Energy & Environmental Research Center

MERCURY CONTROL TECHNOLOGIES FOR ELECTRIC UTILITIES BURNING LIGNITE COALS – PHASE II, FIELD TESTING OF SLIPSTREAM TECHNOLOGY

EERC Proposal No. 2003-0122

Submitted to:

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Amount of Request: $200,000

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March 2003

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ABSTRACT

Approximately 1 year ago, the Energy & Environmental Research Center (EERC) proposed a 3-year, two-phase consortium project to develop and demonstrate mercury control technologies for utilities that burn lignite coal. The overall intent of this project is to help maintain the viability of lignite-fired energy production by providing local utilities with lower-cost options for meeting future mercury regulations. Phase I of the project is well under way, with all major tests and objectives completed. The main thrust under Phase I was to search a range of sorbent-based technologies targeted at removal of Hg^0 from flue gases. Based on preliminary results, two technologies appear to show promise: a fabric filter or the EERC's *Advanced Hybrid*™ filter coupled with sorbent injection. Based on results from Phase I, SaskPower has selected sorbent injection coupled with a fabric filter technology option, a technology patented by EPRI referred to as TOXECON™. Consequently, efforts proposed under Phase II will demonstrate and quantify the effectiveness, performance, and cost of this technology option at the Poplar River Power Station, which is owned and operated by SaskPower.

Total cost for Phase II is expected to range from approximately US$3,000,000–$5,000,000. SaskPower and Environment Canada will directly fund a bulk of the work by funding all design and installation of equipment associated with the slipstream technology. Funding needed to support activities related to test and evaluate the technology is proposed as part of this Phase II proposal. The amount requested by the EERC to conduct these technology performance tests is $1,110,000. Specifically, Phase II funding of $200,000 is requested from the North Dakota Industrial Commission, with matching funds of $200,000 ($100,000 each) from Saskatchewan Power and Environment Canada, sorbent material provided as in-kind from Luscar Ltd., (estimated value $100,000), $260,000 total from North Dakota utilities, and EPRI, and $440,000 through the EERC–U.S. Department of Energy Jointly Sponsored Research Program, for a total of $1,100,000. Phase II activities are expected to be completed within 1½ to 2 years, with construction activities completed within 6 to 12 months and field tests completed in the following 6 to 9 months.

MERCURY CONTROL TECHNOLOGIES FOR ELECTRIC UTILITIES BURNING LIGNITE COALS – PHASE II, FIELD TESTING OF SLIPSTREAM TECHNOLOGY

PROJECT SUMMARY

The Energy & Environmental Research Center (EERC) is proposing a practically oriented, applied research consortium project that will focus on developing cost-effective mercury control technologies for utilities burning lignite coals. Based on health, emissions, and scientific data, the U.S. Environmental Protection Agency (EPA) and the Canadian Council of the Ministries of Environment (CCME) have determined that mercury from utility power plant emissions should be reduced. In the United States, mercury regulations by EPA are scheduled for promulgation by 2004, and full compliance is expected by 2007. Other initiatives such as the Clear Skies Act have proposed compliance dates of 2010. Power plants in the United States and Canada burning lignite coals have demonstrated higher elemental mercury emissions (Hg^0) compared to plants burning bituminous coals. This form of mercury has proven to be much more difficult to remove than oxidized forms and will require an innovative approach.

Approximately 1 year ago, the EERC proposed a 3-year, two-phase consortium project to develop and demonstrate mercury control technologies for utilities that burn lignite coal. The overall intent of this project is to help maintain the viability of lignite-fired energy production by providing local utilities with lower-cost options for meeting future mercury regulations. Phase I of the project is well under way, with all major tests and objectives completed. The main thrust under Phase I was to develop a better understanding of mercury interactions with flue gas constituents, test a range of sorbent-based technologies targeted at removal of Hg^0 from flue gases, and demonstrate the effectiveness of the most promising technologies at the pilot scale. Based on preliminary results, two technologies appear to show promise: a fabric filter or EERC's

Advanced Hybrid™ filter coupled with sorbent injection. Based on results from Phase I, SaskPower has selected sorbent injection coupled with a fabric filter technology option, a technology patented by EPRI referred to as TOXECON™. Activities proposed under Phase II will continue to demonstrate and quantify the effectiveness, performance, and cost of this technology option at the Poplar River Power Station, which is owned and operated by SaskPower. SaskPower will take responsibility for design and installation of the slipstream technology and serve as host site for technology demonstration tests as described within this proposal. A detailed test plan to evaluate the technology's ability to remove mercury from lignite flue gases will be developed, reviewed, and agreed on by all project sponsors before tests are initiated.

PROJECT DESCRIPTION

Background

Mercury is an immediate concern for the U.S. electric power industry because of EPA's December 2000 decision that regulation of mercury from coal-fired electric utility steam-generating units is appropriate and necessary under Section 112 of the Clean Air Act. After extensive study, EPA determined that mercury emissions from power plants pose significant hazards to public health and must be reduced. The EPA *Mercury Study Report to Congress* (1997) (1) and the *Utility Hazardous Air Pollutant Report to Congress* (1998) (2) both identified coal-fired boilers as the largest single category of atmospheric mercury emissions in the United States, accounting for about one-third of the total anthropogenic emissions. EPA is scheduled to propose regulations by December 2003 and promulgate them by December 2004, with full compliance expected by December 2007. The exact form of regulation is uncertain at this time.

While EPA is pursuing development of a regulation based on a maximum achievable control technology approach (3), Congress and the Bush Administration are proposing multipollutant 3P (SO_x, NO_x, and Hg) approaches (4–6). Recently, July 2002, the Clear Skies Act of 2002 was introduced into the Senate and House of Representatives (5–6). A more recent version was reintroduced in 2003. While utilities strive to have regulations that offer flexibility, each approach certainly has advantages and disadvantages with regard to utility implementation (7). In the end, regardless of the approach taken, it is clear that mercury reductions are expected to be in the range of 50%–90% by 2007 or 2010.

Similarly, Canada has established a consultative process to develop "Canadawide standards" for mercury emissions from coal-fired electricity generation. A process is well under way to evaluate and discuss, in conjunction with a multistakeholder advisory group, options for achieving cost-effective reductions in mercury emissions. The intent is to have a draft standard for review by CCME from all Canadian jurisdictions available for public and government review and finalized in 2003. The most common discussion points for this standard are to achieve significant (>50%) emissions reductions by 2010, with a review in 2005 to address the emerging science in the United States and elsewhere on mercury control. The emission reductions are likely to be achieved by controlling emissions based on coal mercury concentrations rather than directly from some baseline emission rate. The question of controlling mercury emissions from lignite is particularly important in Canada, as about 30% of the mercury emitted from this sector in Canada is derived from Saskatchewan lignite. Standards within Canada are likely to be in the 50%–90% range as stated earlier, with an emphasis toward 90%, if achievable.

Mercury Is a Health Concern

Mercury is a neurological toxin that can cause impairment of mental, sensory, and motor functions to humans, particularly to developing fetuses and children. A congressionally mandated reassessment of the toxicological effects of mercury issued by the U.S. National Research Council (8) in August 2000 reaffirmed EPA's low mercury exposure reference dose of 0.1 μg/kg per day as the scientifically justifiable level for the protection of childbearing women, based on quantifiable findings for low-dose exposure in a large study population in the Faroe Islands. Prompted by these health concerns, mercury is the chemical contaminant responsible, at least in part, for the issuance of approximately 2000 fish consumption advisories. Almost 68% of all advisories issued in the United States are a result of mercury contamination in fish and shellfish. Freshwater lake advisories have more than doubled in the last 5 years, resulting in over 40 states that have issued fish advisories because of mercury. Some states such as Wisconsin have issued statewide advisories. Additionally, the U.S. Food and Drug Administration recently issued an advisory limiting consumption of certain ocean fish. In the northern and eastern parts of Canada, extensive and stringent advisories against eating the fish are issued.

Mercury Emissions from Lignite Coals May Be More Difficult to Control

In general, lignite coals contain comparable levels of mercury but significantly lower levels of chlorine compared to bituminous coals. Lignites typically have chlorine concentrations of less than 200 ppm in the coal, whereas bituminous coals typically have chlorine levels in excess of 1000 ppm. Lignite coals are also distinguished by their much higher calcium contents. These differences in analysis have been shown to have important effects on the quantity and form of mercury emitted from a boiler and on the capabilities of different control technologies to remove mercury from flue gas. The high Cl content that is characteristic of many bituminous coals has consistently been shown to increase the fraction of the more easily removable oxidized form of mercury in the total mercury emission. Conversely, experimental results indicate that low-chlorine coals predominantly form Hg^0 which is substantially more difficult to remove than oxidized mercury (Hg^{2+}). Additionally, the high Ca content generally found in lignite coal appears to further reduce the oxidizing effect of the already low Cl content by removing part of the Cl throughout the combustion process.

A few years ago, the EERC spearheaded a project that evaluated mercury emissions and potential controls for several North Dakota lignites (9). Results from this project confirm that most of the mercury is emitted in the elemental form. Additionally, two Canadian utilities (Ontario Power Generation and SaskPower) that use lignite have performed tests which consistently show that mercury is emitted primarily in the elemental form. Changes in mercury speciation and removal measured across different pollution control devices have been correlated with fuel properties in two papers presented at the September 2000 Air Quality II Conference organized by the Center for Air Toxic Metals (CATM) at the EERC (10, 11). Mercury removals were consistently lower for low-chlorine coals.

Very little published data demonstrate how effective sorbent-based technologies will work for plants that fire lignite coal. That is the primary reason for the testing that was performed under Phase I of this project. Based on preliminary results, in comparison to field test data for other coals, it appears that controlling mercury may be more challenging and costly (12). Results from Phase I (Figures 1 and 2) show that mercury emissions from lignites can vary widely and are mainly in the elemental form, which is consistent with that measured previously at plants in

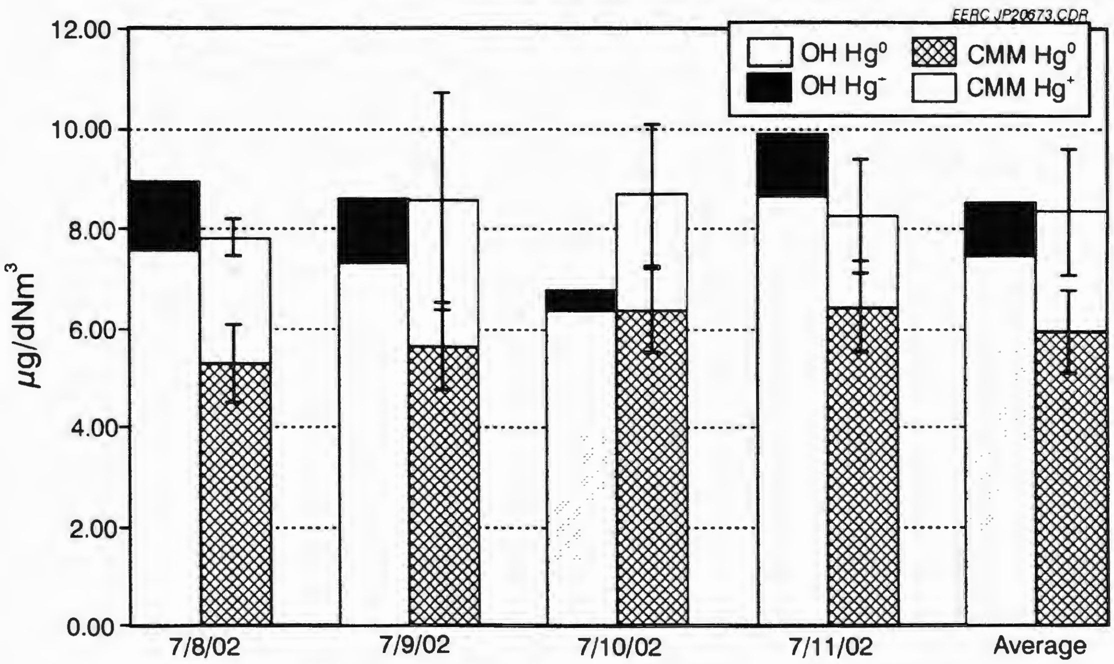

Figure 1. Inlet mercury speciation for Freedom coal ($\mu g/dNm^3$ = microgram per dry normal cubic meter [corrected to 0°C and 3% O_2]).

