March 29, 2007

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

Dear Ms. Fine:

Subject: EERC Proposal No. 2007-0227 Entitled "Phase III – Mercury Control Technologies for Utilities Burning Lignite Coal: Full-Scale Evaluation of Long-Term Balance-of-Plant Effects Resulting from Activated Carbon Injection"

Please find enclosed seven copies of a proposal that addresses a research project that has been formulated by SaskPower and the Energy & Environmental Research Center (EERC). A check is also enclosed in the amount of $100 for the application fee. The purpose of the proposed project is to evaluate potential long-term balance-of-plant (BOP) effects related to the use of activated carbon injection (ACI) for control of mercury at a full-scale power plant (SaskPower's lignite-fired Poplar River Unit 2) for a duration of approximately 1 year.

For the last 5 years, the EERC has worked with SaskPower and North Dakota utilities on behalf of a consortium composed of utilities, engineering firms, and the U.S. Department of Energy (DOE) to undertake a two-phase consortium project to perform pilot-scale and slipstream testing on various sorbents for mercury control that are applicable to utilities burning lignite coal. The Fort Union lignite deposit covers both North Dakota and Saskatchewan. Phase I pilot-scale activities were completed in 2003, which led to the design of a slipstream Emission Control Research Facility (ECRF) test unit that was built at SaskPower's Poplar River Station.

Under the ongoing Phase II activities, the EERC, with support from SaskPower, North Dakota utilities, DOE, and other sponsors, screened and evaluated various sorbent-based technologies on an electrostatic precipitator (ESP)–ACI–fabric filter (FF) slipstream system. This project was successful in several regards: the mercury removal for many of the carbon-based sorbents was remarkably good, showing that removals >80% could be attained for this configuration using various plain and treated carbons. These data allowed SaskPower and the EERC to conduct a preliminary economic analysis considering the use of ACI upstream of a newly installed FF at the Poplar River Station.

However, Phase II testing also showed negative BOP impacts under test conditions, including pressure drop increases that were not sustainable and FF bag effects. Given these findings and the associated increased cost of the ACI–FF technology, it is now desirable to evaluate sorbent injection options upstream of an ESP so that comparable performance, cost data, and BOP impacts can be evaluated. While there has been some full-scale short-term testing at a few of the plants that burn North Dakota lignite, to date, there have been no full-scale tests with ACI that have been conducted for longer than a period of 1–2 months. Industry has voiced concern that this testing is too short and not of adequate duration to evaluate potential BOP impacts. To answer and address this data gap, the EERC, along with SaskPower as the host facility, proposes a project to conduct a yearlong full-scale test of ACI upstream of an ESP to determine long-term effectiveness for mercury removal and to further evaluate BOP impacts.

Once completed, data should be available for injection upstream of an ESP and a FF, allowing for side-by-side comparison of performance and costs for both approaches. This should allow for a more cost-effective evaluation and selection of the appropriate technology by North Dakota utilities before full-scale implementation.

The total cost of completing this project is estimated at approximately $5,000,000. The bulk of the funding will be provided by SaskPower and will be associated with acting as host facility by providing the sorbent material for testing (estimated at $2,000,000–$3,000,000), modification to the test unit and support staff (estimated at an additional $1,000,000). ALSTOM will serve as an advisor to SaskPower. In addition, to support sampling, analysis, and operation/maintenance of the ACI system, the cost for the EERC to support this research project is estimated to be approximately $902,604. The EERC has received a commitment from SaskPower to serve as host site, as well as to provide cash funding in support of the proposed project. The EERC is also seeking $270,703 in funds through the EERC–DOE Jointly Sponsored Research Program (JSRP) to support the project. For the remaining funding of $631,901, the EERC is requesting $300,000 from the NDIC, with the remaining amount being requested from SaskPower.

If you have any questions, you may reach me by phone at (701) 777-5268, by fax at (701) 777-5181, or by e-mail at jpavlish@undeerc.org or Lucinda Hamre by phone at (701) 777-5059 or by e-mail at lhamre@undeerc.org. We thank you for your past support of EERC research and look forward to working with you on this project.

Sincerely,

John H. Pavlish
Senior Research Advisor

JHP/hmv

Enclosures

c/enc: Jeff Burgess, Lignite Energy Council
Jeff Thompson, EERC
Lucinda Hamre, EERC
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PHASE III – MERCURY CONTROL TECHNOLOGIES FOR UTILITIES BURNING LIGNITE COAL: LONG-TERM BALANCE-OF-PLANT EFFECTS RESULTING FROM ACTIVATED CARBON INJECTION

EERC Proposal No. 2007-0227

Submitted to:

Karlene Fine

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

Proposal Amount: $300,000

Submitted by:

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March 29, 2007

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PHASE III – MERCURY CONTROL TECHNOLOGIES FOR UTILITIES BURNING LIGNITE COAL: FULL-SCALE EVALUATION OF LONG-TERM BALANCE-OF-PLANT EFFECTS RESULTING FROM ACTIVATED CARBON INJECTION

ABSTRACT

For the last 5 years, the EERC has worked with SaskPower and ND utilities on behalf of a consortium of utilities, engineering firms, and DOE to undertake a two-phase project to perform pilot-scale and slipstream testing on various sorbents for Hg control that are applicable to utilities burning Fort Union lignite. Phase I pilot-scale activities, completed in 2003, identified promising Hg control approaches and led to the design of a test unit that was built at SaskPower's Poplar River Station. Under Phase II, sorbent-based technologies were evaluated on an electrostatic precipitator (ESP)–activated carbon injection (ACI)–fabric filter (FF) system; many of the carbon-based sorbents (plain and treated) attained >80% Hg removal. However, Phase II testing also showed negative balance-of-plant (BOP) impacts under test conditions, including unsustainable pressure drop increases and FF bag effects. Given these findings and revised economics for the ACI–FF technology, it is now desirable to evaluate sorbent injection options upstream of an ESP to compare performance, cost data, and BOP impacts. While there has been some full-scale short-term testing at a few of the plants that burn ND lignite, to date, there have been no full-scale tests with ACI that have been conducted for longer than 1–2 months. Under this project, a 1-year full-scale demonstration of ACI is proposed at SaskPower's Poplar River Station to address this critical data gap. The total project cost is ~$5,000,000. The bulk of the funding will be provided by SaskPower, associated with acting as a host facility. The research/sampling component, led by the EERC, is ~$902,604, with ~$270,703 from the EERC–DOE Jointly Sponsored Research Program. Of the remaining $631,901, NDIC is requested to provide $300,000, with the remaining funding provided by SaskPower.

PHASE III – MERCURY CONTROL TECHNOLOGIES FOR UTILITIES BURNING LIGNITE COAL: FULL-SCALE EVALUATION OF LONG-TERM BALANCE-OF-PLANT EFFECTS RESULTING FROM ACTIVATED CARBON INJECTION

PROJECT SUMMARY

For the last 5 years, the Energy & Environmental Research Center (EERC) has worked with SaskPower, North Dakota utilities, and the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) to undertake a two-phase consortium project to perform pilot-scale and slipstream testing on various sorbents for mercury control that are applicable to utilities burning Fort Union lignite coal.

Pilot-scale activities for Phase I were completed at the EERC to evaluate sorbent-based technologies that could be effective for removing mercury when combusting Fort Union (Saskatchewan) lignite. Phase I was completed in 2003, with identification of the best-performing activated carbon (AC) candidates and most promising technology (1), which led to the design of a slipstream test unit that was built at SaskPower's Poplar River Station.

