LARGE-SCALE MERCURY CONTROL TECHNOLOGY TESTING FOR LIGNITE-FIRED UTILITIES – OXIDATION SYSTEMS FOR WET FGD

EERC Proposal No. 2004-0045

Submitted to:

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Amount of Request: $172,500

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October 2003

TABLE OF CONTENTS

LIST OF FIGURES iii

LIST OF TABLES iv

ABSTRACT v

PROJECT SUMMARY 1

PROJECT DESCRIPTION 2
- Introduction 2
- Background 3
  - Mercury Emission Control Challenges for Lignite Coals 4
  - Technology Needs for Lignite-Fired Units 6
  - Mercury Oxidation 7
  - Selected Host Sites and Existing Removal Rates 8
  - Improvements in Mercury Capture Through Oxidation 12
- Technical Feasibility and Readiness for Long-Term Field Testing 14
- Benefits of Proposed Technology 15
- Scientific and Technical Basis and Rationale for Further Research 16
- Anticipated Balance of Plant Impacts 17
- Technical Approach 18
- Work Plan 20
  - Task 1 – Testing at MRY Unit 2 20
  - Task 2 – Testing at Monticello 23
- Deliverables 24
- Staffing Plan 25
- Data Collection – QA/QC 25
- Purpose/Clarification 27
- Travel 28
- Technology Transfer, Commercialization, and Market Penetration Potential 29

STANDARDS OF SUCCESS 29

BACKGROUND AND QUALIFICATIONS 30
- Team Qualifications 30
- Team Experience in Related Projects 31
  - The EERC 31
  - URS Corporation 32
  - EPRI 32
  - ADA.ES 33
  - Minnkota Power Cooperative 33

Continued. . .

TABLE OF CONTENTS (continued)

TXU 34
Facilities and Equipment 34

VALUE TO NORTH DAKOTA 35

MANAGEMENT 36

TIMETABLE 38

BUDGET 38

MATCHING FUNDS 38

TAX LIABILITY 40

REFERENCES 40

BUDGET AND BUDGET NOTES 42

RESUMES OF KEY PERSONNEL, ORGANIZATIONAL PROFILES,
AND LETTERS OF SUPPORT ..... APPENDIX A

LIST OF FIGURES

1 Inlet mercury speciation for Freedom, North Dakota, lignite ($\mu g/dNm^3$ = microgram per dry normal cubic meter [corrected to 0°C and 3% O_2]). 6

2 Prediction of chlorine radical formation as a function of temperature and residence time typical of a utility boiler using a kinetic mode (Chemkin). 8

3 Oxidation of mercury through the addition of chlorine-containing additive to coal in EERC pilot-scale testing. 9

4 Comparison of mercury oxidation and HCl flue gas content for a range of salt injections at a North Dakota lignite-fired power plant (8). 9

5 Schematic for MRY Station, Unit 2, showing sampling locations. 11

6 A) MRY OH mercury data obtained in October/November 2002 and B) OH mercury data for Monticello (ICR data). 11

7 Plant schematic for Monticello Unit 3. 13

8 Organizational chart for Hg oxidation and control program. 37

9 Project schedule 38

LIST OF TABLES

1 Description of Test Sites 19

2 General Project Activities 20

3 Staffing Plan for Project 26

4 Project Quality Measures 27

5 Data Quality Objectives for Flue Gas Mercury Analyses by OH Method 28

6 Project Travel 28

7 Summary of Expertise of Key Personnel 31

8 Cost-Share Table 39

LARGE-SCALE MERCURY CONTROL TECHNOLOGY TESTING FOR LIGNITE-FIRED UTILITIES – OXIDATION SYSTEMS FOR WET FGD

ABSTRACT

The overall goal of the project is to resolve Hg control issues facing the lignite industry via a process that will significantly and cost-effectively oxidize Hg^0 in lignite combustion gases, followed by capture in a wet scrubber. This approach will be applicable to virtually every U.S. and Canadian lignite utility. The oxidation process is proven at the pilot scale and in short-term full-scale tests. Additional optimization of oxidation technologies continues, and this project will focus on longer-term full-scale testing. The lignite industry is proactively advancing the understanding of and identifying control options for Hg in lignite combustion gases. About a year ago, the EERC and EPRI began Hg discussions with the Mercury Task Force and utilities firing Texas and Saskatchewan lignites. As a result, this project, one of three, involves establishing Hg oxidation levels upstream of air pollution control devices (APCDs) and removal rates across existing electrostatic precipitator and flue gas desulfurization units, determining associated costs, investigating the possibility of the APCD acting as a multipollutant control device, quantifying the balance of plant impacts of the control technologies, and facilitating technology commercialization. The host sites are Minnkota Power Cooperative Milton R. Young Unit 2 and TXU Monticello Unit 3.