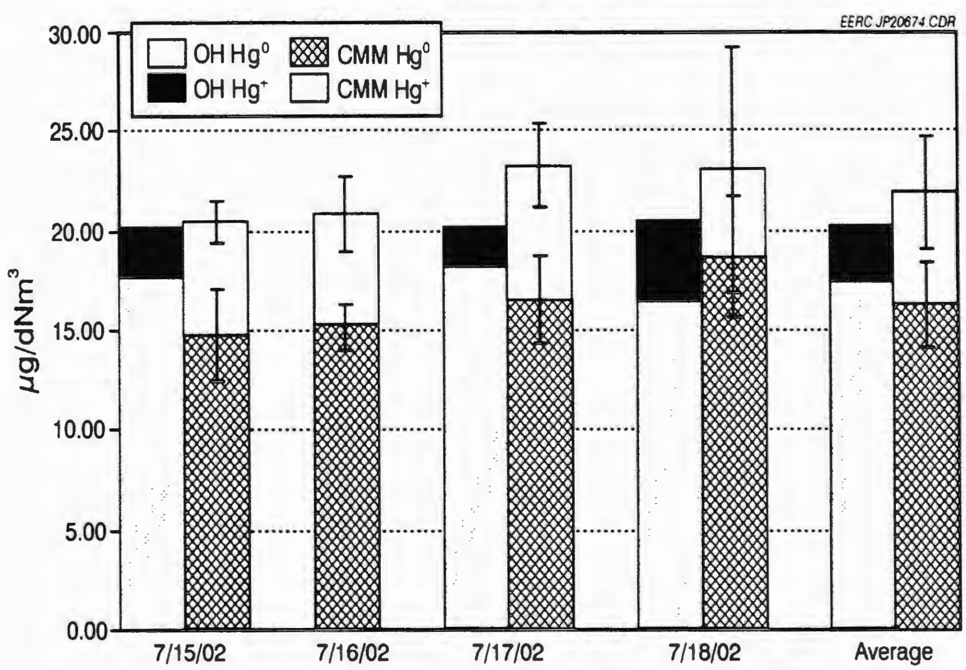

Figure 2. Inlet mercury speciation for Poplar River coal ($\mu g/dNm^3$ = microgram per dry normal cubic meter [corrected to 0°C and 3% O_2]).

Saskatchewan and North Dakota. Based on pilot-scale tests performed under Phase I, it appears that it may be difficult to achieve a high degree of mercury reduction without injecting sorbent at a rather high rate. Figures 3 and 4 show a comparison between injection rates for lignite (based on pilot-scale results) and the other plants that burn bituminous and subbituminous coal. As can be seen from these figures, the injection rate needed to achieve the same level of control compared to the plant with the COHPAC (compact hybrid particulate collector) is on the order of 3–5 times more. Testing activities proposed under Phase II will confirm at full scale the actual injection rates needed to reduce mercury emission levels to target levels and estimate the associated costs with implementing the technology.

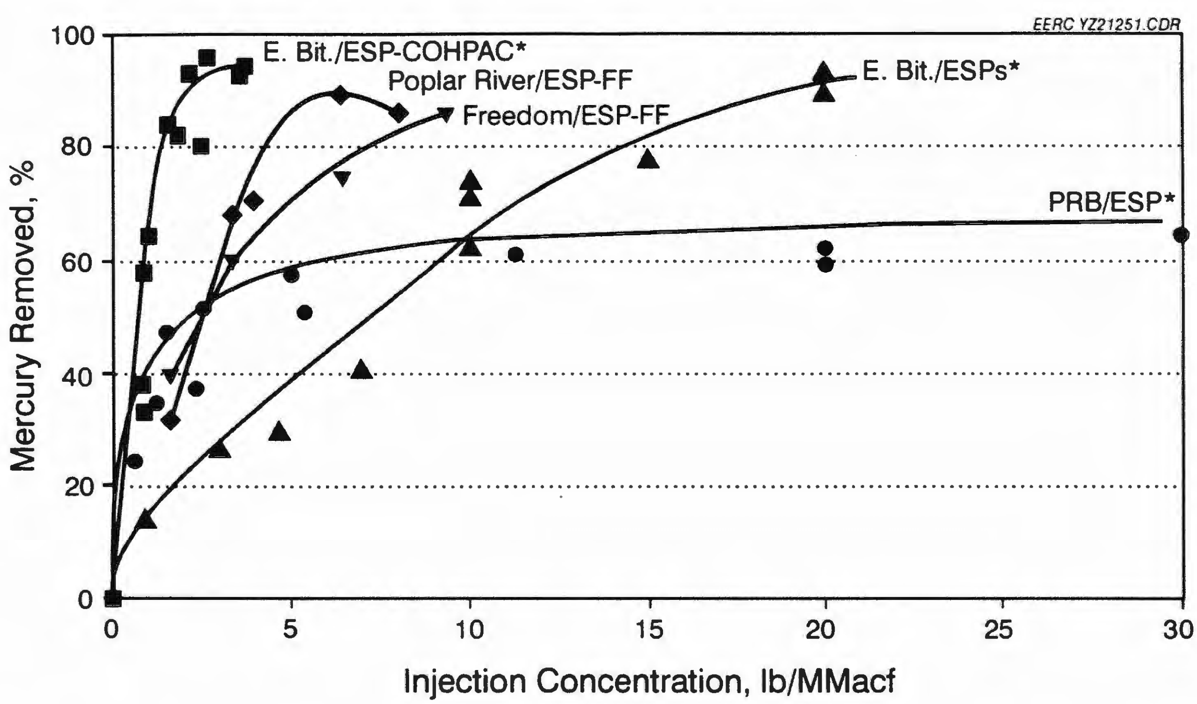

Figure 3. Pilot-scale electrostatic precipitator (ESP)–fabric filter and full-scale COHPAC (compact hybrid particulate collector) and ESP mercury removal efficiencies as a function of activated carbon injection rate (*data from the U.S. Department of Energy [DOE]).

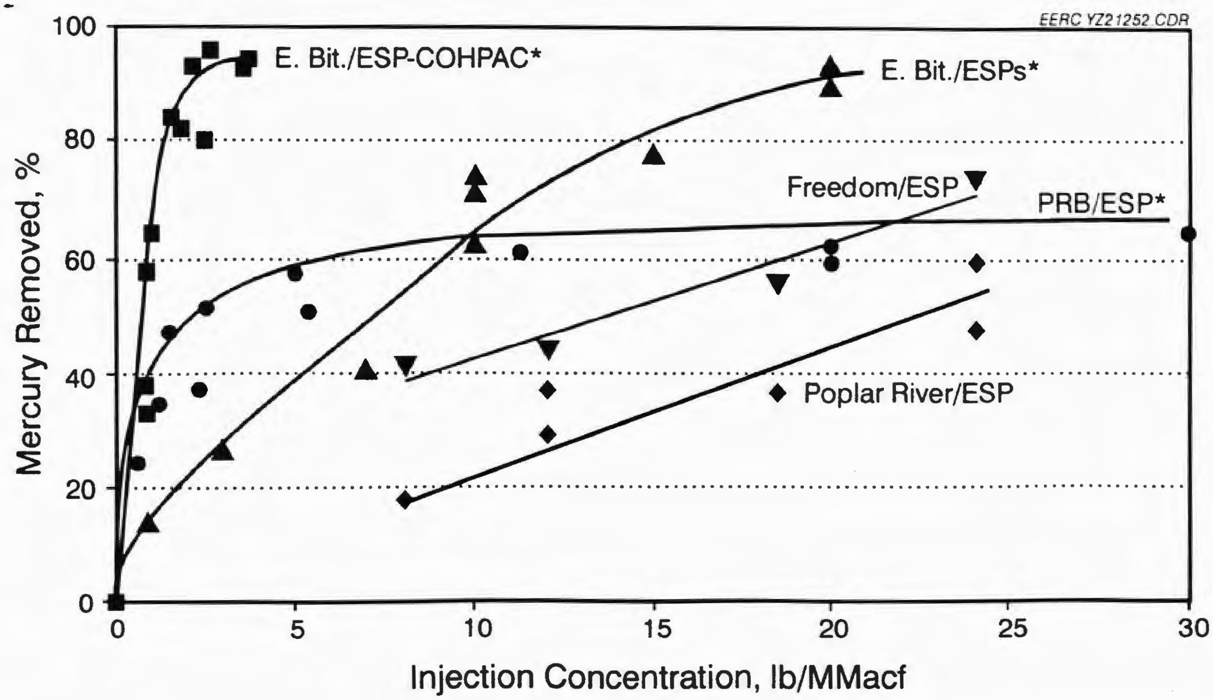

Figure 4. Pilot-scale ESP and full-scale COHPAC and ESP mercury removal efficiencies as a function of activated carbon injection rate (*data from DOE).

OBJECTIVES

The EERC is proposing to continue efforts performed under Phase I to further develop, test, and demonstrate the most effective sorbent-based technologies to control mercury emissions from power plants firing lignite coals. Specific objectives of Phase II of the project include:

- Continue to develop an improved scientific understanding of mercury interactions with flue gas constituents and sorbent-based technologies specifically for lignite-fired systems.
- Design slipstream technology and field-test plan based on Phase I results.
- Design, construct, and install the selected technology at the appropriate scale at the Poplar River Power Station located near Coronach, Saskatchewan.
- Examine effect of critical design and process parameters on mercury capture by performing parametric tests.

- Test the selected technology's ability to capture mercury using various sorbents, injection rates, and short-to-long test periods.
- Vary injection rates to achieve a mercury removal of 50%–90%.
- Monitor mercury emissions over long periods of time to determine technology effectiveness and identify operational problems.
- Quantify the effectiveness, performance, and cost of the selected technology.
- Estimate operating and capital cost for full-scale installation.

APPROACH/WORK PLAN

The proposed project will focus on field testing and demonstration of a sorbent-based technology for mercury control at an electrical power plant firing lignite coal. Pilot-scale data generated under Phase I of this project suggest that mercury emissions can be reduced by injecting a sorbent upstream of a particulate control device. Furthermore, these data also suggest that injecting upstream of an ESP will require a significant amount of activated carbon in order to achieve substantial reduction levels. Alternatively, injecting upstream of a fabric filter device appears to be most effective with regard to expected mercury reductions and minimal use of sorbent material (12).

Based on interest expressed by project sponsors, the work plan for Phase II focuses primarily on the further development, testing, and demonstration of a sorbent-based technology. The two most promising technologies based on Phase I results appear to be injecting downstream of an ESP and upstream of either the EERC's patented *Advanced Hybrid*™ filter or a fabric filter. Injecting a sorbent downstream of an ESP and upstream of a fabric filter is an EPRI-patented technology referred to as TOXECON™. After further review and consideration of each technology, SaskPower has selected the TOXECON™ technology option. The proposed installation site for demonstration of this technology is the Poplar River Power Plant (Figure 5), owned and operated by SaskPower.

The following provides more detailed discussion of the scope of work proposed for Phase II of the project. The details of this scope are subject to change based on input from the consortium members.

Task 1 – Design and Install Slipstream Technology

Work under this task will focus on assembling and providing the information needed to assist in the design of the 1–10-MW slipstream TOXECON™ technology that will be constructed and demonstrated at the Poplar River Plant. Much of the data that are needed has already been generated under Phase I of the project; however, additional data needs are required

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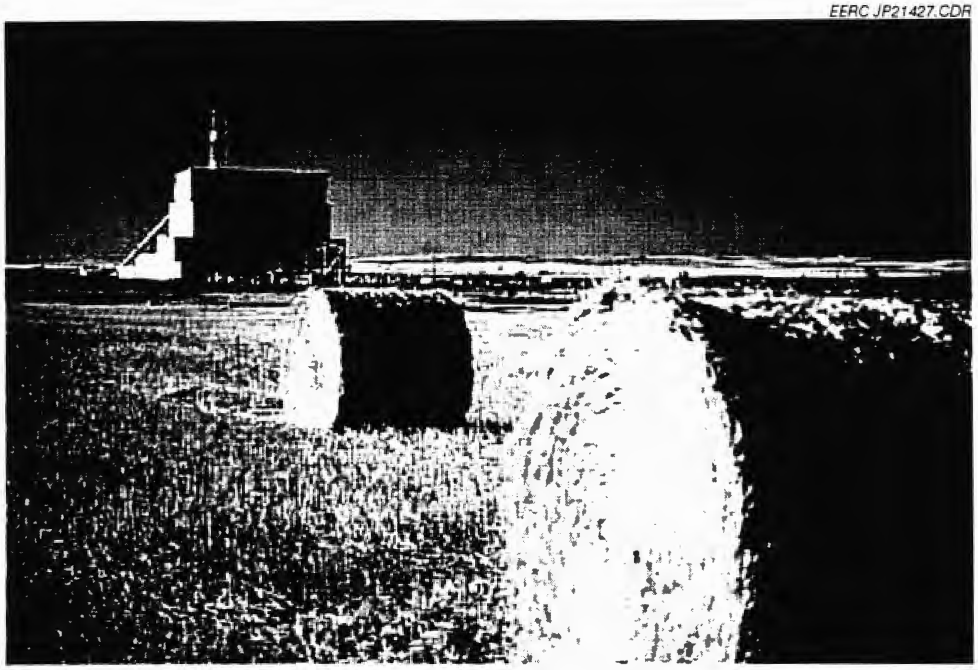

Figure 5. Poplar River Station.

as the final design of the technology moves forward. The EERC proposes to work with the project sponsors, in particular SaskPower, in providing these additional data and addressing design issues as they arise. Additional support that the EERC proposes to provide is as follows:

- Assist in design by providing more specific design information and criteria on the selected technology, as requested by SaskPower.
- Identify and collect test data from other similar tests conducted outside of this project, if available. Assess applicability of data to this project.
- Identify and gather data on number of existing installations and operating experience.
- Identify availability of technology suppliers and design support/assistance.
- Assist in providing review of design and cost estimates of technology and supporting equipment.
- Provide additional bench- and pilot-scale test data targeted at providing specific data needs. Two weeks of testing are budgeted. Specific tests will be discussed and decided on by consensus of all project sponsors.