Under the ongoing Phase II project at SaskPower's slipstream Emission Control Research Facility (ECRF) at SaskPower's Poplar River Station, the EERC, with support from SaskPower, DOE, North Dakota utilities, and other sponsors, screened and evaluated various sorbent-based technologies on an electrostatic precipitator (ESP)–activated carbon injection (ACI)–fabric filter (FF) system. This technology was originally chosen because it provided the most promise for mercury control while affecting the least amount of ash with sorbent. The ECRF further evaluated this option at a larger scale by pulling a slipstream of the flue gas from Unit 1, which allowed evaluation of various sorbent technologies for their effectiveness, performance, and cost for this configuration.

This project was successful in several regards: the mercury removal for many of the carbon-based sorbents was remarkably good, showing that removals >80% could be attained using various plain and treated carbons. In addition, evaluation of performance also allowed SaskPower and the EERC to conduct a preliminary economic analysis considering the use of ACI upstream of a newly installed FF at the Poplar River Station (2).

Phase II tests indicated that pressure drop and filter bag effects were key issues related to ACI. Further, the bags showed greater sensitivity to dust-loading changes than initially thought (3). While the ongoing Phase II project has provided key findings regarding the use of ACI on lignite-fired systems, there are still key questions regarding the long-term use of ACI. Through DOE NETL's mercury program, several short-term full-scale mercury control tests have been conducted at coal-fired utilities, of which some were North Dakota utilities (4–6). However, to date, there have been no full-scale tests on lignite with ACI that have been conducted for longer than a period of 1–2 months. This time frame has been expressed by industry as being too short to adequately evaluate possible long-term balance-of-plant (BOP) effects. To address this data gap, the EERC, along with SaskPower as the host facility, propose to demonstrate ACI upstream of an ESP at SaskPower's lignite-fired Poplar River Power Station to determine long-term effectiveness for mercury removal and to further evaluate BOP impacts for a duration of approximately 1 year.

The total cost of completing this project is estimated at approximately $5,000,000. The bulk of the funding will be provided by SaskPower (with CAN$900,000 through Sustainable Development Technology Canada [SDTC]) and will be associated with acting as host facility (note the cost of the sorbent material alone is estimated at $2,000,000 to $3,000,000). The cost for the EERC to support sampling and testing activities is estimated to be approximately

$902,604. The EERC has received a commitment from SaskPower to serve as host site, as well as to providing cash funding in support of the proposed project. The EERC is also seeking $270,703 in funds through the EERC–DOE Jointly Sponsored Research Program (JSRP) to support the project. For the remaining funding of $631,901, the EERC is requesting $300,000 from the North Dakota Industrial Commission (NDIC), with the remaining funding being requested from SaskPower.

PROJECT DESCRIPTION

Project Background Summary

While Phase II of the existing project showed promising mercury removal results, the economic analysis of the project showed the cost of implementing the ACI–FF appears to be significant (2, 3). Consequently, it is now desirable under Phase III of the proposed project to further evaluate sorbent injection options upstream of an ESP so that similar and comparable performance and cost data can be obtained. Once completed, data should be available for injection upstream of both an ESP (proposed Phase III) and a FF (Phase II), allowing for side-by-side comparison of performance and costs for both approaches. Most importantly, the proposed project will allow adequate time (~ 1 year) to evaluate potential BOP impacts associated with using ACI technology for mercury control. Industry has expressed that long-term testing is urgently needed to minimize unknowns and uncertainties associated with implementing this technology.

Description of Proposed Phase III Testing

The proposed Phase III project is focused on evaluating long-term BOP effects when using ACI upstream of an ESP for mercury control on a full-scale unit. Over half the power plants in North Dakota and all of the plants in Saskatchewan are equipped with ESPs; thus successful application of ACI is critical to industry. Despite several field tests of ACI, limited duration (generally ~30 days) has prevented a thorough evaluation of these potential BOP issues for ESP-only configurations. The proposed test period of 12 months will allow adequate time to identify and quantify possible BOP impacts, addressing this critical data gap. Table 1 shows a brief description of the unit (SaskPower Poplar River Unit 2) at which the long-term demonstration tests are planned.

Project Objectives

The objective of this project is to test full-scale ACI as a mercury control technology for an adequate length of time of at least 1 year to evaluate potential long-term BOP impacts (including erosion and corrosion on the unit) resulting from ACI upstream of an ESP. Specific objectives are as follows:

- Evaluate impact of ACI on ESP operation (increased sparking, buildup on plates, rapping frequency and effectiveness, outlet emission opacity, etc.).

Table 1. SaskPower Poplar River Unit 2 Specifications

Component	Specifications/Notes
Coal Combusted	Fort Union lignite, Poplar River Mine; same as previous pilot-scale ECRF testing under Phase II
Boiler	Babcock & Wilcox opposed-fired wall-fired boiler
Load	310 MW
Mills	6 mills
ESP Specifications	
Manufacturer	American Air Filter
Specific Collection Area (SCA)	Approximately 400 ft^2/1000 acfm
Controller	EPIC III controllers
Casings	Double casings, two parallel bus sections across the width; 10 bus sections in each casing (total of 20 bus sections)
Fields	Five fields in the direction of gas flow
Rappers	Tumbling hammer collecting rappers
Ash Handling	Slurried (mixed with water) and disposed of in lagoon
Ash Sales	None; excessive transportation to reach suitable market

- Evaluate the impact of ACI on downstream ductwork, fans, and stack.
- Evaluate the impact of ACI on ESP hoppers.
- Evaluate the impact of ACI on ash-handling and disposal practices and equipment.
- Evaluate the long-term operability of the ACI system and equipment.
- Evaluate the long-term mercury removal using ACI upstream of an ESP-only configuration.
- Determine mercury capture and the fate of mercury across the unit using a continuous mercury monitor (CMM), as well as Ontario Hydro (OH) method wet-chemistry data, to measure mercury concentrations in the flue gas. This will be compared to mercury analyses of coal and ash.
- Obtain mercury removal and economic data for ACI upstream of a full-scale ESP, which can be compared to previously generated data on the ECRF for ACI upstream of a FF.
- Perform a preliminary economic evaluation of using ACI upstream of an ESP for mercury control including observed BOP impacts.

Test Approach for Full-Scale Tests Using ACI

The EERC will assist the project team in preparing a detailed project test plan by providing suggestions for test conditions, test parameters, candidate sorbents, and quality assurance/quality control (QA/QC). At the start of the project, the EERC will prepare the test plan describing test objectives, sampling methods, sampling frequency, monitoring of BOP issues, data collection, etc., and will distribute it to all sponsors.

In addition, the EERC will provide the technical direction necessary to assist SaskPower with the installation and operation of the commercial-scale ACI system, including engineering information, power and system requirements, etc. The EERC will provide the use of the commercial ACI system (a major benefit to the project) during the demonstration portion of this project. SaskPower is responsible for all on-site costs (crane, foundation, instrumentation, power, etc.) associated with installation. Furthermore, to minimize project costs, SaskPower personnel will monitor the day-to-day operation of the ACI system with off-site support provided by the EERC.

Prior to beginning the testing, the ACI system will be tied into the monitoring/data acquisition system on the ECRF to allow SaskPower and EERC personnel to monitor the system from the ECRF. The data acquisition system will be configured to allow for remote monitoring and troubleshooting by the EERC.

Once the ACI system is operational, short-term parametric tests will be performed with treated (halogenated) and nontreated AC to evaluate performance in terms of mercury removal potential. Since large quantities (hundreds of tons) of sorbent are needed for full-scale testing, ACs to be tested will be limited to supplies that are commercially available or have near-commercial status. At a minimum, DARCO® Hg (nontreated) and DARCO® Hg-LH (treated) from NORIT Americas will be included. Results from these tests will allow the project team to select which sorbent to use during the 1-year demonstration test.

