March 29, 2007

Ms. Karlene Fine
Executive Director
Attn: Lignite Research Program
North Dakota Industrial Commission
State Capitol
600 East Boulevard Avenue, Dept. 405
Bismarck, ND 58505

Dear Ms. Fine:

Subject: EERC Proposal No. 2007-0220

Enclosed please find an original and seven copies of the proposal entitled "Effects of Aging on Treated Activated Carbons." The Energy & Environmental Research Center looks forward to the opportunity to work with the North Dakota Industrial Commission on this rapidly developing opportunity. Also enclosed is the $100 application fee.

If you have any questions, please contact me by telephone at (701) 777-5268 or by e-mail at jpavlish@undeerc.org.

Sincerely,

John H. Pavlish
Senior Research Advisor

JHP/jlk

Enclosures

c/enc: Jeff Burgess, Lignite Energy Council

EFFECTS OF AGING ON TREATED ACTIVATED CARBONS

EERC Proposal No. 2007-0220

Submitted to:

Karlene Fine

North Dakota Industrial Commission
State Capitol
600 East Boulevard Avenue, Dept. 405
Bismarck, ND 58505

Proposal Amount: $40,000

Submitted by:

John H. Pavlish
Lucinda L. Hamre
Edwin S. Olson

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

John H. Pavlish, Project Manager

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

March 29, 2007

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

For both the United States and Canada, testing has been under way for electric utilities to find viable and economical mercury control strategies to meet requirements for the Clean Air Mercury Rule (CAMR), as well as the Canada-Wide Standards (CWS). The technology that holds the most promise to meet the CAMR and the CWS for mercury control in low-chlorine lignite is injection of treated activated carbon (AC) into the flue gas stream. Under a two-phase, multiyear consortium project headed by the Energy & Environmental Research Center (EERC) that consisted of several North Dakota utilities, SaskPower, the U.S. Department of Energy (DOE), the Electric Power Research Institute (EPRI), and the North Dakota Industrial Commission (NDIC), as well as several Canadian entities, testing was performed on a slipstream unit at SaskPower's Poplar River Station's Emission Control Research Facility. Evaluation of various sorbent technologies for their effectiveness, performance, and cost showed that halogenated ACs performed very well, with mercury capture rates often $\geq$ 90%. To explain differences between brominated ACs with respect to reactivity and capacity, a small exploratory task evaluated possible differences resulting from storage conditions and subsequent effects of aging that might somehow alter their chemical or physical properties. Under certain conditions (primarily storage in ambient air), notable performance degradation had occurred in mercury capture efficiency. Given this concern, the EERC proposes to undertake a 10-month project to assess aging effects of brominated ACs. The proposed project is a collaborative effort (costing $120,870) with support from EPRI (for $25,000), SaskPower ($10,000), Otter Tail Power ($5000), and match funds from NDIC (for $40,000) and DOE ($40,870) through the EERC's DOE Jointly Sponsored Research Program) to address this critical need for the lignite industry.

EFFECTS OF AGING ON TREATED ACTIVATED CARBONS

PROJECT SUMMARY

For the last 5 years, the Energy & Environmental Research Center (EERC) has undertaken a two-phase consortium project to pilot- and field-test various sorbents for mercury control that are applicable to utilities burning lignite coal. Activities are complete for Phase I, and a final report was issued in 2003. Under Phase II of a consortium project headed by the EERC that consisted of several North Dakota utilities, SaskPower, the U.S. Department of Energy (DOE), the Electric Power Research Institute (EPRI), and the North Dakota Industrial Commission (NDIC), as well as several Canadian entities, testing was performed on a slipstream unit at SaskPower's Poplar River Station's Emission Control Research Facility (ECRF). This phase is nearly complete, and a final report will be submitted at the same time this proposal is submitted for consideration.

During Phase II, testing allowed team members to evaluate various sorbent technologies for their effectiveness, performance, and cost. The project showed that treated (halogenated) activated carbons performed very well, with mercury capture rates that sometimes exceeded 90%. Treated activated carbons (ACs), in general, provide levels of capture in low-chlorine lignites that are not achievable using plain or nontreated ACs (1–5). Many of the treated ACs are impregnated with various bromine compounds. It was expected that all of these brominated ACs would perform better than nontreated AC and behave similarly with respect to reactivity and capacity for mercury capture, but this was not borne out in testing (4).

Noting these performance differences, the EERC postulated that perhaps there were differences in how the various treated ACs were handled and stored, which subsequently may have introduced an aging effect that somehow altered their chemical or physical properties,

making them less effective at mercury capture. To begin to address these concerns, a small exploratory task was initiated. Although initially limited in scope, the results were considered of sufficient merit to provide insight into what storage conditions may cause sorbent degradation. To ensure that differences were not merely artifacts of the method of commercial production, a fresh supply of AC (Norit DARCO® Hg) was used and treated with bromine by aqueous and gaseous impregnation.

Preliminary results showed that under certain conditions (primarily storage in ambient air), notable performance degradation had occurred, as measured by mercury capture efficiency. These preliminary results were of concern to many of the consortia members, who suggested that additional research be done with a matrix of variables to better understand possible aging effects and determine which factors in storage were of most concern.

Because the primary cost of AC injection technology is the ongoing cost of the carbon, reduced reactivity and capacity is of great concern. Therefore, determining if the mode of storage affects brominated carbons is important to the commercial long-term use of this technology.

PROJECT DESCRIPTION

Project Background Summary

The EERC led a consortium-based, two-phase, multiyear project to investigate several sorbent-based technologies for mercury capture specific to the lignite industry. Phase I identified a limited number of lignite-derived activated carbons that were further tested at a larger scale for their ability to capture mercury. In addition, Phase I identified a COHPAC system with AC injection between the two control devices (known as a TOXECON™ arrangement in the United States) as the most effective means of controlling mercury without negatively affecting the fly ash at SaskPower's Poplar River Station. This facility draws actual flue gas from either Unit 1 or

2 and provides it to the test equipment, which can be configured in many ways. Most of the tests involved injection of AC upstream of a slipstream baghouse into actual flue gas that was drawn downstream of the Unit 1 or 2 electrostatic precipitators. Results showed that treated (halogenated) ACs performed very well, with mercury capture rates often ≥ 90% (4). However, there were unexplained differences between brominated ACs with respect to reactivity and capacity, so a small task was initiated to evaluate possible differences resulting from storage conditions of treated carbons and subsequent effects of aging that might somehow alter their chemical or physical properties, making them less effective toward mercury capture. Preliminary results showed that under certain conditions (primarily storage in ambient air), notable performance degradation had occurred in mercury capture efficiency. Given this concern, the EERC proposes, under the guidance of the project sponsors, to further evaluate possible aging effects. For supporting data and more detailed background information, refer to the background section of this proposal.