The EERC will work with SaskPower, EPRI, and other organizations like Alstom to ensure adequate consideration is given to specific design criteria applicable to the selected technology. The final design, construction, and installation of the technology will be the responsibility of SaskPower. Thus the EERC further assumes and SaskPower agrees, under separate contract, to hire appropriate design and construction firms to properly install the selected technology. Note: it is likely that Alstom will be responsible for installation of the fabric filter system. The EERC will be involved throughout the design and installation process to address specific questions or fill data needs as they arise. As part of this effort and task, the EERC has budgeted 1 week of bench-scale testing and 1 week of pilot-scale testing to provide additional information throughout this project. Specific tests may include sorbent screening tests, additive screening tests, tests to examine specific design parameters (i.e., A/C [air-to-cloth ratio]), tests to examine specific process parameters (i.e., temperature, flue gas condition, etc.), or other tests the project sponsors feel are important and related to this project. These 2 weeks of testing will be discussed and decided on by consensus of all project sponsors. Note: tests could be performed at anytime throughout the project and are not necessarily restricted to work described under Task 1.

The EERC will work with SaskPower and Alstom to ensure adequate sampling ports are available, ensure access is provided for necessary sampling equipment and staff, and to provide input on what type of flue gas analysis and monitors are needed. The EERC will also visit the test site throughout the construction period to ensure that sampling ports are installed properly to support the sampling and technology performance assessment activities that are discussed below.

Throughout this task, all project participants will be advised as to the status of technology design and installation.

Task 2 – Test Technology at Poplar River Plant

The main thrust of this task (and project) is to test, demonstrate, and evaluate the ability of the slipstream technology to effectively capture and reduce mercury emissions from flue gas that is representative of lignite-fired power plants, specifically from the Poplar River Plant. Activities proposed herein are intended to support technology performance testing and sampling activities that will gather data that can be used to fully assess the effectiveness and cost of the installed sorbent-based technology. Based on input from Phase I sponsors, it is requested that a minimum of two sorbents be tested to determine the injection rate that is required to achieve mercury reductions in the range of 50%–90%. The EERC is currently working with Luscar under separate contract to produce and provide an optimized sorbent that will be tested as part of this project. Luscar, as part of its cost share for this project, has indicated that it is committed to providing sufficient quantities of sorbent needed to support all testing activities planned under this project. Phase I sponsors have also indicated that they would like to have the NORIT FGD sorbent tested for comparative purposes. Additionally, the EERC has been approached by other sorbent providers that have expressed interest in having their sorbent evaluated for full-scale application. Consequently, the EERC proposes to develop a test plan that evaluates between two to four different sorbents of which one would be provided by Luscar and one provided by NORIT. The other one or two sorbents (depending on budget availability) will be presented to the project participants for consideration and will not be evaluated to the same degree. Sorbents to be considered must have convincing performance data provided at the expense of the supplier or, based on sponsor consensus, could be tested in the EERC's pilot-scale combustor under similar conditions and technology configurations as selected for demonstration at Poplar River.

Discussions relative to sorbent preparation and delivery will be initiated as the technology design is completed and construction begins. Sorbent material will not be delivered on-site until the technology is operational, to ensure the sorbent material remains in a "fresh" state.

In addition to varying sorbent materials and injection rates, other design, operating, and process parameters may affect mercury capture and, ultimately, cost. These parameters include flue gas flow rate, A/C ratio, temperature, ash loading, pulsing frequency, pressure drop, humidification of flue gas and, possibly, bag material, although pilot-scale results show no effect. The A/C is a critical design parameter that can significantly impact performance and cost. For cost-estimating purposes, the EERC proposes 2–3 weeks of parametric testing to evaluate how varying design and process conditions impact mercury capture. The parameters to be tested and duration of tests will be discussed and decided on by the project sponsors. A comprehensive sampling and technology test plan describing all test parameters and duration will be drafted and sent out for review prior to the start of technology tests.

Based on preliminary input from Phase I sponsors and prior discussions, the following simplified test plan and schedule are presented in Table 1.

Table 1. Simplified Test Plan

Test Condition	Test Duration, days
Shakedown Testing	2–5
Weeklong Tests	
Sorbent 1, Luscar	2–5
Sorbent 2, NORIT FGD	2–5
Sorbent 3, TBD*	2–5
Sorbent 4, TBD**	2–5
Monthlong Test (including parametrics)	
Sorbent 1 or 2 or 3 or 4	20–30
Long-Term (3–6 month) Tests	
Sorbent 1, Luscar	90–180

* To be determined based on sponsor input.
** Depending on budget availability.

Each sorbent will be evaluated at a minimum of two to three different injection rates to determine and quantify the relationship between amount of sorbent injected versus mercury reduction. Mercury reduction targets will range from 50%–90%. The monthlong test will evaluate performance for one selected sorbent at each rate for a longer period of time to ensure that transient effects are accounted. Parametric testing (as discussed above) will also be done during the planned monthlong test period. The long-term tests are designed to prove and evaluate the technology's ability to sustain mercury reduction over a long period of time, determine overall average mercury removal efficiency as plant conditions change, and identify other operating issues that are not likely to show up during a 1–2-week test.

Data will be collected during each test to adequately determine and/or accurately estimate the form and emission of mercury. During shakedown tests, measurements will be taken to establish baseline values which will later be used to determine sorbent/technology effectiveness. As mentioned, prior to testing, a detailed sampling and technology evaluation plan will be developed, reviewed, and approved by the project team. For each test, sampling will be conducted upstream and downstream of the newly installed mercury control technology. Sampling is planned for each test condition (i.e., sorbent, change in design parameter, change in operation, etc.) during the week- and monthlong tests and periodically throughout the long-term tests. Both the Ontario Hydro (OH) mercury speciation sampling method and continuous mercury monitors (CMMs) will be used throughout the tests. Saskatchewan Research Council (SRC) will be responsible for performing all of the OH sampling. SRC routinely does this type of sampling. The EERC will provide on-site analysis of the OH sampling trains and set up and operate the CMMs. SaskPower will provide two complete CMMs with conditioning systems, and the EERC will provide one complete backup system in the event one should fail. The EERC will oversee all mercury sampling and analytical activities. CMM data will be logged continuously as long as the instruments are operational, pending necessary maintenance and unforeseen failures. To minimize cost, OH sampling will be limited to two inlet and two outlet samples at the beginning and end of each relevant test, as determined by the project sponsors. For some tests, only outlet OH samples will be taken for CMM verification. For long-term testing, OH samples will be collected at the beginning, near the middle, and at the end of the test period. These samples will be taken coincident with CMM sampling near the CMM locations during the day shift. The

CMMs will operate 24 hours a day during the entire test period while EERC staff are on-site, assuming difficulties do not arise. Again, during long-term tests, the CMMs will only be operated during the first week, the middle week, and the last week. Assuming SaskPower has available trained personnel, operating a CMM at the outlet over the entire test period will be considered.

During OH sampling, it is expected that the unit and technology will be operated at normal or specified conditions (i.e., prescribed injection rates, etc.). It is expected that operating conditions (i.e., load, O_2, NO_x, SO_2, coal feed, etc.) will be logged by plant personnel during the entire sampling and test period and made available to the EERC in an agreed-upon format.

During each sampling period, coal and fly ash will also be sampled on a daily basis, or per test condition, if deemed necessary. Samples can be taken more frequently if determined necessary and of benefit. The EERC assumes that plant personnel will be available to collect these samples. Although a rigorous mass balance is not planned as part of this project, these samples allow an approximate mercury balance to be determined for quality assurance/quality control (QA/QC) purposes. Chemical characterization of the coal and fly ash will be completed by the EERC.

A total of 4–9 people will be necessary during sampling to conduct the proposed tests. The function of these people is as follows:

- One person (field manager) to oversee implementation of the test plan, operation of the sorbent injection system, operation of the newly installed mercury control technology, and overall sampling and monitoring activities.
- Three people to perform simultaneous inlet and outlet OH samples. SRC will provide these personnel.

- Two people to operate the CMM(s) at the inlet and outlet. The people will remain on-site 8 hr a day during the test period. The EERC will provide one person, and SaskPower will provide the other, since the long-term goal is for SaskPower to have a trained CMM operator. Training will be provided by the EERC for this operator.
- One person to assist in CMM setup, assist in OH setup, and prepare samples for on-site analysis.
- One person (chemist) to perform on-site analysis.
- An additional person to collect solid samples, such as fly ash and coal. It is assumed for the purposes of this proposal that someone at the plant can perform this function.

The EERC will bring two trailers on-site: one to house analytical equipment to analyze OH impinger trains and other samples and another to support CMM operation. SRC will provide all chemicals that are needed for on-site sampling and will dispose of used/unused chemicals according to governing practices within Canada. It is assumed that the plant will provide a suitable location (to park each trailer) and all electrical requirements. Two days will be necessary to set up at the plant and 1 day to tear down.

Since the EERC will oversee testing for relatively long periods of time with several CMMs, large amounts of data will be generated and in need of coordination, compilation, and interpretation. These activities will be carried out as discussed in Task 4.

Task 3 – Evaluate Mercury Impact on Ash

The ash material collected by the newly installed slipstream technology will likely be highly concentrated in mercury and used/unused sorbent (carbon). Therefore, it is not apparent as to how reusable this material may be or how stable the mercury will be under disposal conditions. Throughout the years, the EERC has evaluated a number of ash and sorbent materials and has found them to be relatively stable (13). Thus based on these data, the mercury contained within this material would presumably be rather stable, not mobile. To ensure that this material is disposed of in an environmentally safe manner or used in appropriate reuse applications, the EERC proposes to perform some leachability and thermal and biological tests. Up to six samples will be submitted for short- and long-term leachability tests. The leachate will be analyzed for mercury and all trace elements of relevance to determine their potential to mobilize. Four samples will be subjected to thermal analysis to determine how stable mercury is under slightly elevated thermal conditions. To determine if mercury can be reduced or mobilized by microbial activity, four samples will be exposed to a number of different biologically simulated conditions. The results from these tests should provide an indication as to how immobile the mercury will be when placed in a landfill setting. The EERC will also assess the ash for potential reuse application and perform necessary tests to assist in this determination.

Work under this task will be coordinated with the 3-year project entitled "Mercury and Air Toxic Element Impacts of Coal Combustion By-Product Disposal and Utilization," which the EERC was recently awarded by DOE.

Task 4 – Summarize Technology Performance and Estimate Cost

This project will generate voluminous amounts of data over the short and rather long proposed test periods. Data generated and collected will need to be logged carefully such that the technology can be accurately assessed relative to both short- and long-term mercury capture/reduction. Data generated throughout the test program will be reduced, interpreted, and summarized to determine overall conclusions related to technology performance and costs. Under this task, the EERC proposes the following:

- Data generated throughout the test program will be reduced, compiled, interpreted, and summarized.
- Mercury speciation and total concentration will be calculated at each test location for each test and statistically averaged over short- and long-term tests.
- Mercury collection efficiency will be calculated based on coal inlet concentrations as well as on inlet and outlet measurements. Mercury levels and variability in the flue gas will be compared to the mercury content of the coal.
- Data logged by the plant will be reduced and plotted along with mercury to identify trends and relationships.
- The results of mercury impacts on ash will be summarized and suggestions provided for ash disposal and/or reuse.
- Technology effectiveness relative to mercury control will be calculated for short- and long-term tests. This should provide sponsors with realistic performance values that can be used to guide decisions for future installations.
- Using data gathered under Phase II, the EERC will identify any operational issues that are noted during the test program and comment on potential issues.
- Critical design and process parameters that limit or impact mercury capture will be identified. This information will be used to guide the design of future installations.
- Using data from Phase II, the EERC will work with SaskPower, EPRI, and Alstom to determine the cost of scaling the technology up to a larger scale. Operational and capital costs will be estimated.

- Using data from Phase II, the EERC will work with SaskPower, EPRI, and Alstom to quantify the cost of mercury control and estimate the cost of installing the technology at full-scale power plants.

Task 5 – Reporting and Management

Summary reports, quarterly reports, and presentations will be issued to update the consortium members on the project status and results. Periodic review meetings will be held to present data and allow participants to provide feedback and direction. As part of this task, the EERC proposes to do the following:

- Prepare and issue quarterly reports
- Prepare and issue draft report of week- and monthlong test results
- Prepare and issue a draft report of long-term test results
- Prepare and issue a draft report of Phase II results
- Prepare and issue a final report of Phase II
- Present results throughout the project
- Present results at conferences

In addition to the above, the EERC will manage and coordinate all technology tests and field-testing activities related to technology performance and assessment.

Measurement and Sampling Procedures

Flue Gas Constituent Concentrations. To determine the O_2 levels at each sample location, an ECOM-America portable O_2 analyzer will be used. This portable O_2 analyzer's linearity is verified prior to use using EPA Protocol 1 certified gas standards. Flue gas velocity, moisture, and flow rate determinations will be performed according to EPA Methods 2 and 4 in conjunction with the OH method. The particulate matter at each location will be measured in either an EPA Method 17 or EPA Method 5 configuration as part of the OH train. Other flue gas constituents such as CO_2, NO_x, SO_2, and CO will be obtained either with the same portable analyzer used to measure O_2 and/or from plant CEMs (continuous emission monitors).

Ontario Hydro Mercury Speciation Method. Speciated mercury analyses will be performed using ASTM Method D6784-02, "Standard Test Method for Elemental, Oxidized, Particle-Bound and Total Mercury in Flue Gas Generated from Coal-Fired Stationary Sources (Ontario Hydro Method)." This is the method selected by EPA for its Information Collection Request. The OH method has been extensively tested at the bench-, pilot-, and full-scale by the EERC and others and has been proven to provide the best data for coal-fired boilers (8). The method is available directly from ASTM at http://www.astm.org/cgi bin/SoftCart.exe/DATABASE.CART/PAGES/D6784.htm?E+mystore.