Unit 2 (the test unit) is planned to have an outage in late May to early June 2007. During this outage, general maintenance (cleaning, repairs, etc) and small upgrades will be made to the ESPs. This will also allow a good opportunity for inspection and to establish the baseline condition of relevant equipment and associated ductwork, discussed in more detail later. Following the outage, before AC is injected, the EERC proposes to perform sampling as shown in Table 2 to establish baseline flue gas conditions. Once baseline conditions are established, the

Table 2. Proposed Sampling to Support Evaluation of BOP Effects

Tests to Be Performed	Conditions	Purpose
Baseline Testing, without ACI		
OH Method Testing	Three at ESP inlet; three at outlet	Accepted method for determination of total and speciated Hg
CMMs (purchased and operated by SaskPower)	Continuous operation at ESP outlet	Monitor Hg emissions
Coal Analysis	Proximate–ultimate, Btu, Hg, Cl, trace metals	Establish the baseline values prior to ACI testing
Ash Analysis	Hg, Cl, C, trace metals	Establish the baseline values prior to ACI testing
Metal Coupons	Metal coupons upstream of ACI location or on other unit	Evaluate baseline erosion/corrosion resulting from operation without ACI
ACI Testing		
OH Method Testing	Two sets of three at ESP inlet and outlet; performed over 12 months	Accepted method for determination of total and speciated Hg
CMMs (belonging to and operated by SaskPower)	Continuous operation at ESP outlet	Monitor Hg emissions
Metal Coupons	Metal coupons downstream of ACI location	Evaluate erosion/corrosion resulting from ACI
Coal Analysis	Proximate–ultimate, Btu, Hg, Cl, trace metals	Establish the values during ACI testing
Ash Analysis	Hg, Cl, C, trace metals	Establish the values during ACI testing
Expanded Sampling – Trace Metal and Particulates		
Particulate Sampling	Conduct particulate matter testing at the inlet of ESP (with multicyclone) and stack (with cascade impactor)	Establish the dust-loading capture by the ESP and “slippage” of AC, as measured by outlet emissions
Trace Metal Analysis	Three sets of Method 29 tests (analyze for six trace metals of concern)*	Accepted method for determination of trace metals, including Hg
Coal Analysis	Trace metals, including Hg	Establish effect of ACI on trace metal capture and emissions
Ash Analysis	Trace metals, including Hg	Establish effect of ACI on trace metals in ash

* Results from previous trace metal analysis under Phase II will be used to narrow the number of trace elements down to six.

ACI system will be turned on and operated continuously for approximately 1 year, contingent on unit availability. Table 2 shows the sampling activities that the EERC proposes to conduct throughout the demonstration phase of the project. The sampling activities, shown in Table 2 under *ACI Testing*, are considered necessary and the minimal sampling needed to support the project. The sampling shown under *Expanded Sampling* allows for sampling of particulate and trace elements, which is also of interest to industry, but not absolutely required. Activities proposed under *Expanded Sampling* are discussed in more detail in a separate section later.

Because evaluation of BOP impacts is a key to this project, during the planned outage, the EERC will work with SaskPower to conduct an in-depth evaluation of the test unit. Details will be discussed with project sponsors during development of the detailed test plan, but the evaluation will, at a minimum, establish baseline conditions of ductwork and all aspects of the ESP (internal components, operational status, historical performance, etc.) so that BOP impacts can be observed/measured/compared against these starting conditions as long-term testing progresses. As testing progresses, SaskPower personnel through consultation with the EERC will be requested to conduct regularly scheduled assessments, using digital cameras, visual observations and, should conditions worsen, physical samples will be taken (for possible forensic analysis) in order to compare to baseline conditions. Assessments will be time/date marked and documented such that degradation can be determined, should it occur as a result of ACI. Any and all problems, either with the ACI system or Unit 2 operations will be noted and documented.

The EERC proposes to aid in the BOP assessment by inserting two types of metal coupons; placement of the coupons will allow a direct comparison of erosion/corrosion potential introduced by ACI. The two options for placement will be discussed with team members to decide on the preferred option: 1) upstream and downstream of the ACI location or

2) downstream of the ACI location on Unit 2 and in a comparable location on Unit 1 (the untreated unit). Previous testing using metal coupons for erosion/corrosion potential at North Dakota plants has been done over periods of time too short to note impacts; this project will allow analysis of the coupons at the end of the test period, providing a more direct measure of BOP impacts to the ESP or ductwork and may show minute changes that may not be evident in the unit until metal fatigue or failure occurs.

The EERC proposes that method samples be obtained to establish baseline mercury removals across the ESP and to evaluate mercury control with ACI over time. As proposed in Table 2, periodic OH method sampling (baseline, midterm, and conclusion of tests) will provide data to evaluate mercury speciation and control over time as well as evaluate long-term operation of the CMM. Coal and ash sampling and analysis concurrent with OH method sampling will provide data to determine the fate of mercury across the unit.

Several field studies have shown (albeit of shorter duration than that proposed here) that while treated AC may provide significant mercury removals, the BOP impacts are usually the key factor in determining whether a utility will continue to use ACI as its cost-effective mercury removal strategy (7–9). To assist in this assessment, a preliminary economic assessment that includes easy-to-quantify BOP issues related to ACI use at Poplar River will be performed. As mentioned earlier, few studies of ACI have exceeded a month in duration and, therefore, do not include BOP impacts. This project affords a perfect opportunity to consider long-term implications of using ACI as a mercury control strategy. The economic analysis proposed is intended to be rather straightforward and simple, taking into consideration factors that can be easily estimated and/or accounted for. The analysis is not intended to serve as a detailed or comprehensive economic assessment that necessitates detailed estimates and engineering study.

Large amounts of data will be generated during the course of testing. As mentioned earlier, the ACI equipment will be upgraded to allow for remote monitoring and control, except for manual start-up procedures should a shutdown be triggered by operating conditions. Remote monitoring allows both SaskPower and the EERC to view in near-real time the operations of the unit, ACI rates, emission rates (including mercury concentrations), etc. As data are being logged, they will be interfaced with a data-logging system for which the EERC and SaskPower will have access at any time. On a regular basis, researchers from both SaskPower and the EERC will review operation conditions and data. Although SaskPower personnel have gained considerable experience with ACI during Phase II activities, if problems arise with ACI, EERC researchers will either provide guidance remotely or travel to the site, as determined by the severity of issues and the amount of time spent on-site during previous weeks. If required, the EERC will also interface with NORIT Americas personnel to troubleshoot operational/data management issues with the ACI equipment. This will include any adjustments that are made to the proprietary programming for the system.

The EERC will download data, perform data reduction and analysis, and report data to sponsors in a final report. In addition, regular conference calls will be held with sponsors on at least a quarterly basis to apprise them of test conditions and results. More frequent discussions will be initiated if problems arise or decisions need to be made that impact testing. It is also anticipated that, because of the importance to the research community, the EERC and/or SaskPower personnel will attend at least three conferences where test results and data will be presented. At least one of these is assumed to be the annual DOE Review Meeting in Pittsburgh, Pennsylvania.

Expanded Sampling

Expanding the sampling campaign to meet industries needs, the EERC proposes to perform additional testing at the full scale to evaluate possible increased particulate emissions that may result from injecting quantities of AC upstream of an ESP. This is of concern to North Dakota utilities as their permits do not allow for increased particulate emissions. Further assessment is warranted, especially since several field studies have shown that ACI can directly affect the dust loading and, possibly, emissions. Some recent data suggest that ACI may slightly lower opacity; however, this is very controversial and needs further verification. This project offers an opportunity to assess ESP dust loading and emissions throughout the ACI demonstration phase. For this sampling, the EERC recommends particulate matter (PM) sampling using multicyclones, cascade impactors, filters, and other appropriate bulk collection methods. These methods will provide total dust loading (emissions), as well as size distribution of the particulate matter, where appropriate, and can be used to gauge whether PM emissions have increased or decreased. Initial sampling efforts will focus on bulk ash sampling at the ESP outlet to determine mass emissions and degree of AC penetration. As knowledge is gained on these emissions, other more sophisticated methods will be applied to obtain size-segregated samples that can be used for particulate characterization. In addition to these samples, SaskPower has newly installed opacity monitors which will provide data the EERC can use to provide a relative difference between baseline and injection conditions. However, the EERC recognizes that opacity monitors do not directly measure mass, so, as proposed, more detailed information is needed to evaluate the effect of ACI.