Proposed Testing

Based on initial results (as discussed in the background section following), further testing is suggested to elucidate the effect of storage in ambient air. During discussions with project members, six key variables were identified as important and needing further evaluation. These include the following:

- *Effect of storage time*: Do changes (as measured by loss in effectiveness) occur slowly or rapidly?
- *Effect of storage moisture (humidity):* Does ambient moisture content affect the rate of deterioration in performance? To what extent?

- *Effect of storage temperature*: Does storage temperature affect the rate of deterioration or stability in storage?
- *Effect of sorbent bromine content*: Does the bromine content affect the rate of deterioration and or stability?
- *Effect of test conditions*: Do storage conditions affect results under low- vs. high-acid gas conditions? That is, do the test conditions affect interpretation of the storage/aging results?
- *Effect of structure and/or surface area*: Do the storage conditions affect carbon structure, reactivity, and/or surface area? Is the surface area affected with time or under different storage conditions? Is there a correlation between reactivity and the Br 3p peak as measured by x-ray photoelectron spectroscopy (XPS) (4)?

To address these questions (as objectives), which Phase II project sponsors determined to be of the greatest importance, in a controlled experimental manner, the test matrix is proposed as shown in Table 1. To control for possible differences in the time required for development, production, and/or shipment of commercially treated AC, the EERC proposes to create fresh sorbents in the laboratory using gaseous elemental bromine treatment of DARCO Hg at three different concentrations, 1%, 5%, and 10% (by weight). Each of the freshly created sorbent samples will be evaluated for reactivity and capacity using the EERC's mercury bench-scale system (also used in Phase I and II testing and described later under equipment section) under simulated flue gases shown in Table 2. It is planned to use both low-acid gases, typical of lignite-derived flue gas, and high-acid gas conditions, typical of an eastern bituminous coal, as shown in Table 2. In addition to bench-scale tests, advanced analytical techniques (discussed later in more detail in the equipment and analytical section), as shown in Table 1, will be applied to further

characterize and/or detect physical, surface, and chemical changes that may occur over increasing storage times.

To simulate realistic storage conditions, each sorbent sample will be exposed to different controlled storage times, temperatures, and humidity conditions, as shown in Table 1. Ambient air will be controlled to the stated conditions, which prior initial tests indicate as those most

Table 1. Proposed Test Matrix

Test Parameter	Br Content, %	Humidity, %	Storage Time, days	Storage Temp, °F	Mercury Bench-Scale Test Condition	Analysis
Baseline Condition	5	–	0	80	Baseline (2 samples) (low and high acid[1])	XAFS, XPS, Surface Analysis (SA)
Storage Time	5	80	5	80	Low	XPS, SA
Storage Time	5	80	15	80	Low	XPS, SA
Storage Time	5	80	30	80	Low and high acid (2 samples)	XAFS, XPS, SA
Storage Time	5	80	45	80	Low	XPS, SA
Storage Time	5	80	90	80	Low and high acid (2 samples)	XAFS, XPS, SA
Storage Time	5	80	180	80	Low	XPS, SA
Temperature	5	60	90	120	Low	XPS, SA
Temperature	5	80	180	120	Low	XPS, SA
Moisture	5	60	90	80	Low	XPS, SA
Moisture	5	60	180	80	Low	XPS, SA
Br Concen.	1	80	0	80	Baseline (Low)	XAFS, XPS, SA
Br Concen.	1	80	90	80	Low	XAFS, XPS, SA
Br Concen.	15	80	0	80	Baseline (Low)	XAFS, XPS, SA
Br Concen.	15	80	90	80	Low	XAFS, XPS, SA

[1] Gas constituents for each condition are shown in Table 2.

Table 2. Flue Gas Constituents for Test Conditions

Flue Gas Constituent	Low-Acid Condition	High-Acid Condition
O_2, %	6	6
CO_2, %	12	12
H_2O, %	15	8
SO_2, ppm	580	1600
N_2	Balance	Balance
NO, ppm	120	400
NO_2, ppm	6	20
HCl, ppm	1	50
Hg^0, ppm	12	12

important (4). To ensure data quality, the EERC will construct storage chambers that allow for accurate control of air temperature and moisture conditions. Results from these tests will be compared to those obtained earlier and will be reported in a separate report to the supporting project members. For this project, production of the activated carbons, storage/aging tests, and bench-scale measurement will all be conducted in controlled laboratory environments that operate according to University, state, and federal environmental guidelines. There will be no adverse environmental impacts as a result of the tests. Rather, since activated carbon is considered the mercury control option that most utilities are likely to employ to meet the CAMR or CWS, the outcome of this project will ensure that utilities are able to achieve the highest level of mercury capture possible. If this project shows that storage and handling of treated ACs can lead to degradation of the performance of treated ACs, it is important to both industrial partners and the general research community. Several economic analyses have shown that the cost of the activated carbon is the largest ongoing factor when using ACI as a mercury control strategy. While cost estimates for mercury removal on a per-pound basis have been adjusted down over the last 5 years, the cost of carbon still remains the largest expenditure and thus must be optimized if at all possible.

STANDARDS OF SUCCESS

As was done in the original exploratory task to test aging effects on treated carbons, several controls will be implemented to ensure valid and reliable data. First, all treated carbon(s) will be produced at the same time to ensure that production variables are not the cause of different capacities/reactivities. Also, using a simulated flue gas of known concentrations of various constituents allows maximum control and minimal variability in flue gas concentrations. All sorbent samples will be placed in storage chambers that are capable of maintaining the stated

test conditions over several months. Procedures will be implemented to ensure steady-state conditions are maintained. Routine and advanced analytical techniques will be applied to provide further insight into possible changes in sorbent physical, surface, and chemical properties. The EERC is familiar with these techniques as they have been applied with success in the initial stages of this project.