Coal and Fly Ash. The EERC has an automated direct mercury analyzer (DMA-80, Milestone, Inc.) that was recently validated as EPA Method 7473, "Mercury in Solids and Solutions by Thermal Decomposition Amalgamation and Atomic Absorption Spectrophotometry." Method 7473 integrates thermal decomposition sample preparation, amalgamation preconcentration, and atomic absorption detection, thus reducing the total analysis time of most samples to <5 min. The analyzer has an automated sample system that allows multiple samples to be analyzed consecutively.

The following analyses will be performed on selected samples of coal and fly ash collected from the filtering device or ESP hoppers.:

- Coal

- Mercury
- Chlorides
- Ultimate/proximate
- Btu
- X-ray fluorescence (XRF) (major and some trace elements)

• Fly Ash

- Mercury
- Loss on ignition (carbon content)
- XRF (major elements and some trace elements)

Mercury CMMs. The EERC assumes that SaskPower will provide two complete mercury CMMs for dedicated use to this project. In the event that one should fail, the EERC will provide one backup system. The EERC will assist SaskPower in recommending and selecting the analyzers and related systems for this project. As backup, the EERC has three different types of mercury CMMs available for these tests: the Semtech Hg 2000, the PS Analytical Sir Galahad, and the Tekran. These instruments, when used in conjunction with the EERC conversion system, are able to measure speciated mercury. The instruments are briefly described below.

PS Analytical Sir Galahad. The Sir Galahad analyzer was initially used to monitor total mercury continuously in the urban environment and in natural gas, but it can also be used in a variety of gaseous media including combustion flue gas. The analyzer is based on the principle of atomic fluorescence which provides an inherently more sensitive signal than atomic absorption. The system uses a gold-impregnated silica support for preconcentrating the mercury and separating it from potential interferences that degrade sensitivity.

The Sir Galahad requires a four-step process to obtain a flue gas mercury measurement. In the first step, 2 L of flue gas is pumped through a gold trap maintained at a constant temperature. Before the mercury is desorbed from the gold trap, a flushing step is initiated to remove any flue gas that may be present, because it has a damping effect on the mercury fluorescence. When this is completed, the analysis step begins. The heating coil is activated, and the gold trap is heated to approximately 500°C. This desorbs the mercury from the trap, and the mercury is carried into the fluorescence detector. The gold trap is cooled rapidly by pumping argon over it, in preparation for the next sample. The total time for the entire process is about 5 minutes.

The system is calibrated using Hg^0 as the primary standard. The Hg^0 is contained in a closed vial which is held in a thermostatic bath. The temperature of the mercury is monitored, and the amount of mercury is measured using vapor pressure calculations. Typically, the calibration of the unit has proven stable over a 24-hour period.

Tekran. The Tekran analyzer was initially used primarily to monitor ambient mercury, but it can also be used in a variety of gaseous media, including combustion flue gas. The analyzer is based on the principle of atomic fluorescence which provides an inherently more sensitive signal than atomic absorption.

Semtech Hg 2000. The commercial Semtech Hg 2000 mercury analyzer (Semtech Metallurgy AB, Lund, Sweden) is essentially a portable Zeeman-modulated cold-vapor atomic absorption (CVAA) spectroscope that can monitor Hg^0 continuously. The analyzer uses Zeeman effect background correction by applying a modulated magnetic field to a mercury lamp to minimize interferences from the presence of SO_2, hydrocarbons, and fine particulate in the flue gas sample. The operating range of the analyzer is 0.3 $\mu g/Nm^3$ to 20 mg/Nm^3 Hg^0, as specified by Semtech Metallurgy AB. The Semtech Hg 2000 has also been certified by TUEV Rheinland for determining compliance with the German legal limit of 50 μg/Nm^3 for total mercury from waste incinerators.

EERC FACILITIES AND CAPABILITIES

The EERC has the trained personnel, analytical facilities, and laboratory and field-testing equipment needed to support this project, including analytical equipment, CMMs, and a full-range of bench- and pilot-scale systems. No equipment purchases are anticipated.

Field-Sampling Capabilities

The EERC has two fully equipped trailers that have been used for sampling activities at numerous power plants. These trailers house all the equipment necessary to perform a number of EPA methods, including EPA Methods 5 and 17 for particulate sampling. This includes sampling boxes, probes, weighing scales, filters, filter holders, and any railings that may be necessary. However, what makes EERC sampling capabilities unique is the ability to do mercury analysis in the field. In doing so, the EERC maintains an exceptionally high level of QA/QC. Because the mercury blank and spike results are obtained in the field (usually within 4–6 hours), any problems can be corrected immediately. If the samples are sent to a laboratory for analysis, the results are not known until after the sampling team has left the facility. To do the mercury analysis in the field, the EERC trailer is equipped with a Leeman CVAA spectrophotometer and a DMA-80 analyzer (Milestone, Inc). The DMA-80 allows the EERC to do coal and ash mercury analysis in the field. This technique was recently validated as EPA Method 7473, entitled "Mercury in Solids and Solutions by Thermal Decomposition Amalgamation and Atomic Absorption Spectrophotometry."

In addition to the equipment necessary to perform mercury wet-chemistry sampling procedures, the EERC also has three different types of CMMs:

- Two Semtech mercury 2010s
- Five PS Analytical Sir Galahads
- Five Tekrans

The EERC has used these monitors successfully to directly measure stack emissions in all the field sampling done for the past 3 years.

Mercury Research Laboratory

The MRL specializes in bench-scale systems studying Hg, SO_x/NO_x, and catalysts, with capabilities for other similar work (Figure 6). Two bench-scale systems capable of simulating flue gas conditions, such as temperature, particulate loadings, A/C ratios, and different gas concentrations (e.g., SO_2, O_2, CO, CO_2), are used for varied experimentation.

The EERC has numerous analyzers (listed below) and is experienced with many sampling and analytical standards and methods:

- Analyzers
  - Two Semtech mercury analyzers
  - EPM mercury analyzer
  - Five Sir Galahad mercury analyzers
  - BIOS gas flow calibrator
  - Gilibrator gas flow calibrator
  - Porter mass flow controllers
  - Three portable ECOM gas analyzers

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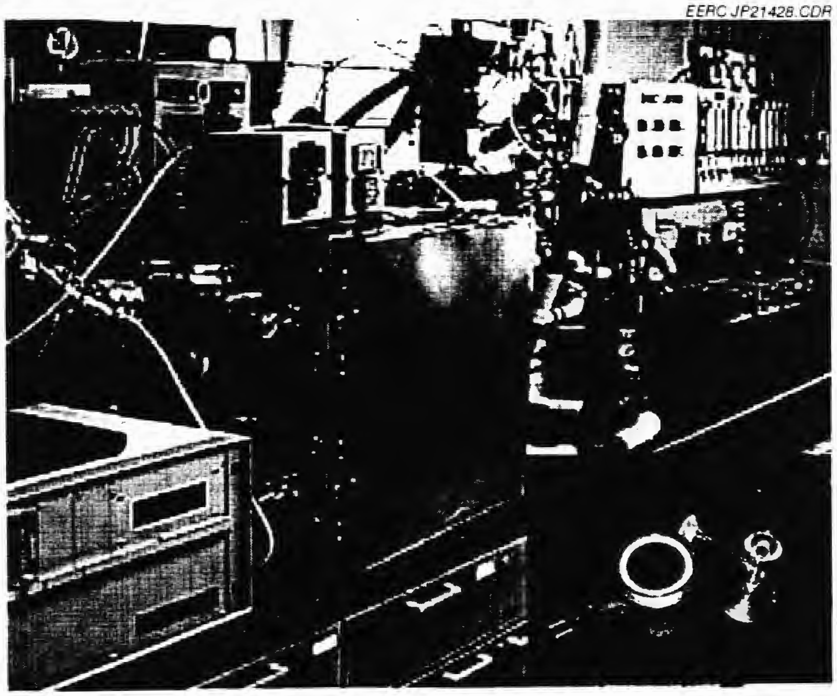

Figure 6. EERC's mercury laboratory.

- Bench-scale test cells
- TSI Tris-Jet aerosol generator
- TSI aerodynamic particle sizer
- TSI condensation particle counter
- Five Tekran mercury analyzers

- Sampling Methods
  - Method 5 – Determination of Particulate Emissions from Stationary Sources
  - Modified Method 5 – Determination of Volatile Organic Compounds from Stationary Sources
  - Method 6 – Determination of Sulfur Dioxide Emissions from Stationary Sources

- Method 8 – Determination of Sulfuric Acid Mist and Sulfur Dioxide Emissions from Stationary Sources
- Method 13 – Determination of Total Fluoride Emissions from Stationary Sources
- Method 17 – Determination of Particulate Emissions from Stationary Sources (in-stack filtration method)
- Method 23 – Determination of Halogenated Organics from Stationary Sources
- Method 26 – Determination of Hydrogen Chloride Emissions from Stationary Sources
- Method 29 – Determination of Metals Emissions in Exhaust Gases from Hazardous Waste Incineration and Similar Combustion Processes (Sb, As, Ba, Be, Cd, Cr, Cu, Pb, Mn, Hg, Ni, Se, Ag, Tl, and Zn)
- Tris-buffer method
- OH method
- Other mercury-sampling methods that are not yet recognized or validated by EPA, including the Research Triangle Institute method and dry OH method
- Method 101A – Determination of Mercury from Stationary Sources
- Ammonia sampling to determine the amount of ammonia in a sample from a stationary source
- Rader sampler for high-volume particle collection

Bench-Scale Testing Services

- Ash resistivity to determine the resistivity of fly ash
- Particle characteristics to help determine collection efficiencies

- Mercury and other trace elements
- Particle reentrainment
- Screening of potential sorbents and/or filter materials
- Evaluation of SO_x/NO_x impacts
- Evaluation of ammonia impacts
- Catalyst evaluations
- Ash and particle characteristics testing, including cohesion measurements

Conversion and Environmental Process Simulator. The conversion and environmental process simulator (CEPS) is used to research and investigate the transformation of toxic trace metals, such as Hg, As, and Pb, during the combustion of coal and other fuels or waste materials (Figure 7). The CEPS is designed to nominally top-fire 4.4 lb/hr (2 kg/hr) of pulverized coal, with a heat input of 40,000 Btu/hr. Other solid or liquid fuels can be utilized with slight system modifications. It is designed to maintain the flue gas (approximately 8 scfm) generated by the combustion of the fuel at a maximum of 1500°C (2732°F) for the first 12 ft of the system, which is referred to as the radiant zone. The first 9 ft of the heated radiant zone has an inside diameter of 6 in., with the last heated zone reducing down to 3 in. The radiant zone exit is through a horizontal 1.5-in.-i.d. ceramic tube. A portion of the particulate is removed before the convective pass section of the CEPS. After the convective section, flue gas flows through an optional ash-fouling test section, a cyclone for final removal of particulate, and an air eductor and up to a stack through the roof of a new pilot facility at the EERC.

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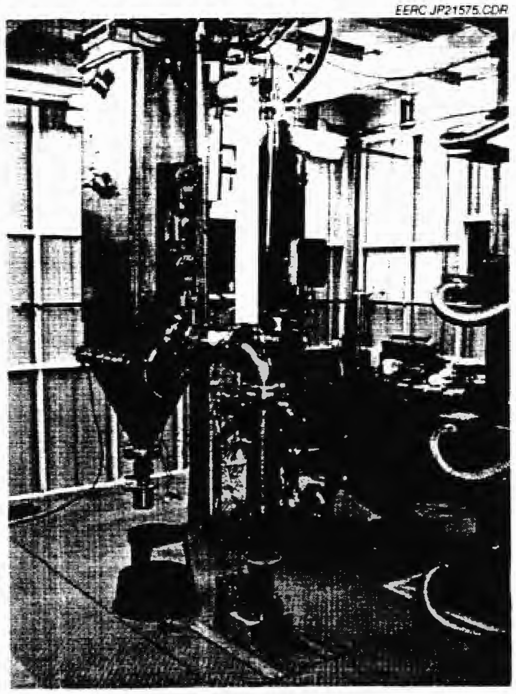

Figure 7. Conversion and environmental process simulator.

Pilot-Scale Combustion Facilities

Particulate Test Combustor (PTC). The PTC is a 550,000-Btu/hr pulverized coal-fired unit designed to generate fly ash and flue gas chemistry representative of that produced in a full-scale utility boiler (Figure 8). Coal is introduced to the primary airstream via a screw feeder and ejector. An electric air preheater is used for precise control of the combustion air temperature. The PTC instrumentation permits system temperatures, pressures, flow rates, flue gas constituent concentrations, and baghouse or ESP operating data to be monitored continuously and recorded on a data logger.