Total project cost is $2,150,767. DOE will provide $1,602,195. Utility sponsors providing aggregate cash ($57,500) and in-kind ($318,572) funding are ADA.ES; SaskPower; Coteau Properties Co.; Falkirk Mining Co.; BNI Coal, Ltd.; Dakota Westmoreland Corp.; Great River Energy; Basin Electric Power Coop.; Otter Tail Power Co.; Montana-Dakota Utilities Co.; EPRI; TXU Energy; and Minnkota Power Coop. This proposal requests $172,500 from NDIC.

LARGE-SCALE MERCURY CONTROL TECHNOLOGY TESTING FOR LIGNITE-FIRED UTILITIES – OXIDATION SYSTEMS FOR WET FGD

PROJECT SUMMARY

The overall objective of this project is to demonstrate the effectiveness of chemical addition for reducing mercury (Hg) emissions from flue gas derived from lignite. Full-scale tests will be performed at Minnkota Power Cooperative Milton R. Young (MRY) Station Unit 2 and TXU Energy (TXU) Monticello Station Unit 3 to evaluate chemical addition performance across an electrostatic precipitator (ESP) wet scrubber configuration.

The objective of the MRY Unit 2 testing is to determine the impact of chemical addition on Hg speciation, overall Hg removal from the flue gas using the combination of the ESP and wet scrubber, and impact of the chlorine-containing salt on corrosion and deposition on system components. The objective of the Monticello testing is to provide additional data on Hg oxidation and removal efficiency when a lignite coal from Texas is fired. Data from this program will be used to perform an economic analysis of the costs associated with full-scale implementation of a chemical addition system.

The scope of work is aimed at testing Hg oxidation technology for controlling Hg emissions at two lignite-fired power plants equipped with wet flue gas desulfurization (FGD) systems: MRY Unit 2 (cyclone-fired, North Dakota lignite, ESP, wet FGD) and Monticello Unit 3 (wall-fired, Texas lignite, ESP, wet FGD). The technology involves the injection of a chemical additive with the lignite or injection into the furnace to oxidize Hg upstream of a wet FGD system. The two plants with different firing systems and lignite types will be tested to determine degree of Hg oxidation as a function of chemical addition rate, Hg removal efficiencies, economics, and balance of plant impacts. The additive will be added at rates equivalent to 300 to

1000 ppm chlorine in the coal during the parametric testing, with a target of less than 500 ppm in the coal for long-term testing.

PROJECT DESCRIPTION

Introduction

The Energy & Environmental Research Center (EERC) is proposing to lead a consortium-based effort directed toward resolving the Hg control issues facing the lignite industry. Specifically, the EERC team, including EPRI; URS Corporation; ADA.ES; the North Dakota Industrial Commission (NDIC); SaskPower; and the Mercury Task Force, which includes Basin Electric Power Cooperative; Otter Tail Power Company; Great River Energy; TXU; Montana–Dakota Utilities Co.; Minnkota Power Cooperative; BNI Coal, Ltd.; Dakota Westmoreland Corporation; Falkirk Mining Company, and Coteau Properties Company, are proposing to significantly and cost-effectively oxidize elemental mercury (Hg^0) in lignite combustion gases, followed by capture in a wet scrubber. This approach will be applicable to virtually every lignite utility in the United States and Canada and potentially impact subbituminous utilities. The oxidation process is proven at the pilot scale and in short-term full-scale tests. Additional optimization is continuing on oxidation technologies, and this proposal will focus on longer-term full-scale testing.

The lignite industry has been proactive in advancing the understanding of and identifying control options for Hg in lignite combustion flue gases. Approximately 1 year ago, the EERC and EPRI began a series of Hg-related discussions with the Mercury Task Force as well as utilities firing Texas and Saskatchewan lignites. This proposal is one of three being submitted by the consortium to perform large-scale Hg control technology testing to address the specific needs and challenges to be met in controlling Hg from lignite-fired power plants.

This proposal involves Hg oxidation upstream of a system equipped with an ESP followed by wet FGD. The project team involved in conducting the technical aspects of the project includes the EERC, URS, and ADA.ES. The host sites include Minnkota Power Cooperative MRY Unit 2 and TXU Monticello Unit 3. The work will involve establishing Hg oxidation levels upstream of air pollution control devices (APCDs) and removal rates across existing ESP and FGD units, determining costs associated with those removal rates, investigating the possibility of the APCD acting as a multipollutant control device, quantifying the balance of plant (BOP) impacts of the control technologies, and facilitating technology commercialization.