The standard of success for this project is to address a critical question that applies to the lignite industry as it begins to use sorbent injection technology to reduce mercury emissions. The project aims to provide the lignite industry with data to aid in understanding whether storage time and/or conditions can affect sorbent effectiveness and, if so, what physical, surface, and chemical properties of the sorbents change over time to degrade effectiveness. These results may have many implications, such as production/handling methods/systems of commercially treated sorbents, delivery times of sorbents, on-site storage times, shelf life, and systems that may need to be specially designed to preserve sorbent properties and effectiveness.

BACKGROUND

Both the United States and Canada released statements in the late 1990s notifying utilities that mercury would likely be controlled in the near future. On both sides of the border, testing has been under way to find viable and economical mercury control strategies to meet requirements for the Clean Air Mercury Rule, as well as the Canada-Wide Standards. Of the mercury control measures that are commercially available, sorbent injection, particularly of treated ACs, has shown the most promise for economical reduction of mercury emissions (6–8). However, the potential negative aspects of sorbent injection, whether they involve balance-of-plant (BOP) impacts or the stability of the AC, merit further investigation so that the optimal

performance can be assured, resulting in less uncertainty associated with implementing the technology.

Prior Testing of Treated Carbons to Evaluate Aging Effects

Of the mercury control technologies that are commercially available, brominated activated carbons are among those that hold the greatest promise for mercury control, especially for low-rank coals, because of their higher capture of elemental mercury compared with untreated activated carbons in most cases (6–8). To date, outside of this project, little or no testing has been done to test the stability of treated (halogenated) activated carbons when stored for different periods of time under different ambient conditions that are typical and varied across North America.

Tests on SaskPower's ECRF included both treated and untreated carbons. During screening tests, several brominated carbons were tested against Luscar and Norit DARCO Hg. It was expected that the bromine-treated carbons would all have similar performance and behave similarly. However, tests indicated different performance between carbons; differences in length and mode of storage were considered as a possible explanation for this observed behavior. To begin to answer the observed differences in performance between these treated carbons, a small suite of tests were initiated to further evaluate sorbent reactivity and capacity: reactivity is of significant concern when carbons are to be used in environments with short residence times, such as when injecting upstream of an electrostatic precipitator; capacity is a measure of the maximum amount of mercury that can be sorbed by the sorbent and is of critical importance in fixed-bed or baghouse applications.

Objectives of Previous Aging Tests for Treated Carbons

Specific objectives of the previous task included the following:

- Determine the effects of storage conditions on halogenated activated carbon performance, as measured by mercury capture efficiency.
- Evaluate both the reactivity and capacity of the carbons using a bench-scale system to control for flue gas constituents and temperature.
- Attempt to determine the speciation and loss of bromine using XPS.
- Eliminate unknown aging effects by producing fresh activated carbons by various treatment methods.

Testing Procedures Previously Used

Since there are several potential methods for impregnation of bromine into the activated carbon, treated carbons were prepared in several ways and stored under several identical conditions to determine if carbons prepared differently would behave the same way if stored the same. To control for possible differences in the development/production/shipment of commercially treated AC, treated ACs were created in the laboratory with bromine using four different methods:

- AC treatment with 5% gaseous elemental bromine
- AC treatment with a gaseous bromine that was later vacuum-dried
- An AC that was treated with aqueous bromine
- A carbon that was treated with elemental bromine at an elevated temperature

These sorbent samples were all compared to a Norit DARCO Hg standard activated carbon (untreated), which provides the largest control set of data. Fresh AC batches were divided and

subjected to different storage conditions for 90 days and then retested against the performance of the freshly prepared ACs. The storage conditions used were:

- Ambient air with uncontrolled moisture
- N_2 at 0°C
- N_2 at 25°C
- Dry air at 25°C
- Untreated carbon stored in N_2 at 25°C (control sample)

The EERC's bench-scale mercury system using simulated flue gas was used to evaluate initial reactivity and the capacity of the treated ACs that had been stored as noted above. Structural features were investigated using XPS of initial and stored samples to determine changes in the chemical associations of carbon, oxygen, sulfur, chlorine, and bromine at the sorbent surface.

Initial Results

Table 3 shows the results of testing the freshly prepared carbons for reactivity and capacity on the EERC bench-scale system. As can be seen from this table, no induction time (columns 2 and 3) was required for the freshly treated carbons, showing immediate complete reactivity with the mercury in the gas stream. Breakthrough time (column 4), an indication of mercury capacity, was twice that of the standard carbon control. Despite different methods of preparation (column 1), speciation was similar for all of the samples, except for the vacuum-dried carbon.

Table 4 shows the comparison between the initial treated AC response times (shown in Table 3) to those obtained 90 days later for the sorbent samples stored under nitrogen. As can be seen from the table, irrespective of the preparation method, the initial reactivity was not affected. In

each case, storage in ambient conditions (Table 5) resulted in a shorter breakthrough time, showing decreased capacity for mercury sorbance.

Table 3 shows the best-performing treated AC that was subjected to the different storage conditions (column 2). Whether stored at 0°C, 25°C, under N_2, and or in dry air, each gave similar reactivities and capacities compared to the initial carbon. However, when stored in ambient air, results as highlighted in Tables 3, 4, and 5 show that the carbon had reduced reactivity and a fairly significant reduction in capacity, as shown by a much lower breakthrough time (Table 5, column 5). This is an important consideration, since most facilities are not designed to store treated ACs in tightly controlled environments. While speciation is of particular interest, this small sample set showed similarity between all the samples; therefore, no correlation between reactivity and bromine speciation is evident from these tests.

Table 3. Bench-Scale Results for Freshly Brominated Sorbents

Bromination Method	Initial, % of inlet	Induction, minutes	50% Breakthrough, minutes	Bromide Concentration, %
Gaseous Br_2, 25°C	0	0	48	77
Gaseous Br_2, 25°C, Using Vacuum-Dried AC	2	0	46	58
Aqueous Br_2, 25°C	5	0	38	81
Gaseous Br_2, 60°C	2	0	46	79
No Br_2 Control	47	20	24	–

Table 4. Bench-Scale Results for Suite of Sorbents, stored 90 days in N_2 at 25°C

Bromination Method	Initial, % of inlet	Induction, minutes	50% Breakthrough, minutes	Bromide Concentration, %
Gaseous Br_2, 25°C	2	0	45	85
Gaseous Br_2, 25°C, Using Vacuum-Dried AC	2	0	32	69
Aqueous Br_2, 25°C	3	0	30	82
Gaseous Br_2, 60°C	2	0	36	78
No Br_2 Control	40	15	22	–