The PTC is designed to operate in conjunction with either a fabric filter or ESP. The baghouse vessel is a 20-in.-i.d. chamber that is heat-traced and insulated, with the flue gas introduced near the bottom. Since the combustor produces about 200 acfm of flue gas at 149°C (300°F), three 13-ft by 5-in. bags provide an A/C of 4 ft/min. Each bag is cleaned separately with

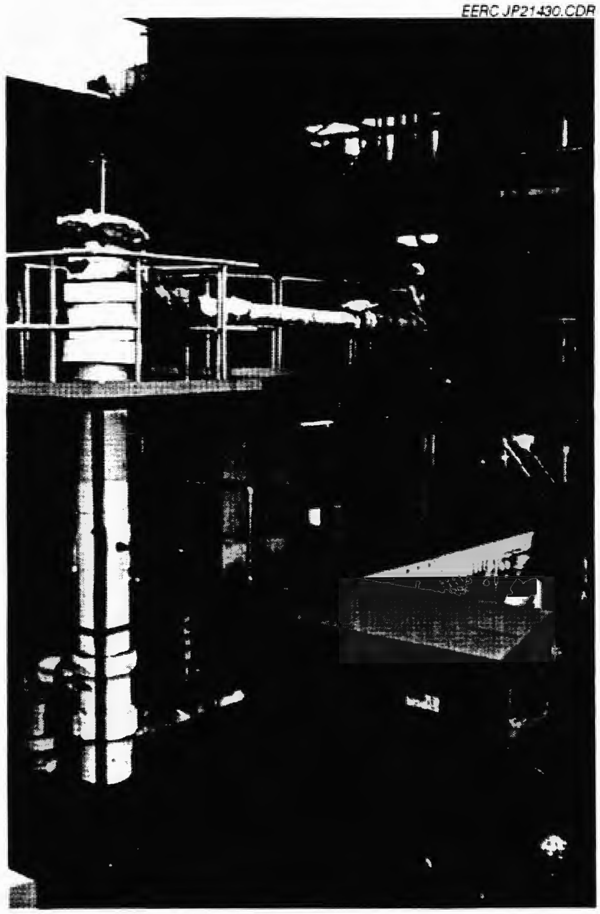

Figure 8. Particulate test combustor.

its own diaphragm pulse valve. In order to quantify differences in pressure drop for different test conditions, the bags are cleaned on a time basis, rather than with the cleaning cycle initiated by pressure drop. Once bag cleaning is initiated, all three bags are pulsed in rapid succession on-line.

Instead of directing the flue gas through a fabric filter, a single-wire, tubular ESP can be used in its place. The ESP is designed to provide a specific collection area of 125 ft^2 of area/1000 acfm at 149°C (300°F). Since the flue gas flow rate for the PTC is 130 scfm, the gas velocity through the ESP is 5 ft/min. The plate spacing for the unit is 11 in. The ESP has an electrically isolated plate that is grounded through an ammeter, allowing continual actual plate current to ensure consistent operation of the ESP from test to test. The tubular plate is suspended by a load cell which helps to monitor rapping efficiency. In addition, sight ports are located at the top of the ESP to allow for on-line inspection of electrode alignment, sparking, rapping, and dust buildup on the plate. The ESP was designed to facilitate thorough cleaning between tests so that all tests can begin on the same basis.

STANDARDS OF SUCCESS

The EERC is committed to delivering consistent and high-quality research that meets its clients' needs and expectations. An organizationwide quality management system is in effect that governs all programs within the organization. This project is required to be in compliance with the *Quality Manual* and any project-specific QA procedures that are identified, thus ensuring that any requirements relating to quality and compliance with applicable regulations, codes, and protocols are adequately fulfilled. Additionally, a test plan will be developed and reviewed by project sponsors to ensure project objectives are met.

The standards of success for Phase II of this project will be measured through successful field demonstration of the selected mercury control technology. The mercury control technology needs to demonstrate technical viability and the potential for economic viability based on the design and process conditions and sorbent requirements. The technical objective of the technology is to effectively reduce mercury emissions by at least 50%, with an upward target goal of 90%. The economic objective is to reduce mercury emissions for less than US$20,000/lb-Hg removed based on sorbent technology equipment requirements, utilization rates, and required plant modifications. Estimates by EPA range from US$5000–US$25,000/lb-Hg removed, and DOE estimates are from US$25,000–US$70,000/lb-Hg. Preliminary calculations for this technology based on Phase I results indicate that mercury costs as low as US$10,000/lb-Hg removed can be achieved, assuming that both design requirements and sorbent usage rates can be reduced to optimal levels. The outcome of the proposed tests is to delineate these optimal levels.

BACKGROUND

The EERC has been a leader in mercury research for several years and is viewed as an expert in the field. Additionally, the EERC has over 50 years of experience with low-rank coals and has a track record as a leading research, development, demonstration, and commercialization organization. In recent years, EERC researchers have been in the forefront of advancing the understanding of mercury chemistry, measurement, transformations, solid–gas interactions, and development of control technologies (14–19). Several different approaches have been tested by the EERC to effectively reduce mercury emissions, as shown below:

- Gas impacts (e.g., HCl, Cl, NO, NO_2, CO, CO_2, SO_2, O_2, and H_2O)
- Activated carbon (AC) (e.g., wood derived, biobased, bituminous derived, lignitic derived, chemically activated North Dakota lignite, etc.). Impregnated ACs (e.g., iodine, sulfur, phosphorus, nitrogen, etc.)
- Aerogels (e.g., RF aerogel and carbonized RF aerogel)
- Salts (e.g., NaCl, CaCl, $MnSO_4$, $Mn(NO_3)_2$, $FeCl_3$, $Fe(NO_3)_3$, $FeSO_4$, $Fe_2(SO_4)_3$, etc.)
- Metal oxides (e.g., TiO_2, V_2O_3, α-Al_2O_3, MnO_2, MnOOH, Mn_2O_3, CrO_3, NiO, CoO, Na_2O, CuO, etc.)
- Iron oxides (e.g., hematite, maghemite, feroxyhyte, geothite, lepidocrocite, Mn-Fe geothite, magnetite, ferrihydrite, etc.)
- Precious metals (e.g., Au and Ag)

- Minerals (e.g., zeolite, kaolinite, lime, several manganese-based minerals, etc.)
- Ashes (bottom and fly ash from several coal types)
- Fabric filters (e.g., Ryton® and polytetrafluoroethylene)
- Temperature effects (i.e., gas cooling, humidification, etc.)
- Entrained-flow vs. packed-bed design

While progress has been made in developing and testing sorbents that will remove mercury from plants firing low-rank coals, full-scale data are needed to confirm effectiveness. Some sorbents have improperly been tested and reported in peer-reviewed literature by others to be effective at capturing Hg^0 in tests performed on bench-scale systems using simple simulated gas mixtures or, in some cases, just nitrogen. EERC research has shown that tests performed without the full complement of gas species in the coal combustion flue gas lead to false conclusions about sorbent effectiveness and application. Fly ash properties and flue gas constituents such as nitrogen oxides, sulfur dioxide, chlorine (Cl_2 and HCl), and water vapor all play a critical role in the ability of a sorbent (or ash) to capture Hg^0. Consequently, before technologies can be fully implemented, full-scale testing is needed to confirm and verify results generated under bench- and pilot-scale conditions.

QUALIFICATIONS

Phase II of the project will be managed by Mr. John Pavlish, with assistance from Mr. Mike Holmes. Mr. Jeff Thompson will serve as field manager.

Mr. Pavlish served as project manager for Phase I and has managed numerous federal and commercial projects involving mercury research and control and is the Director of CATM, a multiyear, multimillion-dollar program at the EERC. Mr. Pavlish's primary duties will be to oversee all activities within the project and ensure that all project objectives and milestones are met.

Mr. Holmes is an expert in the field of mercury and flue gas emission control. He has managed numerous projects involving sorbent testing and development for mercury control as well as duct injection, dry scrubbing, and wet scrubbing projects for the control of Hg and SO_2 emissions. Mr. Holmes' primary duties for the project will be to assist the project manager of specific assignments and oversee and coordinate day-to-day activities.

Mr. Thompson is an expert in the field of mercury and flue gas emission sampling and measurement. He has been involved in numerous projects involving testing and sampling in the field. Mr. Thompson's primary duties for the project will be to implement the test plan in the field and oversee and coordinate all day-to-day field activities.

Detailed resumes are attached in Appendix A.

VALUE TO NORTH DAKOTA

Phase II of the project will continue to focus on developing effective mercury control sorbent technologies for conventional power plants firing lignite coals equipped with ESPs and/or fabric filters. Cost-effective mercury control options are critically needed to address forthcoming mercury regulations. It is anticipated that this phase of the project will provide key information to consortium members throughout the duration of the project, with all results and reports transferred to project sponsors by the end of the project. Key benefits that will be realized by each participant include:

- Direct input into developing a test plan that addresses critical design parameters and process conditions to evaluate the technology's effectiveness and application to plants owned and operated by participating organizations.
- Demonstration of a sorbent-based technology at a full-scale power plant. Data generated from the demonstration will provide invaluable insight into technology applicability. Overall effectiveness of the technology will be quantified as well as limitations and/or problems of implementation. The technology to be tested offers promise for relatively high levels of mercury reduction, especially applicable to units equipped with ESPs (over 2/3 of the plants in ND are equipped with ESPs) or newly constructed power plants.
- Performance and cost data to assist in developing specific compliance strategies for participating organizations. Data available will be directly applicable to coals and plants that are part of this project.
- Information on impacts of design and process parameters on mercury control efficiency. These data will allow for a more optimized design and will minimize cost of future installations.
- Information on mechanisms of mercury transformations, potential oxidation, and interactions with fly ash, flue gas components, and select sorbents.
- Collaborative research and interaction between stakeholders with a common interest in developing cost-effective control technologies.
- Immediate access to comprehensive reports.
- Access to presentations and peer-reviewed technical journal articles prior to publication. The project team will be involved in authoring or coauthoring publications.

In North Dakota, over 18,000 jobs, $1.3 billion in business volume, and $60 million in tax revenue are generated by the lignite industry each year. North Dakota produces over 30 million tons of lignite annually, and thousands of tons of lignite are fired by North Dakota power plants daily (20). North Dakota's economy depends on lignite production and use. Determining cost-effective technologies that will increase its efficient and environmentally safe use will, ultimately, lead to the demand for greater production. Preliminary data also suggest that activated carbon produced from high-sodium North Dakota lignite may be an effective sorbent for mercury control for a utility market reaching across the United States and Canada. Increased lignite production and use in North Dakota will result in more jobs in all lignite-related industries in the state.

MANAGEMENT

The proposed project is organized as a consortium; therefore, each participant will have equitable input into the project's direction and access to the deliverables. Regular meetings will be held to share information, facilitate communication among all project participants, and guide project decisions. The project will be executed by the EERC, with project management responsibilities under Mr. John Pavlish. Mr. Pavlish will receive technical support as well as assistance in management of the project tasks from Mr. Mike Holmes. Both have been closely involved in Phase I of the project.

An organizational chart, shown in Figure 9, shows the roles of the participating organizations. In summary, the EERC proposes to manage all activities related to technology testing and assessment. SaskPower agrees to design, install, and make accessible the technology discussed throughout. SaskPower also agrees to establish a subcontract with SRC to perform OH

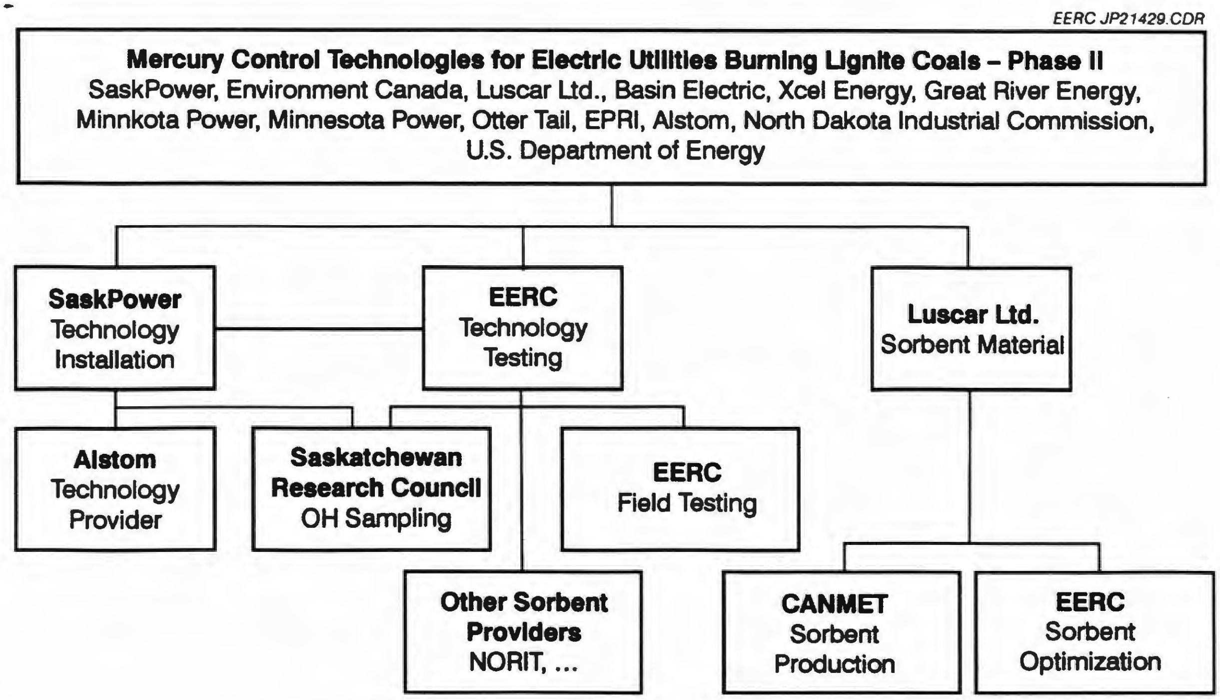

Figure 9. Project management overview.

sampling during technology testing activities. Alstom will provide technical support to SaskPower during technology design and installation. Luscar agrees to provide adequate quantities of sorbent to meet all testing needs. CANMET will produce this sorbent material using its scaled-up pilot plant facility. Sorbents (or additives) from other suppliers will be arranged by the EERC. Letter of support from the various organizations are shown in Appendix B.