In addition, the EERC conducted EPA Method 29 tests on SaskPower’s ECRF under Phase II (3). Although testing was limited, the tests indicated that six trace elements were of most concern. Therefore, to further evaluate these elements, the EERC proposes to conduct M29 sampling prior to the ACI location and after the ESP (three of each). For purposes of QA/QC, sampling will also include blanks and spikes. To minimize costs, the resulting digested solutions will only be analyzed for the six trace elements that were identified earlier. These data are of interest to North Dakota and Saskatchewan utilities as they seek to understand what other trace metals may be affected by ACI.

Test Equipment

Continuous Mercury Monitor

For the full-scale effort, a CMM will be set up and operated by SaskPower personnel at the ESP outlet of Unit 2 for the duration of the project to facilitate evaluation of mercury emissions. To support testing, SaskPower will purchase, install, and operate the CMM. SaskPower has several years of experience operating CMMs; the EERC will provide suggestions and feedback regarding operation of the CMM if needed.

ACI System

The ACI skid for this project will be provided by the EERC and is a commercial-scale unit that was fabricated by NORIT Americas and includes instrumentation necessary to allow the system to follow load. The EERC purchased this system under DOE Agreement No. DE-FC26-03NT41989 and has used it to support short-term full-scale testing on various ACI tests at a number of sites.

For safety and control, a 4–20-mA signal provides feedback to the control unit and takes the system off-line should a problem occur. This prevents injection of any AC during a period when operations are outside stated parameters. If the system goes off-line, a manual restart sequence is required to ensure that the problems that caused it to go off-line have been remedied.

For example, if the signal shuts the ACI system down, a manual restart will be needed after ensuring that the operational signal has been restored. This manual start-up sequence is an important safety precaution and will not be overridden.

Prior to beginning the testing, the ACI system at SaskPower will be tied into the monitoring/data acquisition system on the ECRF to allow SaskPower and EERC personnel to monitor the system from the ECRF. The data acquisition system will be configured to allow for remote monitoring and troubleshooting by the EERC.

AC will be injected into the flue gas duct upstream of the ESP. The control panel for the AC system will be configured to allow the AC feed rate to be set and controlled proportionally to the unit load in megawatts. Multipoint calibration of the ACI will be completed on-site via measurement of weight versus time. Calibration verification will take place after setup and, at a minimum, semiannually thereafter. Should the calibration verification fall outside ±15%, the system will be recalibrated. The data collection system will record the AC system feeder screw speed for the entire test period, along with the load signal from the plant. The AC feed rate in lb/Macf will be calculated based on the feeder screw feed, calibration data correlating feeder screw speed to pounds of carbon per hour, and flue gas flow data.

Wet-Chemistry Sampling

The EERC will provide the sampling and analytical equipment needed to perform the OH method sampling. During the OH method sampling, the EERC will bring analytical equipment to SaskPower’s on-site laboratory to ensure that samples can be analyzed in a very timely manner. This is also done to ensure that the full suite of tests fall within permissible ranges.

DELIVERABLES

Project deliverables will include regular updates of progress to key team members including NDIC, EERC, DOE NETL, and SaskPower. Regular quarterly reports will be submitted to DOE and sponsors. The project will generate a lot of important data which the EERC will compile, reduce, interpret, present, and include in a final report to all sponsors. A draft report that provides comprehensive results will be submitted to sponsors for comment and review. After inclusion of these comments, a final report will be submitted to all project sponsors. Specific reporting requirements required by NDIC will also be addressed.

Another key outcome of this research is presentation of project results at the DOE NETL Project Review Meeting that is normally scheduled in Pittsburgh, Pennsylvania. The EERC will also seek other opportunities to disseminate project results as they become available.

STANDARDS OF SUCCESS

The successful outcome of this project will identify and detail the long-term BOP impacts related to ACI, allowing utilities to implement the technology with much less uncertainty. Pretest and posttest assessment of such elements as ESP components, ductwork, fans, ESP ash hoppers, and stack erosion and corrosion will allow for long-term assessment of BOP impacts. All aspects of the ESP (internal components, operational status, historical performance, etc.) will be observed/measured/compared as long-term testing progresses. Additional data will come from morphological assessment of metal coupons in the ductwork.

Successful testing will result in huge amounts of data that will be compared to unit operational data and will be subjected to QA/QC measures. These data will be shared with project personnel on a regular basis. Instrumentation is being updated to allow for remote monitoring and control by the EERC to ensure reliable performance of the ACI system, remote troubleshooting, and near-real-time access to data and plant operations. Plant operational data will be collected prior to and during ACI to allow researchers to evaluate unit operations, primarily that of the ESP (negative impacts would include increased sparking, buildup on plates, rapping frequency and effectiveness, outlet emissions, etc.). Successful project completion will also allow researchers to evaluate the ash-handling equipment and practices required for safe handling of fly ash mixed with AC.

Although it is assumed that mercury removal will be fairly consistent over the course of testing, successful completion of this project will yield long-term mercury removal as measured by CMMs, OH method wet-chemistry data, and analysis of coal and fly ash samples.

Finally, the measure of success will be to generate data (mercury removal and BOP) of sufficient duration and quality to perform a preliminary economic evaluation of long-term ACI use upstream of a full-scale ESP for mercury control. This project will be one of the very first to demonstrate long-term viability of ACI for mercury removal in a lignite-fired power plant. The proposed team of SaskPower (ALSTOM will service as SaskPower's advisor), NDIC, DOE, and the EERC has a demonstrated track record of completing projects with success, and the outcome of this project is expected to be the same.

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. North Dakota utilities through projects with the EERC and DOE have tested a number of mercury control options at full scale under short-term tests (usually a month or less). Of the mercury-control options that are near-commercial, sorbent injection, particularly of treated ACs, has shown the most promise for economical reduction of mercury emissions (10–12). However, these economics are based on short-term tests and do not include any potential long-term potential BOP impacts. Utilities have expressed with great concern that these long-term effects need to be known (and quantified) before they feel comfortable and confident in installing the technology at their plants. Consequently, to address this industrywide concern, it is critical that a long-term demonstration of the technology be carried out. This project proposes to demonstrate continuous sorbent injection of AC for over 1 year, which should be of adequate duration to discover any BOP impacts that may arise due to ACI.

QUALIFICATIONS

The project team members have considerable experience with sorbent injection projects and assessment of BOP issues. In addition, team members have all worked together in the past on a number of collaborative projects with successful outcomes.

EERC EXPERIENCE

As a former federal research facility, the EERC has over 50 years of coal research with extensive experience in low-rank coals (lignite and subbituminous). Since 1990, the EERC has conducted over 200 mercury projects, ranging from fundamental mercury chemistry projects to full-scale demonstrations of mercury control technologies. The EERC has served as the primary contractor for a number of full-scale mercury control research projects funded by DOE, many of which were cofunded and supported through a consortium that typically consists of electric utilities, industrial groups (like Electric Power Research Institute [EPRI]), engineering firms, coal companies, etc. The EERC has a good working relationship with both Canadian and U.S. utility stakeholders. Its reputation is known internationally and its research is shared globally.