Table 5. Bench-Scale Results for Best Sorbent, stored 90 days at varied conditions

Bromination Method	Storage Method	Initial, % of inlet	Induction, minutes	50% Breakthrough, minutes	Bromide Concentration, %
Gaseous Br_2, 25°C	N_2 at 0°C	0	0	45	74
Gaseous Br_2, 25°C	N_2 at 25°C	2	0	45	85
Gaseous Br_2, 25°C	Moist air at 25°C	5	0	30	78
Gaseous Br_2, 25°C	Dry air at 25°C	3	0	45	75
No Br_2 Control	N_2 at 25°C	40	15	22	–

Initial tests showed that there is no change in the reactivity of a 5% gas-phase (25°C) bromine-treated activated carbon (base carbon is Norit DARCO Hg) during storage under nitrogen. However, storage of the same carbon in ambient air showed a small decrease in reactivity and a significant decrease in capacity. There were slight changes in bromine speciation (defined as percent anionic bromide as determined by high-resolution Br 3d XPS), but the changes did not appear to correlate with reactivities or capacities. Albeit, this was a limited dataset, investigation of other bromine-treated carbons showed that little reactivity was lost, but capacities generally decreased with storage time.

Equipment and Analytical Support

To support the testing described herein, the EERC proposes to use the following equipment and systems, which the EERC currently owns.

EERC Bench-Scale Mercury System

The EERC fixed-bed mercury system is used to determine the mercury reactivity and capacity of a given sorbent under different controlled flue gas conditions; it continues to be the best experimental approach for screening sorbents and has led to major discoveries concerning the effects of flue gas components on sorbent performance. The thin-bed reactor consists of a

Teflon-coated, 2.5-in.-diameter dust-loading filter holder. A quartz filter loaded with sorbent makes up the actual thin bed. The filters are uniformly coated with the sorbents by pulling a vacuum on the outlet side of the filter holder and feeding the sorbent at the inlet side. The process is repeatable for mass loadings down to 10 mg. The thin-bed assembly is maintained at the desired temperature inside an oven which can be controlled to ±1°C. Previous tests have established the repeatability of the results and demonstrated good mercury mass balances. The instrument is calibrated using standard injections of mercury vapor at known temperature and volume. The known inlet mercury concentration produced by the bench-scale system is measured before and after each test to ensure there have been no problems with the equipment during the test. The known inlet mercury concentration is based on the total flow rate of the flue gas constituents and the permeation rates of the elemental mercury and mercuric chloride sources. The flow rates are controlled by mass flow controllers which are periodically calibrated with a Gilibrator, which is a primary standard for flow measurement. The permeation rates of the mercury sources are periodically confirmed with either EPA Method 101A samples or Ontario Hydro (OH) method samples.

EERC's procedure for screening Hg sorbents in a fixed-bed bench-scale system follows these steps: Before the start of each test, the inlet mercury concentration in the flue gas is measured by the continuous mercury monitor (CMM). The sample is then plumbed into the system while ambient air is analyzed for mercury until the amount of mercury measured is less than 0.3 $\mu g/m^3$. At the start of the test, flue gas is applied to the fixed bed at 29.9 scfm. For each sample, a measurement is made of the initial reactivity or induction period. Flue gas is then passed through the sample until mercury breakthrough reaches at least 75% of the inlet concentration. A diagram of the system is shown in Figure 1.

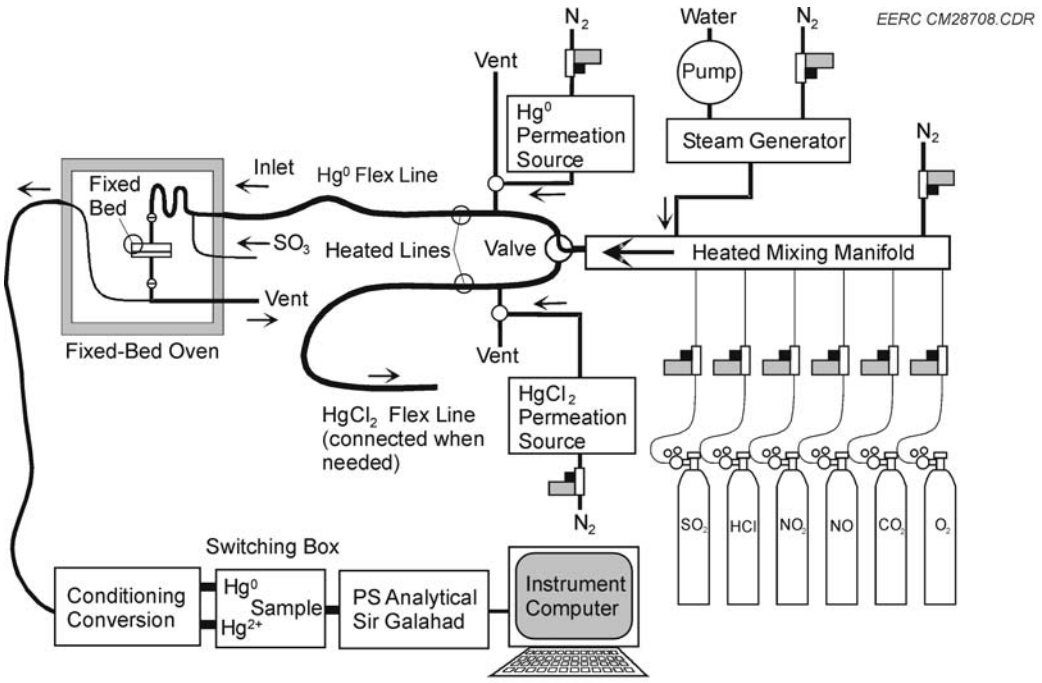

Figure 1. Schematic of EERC bench-scale apparatus.

Continuous Mercury Monitors

For the EERC bench-scale mercury test system, a CMM is used that is based on atomic absorption. A P.S. Analytical (PSA) CMM with a wet-chemistry conditioning/conversion unit was used upstream of the filter sorbent assembly to measure both the elemental and total mercury at the inlet and outlet of the fixed-bed reactor. In order to monitor oxidized forms of mercury, a $SnC1_2$ reduction cell is used prior to the analyzer to convert all forms of mercury to Hg^0 for analysis.