The other proposals cover sorbent injection technologies for systems equipped with ESPs and those equipped with spray dryer absorbers combined with fabric filters (SDA/FF) and an alternative oxidation technology. The overall intent of the proposed testing is to help maintain the viability of lignite-fired energy production by providing utilities with lower-cost options for meeting future Hg regulations.

Background

Hg is an immediate concern for the U.S. electric power industry because of the U.S. Environmental Protection Agency's (EPA) December 2000 decision that regulation of Hg from coal-fired electric utility steam-generating units is appropriate and necessary under Section 112 of the Clean Air Act (1). EPA determined that Hg emissions from power plants pose significant hazards to public health and must be reduced. The EPA *Mercury Study Report to Congress* (1997) (2) and the *Utility Hazardous Air Pollutant Report to Congress* (1998) (3) both identified coal-fired boilers as the largest single category of atmospheric Hg 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 2007. The exact form of regulation is uncertain at this time. While EPA is developing a regulation based on a maximum achievable control technology (MACT) approach, Congress is discussing multipollutant (SO_x, NO_x, and Hg) approaches. One multipollutant approach, the Clear Skies Act of 2002, has the backing of the Bush Administration and was introduced into the Senate and House of Representatives in July 2002. A more recent version was reintroduced in 2003. Numerous other bills have also been proposed, but regardless of the approach taken, it is clear that Hg reductions are expected to be in the range of 46%–90% by 2007 or 2010 with an increase in the low-end values to 69% by 2018.

Despite the fact that Hg regulations for coal-fired utilities are imminent, significant issues remain and need to be resolved. The U.S. Department of Energy National Energy Technology Laboratory (DOE NETL) has acknowledged that data gaps exist for Hg control technologies for the immense U.S. reserves of lignite and subbituminous coals. The primary challenge is that these coals produce flue gases where difficult-to-control Hg^0 is the dominant form. The information collection request (ICR) indicates questions still exist regarding the impact of various APCDs and technologies for lignite-fired units on their ability to control Hg^0 emission. The lignite-based consortium believes there is critical need for large-scale Hg oxidation testing at lignite-fired power plants equipped with an ESP and wet FGD. This proposal has been developed based on the input of the consortium members and DOE guidance provided in the solicitation to address these issues.

Mercury Emission Control Challenges for Lignite Coals. In general, lignitic coals are unique because of highly variable ash content, ash that is rich in alkali and alkaline-earth elements, high oxygen levels, high moisture levels, and low chlorine content. Lignite coals typically contain comparable levels of Hg but significantly lower levels of chlorine compared to

bituminous coals. Lignites have chlorine concentrations well below 200 ppm in the coal, whereas Appalachian and Illinois Basin bituminous coals can have chlorine levels in excess of 1000 ppm. These differences in composition have been shown to have important effects on the form of Hg emitted from a boiler and the capabilities of different control technologies to remove Hg from flue gas. Coals containing chlorine levels greater than 200 ppm typically produce flue gas dominated by more easily removable mercuric compounds (Hg^{2+}), most likely mercuric chloride ($HgCl_2$). Conversely, experimental results indicate that low-chlorine (<50-ppm) coal combustion flue gases (typical of lignite) contain predominantly Hg^0, which is substantially more difficult to remove than Hg^{2+} (3). Additionally, the generally high alkali and alkaline-earth contents of lignite coals may reduce the oxidizing effect of the already-low chlorine content by reactively scavenging chlorine species (Cl, HCl, and Cl_2) from the combustion flue gas. The level of chlorine in flue gases of recently tested lignites from North Dakota and Saskatchewan ranged from 2.6 to 3.4 ppmv, with chlorine contents ranging from 11 to 18 ppmw in the coal on a dry basis, respectively.

Very little published data exist demonstrating the effectiveness of oxidation technologies for plants firing lignite coal. Lignite-fired power plants have shown a limited ability to control Hg emissions in currently installed ESPs, SDAs, and wet FGD systems (4). This low level of control can be attributed to the high proportions of Hg^0 present in the flue gas. Typically, the form of Hg in the pulverized and cyclone-fired units is dominated by the Hg^0 content being greater than 85% of the total, and the average emitted from North Dakota lignite-fired power plants is roughly 6.3 lb/TBtu (4, 5). Figure 1 shows resulting Hg emissions measured using the Ontario Hydro (OH) method and continuous mercury monitors (CMMs) or continuous emission monitors (CEMs) for Hg at the furnace exit during pilot tests at EERC with North Dakota lignite.

