-rank coal ash to cause blinding or masking of selective catalytic reduction (SCR) catalysis and to determine the degree of elemental mercury conversion across the catalysis.

FY01-XXXVII-103: "Mercury Control Options Evaluation at Coal Creek Station, Underwood, North Dakota and Stanton Station, Stanton, North Dakota": Program Funding: $95,000; Total Project Costs: $190,000. Objective: To evaluate options for minimizing or controlling mercury air emissions from Great River Energy's Stanton and Coal Creek Stations.

FY01-XXXVII-105: "Pilot Scale Study of Mercury Oxidation Catalysts at Coal Creek Station": Program Funding: $50,000; Total Project Costs: $1,184,600. Objective: To evaluate the effectiveness of catalyst materials to oxidize elemental mercury content in the flue gas from coal-fired power plants. A goal is to convert elemental mercury to ionic mercury, permitting mercury removal in conventional flue gas desulfurization systems.

FY02-XLIV-111: "Center for Air Toxic Metals Affiliates Program Continuation of Membership": Program Funding: $75,000; Total Project Costs: $3,750,000. Objective: To further the understanding of the behavior of potential toxic metals in coal-fired utilities, other fossil fuel systems, waste-to-energy systems and waste incinerators. A specific objective of the Center for Air Toxic Metals program is the study of the fate and control of mercury emissions from coal-fired systems.

FY02-XLIV-112: "Mercury Control Options Evaluation, Phase II Stanton Station": Program Funding: $80,000; Total Project Costs: $220,000. Objective: To evaluate mercury control options at the Stanton Station. Specific objectives are to evaluate the effectiveness of the chemical additives to convert elemental mercury to ionic mercury and to evaluate the effectiveness of the MerCap technology based on the use of gold plates inserted in the combustion gas stream to absorb mercury.

FY02-XLV-114: "Mercury Control Technologies for Electric Utilities Burning Lignite Coals": Program Funding: $150,000; Total Project Costs: $833,000. Objective: To develop cost-effective elemental mercury control technologies for utilities burning lignite coals. Specific Objectives: To develop an understanding of mercury interactions with flue gas constituents, identify candidate chemical agents and sorbents and conduct laboratory screening tests, and conduct pilot-scale tests to identify candidate sorbents for future field tests at a lignite-fired plant.

FY03-XLVII-116: "Long-Term Mercury Modeling at ND Power Plants": Program Funding: $129,000; Total Project Costs: $446,667. Objective: Conduct long-term monitoring of mercury emissions at the Milton R. Young Unit 2 and R.M. Heskett Unit 2 plants to determine emission levels and variations due to coal and operations and to quantify levels of oxidized versus elemental mercury.

FY03-XLVIII-117: "Mercury and Air Toxic Element Impacts of Coal Combustion By-Product Disposal and Utilization": Program Funding: $37,500; Total Project Costs: $1,600,000. Objective: Evaluate potential impacts of mercury and other air toxic elements on the management of coal combustion by-products (long-term storage and utilization products).

FY03-XLIV-118: "Mercury Control Technologies for Electric Utilities Burning Lignite Coals – Phase II, Field Testing of Slipstream Technology": Program Funding: $200,000; Total Project Costs: $1,100,000. Objective: Using a slipstream baghouse (up to nominal 10 MW), demonstrate a low-cost mercury control using activated char at Saskatchewan Power's lignite-fired Popular River power station.

FY03-XLIV-119: "Impact of SCR Catalyst on Mercury Oxidation in Lignite-Fired Combustion Systems": Program Funding: $30,000; Total Project Costs: $100,000. Objective: Mercury measurements will be conducted upstream and downstream of the slipstream SCR catalyst bed to determine if mercury oxidation occurs and to quantify long-term declining oxidation due to aging of the catalyst or due to lignite-derived flue gas contaminants.