Analytical Analyses: EERC and Outside Labs

The EERC has all of the necessary analytical equipment and instruments needed to support routine analyses for the proposed work, with the exception of XPS and x-ray absorption fine-structure (XAFS) analysis, which must be submitted to outside labs. Structural features of the

initial and stored samples will be analyzed using XPS to determine changes in the chemical associations of carbon, oxygen, sulfur, chlorine, and bromine at the sorbent surface. This analysis will be performed by Evans Analytical Laboratories in Minneapolis, Minnesota. Detailed speciation data (the different forms of bromine) on the carbon surfaces will be evaluated by Dr. Frank Huggins using XAFS at Brookhaven National Laboratory in Brookhaven, New York. Additionally, the EERC will do surface analysis using carbon tetrachloride surface analysis (CCL4) to determine relative change in the surface area of the sorbents as they age under various conditions.

QUALIFICATIONS

The EERC has performed hundreds of sorbent-related tests, ranging from bench to full scale, over the last decade, including several full-scale projects involving DOE and NDIC funding to evaluate short- and long-term (~30 days) sorbent injection effectiveness at a number of lignite-fired power plants. The EERC has conducted numerous tests of sorbents, both treated and untreated, carbon-based and noncarbon-based, to understand the various factors that affect activated carbons. The AC model developed at the EERC (9) to explain interactions with various flue gas constituents has been used worldwide as a predictive tool for AC injection.

VALUE TO NORTH DAKOTA

In the past, low-chlorine coals were considered to be the most problematic and challenging for mercury control. However, treated carbons (including those that are halogenated by bromine) have shown the best mercury capture for lignite-derived flue gas. For lignite-fired utilities in the United States and Canada to effectively and economically meet the requirements of the Clear Air Mercury Rule (CAMR) and the Canada-Wide Standards (CWS), respectfully, mercury control measures must be effective in various configurations and be consistent in performance. Also,

lignite-derived activated carbons using Fort Union coals have shown tremendous commercialization promise; it is therefore important to know the effects of halogenation on any new activated carbons that are being produced to meet the urgent market needs of lignite-fired utilities so that production, transportation, shipment, delivery, and on-site storage issues are best understood, and potential negative effects minimized. This project will address issues associated with aging and storage of treated activated carbons and will provide data to minimize uncertainties associated with applying treated sorbents for mercury control by utilities burning lignite coal.

MANAGEMENT

This project will be managed by Mr. John Pavlish, who also serves as the Director of the EERC's Center for Air Toxic Metals® (CATM®). Mr. Pavlish has been the project manager over several mercury control projects in both the United States and Canada at all scales of testing. Through the CATM program, a U.S. Environmental Protection Agency (EPA)-funded Center of Excellence, he has been responsible for overseeing both fundamental and applied research that has included numerous mercury-related research activities. Mr. Pavlish will oversee this project and will ensure that milestones are met and that reporting is being addressed in a timely manner.

Dr. Edwin Olson will serve as the Principal Investigator to oversee and perform the laboratory-related activities, including the actual production of the brominated ACs. He will also interpret results from these tests and coordinate with others within the Center to facilitate timely dissemination of project results. He will also use these results to continue development of a sorbent reaction model that is used by many for prediction of AC–flue gas interactions.

Ms. Katie Hill Brandt is the engineer who will operate the bench-scale system and perform the mercury control tests on the sorbents. She will also be responsible for data reduction in conjunction with these tests.

Ms. Lucinda Hamre will assist Mr. Pavlish and Dr. Olson with project-related management and reporting functions, as well as technical support.

Mr. Pavlish and Dr. Olson will assess the outcome of the bench-scale tests. A direct comparison will be made between fresh and aged ACs from various storage modes. Dr. Olson will also oversee and assist with the interpretation of surface analyses and XPS results in their evaluation of aging effects. EERC staff will assist with laboratory-related analyses, except for the XPS analysis, which will be sent to a certified laboratory for analysis.

TIMETABLE

This project is an outcome of a multiyear effort to evaluate mercury control technologies. The project time frame for this proposed work will be 10 months, as is proposed in Table 6. The end of this project is proposed as March 31, 2008, in order to comply with the end date of the EERC–DOE Jointly Sponsored Research Program (JSRP). However, it is possible that this project will request a no-cost extension to finish the matrix as presented.

Reporting will be done quarterly to comply with DOE guidelines. Quarterly reports will be distributed to all team members. Other reporting requirements, including those specific to NDIC, will be addressed in the contract.

BUDGET

The total cost for this proposed work is $120,870, with matching funds as noted below.

MATCHING FUNDS

This project is proposed to include some of the members of Phase II work. The work is planned for a total project cost of $120,870. Contributing partners for this project are as follows:

- DOE through the existing EERC–DOE JSRP – $40,870
- EPRI – $25,000
- SaskPower – $10,000
- Otter Tail Power Company – $5000
- NDIC – $40,000

Table 6. Project Time Line for Add-On Activities

Project Activity	Period of Activity
Phase I	February 2002 – December 2003
Phase II – Field Demonstration	2003–March 2007 (report finalized)
Treated AC Aging Tests	
Design and Build Storage-Controlled Chambers	June 2007
Produce Fresh Brominated ACs	June 2007
Evaluation of ACs at Bench Scale	June–December 2007
XPS, XAFS, Surface Analysis of ACs	June–December 2007
Reporting to Sponsors	January–March 2008

A letter of commitment from EPRI is found in Appendix C. Given the nature of the work and DOE's involvement in the prior project, it is expected that DOE will grant approval. If for some reason all of the partners are not able to fulfill their commitment, the scope of work will be discussed with all funding partners and readjusted to fit the available amount.