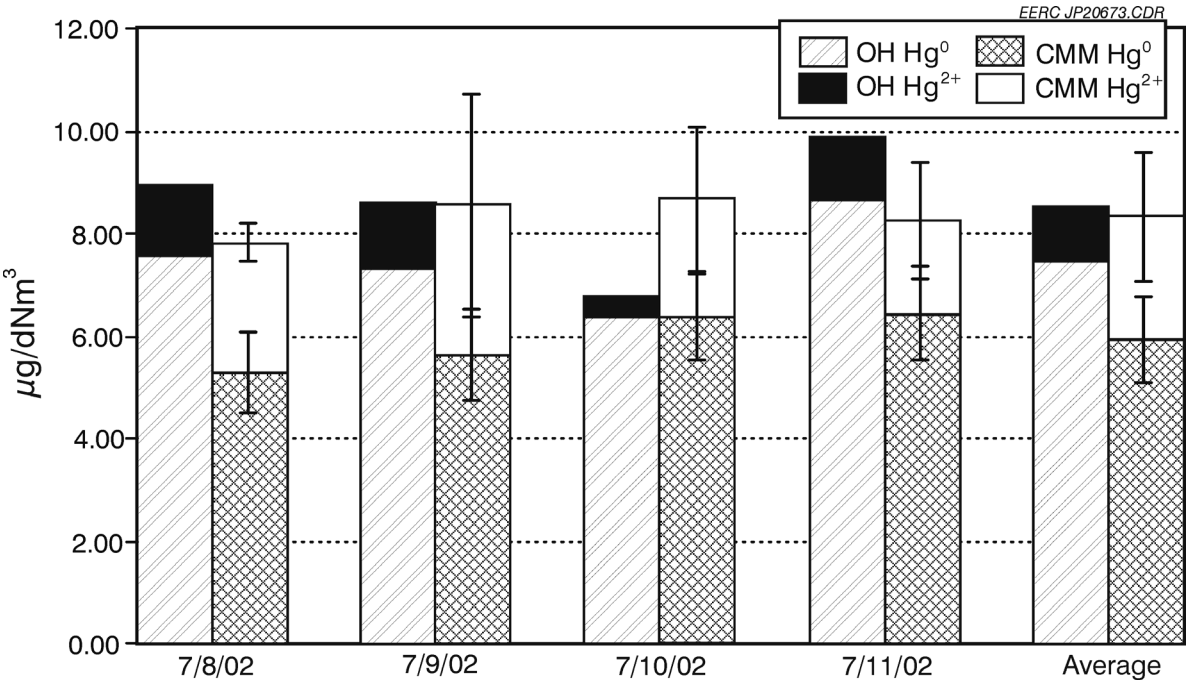


Figure 1. Inlet mercury speciation for Freedom, North Dakota, lignite (µg/dNm^3 = microgram per dry normal cubic meter [corrected to 0°C and 3% O_2]).

These results are consistent with the ICR results discussed above and with the recent baseline data for the proposed test sites, as shown later.

Technology Needs for Lignite-Fired Units. A primary objective of the lignite-based consortium collaborating on this proposal is testing low-cost Hg control options centered around existing APCDs in order to provide economical options for lignite-fired utilities. Lignite power plants are typically minemouth plants that fire lignites from several seams and are designed specifically for the slagging and fouling and heat release rates typical of lignites.

Currently, the Hg control strategies for lignite-fired power plants involve first the enhancement of existing control technologies and second the investigation and development of new control technologies. The strategies that have shown sufficient success to warrant field testing include enhanced sorbent injection upstream of an ESP or SDA/FF and Hg oxidation upstream of wet FGD or SDA systems. There is a relatively even split between these three

emission control configurations for lignite-fired utilities in North Dakota, while roughly half of the Texas units are equipped with wet FGD systems. The subject DOE solicitation identifies testing of technologies for the SDA/FF and wet FGD configurations for lignite coals as areas of critical need and shows uncertainty associated with the need for the ESP systems.

Mercury Oxidation. Hg oxidation technologies being investigated for lignites include catalysts and chemical agents. The catalysts that have been tested include selective catalytic reduction catalyst for NO_x reduction, noble metal-impregnated catalysts, and oxide-impregnated catalysts. The chemical agents include chlorine-containing salts and cofiring fuels that contain oxidizing agents (6, 7).

Theoretically, the use of chloride compounds to oxidize Hg^0 to Hg^{2+} makes sense. The evidence includes chemical kinetic modeling of bench-scale test results indicating that the introduction of chloride compounds into the high-temperature furnace region will likely result in the production of atomic chlorine and/or molecular chlorine, which are generally thought to be the dominant Hg^0 reactants in coal combustion flue gases (6). The formation of atomic chlorine is a key pathway involved in the chemical reaction mechanisms that result in the oxidation of Hg^0 (6). The pathway for Hg oxidation is by gas-phase Hg^0 oxidation by atomic chlorine (chlorine radical). Recent kinetic modeling of chlorine radical formation as a function of temperature and residence time is shown in Figure 2. The results indicate the importance of temperature on the abundance of chlorine radicals. Recent work, supported by EPRI, indicated that injection of HCl in lower-temperature regions downstream of the boiler was ineffective in oxidizing Hg^0 while injection of salt into the furnace resulted in significant oxidation (8).