FY03-XLIV-120: "Pilot- and Full-Scale Demonstration of Advanced Control Technologies for Lignite-Fired Power Plants": Program Funding: $150,000; Total Project Costs: $1,300,000. Objective: Based on previous efforts, continue development of the selected elemental mercury emission control processes: 1) activated carbon injection upstream of an ESP combined with sorbent enhancement, 2) mercury oxidation and control using wet and dry scrubbers, 3) enhanced oxidation at a full-scale power plant using tire-derived fuel (TDF) and oxidizing catalysts, and 4) mercury absorption using advanced absorption inserts inside baghouse fabric filters.

FY03-XLIV-122: "Thermal Precombustion Mercury Removal Process for Low-Rank Coal-Fired Power Plants": Program Funding: $139,403; Total Project Costs: $956,962. Objective: Evaluate a precombustion thermal-based technology for the removal of mercury from low-rank coals, both subbituminous and lignite.

FY04-L-124: "Enhancing Carbon Reactivity in Mercury Control in Lignite-Fired Systems": Program Funding: $600,000; Total Project Costs: $5,732,195. Objective: Substantially enhance the capability of carbon sorbents to remove Hg from lignite combustion flue gas to achieve a high level of cost-effective control in full-scale field tests.

FY04-L-125: "Large-Scale Mercury Control Technology Testing for Lignite-Fired Utilities – Oxidation Systems for Wet FGD": Program Funding: $172,500; Total Project Costs: $2,150,767. Objective: Demonstrate a mercury "chemical addition" oxidation process in flue gas upstream of pollution control equipment, specifically, electrostatic precipitators followed by wet scrubbers. Host sites are Minnkota Power Cooperative MRY (cyclone-fired, ESP wet scrubber) Unit 2 and Texas Utilities Monticello (wall-fired, ESP, wet scrubber) Unit 3.

FY04-L-126: "Addendum: Evaluation of Pilot Wet Scrubber in Conjunction with Mercury Oxidation Catalysts": Program Funding: $42,000; Total Project Costs: $84,000. Objective: This effort is an amendment to Contract FY01-XXXVIII-105. The combined project will evaluate wet scrubber capture efficiency of elemental mercury oxidized by low-temperature catalysts located after an electrostatic precipitator. Recent DOE data challenge the assumed high-efficiency capture of catalytically oxidized mercury in a wet scrubber.

FY05-LI-130: "The Health Implications of the Mercury–Selenium Interaction": Program Funding: $50,000; Total Project Costs: $158,846. Objective: Explore interactions between mercury and selenium in experimental models designed to closely approximate human patterns of exposure. The project will examine the effects of dietary intakes of methylmercury and the protective effects of dietary selenium.

FY05-LI-131: "Investigation of Mercury and Carbon-Based Sorbent Reaction Mechanisms": Program Funding: $54,000; Total Project Costs: $240,870. Objective: Improve mercury capture efficiency of carbon sorbents through a better understanding of mercury–sorbent mechanisms. Project will produce information to develop more effective and lower-cost sorbent to control elemental mercury emissions.

FY05-LII-135: "Assessment of Mercury Control Options and Ash Behavior in Fluidized-Bed Combustion Systems": Program Funding: $200,000; Total Project Costs: $900,000. Objective: Evaluate mercury control options in a circulating fluidized-bed combustion (CFBC) system to evaluate Hg speciation, identify effective control approaches and evaluate impact of chemical oxidation chemicals on corrosion and ash be agglomeration.

FY05-LII-136: "Center for Air Toxic Metals Affiliates Program – 3 Year Continuation of Membership": Program Funding: $45,000; Total Project Costs: $3,000,000. Objective: Continue science-based research on toxic trace metals under an EPA–industry-supported Center for Air Toxic Metals Affiliates Program to further the understanding of the behavior of potential toxic metals in coal-fired utilities, other fossil fuel systems, waste-to-energy systems, and waste incinerators. A specific objective of the Center for Air Toxic Metals program is the study of the fate and control of mercury emissions from coal-fired systems. This project is a continuation of Projects FY95-XX-62, FY99-XXXII-89, and FY02-XLIV-111.