TAX LIABILITY

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

REFERENCES

1. Holmes, M.J.; Wocken, C.A.; Thompson, J.S.; Pavlish, J.H.; Martin, C.L.; Eriksen, B.; McDonald, D.; Brickett, L.A. Mercury Control Test Results for Western Coals – Activated Carbons and Sorbent Enhancement Additives. In *Proceedings of the Power-Gen International 2005 Conference*, Las Vegas, NV, Dec 6–8, 2005.
2. Thompson, J.S.; Pavlish, J.H.; Holmes, M.J.; Bush, C. Enhancing Carbon Reactivity for Mercury Control: Field Test Results from Leland Olds. Abstract for the EPRI–EPA–A&WMA Power Plant Air Pollutant Control "Mega" Symposium, Washington, DC, Aug 30 – Sept 2, 2004.
3. 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 1 Bench- and Pilot-Scale Testing*; Final Report (Feb 1 – March 31, 2003) for U.S. Department of Energy National Energy Cooperative Agreement No. DE-FC26-98FT40321; EERC Publication 2003-EERC-10-03; Energy & Environmental Research Center: Grand Forks, ND, Oct 2003.
4. Pavlish, J.H.; Thompson, J.S.; Almlie, J.C.; Hamre, L.L..; Musich, M.A.; Heebink, L.V.; Crocker, C.R.; Olson, E.S. *Mercury Control Technologies for Electric Utilities Burning Lignite Coal – Phase II*; Final Report (June 1, 2003 – Dec 31, 2007) for U.S. Department of Energy National Energy Cooperative Agreement No. DE-FC26-98FT40321; Energy & Environmental Research Center: Grand Forks, ND, March 2008.
5. Sjostrom, S.M.; Wilson, C. Full-Scale Evaluation of Carbon Injection for Mercury Control at a Unit Firing High Sulfur Coal. Presented at the Mercury Control Technology R&D Program Review Meeting, Pittsburgh, PA, Dec 11–13, 2006.

6. Jones, A.P.; Hoffmann, J.W.; Smith, D.N.; Feeley, T.J. III; Murphy, J.T. *DOE/NETL's Phase II Mercury Control Technology Field Testing Program: Preliminary Economic Analysis of Activated Carbon Injection*; Report for U.S. Department of Energy Office of Fossil Energy National Energy Technology Laboratory Innovations for Existing Plants Program; April 2006.

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

8. Pavlish, J.H.; Hamre, L.L.; Laudal, D.L.; Holmes, M.J.; Weber, G.F.; Hajicek, D.R.; Pavlish, B.M. *Technical Review of Mercury Options For Canadian Utilities – A Report to the Canadian Council of Ministers of the Environment*; Final Report to the Canadian Council of Ministers of the Environment; Contract No. 348-2005; EERC Publication 2005-EERC-03-07; Energy & Environmental Research Center: Grand Forks, ND, Mar 2005.

9. Olson, E.S.; Laumb, J.D.; Benson, S.A.; Dunham, G.E.; Sharma, R.K.; Mibeck, B.A.; Miller, S.J.; Holmes, M.J.; Pavlish, J.H. An Improved Model for Flue Gas–Mercury Interactions on Activated Carbons. Presented at the DOE–EPRI–EPA–A&WMA Power Plant Air Pollutant Control "Mega" Symposium, Washington, DC, May 19–22, 2003.

EFFECTS OF AGING ON TREATED ACTIVATED CARBONS
NDIC/EPRI/SASK POWER/OTTER TAIL POWER/DOE
PROPOSED START DATE: 6/01/07
PROPOSAL NO. 2007-0220

SUMMARY BUDGET

CATEGORY	TOTAL HRS	TOTAL $COST	INDUSTRY SHARE HRS	INDUSTRY SHARE $COST	NDIC SHARE HRS	NDIC SHARE $COST	EERC JSRP SHARE HRS	EERC JSRP SHARE $COST
TOTAL DIRECT LABOR	739	$ 28,010	147	$ 5,657	248	$ 7,644	344	$ 14,709
FRINGE BENEFITS		$ 14,285		$ 2,886		$ 3,898		$ 7,501
TOTAL LABOR		$ 42,295		$ 8,543		$ 11,542		$ 22,210
OTHER DIRECT COSTS								
TRAVEL		$ 2,361		$ -		$ -		$ 2,361
SUPPLIES		$ 3,380		$ 2,125		$ 1,000		$ 255
FEES		$ 30,365		$ 14,900		$ 13,069		$ 2,396
COMMUNICATION - PHONES & POSTAGE		$ 250		$ 20		$ 30		$ 200
OFFICE (PROJECT SPECIFIC SUPPLIES)		$ 301		$ 52		$ -		$ 249
TOTAL OTHER DIRECT COST		$ 36,657		$ 17,097		$ 14,099		$ 5,461
TOTAL DIRECT COST		$ 78,952		$ 25,640		$ 25,641		$ 27,671
FACILITIES & ADMIN. RATE - % OF MTDC	VAR	$ 41,918	56%	$ 14,360	56%	$ 14,359	47.7%	$ 13,199
TOTAL PROJECT COST		$ 120,870		$ 40,000		$ 40,000		$ 40,870

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.

EFFECTS OF AGING ON TREATED ACTIVATED CARBONS
NDIC/EPRI/SASK POWER/OTTER TAIL POWER/DOE
PROPOSED START DATE: 6/01/07
PROPOSAL NO. 2007-0220