Recently, work in Canada included projects with several utilities, the Canadian Electricity Association (CEA), and the Canadian Council of Ministers of the Environment (CCME). Although mercury has been the primary concern to date, the EERC continues to also focus on other related issues such as trace metals, novel sorbent developments that reduce other flue gas constituents, and by-product evaluations.

Several key documents have come out of EERC expertise, including the technical reports that were written for both CEA and CCME, which provided technical review and guidance for mercury control technologies that are potentially applicable to coal-fired electric power generation plants. The EERC is currently in the process of writing a book on mercury and the challenges it presents for the lignite industry.

The EERC Center for Air Toxic Metals® (CATM®) (www.undeerc.org/catm) focuses on critical research issues related to air toxic metals, in particular mercury. This Center of Excellence also conducts research and ensures that its data and results are distributed globally. In addition to providing key findings being considered during discussions leading to regulations/ standards both in the United States and Canada, CATM researchers are also involved in international forums to ensure that stakeholders obtain the most current information, including technical newsletters, workshops, working groups, and technical conferences such as the Air Quality Conferences (www.undeerc.org/aboutus/pastevents/conferences.asp) that have drawn international experts in mercury from around the world to present the most current research and developments regarding mercury control technologies.

The EERC is considered a leading expert in mercury measurement in coal-fired flue gas. The OH mercury speciation method (ASTM [American Society for Testing and Materials] International D6784-02) was partially developed and validated by the EERC. In fact, the method was written for ASTM by EERC personnel. For over 5 years, the EERC has actively worked with vendors of mercury continuous emission monitors (CEMs) to help them provide instruments that will effectively meet the needs of power producers and the research community. The EERC has done mercury sampling at over 50 different plants in North America during the past 10 years as part of various research programs.

Several power plants have asked the EERC to provide analytical support and QA/QC control for their programs. The EERC has extensive experience with the OH sampling method, U.S. Environmental Protection Agency (EPA) Method 29, and EPA Method 101 analysis for mercury, as well as analysis of coal, fly ash, wet flue gas desulfurization (FGD) materials, and other coal combustion by-products.

The EERC and CATM in particular are involved in ongoing analytical methods development and refinement to ensure that analytical and measurement techniques are valid, accurate, and as rapid and economical as possible. Toward this goal, the EERC participates in extensive round-robin testing and maintains a rigorous centerwide QA/QC program.

Because of the expertise gained from conducting several long-term (~1-month duration) field-scale projects, the EERC is well suited to assist SaskPower with the preparations needed to carry out a project of this magnitude. EERC researchers, together with the DOE Performance Monitor, will provide guidance to SaskPower management and operations personnel to assess the current state of the unit prior to beginning testing, coordinate the preparation of a test plan that will include necessary test conditions to meet testing objectives and address necessary preparatory measures (especially those issues that have the potential to be problematic during the course of testing), test parameters, candidate sorbents, and QA/QC. The EERC will monitor the ACI equipment remotely and will either guide SaskPower in the manual inspection and start-up procedures necessary before restarting the equipment or will be on-site to troubleshoot the conditions that caused automatic ACI shutdown procedures to be initiated. During the course of testing, the EERC will be on-site numerous times to oversee the testing as well as to perform necessary sampling.

EERC Research Experience

Mr. John Pavlish, a Senior Research Manager, will serve as the EERC Project Manager and will be responsible for the oversight of the project. Mr. Pavlish has over 20 years of experience with advanced combustion systems. He has extensive research experience in the area of mercury research and control technologies. He is currently the project manager for the Phase II work that is being completed with funding from DOE, SaskPower, and a consortium of other stakeholders, making him very familiar with the ECRF and the combustion unit proposed in this research as well as the team members who will be involved to carry out this work. Mr. Pavlish also is the Project Manager for one of DOE NETL's large-scale Phase II mercury control projects funded by DOE, TXU, and a consortium of stakeholders. He has also served as the project manager on several full-scale projects, both in the United States and in Canada. In addition to his responsibilities, Mr. Pavlish also serves as the Director for the CATM Program at the EERC, through which he oversees diverse aspects of trace metal research that include transformation mechanisms; control and analytical method assessment and development; trace metal control technology development and assessment; health effects related to trace metals; emerging issues related to trace metals; and outreach/publication of these results. His resume can be found in Appendix A.

Mr. Jeff Thompson will serve as the Principal Investigator for this project. He has worked closely with Mr. Pavlish and other senior-level researchers at the EERC to oversee the on-site field activities conducted on the ECRF as well as at a number of full-scale projects. He is very familiar with the Polar River Power Station and has led all field activities conducted through the EERC at the ECRF. As a research chemist, his experience includes over 15 years of laboratory and field activities to determine the fate and transport of mercury in the environment; management of field research activities; development and refinement of methods for trace element sampling and analysis; project planning and oversight; data management and reporting, and QA/QC of data for research projects. He has been a CATM researcher for several years as well. Mr. Thompson has been a key person at the EERC for the development and evaluation of CEMs. His analytical experience includes several techniques using a wide array of instrumentation and procedures including, but not limited to, mercury CEMs, inductively coupled argon plasma spectroscopy, ion chromatography, furnace atomic absorption, cold-vapor generation, hydride generation, atomic absorption, atomic fluorescence, and microwave digestion techniques.

SASKPOWER RESEARCH EXPERIENCE

SaskPower has been involved in mercury research with the EERC, North Dakota utilities, DOE NETL, and the Canadian government for several years to address control issues. In early 2001, it worked closely with North Dakota utilities, the EERC, and DOE NETL to develop a project to investigate various sorbent-based technologies and their effectiveness. This Phase I project included a diverse group of stakeholders to produce and test both carbon- and noncarbon-based sorbents for mercury control. Through a series of tests conducted at the EERC, the project was scaled up to include pilot-scale testing to determine the most appropriate configuration for continued testing of several sorbents that were in various stages of development. The configuration that was identified at the pilot scale was an ESP–ACI–FF configuration (known as

TOXECON®), which had very limited testing for mercury control, but was touted by many as the best alternative for mercury control, providing good AC contact with flue gas while still preserving the majority of the ash for sale. Under Phase II activities, SaskPower, with support from the Canadian government, undertook a construction process to build a slipstream unit (the ECRF) that had instrumentation and data acquisition systems that allowed the EERC to scale up the testing on actual lignite-derived flue gas, thereby filling key data gaps concerning mercury control. Their involvement has allowed several sorbents to be tested and compared against one another on Fort Union (Saskatchewan) lignite, showing relative capture. Their on-site laboratory was used to provide backup coal and ash analysis on a regular basis. A core group of SaskPower researchers has been involved on an ongoing basis, led by Dr. David Smith of SaskPower.

SaskPower Project Management

Dr. Smith is the Project Leader of Environmental Initiatives, Operations Support, with SaskPower. He leads a team of research engineers and operators to conduct several projects related to emission control and coal utilization by-product management issues. In a larger sense, he is a key liaison between SaskPower, several industrial and governmental organizations, operations, and researchers. He has worked closely with federal, provincial, and other government leaders to perform research related to mercury control to meet current and future emission regulations and standards. He has been a key manager over Phase I and II activities with the EERC and oversaw the development and construction of the ECRF. He will continue to play a key role in this proposed work. Dr. Smith will be assisted by Mr. Conway Nelson and Mr. Steve Podwin, both of whom have been involved in previous collaborative research at SaskPower.

DOE NETL RESEARCH EXPERIENCE AND INVOLVEMENT

As soon as a contract is established with DOE NETL, a project manager will be assigned. This person typically has several years of experience in mercury-related research and collaborates with project managers from the other organizations to ensure that all details of the project have been planned and executed in order to achieve success. This involvement includes review of the test plan (and test matrix) through review of the draft final report, as well as involvement with the deliverables for the project.