FY05-LII-137: "Mercury Oxidation via Catalytic Barrier Filters: Phase II": Program Funding: $15,000; Total Project Costs: $245,000. Objective: Continue development of Hg emission control using baghouse filters impregnated with catalytic oxidizers to verify promising data from small-scale proof-of-concept tests. The concept would be applicable to utilities using fabric filter with capture of Hg and fly ash in a baghouse subsystem.

FY05-LIII-139: "Investigation of Mercury and Carbon-Based Sorbent Reaction Mechanism – Comparison of Surface Analysis Techniques": Program Funding: $19,500; Total Project Costs: $60,000. Objective: This project is an extension of LRC-LI-131. Additional fundamental work will focus on bonding on carbon surfaces using two more refined techniques of x-ray photoelectron spectroscopy and x-ray absorption fine structure spectroscopy. The results will define carbon sorbent surface structural features before and after exposure to a flue gas stream, providing direction to improving effectiveness.

APPENDIX B

BUDGET

CONTROLLING MERCURY EMISSIONS FOR UTILITIES FIRING LIGNITES
FROM NORTH AMERCIA SUMMARY REPORT
NDIC
PROPOSED START DATE: 12/01/05
EERC PROPOSAL #2006-0062

SUMMARY BUDGET

CATEGORY		TOTAL HRS	TOTAL $COST	NDIC SHARE HRS	NDIC SHARE $COST	INDUSTRY SHARE HRS	INDUSTRY SHARE $COST	EERC JSRP SHARE HRS	EERC JSRP SHARE $COST
TOTAL DIRECT LABOR		438	$ 17,361	224	$ 8,610	43	$ 2,084	171	$ 6,667
FRINGE BENEFITS - % OF DIRECT LABOR	51%		$ 8,854		$ 4,391		$ 1,063		$ 3,400
TOTAL LABOR			$ 26,215		$ 13,001		$ 3,147		$ 10,067
OTHER DIRECT COSTS									
TRAVEL			$ 310		$ 310		$ -		$ -
COMMUNICATION - PHONES & POSTAGE			$ 50		$ 32		$ 18		$ -
OFFICE (PROJECT SPECIFIC SUPPLIES)			$ 2,475		$ 2,402		$ 40		$ 33
SUPPLIES			$ 150		$ 25		$ -		$ 125
FEES			$ 400		$ 256		$ -		$ 144
TOTAL OTHER DIRECT COST			$ 3,385		$ 3,025		$ 58		$ 302
TOTAL DIRECT COST			$ 29,600		$ 16,026		$ 3,205		$ 10,369
FACILITIES & ADMIN. RATE - % OF MTDC		VAR	$ 15,715	56%	$ 8,974	56%	$ 1,795	47.7%	$ 4,946
TOTAL PROJECT COST			$ 45,315		$ 25,000		$ 5,000		$ 15,315

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.

CONTROLLING MERCURY EMISSIONS FOR UTILITIES FIRING LIGNITES
FROM NORTH AMERCIA SUMMARY REPORT
NDIC
PROPOSED START DATE: 12/01/05
EERC PROPOSAL #2006-0062