TIMETABLE

Phase II of the project is scheduled for a 2-year period, with specific milestones to be developed after the initial meeting with all project sponsors. Phase I activities are under way and near completion; a final report is in preparation. Phase II activities are expected to be completed within 1½ to 2 years, with construction activities completed within 6 to 12 months and demonstration tests completed in the following 6 to 9 months. Figure 10 provides a view of the

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Figure 10. Project schedule.

entire project schedule. Figure 11 shows the schedule specific to Phase II activities and assumes 2 years for completion, but the actual schedule may be shorter, depending on how long it takes to install the slipstream technology. Key results will be delivered to project sponsors throughout the duration of the project via planning and review meetings, quarterly reports, and a final report documenting the Phase II results.

BUDGET

Overall Phase II cost and funding are estimated as follows and are shown in more detail in Table 2:

- Saskatchewan Power and Environment Canada will provide a US$200,000 contract to the EERC for field testing, an SRC subcontract for OH sampling, and the capital cost for design and installation of the slipstream technology. The overall value is approximately US$1,600,000–US$3,600,000.

Table 2. Phase II Potential Funding Sources (US$)

	Phase I	Phase II (2 years)		
Funding Source	Total	Technology Cost*	Field Tests**	Total
Canadian Sources				
SaskPower	$100,000	$1,000,000–$3,000,000	$300,000	$1,600,000–$3,600,000
Environment Canada	$100,000		$300,000	
Alstom		$250,000		$250,000
Luscar Ltd.	$25,000		$100,000–$200,000	$100,000–$200,000
U.S. Sources				
North Dakota Utilities and EPRI	$125,000		$260,000	$260,000
North Dakota Industrial Commission	$150,000		$200,000	$200,000
U.S. DOE through EERC JV Program	$333,000		$440,000	$440,000
Total	$833,000	$1,250,000–$3,250,000	$1,600,000–$1,700,000	$2,850,000–$4,950,000

* Cost associated with technology installation covered by SaskPower.
** Costs would be incurred over 2 years. $1,666,600 to EERC for technology testing. SaskPower will subcontract to SRC for OH sampling. Luscar will provide in-kind coast share by providing sorbent material for testing.

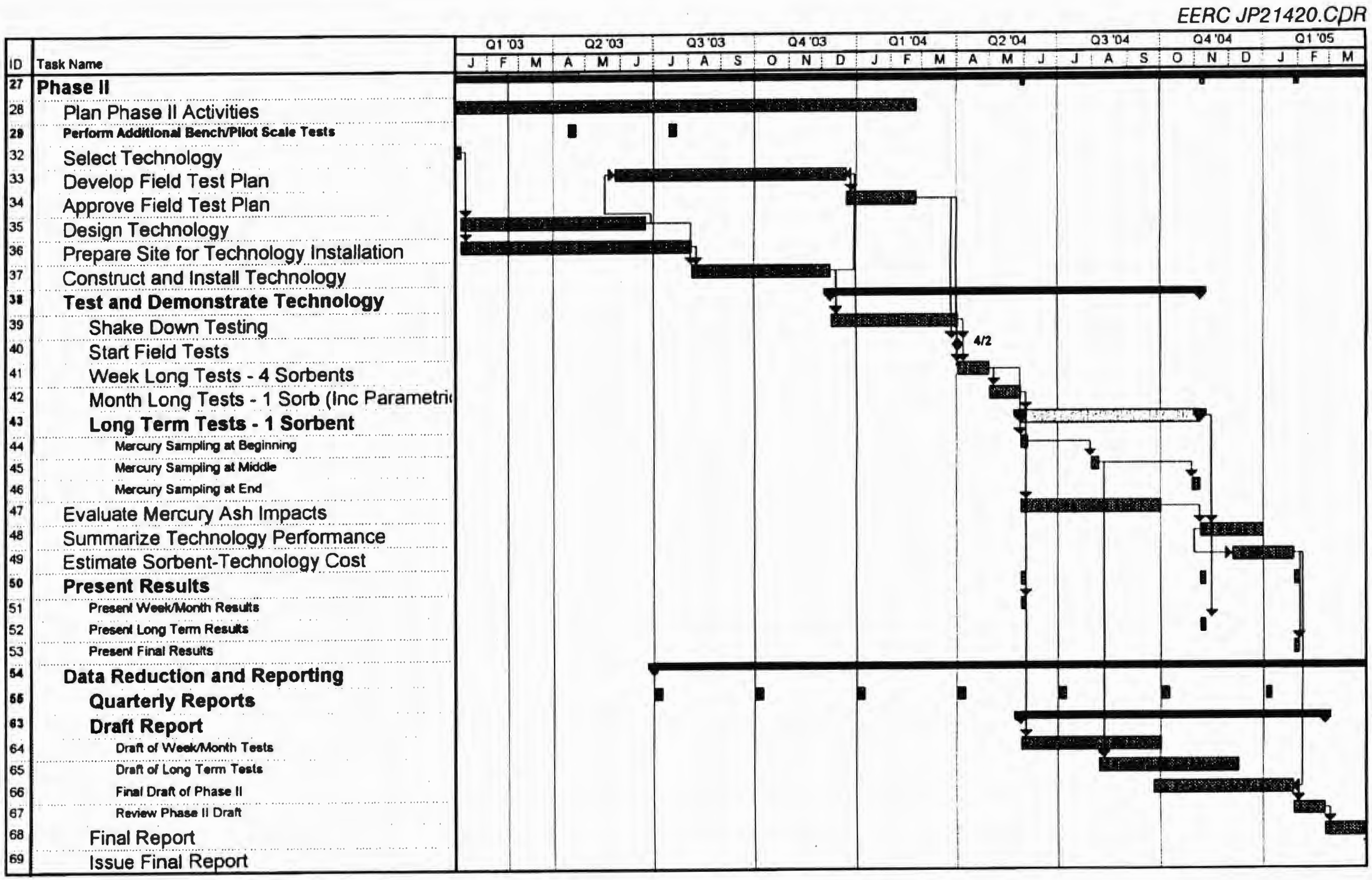

Figure 11. Project schedule for Phase II.

- Alstom will provide technical support for design and installation of the slipstream technology, valued at over $250,000.
- Luscar Ltd. will provide sorbent material at a value greater than US$100,000.
- Participating North Dakota utilities will provide a combined total of US$200,000.
- North Dakota Industrial Commission will provide US$200,000.
- EPRI will provide US$100,000.
- The EERC–DOE Jointly Sponsored Research Program (JSRP) will provide US$466,600.
- The total for Phase II is expected to cost approximately US$3,000,000–US$5,000,000.
- Total funds provided to the EERC as proposed for technology performance testing is US$1,100,000. SaskPower and Environment Canada will fund all design, installation, and capital cost of technology equipment; a subcontract with SRC for OH sampling; and funds (in addition to those provided by other sponsors) to the EERC for technology performance verification testing, mercury sampling, data reduction, and reporting.

Funding to support technology-testing efforts discussed specifically in this proposal are broken down as follows:

- Saskatchewan Power and Environment Canada, US$200,000
- Luscar Ltd., US$0 (they provide sorbent material)
- North Dakota utilities, US$200,000 total from all participating North Dakota utilities.
- North Dakota Industrial Commission, US$200,000.
- EPRI, US$100,000.
- EERC- DOE JSRP, US$466,600.
- Total for EERC technology testing, $1,166,600.

Note: SRC OH sampling activities are funded separately by SaskPower. Letters of funding support are included in Appendix B.

Approximate costs for efforts proposed to be done by the EERC are listed in Table 3. The cost for Phase I is shown only for reference. Phase II costs are estimated based on current discussions and feedback from Phase I sponsors. Since the project was originally proposed as a multiphase project, it is presumed that all existing sponsors are interested in supporting Phase II activities.

Table 3. Project Costs by Task

Phase	Phase Description	Cost
I	Development and Testing of Sorbents at EERC Bench-Pilot-Scale Facilities	$833,000
II	Field Testing of Slipstream Technology at Poplar River Power Plant	$1,100,000
II	Task 1 – Design and Install Slipstream Technology	$150,000
II	Task 2 – Test Technology at Poplar River Plant	$640,000
II	Task 3 – Evaluate Mercury Impact on Ash	$60,000
II	Task 4 – Summarize Technology Performance and Cost	$100,000
II	Task 5 – Reporting and Management	$150,000

A budget breakdown by task is presented in Table 4. Note: the EERC does not plan on purchasing any equipment. The relatively high travel, supplies, and laboratory expenses are expected and justified by the extensive duration of on-site testing and on the type and number of samples to be analyzed.

Table 4. Budget Breakdown by Task

	Task 1	Task 2	Task 3	Task 4	Task 5	Total
Labor	$60,889	$273,878	$27,862	$60,434	$84,775	$507,838
Travel	$812	$80,506		$4918	$7266	$93,502
Supplies	$300	$13,290				$13,590
Analysis	$34,332	$47,501	$11,411			$93,244
Other	$1120	$7804	$125	$511	$5233	$14,793
F & A Costs (Indirect)	$51,232	$220,142	$20,477	$34,296	$50,886	$377,033
Total	$148,685	$643,121	$59,875	$100,159	$148,160	$1,100,000

MATCHING FUNDS

Total cost for Phase II is expected to range from approximately US$3,000,000 to US$5,000,000. SaskPower and Environment Canada will directly fund a bulk of the work by funding all design and installation of equipment associated with the slipstream technology. Letters of commitment are provided in Appendix B. Funding needed to support testing activities to test technology performance is proposed as part of this Phase II proposal. The amount being requested by the EERC for purposes of testing the technology is US$1,100,000. Phase II funding is requested from the North Dakota Industrial Commission of US$200,000, with matching funds of US$200,000 (US$100,000 each) from Saskatchewan Power and Environment Canada, sorbent material provided as in-kind from Luscar Ltd. (estimated value US$100,000), US$260,000 total from North Dakota utilities and EPRI, and US$440,000 through the EERC–DOE JSRP, for a total of US$1,100,000.

A majority of the required matching funds identified above are already committed. Letters of commitment and support are included in Appendix B for SaskPower, Luscar Ltd., SRC, North Dakota utilities, and EPRI. Alstom is providing technical and in-kind support for the design and installation of the slipstream technology and may consider participation in testing activities described in this proposal. Luscar Ltd. is committed to providing adequate supplies of sorbent to meet testing purposes. CANMET will produce the sorbent using its scaled-up pilot-scale facilities based on conditions provided by the EERC.

Three items are required from NDIC for inclusion in the EERC's proposal to DOE:

- A formal commitment to the project. This can be a letter of commitment, a purchase order, or a signed contract.

- A biographical sketch or resume for the NDIC project manager and/or key technical contributor.
- A short overview of NDIC.

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 INFORMATION

Confidential information is neither contained in this proposal nor anticipated as a result of these research activities.

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SUMMARY BUDGET - ALL YEARS

MERCURY CONTROL TECHNOLOGIES FOR ELECTRIC UTILITIES BURNING LIGNITE COALS-PHASE II
DOE/NDIC/INDUSTRIAL CLIENTS
PROPOSED START DATE: JUNE 1, 2003
EERC PROPOSAL #2003-0122

CATEGORY		TOTAL HRS	TOTAL $COST	NDIC SHARE HRS	NDIC SHARE $COST	OTHER COMMERCIAL HRS	OTHER COMMERCIAL $COST	EERC JSRP SHARE HRS	EERC JSRP SHARE $COST
TOTAL DIRECT LABOR		11,633	$ 335,345	2,064	$ 59,481	4,742	$ 136,769	4,827	$ 139,095
TOTAL FRINGE BENEFITS	VAR		$ 172,493		$ 30,577		$ 70,328		$ 71,588
TOTAL LABOR			$ 507,838		$ 90,058		$ 207,097		$ 210,683
OTHER DIRECT COSTS									
TRAVEL			$ 93,502		$ 16,717		$ 38,450		$ 38,335
COMMUNICATION - PHONES & POSTAGE			$ 1,580		$ 283		$ 650		$ 647
DATA PROCESSING - SOFTWARE			$ 300		$ 54		$ 123		$ 123
OFFICE (PROJECT SPECIFIC SUPPLIES)			$ 1,545		$ 274		$ 629		$ 642
SUPPLIES			$ 13,590		$ 2,419		$ 5,599		$ 5,572
GENERAL (FREIGHT, FOOD, MEMBERSHIPS, ETC.)			$ 750		$ 134		$ 309		$ 307
EQUIPMENT > $5000			$ 6,160		$ -		$ -		$ 6,160
FEES			$ 97,702		$ 18,266		$ 42,015		$ 37,421
TOTAL OTHER DIRECT COST			$ 215,129		$ 38,147		$ 87,775		$ 89,207
TOTAL DIRECT COST			$ 722,967		$ 128,205		$ 294,872		$ 299,890
FACILITIES & ADMIN. RATE - % OF MTDC		VAR	$ 377,033		$ 71,795		$ 165,128	47.7%	$ 140,110
TOTAL ESTIMATED COST			$1,100,000		$ 200,000		$ 460,000		$ 440,000

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

DETAILED BUDGET - ALL YEARS

MERCURY CONTROL TECHNOLOGIES FOR ELECTRIC UTILITIES BURNING LIGNITE COALS-PHASE II
DOE/NDIC/INDUSTRIAL CLIENTS
PROPOSED START DATE: JUNE 1, 2003
EERC PROPOSAL #2003-0122