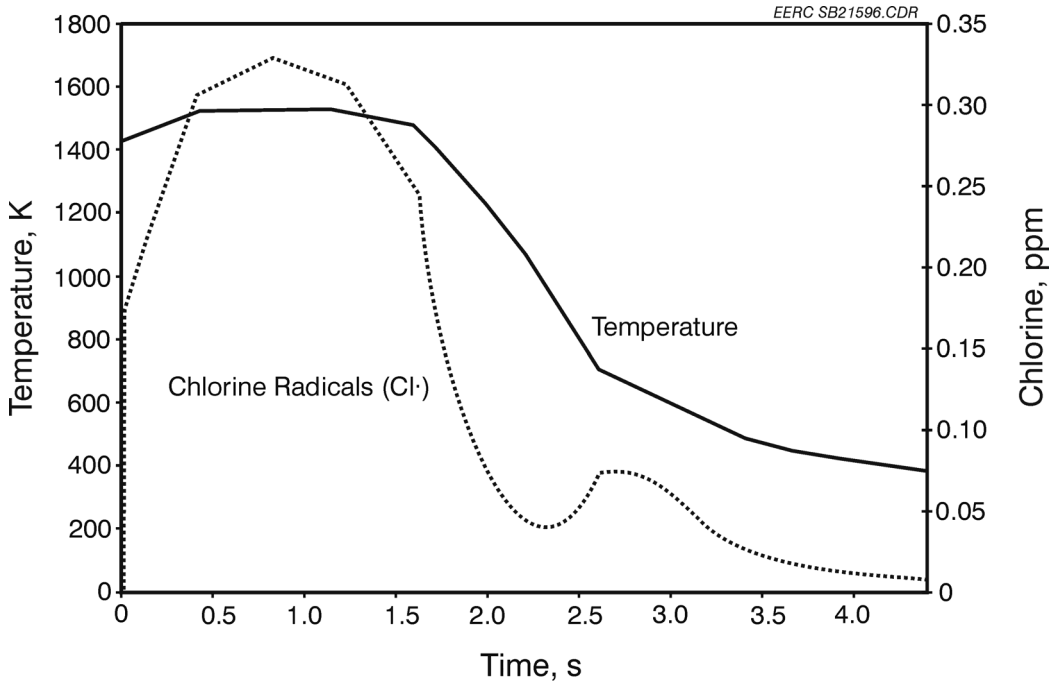


Figure 2. Prediction of chlorine radical formation as a function of temperature and residence time typical of a utility boiler using a kinetic mode (Chemkin).

Fuel additives for Hg oxidation have recently been tested in a pilot-scale system. Chemical additives or oxidants such as chloride salts have shown the ability to convert Hg^0 to more reactive oxidized forms, as shown in Figure 3. In addition, recent EPRI short-term testing conducted at a 70-MW_e pulverized-coal-fired North Dakota power plant indicated the injection of chloride salts can result in increased Hg oxidation in the flue gas (8). Hg oxidation of up to 70% was observed at a salt injection rate that resulted in an HCl concentration of 110 ppm in the flue gas, as shown in Figure 4. In addition, the injection of salt resulted in enhanced removal of Hg across the SDA/FF with removal efficiencies of up to 50% in short-term field testing (8).

Selected Host Sites and Existing Removal Rates. Because of the promise seen in oxidation of Hg in flue gases produced from lignite coals, the project team proposes to conduct long-term field testing of Hg oxidation and removal using a wet FGD at the Minnkota Power