DETAILED BUDGET

LABOR	LABOR CATEGORY	HOURLY RATE	TOTAL HRS	TOTAL $COST	INDUSTRY SHARE HRS	INDUSTRY SHARE $COST	NDIC SHARE HRS	NDIC SHARE $COST	EPRI SHARE HRS	EPRI SHARE $COST	SASK POWER SHARE HRS	SASK POWER SHARE $COST	OTTER TAIL SHARE HRS	OTTER TAIL SHARE $COST	EERC JSRP SHARE HRS	EERC JSRP SHARE $COST
PAVLISH, J.	PROJECT MANAGER	$ 59.51	50	$ 2,976	20	$ 1,190	-	$ -	8	$ 476	8	$ 476	4	$ 238	30	$ 1,786
OLSON, E.	PRINCIPAL INVESTIGATOR	$ 51.86	160	$ 8,298	40	$ 2,074	18	$ 933	-	$ -	22	$ 1,141	-	$ -	120	$ 6,224
HILL-BRANDT, K.	RESEARCH SCIENTIST/ENGINEER	$ 25.94	120	$ 3,113	88	$ 2,283	88	$ 2,283	-	$ -	-	$ -	-	$ -	32	$ 830
HAMRE, L.	RESEARCH SCIENTIST/ENGINEER	$ 23.67	80	$ 1,894	40	$ 947	-	$ -	-	$ -	14	$ 331	26	$ 616	40	$ 947
----------	SENIOR MANAGEMENT	$ 59.15	44	$ 2,603	-	$ -	-	$ -	-	$ -	-	$ -	-	$ -	44	$ 2,603
----------	RESEARCH SCIENTIST/ENGINEER	$ 32.92	123	$ 4,049	123	$ 4,049	60	$ 1,975	-	$ -	63	$ 2,074	-	$ -	-	$ -
----------	RESEARCH TECHNICIAN	$ 21.80	58	$ 1,264	-	$ -	-	$ -	-	$ -	-	$ -	-	$ -	58	$ 1,264
----------	TECHNOLOGY DEV. MECH.	$ 25.67	80	$ 2,054	80	$ 2,054	80	$ 2,054	-	$ -	-	$ -	-	$ -	-	$ -
----------	TECHNICAL SUPPORT SERVICES	$ 17.70	24	$ 425	4	$ 71	2	$ 35	-	$ -	-	$ -	2	$ 36	20	$ 354
			739	$ 26,676	395	$ 12,668	248	$ 7,280	8	$ 476	107	$ 4,022	32	$ 890	344	$ 14,008
ESCALATION ABOVE CURRENT BASE		5%		$ 1,334		$ 633		$ 364		$ 24		$ 201		$ 44		$ 701
TOTAL DIRECT LABOR				$ 28,010		$ 13,301		$ 7,644		$ 500		$ 4,223		$ 934		$ 14,709
FRINGE BENEFITS - % OF DIRECT LABOR		51%		$ 14,285		$ 6,784		$ 3,898		$ 255		$ 2,154		$ 477		$ 7,501
TOTAL LABOR				$ 42,295		$ 20,085		$ 11,542		$ 755		$ 6,377		$ 1,411		$ 22,210
OTHER DIRECT COSTS																
TRAVEL				$ 2,361		$ -		$ -		$ -		$ -		$ -		$ 2,361
SUPPLIES				$ 3,380		$ 3,125		$ 1,000		$ 370		$ -		$ 1,755		$ 255
OUTSIDE LABS				$ 14,900		$ 14,900		$ -		$ 14,900		$ -		$ -		$ -
COMMUNICATION - PHONES & POSTAGE				$ 250		$ 50		$ 30		$ 1		$ 13		$ 6		$ 200
OFFICE (PROJECT SPECIFIC SUPPLIES)				$ 301		$ 52		$ -		$ -		$ 20		$ 32		$ 249
PARTICULATE ANALYSIS				$ 12,909		$ 12,909		$ 12,909		$ -		$ -		$ -		$ -
PROCESS CHEM. & DEV. LAB.				$ 2,075		$ -		$ -		$ -		$ -		$ -		$ 2,075
GRAPHICS SUPPORT				$ 321		$ -		$ -		$ -		$ -		$ -		$ 321
SHOP & OPERATIONS SUPPORT				$ 160		$ 160		$ 160		$ -		$ -		$ -		$ -
TOTAL OTHER DIRECT COST				$ 36,657		$ 31,196		$ 14,099		$ 15,271		$ 33		$ 1,793		$ 5,461
TOTAL DIRECT COST				$ 78,952		$ 51,281		$ 25,641		$ 16,026		$ 6,410		$ 3,204		$ 27,671
FACILITIES & ADMIN. RATE - % OF MTDC			VAR	$ 41,918	56%	$ 28,719	56%	$ 14,359		$ 8,974		$ 3,590		$ 1,796	47.7%	$ 13,199
TOTAL PROJECT COST				$ 120,870		$ 80,000		$ 40,000		$ 25,000		$ 10,000		$ 5,000		$ 40,870

EFFECTS OF AGING ON TREATED ACTIVATED CARBONS
PROPOSAL NO. 2007-0220

DETAILED BUDGET - FEES

			TOTAL
PARTICULATE ANALYSIS	**RATE**	#	**$COST**
BENCH SCALE SIMULATOR (PER HOUR)	$135	72	$ 9,720
MERCURY CEM (PER DAY)	$286	9	$ 2,574
SUBTOTAL			$ 12,294
ESCALATION		5%	$ 615
TOTAL PARTICULATE ANALYSIS			$ 12,909
PROCESS CHEM. & DEV. LAB.	**RATE**	#	**$COST**
MISC (HOURLY)	$58	8	$ 464
LAB USE RATE	$12	126	$ 1,512
SUBTOTAL			$ 1,976
ESCALATION		5%	$ 99
TOTAL PROCESS CHEM. & DEV. LAB.			$ 2,075
GRAPHICS SUPPORT	**RATE**	#	**$COST**
GRAPHICS (HOURLY)	$51	6	$ 306
SUBTOTAL			$ 306
ESCALATION		5%	$ 15
TOTAL GRAPHICS SUPPORT			$ 321
SHOP & OPERATIONS SUPPORT	**RATE**	#	**$COST**
TECHNICAL DEVELOPMENT HOURS	$1.90	80	$ 152
SUBTOTAL			$ 152
ESCALATION		5%	$ 8
TOTAL SHOP & OPERATIONS SUPPORT			$ 160

EFFECTS OF AGING ON TREATED ACTIVATED CARBONS
PROPOSAL NO. 2007-0220

DETAILED BUDGET - TRAVEL

USED TO CALCULATE ESTIMATED TRAVEL EXPENSES

DESTINATION	AIRFARE	LODGING	PER DIEM	CAR RENTAL	REGIST.
Unspecified Destination (USA)	$ 750	$ 150	$ 64	$ 75	$ 525

PURPOSE/DESTINATION	NUMBER OF TRIPS	NUMBER OF PEOPLE	NUMBER OF DAYS	AIRFARE	LODGING	PER DIEM	CAR RENTAL	MISC.	REGIST.	TOTAL
Conference or Presentation/Unspecified Dest. (USA)	1	1	4	$ 750	$ 450	$ 256	$ 300	$ 80	$ 525	$ 2,361

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 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 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.

APPENDIX A

RESUMES OF KEY PERSONNEL

JOHN H. PAVLISH
Senior Research Advisor
Energy & Environmental Research Center (EERC)
University of North Dakota (UND)
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018 USA
Phone (701) 777-5000, Fax (701) 777-5181
E-Mail: jpavlish@undeerc.org

Principal Areas of Expertise

Mr. Pavlish's principal areas of interest and expertise include research and consultation on air toxic issues; hazardous air pollutants (HAPs) with emphasis on mercury; the effects of fuel quality and ash on combustion, gasification, and power plant system performance; generation recovery; steam generator performance and reliability; emission reduction control technologies and flue gas-processing equipment; and economic and feasibility analyses on control technologies and energy conversion systems.