LABOR	LABOR CATEGORY	HOURLY RATE	YEAR ONE TOTAL HRS	YEAR ONE TOTAL $COST	YEAR TWO TOTAL HRS	YEAR TWO TOTAL $COST	ALL YEARS TOTAL HRS	ALL YEARS TOTAL $COST	NDIC SHARE		OTHER COMM SHARE		EERC JSRP SHARE HRS	EERC JSRP SHARE $COST
PAVLISH, J.	PROJECT MANAGER	$ 44.47	600	$ 26,682	680	$ 30,240	1,280	$ 56,922	229	$ 10,184	526	$ 23,390	525	$ 23,348
HOLMES, M.	PRINCIPAL INVESTIGATOR	$ 42.18	490	$ 20,668	480	$ 20,246	970	$ 40,914	173	$ 7,297	399	$ 16,830	398	$ 16,787
THOMPSON, J.	RESEARCH SCIENTIST/ENGINEER	$ 26.99	370	$ 9,987	920	$ 24,831	1,290	$ 34,818	231	$ 6,235	530	$ 14,305	529	$ 14,278
BENSON, S.	RESEARCH SCIENTIST/ENGINEER	$ 48.02	32	$ 1,536	8	$ 384	40	$ 1,920	7	$ 336	17	$ 816	16	$ 768
--------------	SENIOR MANAGEMENT	$ 48.20	49	$ 2,361	124	$ 5,977	173	$ 8,338	31	$ 1,494	72	$ 3,471	70	$ 3,373
--------------	RESEARCH SCIENTIST/ENGINEER	$ 26.94	443	$ 11,934	4,288	$ 115,519	4,731	$ 127,453	828	$ 22,306	1,905	$ 51,321	1,998	$ 53,826
--------------	RESEARCH TECHNICIAN	$ 18.42	42	$ 774	207	$ 3,813	249	$ 4,587	45	$ 829	102	$ 1,879	102	$ 1,879
--------------	TECHNOLOGY DEV. OPER.	$ 18.49	640	$ 11,834	-	$ -	640	$ 11,834	115	$ 2,126	263	$ 4,863	262	$ 4,845
--------------	TECHNOLOGY DEV. MECH.	$ 20.79	120	$ 2,495	-	$ -	120	$ 2,495	22	$ 457	49	$ 1,019	49	$ 1,019
--------------	UNDERGRAD-RES.	$ 8.40	1,000	$ 8,400	800	$ 6,720	1,800	$ 15,120	322	$ 2,705	740	$ 6,216	738	$ 6,199
--------------	TECHNICAL SUPPORT SERVICES	$ 14.62	180	$ 2,632	160	$ 2,339	340	$ 4,971	61	$ 892	139	$ 2,032	140	$ 2,047
			3,966	$ 99,303	7,667	$ 210,069	11,633	$ 309,372	2,064	$ 54,861	4,742	$ 126,142	4,827	$ 128,369
ESCALATION ABOVE CURRENT BASE		VAR		$ 4,965		$ 21,008		$ 25,973		$ 4,620		$ 10,627		$ 10,726
TOTAL DIRECT LABOR				$ 104,268		$ 231,077		$ 335,345		$ 59,481		$ 136,769		$ 139,095
FRINGE BENEFITS - % OF DIRECT LABOR-STAFF		54%		$ 51,542		$ 120,790		$ 172,332		$ 30,548		$ 70,261		$ 71,523
FRINGE BENEFITS - % OF DIRECT LABOR-STUDENT		1%		$ 88		$ 73		$ 161		$ 29		$ 67		$ 65
TOTAL FRINGE BENEFITS		VAR		$ 51,630		$ 120,863		$ 172,493		$ 30,577		$ 70,328		$ 71,588
TOTAL LABOR				$ 155,898		$ 351,940		$ 507,838		$ 90,058		$ 207,097		$ 210,683
OTHER DIRECT COSTS														
TRAVEL				$ 19,640		$ 73,862		$ 93,502		$ 16,717		$ 38,450		$ 38,335
COMMUNICATION - PHONES & POSTAGE				$ 535		$ 1,045		$ 1,580		$ 283		$ 650		$ 647
DATA PROCESSING - SOFTWARE				$ 300		$ -		$ 300		$ 54		$ 123		$ 123
OFFICE (PROJECT SPECIFIC SUPPLIES)				$ 625		$ 920		$ 1,545		$ 274		$ 629		$ 642
SUPPLIES				$ 300		$ 13,290		$ 13,590		$ 2,419		$ 5,599		$ 5,572
GENERAL (FREIGHT, FOOD, MEMBERSHIPS, ETC.)				$ 250		$ 500		$ 750		$ 134		$ 309		$ 307
EQUIPMENT > $5000				$ -		$ 6,160		$ 6,160		$ -		$ -		$ 6,160
NATURAL MATERIALS ANALYTICAL RES. LAB.				$ 1,512		$ -		$ 1,512		$ 270		$ 622		$ 620
FUELS & MATERIALS RESEARCH LAB.				$ 1,518		$ 10,425		$ 11,943		$ 2,121		$ 4,879		$ 4,943
ANALYTICAL RESEARCH LAB.				$ 4,330		$ 22,308		$ 26,638		$ 5,403		$ 12,427		$ 8,808
PARTICULATE ANALYSIS				$ 12,396		$ 24,077		$ 36,473		$ 6,521		$ 14,998		$ 14,954
PROCESS CHEM. & DEV. LAB.				$ 515		$ 2,102		$ 2,617		$ 468		$ 1,076		$ 1,073
FUEL PREP. AND MAINTENANCE				$ 1,470		$ -		$ 1,470		$ 263		$ 604		$ 603
PARTICULATE TEST COMBUSTOR MAINT.				$ 9,314		$ -		$ 9,314		$ 1,589		$ 3,656		$ 4,069
GRAPHICS SUPPORT				$ 1,884		$ 2,574		$ 4,458		$ 797		$ 1,834		$ 1,827
SHOP & OPERATIONS SUPPORT				$ 1,277		$ -		$ 1,277		$ 228		$ 525		$ 524
OUTSIDE LABS				$ 2,000		$ -		$ 2,000		$ 606		$ 1,394		$ -
TOTAL OTHER DIRECT COST				$ 57,866		$ 157,263		$ 215,129		$ 38,147		$ 87,775		$ 89,207
TOTAL DIRECT COST				$ 213,764		$ 509,203		$ 722,967		$ 128,205		$ 294,872		$ 299,890
FACILITIES & ADMIN. RATE - % OF MTDC		VAR		$ 112,377		$ 264,656		$ 377,033	56%	$ 71,795	56%	$ 165,128	47.7%	$ 140,110
TOTAL ESTIMATED COST				$ 326,141		$ 773,859		$ 1,100,000		$ 200,000		$ 460,000		$ 440,000

DETAILED BUDGET - YEAR ONE

MERCURY CONTROL TECHNOLOGIES FOR ELECTRIC UTILITIES BURNING LIGNITE COALS-PHASE II
DOE/NDIC/INDUSTRIAL CLIENTS
PROPOSED START DATE: JUNE 1, 2003
EERC PROPOSAL #2003-0122

			TOTAL YEAR ONE		COMMERCIAL SHARE		EERC JSRP SHARE	
LABOR	**LABOR CATEGORY**	**HOURLY RATE**	**HRS**	**$COST**	**HRS**	**$COST**	**HRS**	**$COST**
PAVLISH, J.	PROJECT MANAGER	$ 44.47	600	$ 26,682	354	$ 15,742	246	$ 10,940
HOLMES, M.	PRINCIPAL INVESTIGATOR	$ 42.18	490	$ 20,668	289	$ 12,190	201	$ 8,478
THOMPSON, J.	RESEARCH SCIENTIST/ENGINEER	$ 26.99	370	$ 9,987	218	$ 5,884	152	$ 4,103
BENSON, S.	RESEARCH SCIENTIST/ENGINEER	$ 48.02	32	$ 1,536	19	$ 912	13	$ 624
--------------	SENIOR MANAGEMENT	$ 48.20	49	$ 2,361	30	$ 1,446	19	$ 915
--------------	RESEARCH SCIENTIST/ENGINEER	$ 26.94	443	$ 11,934	203	$ 5,469	240	$ 6,465
--------------	RESEARCH TECHNICIAN	$ 18.42	42	$ 774	25	$ 461	17	$ 313
--------------	TECHNOLOGY DEV. OPER.	$ 18.49	640	$ 11,834	378	$ 6,989	262	$ 4,845
--------------	TECHNOLOGY DEV. MECH.	$ 20.79	120	$ 2,495	71	$ 1,476	49	$ 1,019
--------------	UNDERGRAD-RES.	$ 8.40	1,000	$ 8,400	590	$ 4,956	410	$ 3,444
--------------	TECHNICAL SUPPORT SERVICES	$ 14.62	180	$ 2,632	106	$ 1,550	74	$ 1,082
			3,966	$ 99,303	2,283	$ 57,075	1,683	$ 42,228
ESCALATION ABOVE CURRENT BASE		5%		$ 4,965		$ 2,854		$ 2,111
TOTAL DIRECT LABOR				$ 104,268		$ 59,929		$ 44,339
FRINGE BENEFITS - % OF DIRECT LABOR-STAFF		54%		$ 51,542		$ 29,551		$ 21,991
FRINGE BENEFITS - % OF DIRECT LABOR-STUDENT		1%		$ 88		$ 52		$ 36
TOTAL FRINGE BENEFITS		VAR		$ 51,630		$ 29,603		$ 22,027
TOTAL LABOR				$ 155,898		$ 89,532		$ 66,366
OTHER DIRECT COSTS								
TRAVEL				$ 19,640		$ 11,588		$ 8,052
COMMUNICATION - PHONES & POSTAGE				$ 535		$ 316		$ 219
DATA PROCESSING - SOFTWARE				$ 300		$ 177		$ 123
OFFICE (PROJECT SPECIFIC SUPPLIES)				$ 625		$ 369		$ 256
SUPPLIES				$ 300		$ 177		$ 123
GENERAL (FREIGHT, FOOD, MEMBERSHIPS, ETC.)				$ 250		$ 148		$ 102
EQUIPMENT > $5000				$ -		$ -		$ -
NATURAL MATERIALS ANALYTICAL RES. LAB.				$ 1,512		$ 892		$ 620
FUELS & MATERIALS RESEARCH LAB.				$ 1,518		$ 896		$ 622
ANALYTICAL RESEARCH LAB.				$ 4,330		$ 3,750		$ 580
PARTICULATE ANALYSIS				$ 12,396		$ 7,314		$ 5,082
PROCESS CHEM. & DEV. LAB.				$ 515		$ 304		$ 211
FUEL PREP. AND MAINTENANCE				$ 1,470		$ 867		$ 603
PARTICULATE TEST COMBUSTOR MAINT.				$ 9,314		$ 5,245		$ 4,069
GRAPHICS SUPPORT				$ 1,884		$ 1,112		$ 772
SHOP & OPERATIONS SUPPORT				$ 1,277		$ 753		$ 524
OUTSIDE LABS				$ 2,000		$ 2,000		$ -
TOTAL OTHER DIRECT COST				$ 57,866		$ 35,908		$ 21,958
TOTAL DIRECT COST				$ 213,764		$ 125,440		$ 88,324
FACILITIES & ADMIN. RATE - % OF MTDC		VAR		$ 112,377	56%	$ 70,246	47.7%	$ 42,131
TOTAL ESTIMATED COST				$ 326,141		$ 195,686		$ 130,455

DETAILED BUDGET - YEAR TWO

MERCURY CONTROL TECHNOLOGIES FOR ELECTRIC UTILITIES BURNING LIGNITE COALS-PHASE II
DOE/NDIC/INDUSTRIAL CLIENTS
PROPOSED START DATE: JUNE 1, 2003
EERC PROPOSAL #2003-0122