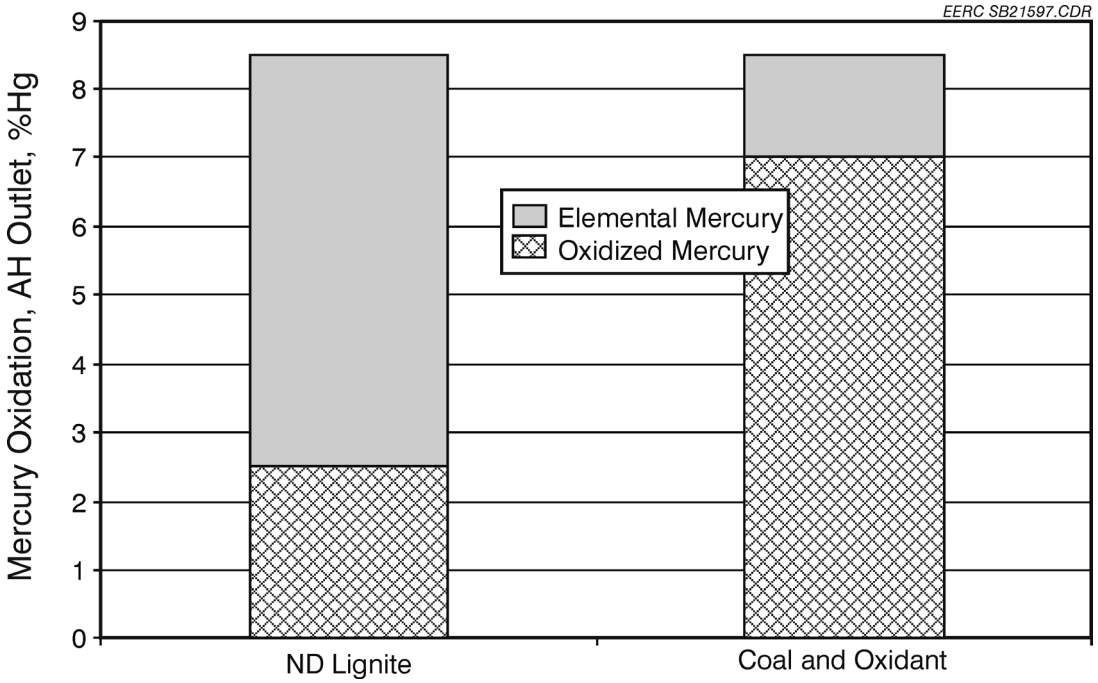


Figure 3. Oxidation of mercury through the addition of chlorine-containing additive to coal in EERC pilot-scale testing.

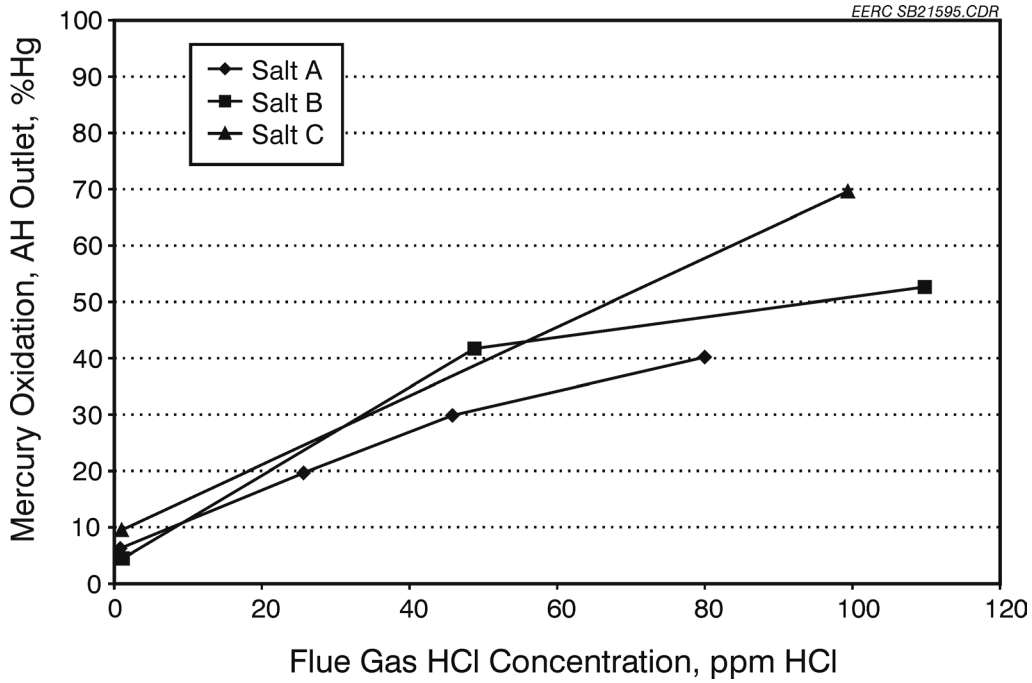


Figure 4. Comparison of mercury oxidation and HCl flue gas content for a range of salt injections at a North Dakota lignite-fired power plant (8).

Cooperative's MRY Station Unit 2 near Center, North Dakota, and TXU's Monticello Station Unit 3 near Mt. Pleasant, Texas.