DETAILED BUDGET

LABOR	LABOR CATEGORY	HOURLY RATE	TOTAL HRS	TOTAL $COST	NDIC SHARE HRS	NDIC SHARE $COST	INDUSTRY SHARE HRS	INDUSTRY SHARE $COST	EERC JSRP SHARE HRS	EERC JSRP SHARE $COST
BENSON, S.	PROJECT MANAGER	$ 57.46	200	$ 11,492	104	$ 5,976	30	$ 1,724	66	$ 3,792
WIXO, C.	PRINCIPAL INVESTIGATOR	$ 27.70	100	$ 2,770	56	$ 1,551	13	$ 360	31	$ 859
----------	SENIOR MANAGEMENT	$ 56.92	17	$ 968	-	$ -	-	$ -	17	$ 968
----------	RESEARCH TECHNICIAN	$ 20.92	21	$ 439	-	$ -	-	$ -	21	$ 439
----------	TECHNICAL SUPPORT SERVICES	$ 16.92	100	$ 1,692	64	$ 1,083	-	$ -	36	$ 609
			438	$ 17,361	224	$ 8,610	43	$ 2,084	171	$ 6,667
ESCALATION ABOVE CURRENT BASE		0%		$ -		$ -		$ -		$ -
TOTAL DIRECT LABOR				$ 17,361		$ 8,610		$ 2,084		$ 6,667
FRINGE BENEFITS - % OF DIRECT LABOR		51%		$ 8,854		$ 4,391		$ 1,063		$ 3,400
TOTAL LABOR				$ 26,215		$ 13,001		$ 3,147		$ 10,067
OTHER DIRECT COSTS										
TRAVEL				$ 310		$ 310		$ -		$ -
COMMUNICATION - PHONES & POSTAGE				$ 50		$ 32		$ 18		$ -
OFFICE (PROJECT SPECIFIC SUPPLIES)				$ 2,475		$ 2,402		$ 40		$ 33
SUPPLIES				$ 150		$ 25		$ -		$ 125
GRAPHICS SUPPORT				$ 400		$ 256		$ -		$ 144
TOTAL OTHER DIRECT COST				$ 3,385		$ 3,025		$ 58		$ 302
TOTAL DIRECT COST				$ 29,600		$ 16,026		$ 3,205		$ 10,369
FACILITIES & ADMIN. RATE - % OF MTDC			VAR	$ 15,715	56%	$ 8,974	56%	$ 1,795	47.7%	$ 4,946
TOTAL PROJECT COST				$ 45,315		$ 25,000		$ 5,000		$ 15,315

CONTROLLING MERCURY EMISSIONS FOR UTILITIES FIRING LIGNITES
FROM NORTH AMERCIA SUMMARY REPORT
EERC PROPOSAL #2006-0062

DETAILED BUDGET - FEES

GRAPHICS SUPPORT	**RATE**	#	**$COST**
GRAPHICS (HOURLY)	$50	8	$ 400
SUBTOTAL			$ 400
ESCALATION		0%	$ -
TOTAL GRAPHICS SUPPORT			$ 400

CONTROLLING MERCURY EMISSIONS FOR UTILITIES FIRING LIGNITES
FROM NORTH AMERCIA SUMMARY REPORT
EERC PROPOSAL #2006-0062

DETAILED BUDGET - TRAVEL

RATES USED TO CALCULATE ESTIMATED TRAVEL EXPENSES			
DESTINATION	PER MILE	LODGING	PER DIEM
Bismarck, ND	$ 0.33	$ 50	$ 25

PURPOSE/DESTINATION	NUMBER OF TRIPS	PEOPLE	MILES	DAYS	MILEAGE	LODGING	PER DIEM	MISC.	TOTAL
Meeting/Bismarck, ND	1	1	575	2	$ 190	$ 50	$ 50	$ 20	$ 310
TOTAL ESTIMATED TRAVEL									$ 310

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.

Salaries and Fringe Benefits

As an interdisciplinary, multiprogram, and multiproject research center, the EERC employs an administrative staff to provide required services for various direct and indirect support functions. Direct project salary estimates are based on the scope of work and prior experience on projects of similar scope. Technical and administrative salary charges are based on direct hourly effort on the project. The labor rate used for specifically identified personnel is the current hourly rate for that individual. The labor category rate is the current average rate of a personnel group with a similar job description. For faculty, if the effort occurs during the academic year and crosses departmental lines, the salary will be in addition to the normal base salary. University policy allows faculty who perform work in addition to their academic contract to receive no more than 20% over the base salary. Costs for general support services such as grants and contracts administration, accounting, personnel, and purchasing and receiving, as well as clerical support of these functions, are included in the EERC facilities and administrative cost 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: http://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, 2005. 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.