LABOR	LABOR CATEGORY	HOURLY RATE	TOTAL YEAR TWO HRS	TOTAL YEAR TWO $COST	COMMERCIAL SHARE HRS	COMMERCIAL SHARE $COST	EERC JSRP SHARE HRS	EERC JSRP SHARE $COST
PAVLISH, J.	PROJECT MANAGER	$ 44.47	680	$ 30,240	401	$ 17,832	279	$ 12,408
HOLMES, M.	PRINCIPAL INVESTIGATOR	$ 42.18	480	$ 20,246	283	$ 11,937	197	$ 8,309
THOMPSON, J.	RESEARCH SCIENTIST/ENGINEER	$ 26.99	920	$ 24,831	543	$ 14,656	377	$ 10,175
BENSON, S.	RESEARCH SCIENTIST/ENGINEER	$ 48.02	8	$ 384	5	$ 240	3	$ 144
--------------	SENIOR MANAGEMENT	$ 48.20	124	$ 5,977	73	$ 3,519	51	$ 2,458
--------------	RESEARCH SCIENTIST/ENGINEER	$ 26.94	4,288	$ 115,519	2,530	$ 68,158	1,758	$ 47,361
--------------	RESEARCH TECHNICIAN	$ 18.42	207	$ 3,813	122	$ 2,247	85	$ 1,566
--------------	TECHNOLOGY DEV. OPER.	$ 18.49	-	$ -	-	$ -	-	$ -
--------------	TECHNOLOGY DEV. MECH.	$ 20.79	-	$ -	-	$ -	-	$ -
--------------	UNDERGRAD-RES.	$ 8.40	800	$ 6,720	472	$ 3,965	328	$ 2,755
--------------	TECHNICAL SUPPORT SERVICES	$ 14.62	160	$ 2,339	94	$ 1,374	66	$ 965
			7,667	$ 210,069	4,523	$ 123,928	3,144	$ 86,141
ESCALATION ABOVE CURRENT BASE		10.0%		$ 21,008		$ 12,393		$ 8,615
TOTAL DIRECT LABOR				$ 231,077		$ 136,321		$ 94,756
FRINGE BENEFITS - % OF DIRECT LABOR-STAFF		54%		$ 120,790		$ 71,258		$ 49,532
FRINGE BENEFITS - % OF DIRECT LABOR-STUDENT		1%		$ 73		$ 44		$ 29
TOTAL FRINGE BENEFITS		VAR		$ 120,863		$ 71,302		$ 49,561
TOTAL LABOR				$ 351,940		$ 207,623		$ 144,317
OTHER DIRECT COSTS								
TRAVEL				$ 73,862		$ 43,579		$ 30,283
COMMUNICATION - PHONES & POSTAGE				$ 1,045		$ 617		$ 428
DATA PROCESSING - SOFTWARE				$ -		$ -		$ -
OFFICE (PROJECT SPECIFIC SUPPLIES)				$ 920		$ 534		$ 386
SUPPLIES				$ 13,290		$ 7,841		$ 5,449
GENERAL (FREIGHT, FOOD, MEMBERSHIPS, ETC.)				$ 500		$ 295		$ 205
EQUIPMENT > $5000				$ 6,160		$ -		$ 6,160
NATURAL MATERIALS ANALYTICAL RES. LAB.				$ -		$ -		$ -
FUELS & MATERIALS RESEARCH LAB.				$ 10,425		$ 6,104		$ 4,321
ANALYTICAL RESEARCH LAB.				$ 22,308		$ 14,080		$ 8,228
PARTICULATE ANALYSIS				$ 24,077		$ 14,205		$ 9,872
PROCESS CHEM. & DEV. LAB.				$ 2,102		$ 1,240		$ 862
FUEL PREP. AND MAINTENANCE				$ -		$ -		$ -
PARTICULATE TEST COMBUSTOR MAINT.				$ -		$ -		$ -
GRAPHICS SUPPORT				$ 2,574		$ 1,519		$ 1,055
SHOP & OPERATIONS SUPPORT				$ -		$ -		$ -
OUTSIDE LABS				$ -		$ -		$ -
TOTAL OTHER DIRECT COST				$ 157,263		$ 90,014		$ 67,249
TOTAL DIRECT COST				$ 509,203		$ 297,637		$ 211,566
FACILITIES & ADMIN. RATE - % OF MTDC		VAR		$ 264,656	56%	$ 166,677	47.7%	$ 97,979
TOTAL ESTIMATED COST				$ 773,859		$ 464,314		$ 309,545

DETAILED BUDGET - FEES

MERCURY CONTROL TECHNOLOGIES FOR ELECTRIC UTILITIES BURNING LIGNITE COALS-PHASE II
EERC PROPOSAL #2003-0122

NATURAL MATERIALS ANALYTICAL RES. LAB.	RATE	YEAR ONE #	YEAR ONE $COST	YEAR TWO #	YEAR TWO $COST	ALL YEARS #	ALL YEARS $COST
XRFA	$144	10	$ 1.440	-	$ -	10	$ 1.440
SUBTOTAL			$ 1.440		$ -		$ 1.440
ESCALATION		5%	$ 72	10%	$ -	VAR	$ 72
TOTAL NATURAL MATERIALS ANALYTICAL RES. LAB.			$ 1.512		$ -		$ 1.512

FUELS & MATERIALS RESEARCH LAB.	RATE	#	$COST	#	$COST	#	$COST
ASH DETERMINATION	$27	6	$ 162	-	$ -	6	$ 162
BTU	$46	6	$ 276	39	$ 1.794	45	$ 2.070
LOSS ON IGNITION (LOI)	$37	6	$ 222	39	$ 1.443	45	$ 1.665
MISCELLANEOUS	$64	-	$ -	39	$ 2.496	39	$ 2.496
MOISTURE %	$35	6	$ 210	-	$ -	6	$ 210
PROXIMATE ANALYSIS	$52	6	$ 312	39	$ 2.028	45	$ 2.340
SULFUR	$44	6	$ 264	39	$ 1.716	45	$ 1.980
SUBTOTAL			$ 1.446		$ 9.477		$ 10.923
ESCALATION		5%	$ 72	10%	$ 948	VAR	$ 1.020
TOTAL FUELS & MATERIALS RESEARCH LAB.			$ 1.518		$ 10.425		$ 11.943

ANALYTICAL RESEARCH LAB.	RATE	#	$COST	#	$COST	#	$COST
ACID EXTRACTABLE MERC	$29	28	$ 812	-	$ -	28	$ 812
COAL DIGESTION	$144	6	$ 864	39	$ 5.616	45	$ 6.480
CVGAA	$32	28	$ 896	39	$ 1.248	67	$ 2.144
FILTERING	$10	28	$ 280	39	$ 390	67	$ 670
Hg PREP - DIGESTION	$30	28	$ 840	-	$ -	28	$ 840
ICP - MS	$38	6	$ 228	-	$ -	6	$ 228
LEACHING	$109	-	$ -	6	$ 654	6	$ 654
MISCELLANEOUS (SAMPLE)	$36	-	$ -	270	$ 9.720	270	$ 9.720
MIXED ACID DIGESTION	$34	6	$ 204	78	$ 2.652	84	$ 2.856
SUBTOTAL			$ 4.124		$ 20.280		$ 24.404
ESCALATION		5%	$ 206	10%	$ 2.028	VAR	$ 2.234
TOTAL ANALYTICAL RESEARCH LAB.			$ 4.330		$ 22.308		$ 26.638

PARTICULATE ANALYSIS	RATE	#	$COST	#	$COST	#	$COST
BENCH SCALE SIMULATOR (PER HOUR)	$88	40	$ 3.520	-	$ -	40	$ 3.520
EPA DUST LOADING	$135	3	$ 405	-	$ -	3	$ 405
EPA METHOD 29/ONTARIO HYDRO	$273	25	$ 6.825	-	$ -	25	$ 6.825
MERCURY CEM (PER DAY)	$96	11	$ 1.056	228	$ 21.888	239	$ 22.944
SUBTOTAL			$ 11.806		$ 21.888		$ 33.694
ESCALATION		5%	$ 590	10%	$ 2.189	VAR	$ 2.779
TOTAL PARTICULATE ANALYSIS			$ 12.396		$ 24.077		$ 36.473

PROCESS CHEM. & DEV. LAB.	RATE	#	$COST	#	$COST	#	$COST
PREP/GC/CHN	$49	10	$ 490	39	$ 1.911	49	$ 2.401
SUBTOTAL			$ 490		$ 1.911		$ 2.401
ESCALATION		5%	$ 25	10%	$ 191	VAR	$ 216
TOTAL PROCESS CHEM. & DEV. LAB.			$ 515		$ 2,102		$ 2,617

FUEL PREP. & MAINTENANCE	RATE/HR.	#	$COST	#	$COST	#	$COST
FUEL PREP. AND MAINTENANCE	$14	100	$ 1,400	-	$ -	100	$ 1,400
SUBTOTAL			$ 1.400		$ -		$ 1.400
ESCALATION		5%	$ 70	10%	$ -	VAR	$ 70
TOTAL FUEL PREP. & MAINTENANCE			$ 1,470		$ -		$ 1,470

PARTICULATE TEST COMBUSTOR MAINT.	RATE/DAY	#	$COST	#	$COST	#	$COST
PTC MAINTENANCE FEE (DAY)	$887	10	$ 8,870	-	$ -	10	$ 8,870
SUBTOTAL			$ 8.870		$ -		$ 8.870
ESCALATION		5%	$ 444	10%	$ -	VAR	$ 444
TOTAL PARTICULATE TEST COMBUSTOR MAINT.			$ 9.314		$ -		$ 9.314

GRAPHICS SUPPORT	RATE	#	$COST	#	$COST	#	$COST
GRAPHICS (HOURLY)	$39	46	$ 1.794	60	$ 2.340	106	$ 4,134
SUBTOTAL			$ 1.794		$ 2.340		$ 4.134
ESCALATION		5%	$ 90	10%	$ 234	VAR	$ 324
TOTAL GRAPHICS SUPPORT			$ 1.884		$ 2.574		$ 4.458

SHOP & OPERATIONS SUPPORT	RATE	#	$COST	#	$COST	#	$COST
TECHNICAL DEVELOPMENT HOURS	$1.60	760	$ 1,216	-	$ -	760	$ 1,216
SUBTOTAL			$ 1,216		$ -		$ 1,216
ESCALATION		5%	$ 61	10%	$ -	VAR	$ 61
TOTAL SHOP & OPERATIONS SUPPORT			$ 1,277		$ -		$ 1,277

DETAILED BUDGET - TRAVEL

MERCURY CONTROL TECHNOLOGIES FOR ELECTRIC UTILITIES BURNING LIGNITE COALS-PHASE II
EERC PROPOSAL #2003-0122

RATES USED TO CALCULATE ESTIMATED TRAVEL EXPENSES

DESTINATION	AIRFARE	PER MILE	LODGING	PER DIEM	CAR RENTAL	REGIST.
Unspecified Destination (USA)	$ 1,524	$ -	$ 125	$ 50	$ 50	$ 400
Regina, Saskatchewan - flying out of Winnipeg	$ 350	$ 0.31	$ 80	$ 45	$ 50	$ -
Regina, Saskatchewan - driving car	$ -	$ 0.31	$ 55	$ 45		
Regina, Saskatchewan - driving truck	$ -	$ 0.50	$ 55	$ 45		
Bismarck, ND	$ -	$ 0.31	$ 50	$ 20	$ -	$ -
Morgantown, WV (via Pittsburgh, PA)	$ 1,060	$ -	$ 65	$ 38	$ 50	$ -

	NUMBER OF											
PURPOSE/DESTINATION	TRIPS	PEOPLE	MILES	DAYS	AIRFARE	MILEAGE	LODGING	PER DIEM	CAR RENTAL	MISC	REGIST.	TOTAL
Task 1												
Purpose/Bismarck, ND	2	2	600	2	$ -	$ 372	$ 200	$ 160	$ -	$ 80	$ -	$ 812
Task 2												
Conference/Unspecified Dest. (USA)	1	2	-	3	$ 3,048	$ -	$ 500	$ 300	$ 150	$ 120	$ 800	$ 4,918
Purpose/Regina, Sask.	2	2	-	3	$ 1,400	$ -	$ 640	$ 540	$ 300	$ 360	$ -	$ 3,240
Task 5												
Purpose/Unspecified Dest. (USA)	1	2	-	3	$ 3,048	$ -	$ 500	$ 300	$ 150	$ 120	$ 800	$ 4,918
Purpose/Regina, Sask.	2	2	300	3	$ 1,400	$ 186	$ 640	$ 540	$ 300	$ 360	$ -	$ 3,426
Purpose/Bismarck, ND	2	2	600	2	$ -	$ 372	$ 200	$ 160	$ -	$ 80	$ -	$ 812
Contract Rvw Mtg/Morgantown, WV (Pittsburgh, PA)	1	1	-	3	$ 1,060	$ -	$ 130	$ 114	$ 150	$ 60	$ -	$ 1,514
TOTAL ESTIMATED TRAVEL -YEAR ONE												$ 19,640
Task 2												
Pretest/Regina, Sask.	1	2	1,000	4	$ -	$ 310	$ 330	$ 360	$ -	$ 160	$ -	$ 1,160
Fieldwork/Regina, Sask.-car	22	1	1,900	11	$ -	$ 12,958	$ 12,100	$ 10,890	$ -	$ 4,840	$ -	$ 40,788
Fieldwork/Regina, Sask.-truck	4	4	2,200	14	$ -	$ 4,400	$ 11,440	$ 10,080	$ -	$ 4,480	$ -	$ 30,400
Total Task 2												$ 72,348
Task 5												
Contract Rvw Mtg/Morgantown, WV (Pittsburgh, PA)	1	1	-	3	$ 1,060	$ -	$ 130	$ 114	$ 150	$ 60	$ -	$ 1,514
TOTAL ESTIMATED TRAVEL -YEAR TWO												$ 73,862
TOTAL ESTIMATED TRAVEL - ALL YEARS												$ 93,502

DETAILED BUDGET - EQUIPMENT

DESCRIPTION	$COST
Sampling trailer - 11 weeks @ $560/wk	$ 6,160
TOTAL ESTIMATED EQUIPMENT	$ 6,160

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 and in accordance with federal regulations A-21 and A-110. The budget prepared for this proposal is based on a specific start date; this start date is indicated at the top of the EERC budget or identified in the body of the proposal. Please be aware that any delay in the start of this project may result in an increase in the budget. Financial reporting will be at the total project level.

Salaries and Fringe Benefits

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

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

Travel

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

Communications (phones and postage)

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

Office (project-specific supplies)

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

Data Processing

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

Supplies

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

Instructional/Research

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

Fees

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

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

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

General

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

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

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

Facilities and Administrative Cost

The facilities and administrative rate (indirect cost rate) included in this proposal is the rate that became effective July 1, 2002. 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.