MRY Unit 2 is a Babcock & Wilcox (B&W) Carolina-type, radiant boiler designed to burn high-moisture, high-slagging/fouling North Dakota lignite. Nominally rated at 3,050,000 lb/hr, this unit is a cyclone-fired, balanced-draft, pump-assisted circulation boiler. The unit began commercial operation in May 1977 and is base-loaded at 450 MW gross. The unit is equipped with a cold-side ESP for particulate control and a wet FGD unit for SO_2 control. The cold-side ESP has a specific collection area (SCA) of 375 ft^2/1000 acfm. The wet FGD for SO_2 control utilizes alkaline ash and lime. The MRY Station fires North Dakota lignite coal from the Kinneman Creek and Hagel seams at the Center Mine. This plant and configuration are ideal for testing Hg oxidation and Hg control in a wet scrubber. The high-temperature environment in the cyclone will easily vaporize and transform the chlorine species into highly reactive radical forms. The system has been tested for Hg speciation and control.

Recently, flue gas sampling for speciated Hg was conducted on Unit 2 at the ESP inlet, FGD inlet, and the stack from October 22 through November 14, 2002. The sampling was carried out using both the OH method and Hg CEMs (9). A schematic diagram of the plant configuration and sample locations is provided in Figure 5. The sampling involved OH sampling at the ESP inlet, FGD inlet, and the stack. In addition to OH sampling, two Hg CEMs, one at the FGD inlet and one at the stack, were used to monitor speciated Hg levels. The CEMs were operated to obtain 20 days of data at the two locations.

The average Hg speciation results from Unit 2 OH flue gas sampling are summarized in Figure 6A. The average Hg emissions at the stack were 95% Hg^0. Two Hg CEMs were operated at the FGD inlet and stack locations of Unit 2 to gather Hg variability data. Statistical analysis of

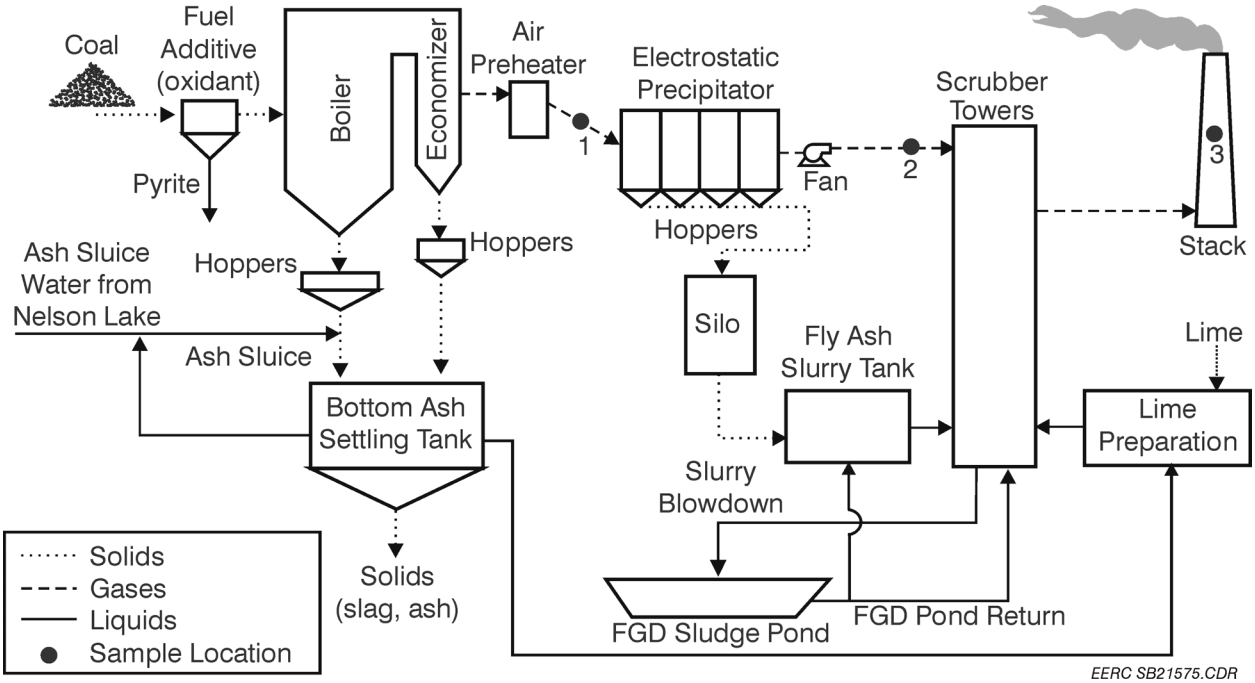


Figure 5. Schematic for MRY Station, Unit 2, showing sampling locations.