VALUE TO NORTH DAKOTA

Several North Dakota power utilities are considering ACI as the mercury control strategy to meet the Clean Air Mercury Rule. While lignite-fired utilities were once thought to pose the biggest challenge for mercury removal, through pursuit of technological advancements, it has since been shown that mercury removals can often exceed 80%–90% by using ACI upstream of a baghouse. Mercury removal rates are somewhat lower (60%–80%) when AC is injected upstream of an ESP, a configuration that is common to North Dakota plants. Over half of the North Dakota plants and all of the plants in Saskatchewan are equipped with ESPs. Consequently, the technology (ACI) and tests proposed are extremely valuable and applicable to North Dakota and Saskatchewan. Additionally, Poplar River burns a Fort Union lignite coal, so results should be very representative of coals burned in North Dakota plants.

If utilities rely only on large-scale short-term projects that have been conducted to date, they put their generation capacity at risk. Many North Dakota and Saskatchewan utilities have expressed concern that tests performed to date have been too short and have not been of adequate duration to address possible BOP issues that may arise should the technology be installed and operated for long periods of time. DOE, among other organizations, have documented that some tests of approximately 1–2 month, including these conducted in Phase II mentioned earlier (13–15), have shown good mercury capture, but because of early signs of BOP impacts, continued use of the technology has been brought into question. Thus it is imperative that North Dakota plants obtain long-term test information to ensure that unit operations go uninterrupted, to ensure long-term reliable ESP performance to meet emission requirements, and to minimize effects on downstream equipment and components, avoiding costly repairs. Information from this project will minimize risk and allow utilities to make more informed decisions. It is possible, of course, that lignite-fired utilities may be able to overcome problems with ACI as they unexpectedly arise. However, from an economic and reliability viewpoint, it is best that potential problems be addressed in advance, before the technology is installed throughout the industry, and before it potentially disrupts power generation.

Also, as the AC market needs increase, it may be possible that North Dakota lignites will be used as feedstock for commercial AC production. This project could provide insightful data to guide processing/manufacturing decisions to overcome BOP impacts. Additionally, as knowledge is gained, it may be possible to use other additives or enhancements that could be used to offset BOP impacts identified during this project.

Finally, it is worth noting that the topic of evaluating potential long-term BOP impact has been a concern and discussed among members of the North Dakota Mercury Task Force. This group has expressed that the need for evaluating potential long-term BOP impacts is of importance and priority. SaskPower, as a project participant in many North Dakota consortia mercury-related projects and a member of the Lignite Energy Council, has been involved in these discussions and is aware of this critical data need, and is supportive of obtaining this type of information through the proposed project. Also, ALSTOM will serve as an advisor to SaskPower.

MANAGEMENT – ROLES OF PROJECT PARTICIPANTS

The proposed team for this project includes SaskPower, which will serve as the site host at its Poplar River Station Unit 2, NDIC, DOE NETL through the EERC–DOE JSRP, and the EERC.

SaskPower

SaskPower agrees to serve as the host site for this project. Because of the long-term nature of the project and the considerable commitment of resources, SaskPower has provided a letter of commitment (Appendix B) indicating that this unit will be available during the duration of the testing. If problems should arise that would substantively change the test program or curtail testing, SaskPower will notify all sponsors immediately so that decisions can be arrived at jointly.

As the major cost to the project, SaskPower has agreed to be responsible for the purchase and delivery of the AC consumed during the proposed testing on Unit 2, which includes both nontreated and treated AC. To ensure that AC is representative of commercially available AC and to ensure that unusual problems, pluggage, and/or damage does not occur to the ACI system, testing will be limited to AC suppliers that have commercial status and a proven long-standing reputation for providing AC suitable for powdered injection.

To minimize project costs, SaskPower personnel will monitor day-to-day operation and troubleshooting of the ACI equipment, if necessary. SaskPower has gained experience with ACI during Phase II and will also be responsible for daily inspection and general maintenance of the ACI equipment, as instructed by the EERC. Daily inspection of the equipment will include a walk-down and visual inspection of the ACI skid and all transport lines, distributors, injection lances and ports, the silo, load cells, air supply, rotary valve, feeders, eductors, variable frequency drives (VFDs), blowers, or other associated equipment. General maintenance, as delineated in the operation's manual, will be performed by SaskPower to support long-term operation and to prevent problems that are the result of a lack of routine maintenance.

SaskPower has agreed to provide access, space, power, and operational support, as necessary. In addition, SaskPower will provide materials and labor for tasks in support of the project, such as providing the foundations for the ACI silo, providing two cranes for erection and dismantling of the ACI silo, providing a crane or other equipment to move test equipment and supplies, installation of injection ports to be specified, providing necessary sampling ports, ensuring that one CMM is moved to the ESP outlet of the full-scale unit at Poplar River, and siting all necessary equipment. Furthermore, SaskPower will ensure that a signal is provided to the ACI skid to provide load data and to act as a permissive signal for the system, thus the system will go off-line should the plant go off-line or operational conditions exceed preset ranges.

SaskPower will also provide the personnel necessary to perform routine coal and ash sampling. SaskPower already performs certain routine lab analyses of these samples. During the early stage of testing, SaskPower is expected to make a best effort to collect daily samples and store them appropriately for analysis. This frequency of sampling is expected to be reduced later, as agreed to by project members. In addition, SaskPower agrees to provide room to store samples for later analysis by the EERC (and DOE, if requested). The frequency of sampling and analysis, as well as storage details, will depend on the nature of testing, the stability of operation, research objectives, etc., and will be discussed and decided on during development of the detailed test plan.

A tremendous amount of operations data will be monitored, recorded, and assessed during the course of this long-term test. SaskPower will continue to provide the resources necessary for EERC researchers to obtain operational and instrumentation data. The specific operations and instrument data that will be needed will be defined during the development of the test plan. It is expected that the same data that have been provided for the ECRF will continue to be made available for the full-scale unit.

EERC

The EERC will assist in the development of the test plan which will occur in close dialogue with all partners. The EERC will facilitate the creation of this document to ensure that all testing is sufficiently planned, that resources are allocated in a timely manner, and to prepare for necessary analyses. The test plan will be distributed to all partners for approval prior to testing.

The EERC will facilitate the changes in the data acquisition and control system to enable remote monitoring and near-real-time viewing of operational data and mercury removal rates. This will entail working with NORIT, the manufacturer of the ACI skid, to ensure that the code is updated. It is understood by all parties that reprogramming the code of the ACI skid nullifies the warranty; further, the code is proprietary. That said, it should also be mentioned that NORIT has been extremely responsive and has ensured that all tests to date have been sufficiently supported, including the reprogramming of the programmable logic controller.

The EERC will assist SaskPower with on-site assistance to prepare for the testing. This will include the technical information necessary to site the equipment, engineering specs for the equipment pad, specifications for the ductwork and wiring changes, and technical information to ensure that all monitoring systems are prepared for the tests.

During the start of the test, the EERC will be on-site to perform wet-chemistry tests and to ensure that the ACI tests are progressing as planned, as well as to assist with troubleshooting that will be needed during testing. The EERC will return to the site two to three times periodically throughout the test duration, presumably near midterm and at the end of the test. The EERC will perform all OH method tests, assist in coupon placement and analysis, and be on-site during some of the BOP assessments. The EERC will perform limited independent coal and ash analysis on samples collected during OH sampling. These will serve to compare and validate analyses performed and provided by SaskPower.

The EERC will compile, reduce, and interpret data and provide results in the form of a report.