Qualifications

B.S., Mechanical Engineering, North Dakota State University, 1984.
A.A.S., Power and Machinery, University of Minnesota – Crookston, 1979.
P.E., Kansas.

Professional Experience

2000 – Center for Air Toxic Metals® Director, EERC, UND. Mr. Pavlish is a Senior Research Advisor and the Director of a multiyear, multimillion dollar Center for Air Toxic Metals (CATM®) program. His responsibilities include developing and managing an array of projects involving air toxic metals (mercury), fuel impacts on energy conversion systems, emissions control technologies for power plant applications, biomass utilization, fuel cell applications, and technical and economic evaluations of various advanced emissions control and energy conversion systems.

1994 – 2003 Senior Research Manager, EERC, UND. Mr. Pavlish's responsibilities included managing research programs related to emissions and control of air toxic substances. In an advisory role, Mr. Pavlish provided direction, vision, and technical review of future research programs. His responsibilities also included supervising research on the effects of fuel quality on combustion and gasification system performance; laboratory, pilot, and field testing; planning and performing specific research projects; evaluating the effects of coal quality and ash on power plant performance, generation recovery, steam generator performance and reliability, formation of hazardous air pollutants, assessment of various control technologies, and flue gas processing equipment; creating, developing, maintaining, testing, and validating innovative computer programs; identifying research opportunities and writing proposals and reports to meet client needs; and managing budgets and personnel on multiple projects.

1993 – 1994 Research Manager, Fuels and Materials Science, EERC, UND. Mr. Pavlish's responsibilities included supervising research on the effects of coal quality on coal combustion and gasification system performance; laboratory, pilot, and field testing; planning and performing specific research projects; evaluating the effects of coal quality and ash on power plant performance, generation recovery, steam generator performance and reliability, formation of hazardous air pollutants, assessment of various control technologies, and flue gas processing equipment; creating, developing, maintaining, testing, and validating innovative computer programs; identifying research opportunities and writing proposals and reports to meet client needs; and managing budgets and personnel on multiple projects.

1984 – 1993 Unit Leader/Systems Engineer, Black & Veatch Engineers–Architects. Mr. Pavlish's responsibilities included providing engineering/technical advice; determining and managing resources; developing and monitoring budgets; developing, overseeing, and maintaining project schedules; conducting formal/informal presentations to clients and at technical conferences; writing the technical scope of work, preparing cost estimates, and providing the supervision and organization of the proposal effort; assisting in the preparation and presentation of appropriate marketing material; planning, performing, and coordinating numerous coal quality impact studies; and creating, developing, maintaining, teaching, and validating innovative computer-based programs for evaluating the impacts that coal/ash constituents have on the combustion process, power plant equipment, overall plant performance, and unit/plant/system generation costs.

1979 – 1981 Service Technician, Crookston Implement, Inc., Crookston, Minnesota. Mr. Pavlish's responsibilities included diagnosing and reconditioning engines, transmissions, air conditioning, fuel, and hydraulic systems.

Professional Memberships

- American Society of Mechanical Engineers
- Air & Waste Management Association
- Advisory Member, BiNational Strategy Utility Mercury Reduction Committee
- Advisory Member, Minnesota Pollution Control Agency (MPCA) Research Advisory Committee
- Advisory Member, MPCA Utilities and Taconite Subcommittee
- Advisory Member, Advanced Emissions Control Development Program

Publications and Presentations

- Has authored and coauthored numerous publications

DR. EDWIN S. OLSON
Senior Research Advisor
Energy & Environmental Research Center (EERC)
University of North Dakota (UND)
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018 USA
Phone (701) 777-5000, Fax (701) 777-5181
E-Mail: eolson@undeerc.org

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

KATIE HILL BRANDT
Research Engineer
Energy & Environmental Research Center (EERC)
University of North Dakota (UND)
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018 USA
Phone (701) 777-5000, Fax (701) 777-5181
E-Mail: khillbrandt@undeerc.org

Principal Areas of Expertise

Ms. Hill Brandt's principal areas of interest and expertise include mercury sorbent evaluation using a fixed-bed bench-scale system, mercury control technology demonstration, and hydrogen and ethanol production.

Qualifications

B.S., Chemical Engineering with a concentration in Biomedical Engineering, Northwestern University, 2003.

Professional Experience

2005 – Research Engineer, Environmental Technologies, EERC, UND. Ms. Hill Brandt's responsibilities involve environmental control research for energy systems, mercury sorbent evaluation using a fixed-bed bench-scale system, mercury measurement and control at pilot-scale and full-scale facilities, and hydrogen production modeling.

2004 – 2005 Field Researcher, EERC, UND. Ms. Hill Brandt's responsibilities included monitoring mercury levels at a coal-fired power plant and summarizing the data obtained there.

Summers 2000 – 2002 Research Assistant, EERC, UND. Ms. Hill Brandt's responsibilities included the following:

- Designed graphs using experimental data from particulate and mercury sampling.
- Prepared and recovered samples for mercury, ammonia, and chlorine detection at a coal-fired power plant and in a pilot plant.
- Created and edited spreadsheets to assist in mercury- and particulate-sampling analysis.
- Repaired and calibrated laboratory equipment.

Professional Memberships

- Air and Waste Management Association

Publications and Presentations

- Has coauthored several publications

APPENDIX B

LETTER OF COMMITMENT

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

March 27, 2007

Mr. John Pavlish
Energy & Environmental Research Center
15 North 23rd Street, Mailstop 9018
Grand Forks, ND 58202-9018

Dear John:

Subject: Letter of Interest and Support for Project "Effects of Aging on Treated Activated Carbons"

I am pleased to submit this letter of support and interest to participate in the bench-scale testing activities that the Energy & Environmental Research Center (EERC) proposes to conduct testing to evaluate the effects of aging on treated carbons. EPRI has a strong interested in continuing to assess issues related to treated activated carbon as a mercury control technology. We believe that this is necessary work that will support the utility industry in their efforts to meet the upcoming regulations for the Clean Air Mercury Rule.

EPRI is very interested in the proposed project and is willing to participate directly with the EERC, the North Dakota Industrial Commission, and other potential sponsors in this work. If the NDIC and DOE provides support for this project, EPRI is willing to commit $25,000 towards this collaborative effort. We hope that NDIC gives the proposed tests serious consideration and wish you success in securing an award.

Sincerely,

Ramsay Chang

Ramsay Chang
EPRI
3412 Hillview Ave
Palo Alto, Ca 9430-1395