DOE

DOE will assign a performance monitor who will be involved in the discussions and plans related to this project, as well as ongoing evaluation of the test results. This involvement will include finalizing details for the test plan, participation in regular conference calls to update the team on project progress, and receiving and reviewing regular reports. It is possible that the DOE performance monitor may choose to conduct a site visit to SaskPower during the course of testing. SaskPower agrees to accommodate them as part of the team, with written prior notice. It is also expected, as part of this agreement, that DOE will require participation in an annual DOE Review Meeting in Pittsburgh, Pennsylvania.

NDIC

NDIC will assign a performance monitor who will be involved in the discussions and plans related to this project, as well as ongoing evaluation of the test results. This involvement will include finalizing details for the test plan, participation in regular conference calls to update the team on project progress, and receiving and reviewing regular reports. It is possible that the

NDIC representative may choose to conduct a site visit to SaskPower during the course of testing. SaskPower agrees to accommodate them as part of the team, with written prior notice.

TIMETABLE

The project is proposed for approximately a 13-month period of performance to meet the contractual end date of the EERC–DOE JSRP agreement. Approximately 12 months will be dedicated toward full-scale testing using a commercial-scale system to deliver AC upstream of the ESP at Poplar River Unit 2; it is fully anticipated that an extension for this project will be requested to allow for reporting. All activities for Phase I were completed within budget, and all reporting is complete. A final report for Phase II activities is in publication (7–9). Table 3 shows the projected schedule of activities that will be performed for this project under Phase III.

BUDGET

The total cost of completing this project is estimated at approximately $5,000,000, most of which is not addressed in this request. The bulk of the funding (over $4,000,000) is associated with acting as host facility, purchasing the AC, and providing support staff for the research project, and will be provided directly by SaskPower. SaskPower has agreed to bear the cost of setting up the AC silo (silo foundation, ductwork, air and power requirements, etc.) as directed by EERC research staff. In addition, the cost of the AC, installation and operation of a CMM for the duration of the project, personnel to do the coal and ash sampling and routine BOP examinations of the unit, and routine coal and ash analyses will be funded directly by SaskPower. The cost for the EERC to support sampling, analytical, engineering, setup, data reduction, reporting, etc., proposed herein amounts to $902,604, which is delineated in the attached EERC budget and budget notes.

Table 3. Proposed Project Time Line

Project Activity	Period of Activity
Preparations for ACI Testing at Full Scale, Including Changes to the Data Acquisition and Control System, Instrumentation, Plant Preparations, Foundations, etc.	March 2007–May 2007
Parametric Testing at Full Scale	March–May 2007
Baseline Testing at Full Scale[1]	June 2007
ACI at Full Scale with Continued Monitoring[2]	May 2007–(March) 2008[3]
Data Reduction, QA/QC, Analysis	May 2007–(March) 2008
Reporting and Management	May 2007–(March) 2008

[1] After spring 2007 planned outage.
[2] Some short-term parametric tests may be done throughout to revalidate test results. Note, fall outage planned for in October. Baseline and parametric may be performed for short duration.
[3] The contractual end date of the EERC–DOE JSRP is March 31, 2008, but it is expected that an extension will be sought. It is expected that the contract for this project will be modified to include an extension and/or a change in the accompanying statement of work (and final end date).

MATCHING FUNDS

This request covers the research and testing aspects specifically addressed in this proposal. The EERC's effort to support activities of this project is estimated to be approximately $902,604, of which the EERC has requested that $270,703 be provided through the EERC–DOE JSRP. Of the remaining amount of $631,901, the EERC requests that NDIC provide $300,000, with SaskPower providing the remaining $331,901, and the other costs (estimated at over $4,000,000, with CAN$900,000 provided through SDTC) related to serving as a host site, as previously mentioned. As part of the NDIC request, the EERC requires that the first $200,000 of NDIC funding go toward funding the base project, which is proposed (see above Table 3) with minimal sampling necessary to adequately evaluate long-term BOP impacts. An additional $100,000 (for a total of $300,000) is being requested from the NDIC to support an expanded set of sampling activities related to particulate and trace element analysis (introduced in Table 3 and discussed separately in the section titled Expanded Sampling).

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.

CONFIDENTIAL MATTER

There is no confidential matter contained in this proposal. In the course of testing various sorbents, confidential information may be discussed and information shared. In addition, certain matters pertaining to SaskPower's business practices and other information will be kept confidential, as outlined in a separate confidentiality agreement between SaskPower and the EERC; it is understood that DOE and NDIC will expect that data related to the project, as well as contextual operational and plant information, will be provided, and made public with the report. It is not expected that development of any intellectual property will result from this project.

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PHASE III - MERCURY CONTROL TECHNOLOGIES FOR UTILITIES BURNING LIGNITE COAL: LONG-TERM EFFECTS OF ACTIVATED CARBON INJECTION
SASKPOWER CORP./US DEPARTMENT OF ENERGY/NORTH DAKOTA INDUSTRIAL COMMISSION
PROPOSED PROJECT START DATE: 6/1/2007
EERC PROPOSAL #2007-0227

BUDGET

	TOTAL		SASKPOWER SHARE		NDIC TOTAL		EERC JSRP SHARE	
CATEGORY	**HRS**	**$COST**	**HRS**	**$COST**	**HRS**	**$COST**	**HRS**	**$COST**
TOTAL DIRECT LABOR	6,737	$ 248,563	2,658	$ 95,225	2,053	$ 73,002	2,026	$ 80,336
FRINGE BENEFITS		$ 126,766		$ 48,565		$ 37,231		$ 40,970
TOTAL LABOR		$ 375,329		$ 143,790		$ 110,233		$ 121,306
OTHER DIRECT COSTS								
TRAVEL		$ 58,760		$ 26,430		$ 21,686		$ 10,644
SUPPLIES		$ 68,407		$ 24,620		$ 20,638		$ 23,149
FEES		$ 50,689		$ 5,525		$ 27,775		$ 17,389
COMMUNICATION - PHONES & POSTAGE		$ 2,677		$ 829		$ 880		$ 968
OFFICE (PROJECT SPECIFIC SUPPLIES)		$ 4,395		$ 1,552		$ 1,520		$ 1,323
GENERAL (FREIGHT)		$ 28,086		$ 10,011		$ 9,575		$ 8,500
TOTAL OTHER DIRECT COST		$ 213,014		$ 68,967		$ 82,074		$ 61,973
TOTAL DIRECT COST		$ 588,343		$ 212,757		$ 192,307		$ 183,279
FACILITIES & ADMIN. RATE - % OF MTDC	VAR	$ 314,261	56.0%	$ 119,144	56.0%	$ 107,693	47.7%	$ 87,424
TOTAL PROJECT COST - US DOLLARS		$ 902,604		$ 331,901		$ 300,000		$ 270,703

BUDGET NOTES

ENERGY & ENVIRONMENTAL RESEARCH CENTER (EERC)

Background

The EERC is an independently organized multidisciplinary research center within the University of North Dakota (UND). The EERC receives no appropriated funding from the state of North Dakota and is funded through federal and nonfederal grants, contracts, or other agreements. Although the EERC is not affiliated with any one academic department, university academic faculty may participate in a project, depending on the scope of work and expertise required to perform the project.

The proposed work will be done on a cost-reimbursable basis. The distribution of costs between budget categories (labor, travel, supplies, equipment, subcontracts) is for planning purposes only. The principal investigator may, as dictated by the needs of the work, reallocate the budget among approved items or use the funds for other items directly related to the project, subject only to staying within the total dollars authorized for the overall program. Escalation of labor and EERC fee rates is incorporated in the budget when a project's duration extends beyond the current fiscal year. Escalation is calculated by prorating an average annual increase over the anticipated life of the project. The current escalation rate of 5% is based on historical averages. The budget prepared for this proposal is based on a specific start date; this start date is indicated at the top of the EERC budget or identified in the body of the proposal. Please be aware that any delay in the start of this project may result in an increase in the budget.

Intellectual Property

If federal funding is proposed as part of this project the applicable federal intellectual property (IP) regulations may govern any resulting research agreement. In addition, in the event that IP with the potential to generate revenue to which the EERC is entitled is developed under this agreement, such IP, including rights, title, interest, and obligations, may be transferred to the EERC Foundation, a separate legal entity.

Salaries and Fringe Benefits

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

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

Travel

Travel is estimated on the basis of UND travel policies which can be found at www.und.edu/dept/accounts/employeetravel.html. Estimates include General Services Administration (GSA) daily meal rates. Travel includes scheduled meetings and conference participation as indicated in the scope of work.

Communications (phones and postage)

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

Office (project-specific supplies)

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

Data Processing

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

Supplies

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

Instructional/Research

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

Fees

Laboratory, analytical, graphics, and shop/operation fees are established and approved at the beginning of the university's fiscal year.

Laboratory and analytical fees are charged on a per sample, hourly, or daily rate, depending on the analytical services performed. Additionally, laboratory analyses may be performed outside the University when necessary.

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

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

General

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

Membership fees (if included) are for memberships in technical areas directly related to work on this project. Technical journals and newsletters received as a result of a membership are used throughout development and execution of the project as well as by the research team directly involved in project activity.

General expenditures for project meetings, workshops, and conferences where the primary purpose is dissemination of technical information may include costs of food (some of which may exceed the institutional limit), transportation, rental of facilities, and other items incidental to such meetings or conferences.

Facilities and Administrative Cost

The facilities and administrative rate (indirect cost rate) included in this proposal is the rate that became effective July 1, 2006. Facilities and administrative cost is calculated on modified total direct costs (MTDC). MTDC is defined as total direct costs less individual items of equipment in excess of $5000 and subcontracts/subgrants in excess of the first $25,000 for each award.

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

JEFFREY S. THOMPSON
Research Scientist
Energy & Environmental Research Center (EERC)
University of North Dakota (UND)
15 North 23rd Street, Stop 9018
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Phone (701) 777-5000, Fax (701) 777-5181
E-Mail: jthompson@undeerc.org

Principal Areas of Expertise

Mr. Thompson's research experience includes 15 years of laboratory and field activities to determine the fate and transport of mercury in the environment; on-site management of field activities related to mercury sampling and demonstration of mercury control technologies; development and refinement of methods for sampling and analysis of trace elements associated with coal combustion processes to support several air toxics research projects; planning, oversight, data reduction and quality assurance/quality control (QA/QC) of data for field research; field sampling of mercury speciation at coal-fired power plants for emissions monitoring and the evaluation of control strategies; and development and evaluation of mercury continuous emission monitors (CEMs) for emissions monitoring at coal-fired utilities. Previous experience also included the development of the enhanced ettringite formation process (EEFP, patent received), a precipitation process for the remediation of hazardous oxyanions; and determination of sediment–water–contaminant interactions to understand the fate and transport of monoethanolamine in the subsurface. Analytical experience includes several techniques using a wide array of instrumentation and procedures including, but not limited to, mercury CEMs, inductively coupled argon plasma spectroscopy, ion chromatography, furnace atomic absorption, cold-vapor generation, hydride generation, atomic absorption, atomic fluorescence, and microwave digestion techniques.

Qualifications

B.S., Chemistry (with Geochemistry option), North Dakota State University, 1989.

Professional Experience

1996 – Research Scientist, EERC, UND. Mr. Thompson's responsibilities include writing proposals to solicit research funding; task management for research projects including planning, oversight, and data reduction and QA/QC activities; on-site management of mercury sampling and control demonstration activities; operation, development, and oversight of Hg CEM field operations; writing reports; and providing technical expertise.

1990 – 1996 Chemist II, EERC, UND. Mr. Thompson's responsibilities included analytical analysis, development of analytical protocols, performing research for various projects, writing reports, and providing technical expertise to project managers.

1986 – 1990 Window Builder, Consolidated Building Supply, Inc., Fargo, North Dakota. Mr. Thompson's responsibilities included building windows, doors, and patio doors with a specialty in bow and bay window construction.

1987 – 1988 Solid-State Chemical Analyst, North Dakota State University, Fargo, North Dakota. Mr. Thompson's responsibilities included analyzing solid unknowns using x-ray fluorescence and x-ray diffraction to determine composition for proper disposal.

1985 Analytical Chemist, General Nutrition Mills, Fargo, North Dakota. Mr. Thompson's responsibilities included operating AA, Polarograph, and automated high-performance liquid chromatograph (HPLC), as well as standard laboratory equipment, as part of tablet and food analysis for quality control.

Publications and Presentations

- Has coauthored numerous publications

APPENDIX B

INDUSTRY PARTICIPANT INFORMATION

SaskPower

Power Production Business Unit
9C – 2025 Victoria Avenue
Regina, Saskatchewan
Canada S4P 0S1
Phone (306) 566-2067
Fax (306) 566-3312

February 15, 2007

Mr. John H. Pavlish
Senior Research Advisor
Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Mailstop 9018
Grand Forks, ND 58202-9018

Dear Mr. Pavlish:

Letter of Interest and Commitment for "Full-Scale Evaluation of Long-Term Balance-of-Plant Effects Resulting from Activated Carbon Injection" at SaskPower's Poplar River Power Station

SaskPower is providing this letter of commitment for EERC's involvement in the full-scale activated carbon injection project at SaskPower's Poplar River Power Station Unit 2 through the project noted above.

This unit combusts the same coal as that tested in Phase II activities at the Emissions Control Research Facility, which tested activated carbon injection into a slipstream fabric filter downstream of Poplar River's ESPs. It is now appropriate to test activated carbon injection on an electrostatic precipitator-only configuration at the full-scale to evaluate long-term mercury removal and balance-of-plant impacts.

SaskPower is willing to commit to this project by providing Poplar River Power Station, Unit 2, as a host site as well as to providing support staff to assist in project-related activities. SaskPower will make the site accessible to immediate project team members and, with advance warning, to the DOE performance monitor during the course of testing. Site visits of other participants or interested parties will be arranged in advance as needed and agreed upon jointly by SaskPower and the EERC.

SaskPower understands that the value of this project is approximately US$802,000 with the U. S. Department of Energy providing approximately US$270,000 through the EERC-DOE Jointly Sponsored Research Program and a consortium of other sponsors providing the remaining approximately US$532,000. SaskPower also understands that EERC is actively seeking other sponsorship support. In order to ensure that this important work proceeds as quickly as possible, SaskPower is prepared to commit approximately US$532,000 toward support of this project on the condition that a research agreement can be reached that is acceptable to all concerned. It is understood that SaskPower's financial support may be reduced if EERC's efforts to secure funding from other sponsors are successful. In the unlikely event that the U.S. Department of

Energy does not co-fund this project for approximately US$270,000 through the EERC-DOE Jointly Sponsored Research Program, SaskPower will work with EERC to determine an appropriate scope of work with the resources available.

To demonstrate a good faith commitment to this project and to fund equipment, transportation and start-up costs, SaskPower agrees to provide an upfront installment of US$100,000.

SaskPower
APPROVED FOR
EXECUTION

Yours truly,

SASKATCHEWAN POWER CORPORATION

Garner Mitchell
Vice-President, Power Production

Myron Gulka-Tiechko
Assistant Secretary

c: Dave Smith, Operations Support, 2901 Powerhouse Drive, Regina
Conway Nelson, Engineering Services, 9SE, Regina