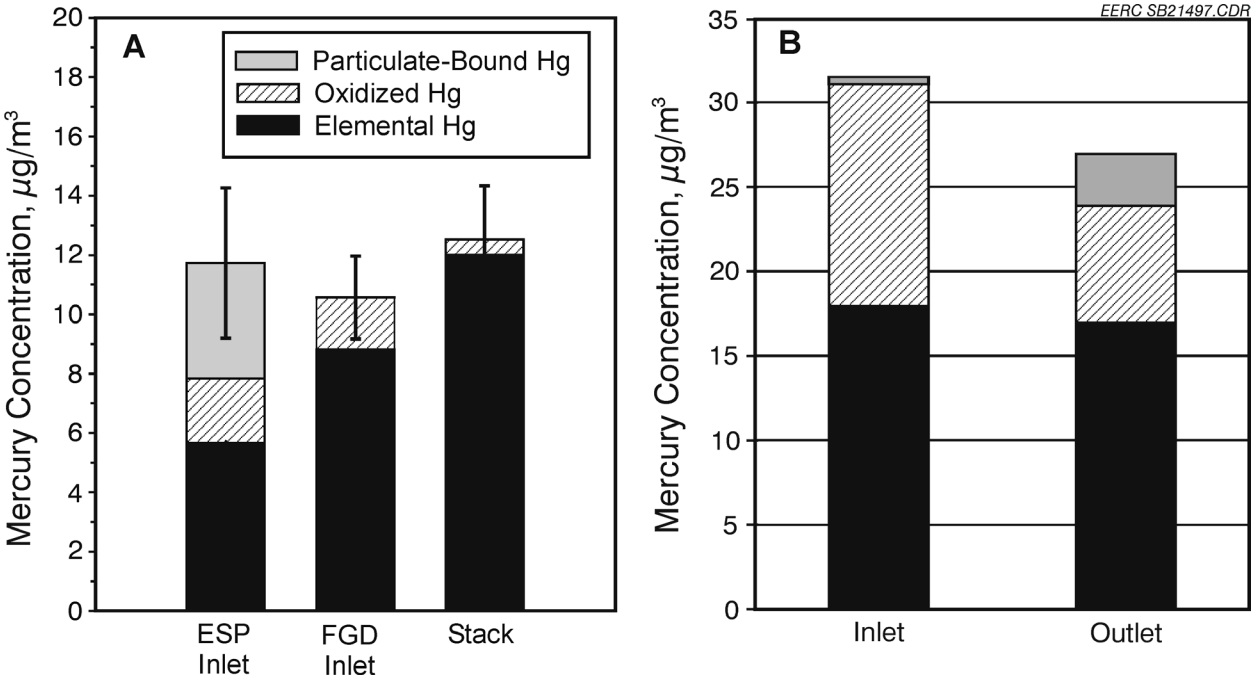


Figure 6. A) MRY OH mercury data obtained in October/November 2002 and B) OH mercury data for Monticello (ICR data).

the Hg CEM data indicates that the average Hg concentration was 10.7 ± 2.7 μg/m^3 (90th percentile) at the FGD inlet and 9.3 ± 2.2 μg/m^3 at the stack. Hg-level fluctuations due to minor coal changes as well as other variability in plant operations were found to fall within 24% of the average. A Hg balance for MRY Unit 2 (10) was determined by comparing the rate of Hg entering plant to the rate of Hg leaving the plant. The resulting material balances ranged from 102% to 103%.

The second site is the Monticello Unit 3 power plant located near Mt. Pleasant, Texas. This site is also well characterized for Hg speciation, emissions, and variability. In addition, it provides an opportunity to test the Hg oxidation technology on a Texas lignite. Figure 7 illustrates the Unit 3 gas path. Unit 3 has a 750-MW B&W opposed-fired, Carolina-type Universal Pressure boiler that fires Texas lignite coal from the Upper and Lower Wilcox seam. The unit was placed in commercial operation in 1978 and fires 640 tons/hr of Texas lignite at full rated load. Downstream of the air preheater, the gas flows through a cold-side ESP constructed by Research Cotrell. The ESP has ten fields with an SCA of 900 ft^2/1000 acfm. The ESP outlet temperature is nominally 300°F.

The results of Hg speciation measurements at the inlet and outlet of the scrubbers at the Monticello Unit 3 plant are shown in Figure 6B. The results of the OH method indicate that 57% of the total Hg is in the elemental form entering the wet FGD and that the Hg^0 is not captured with the wet FGD. Results from the ICR tests at Monticello Unit 3 suggest approximately 15% Hg removal across the FGD system, which is consistent with the trends for other units firing low-rank lignite coals.

Improvements in Mercury Capture Through Oxidation. Currently, the Hg emitted from the MRY Unit 2 and Monticello Unit 3 is dominated by the elemental form. The results of

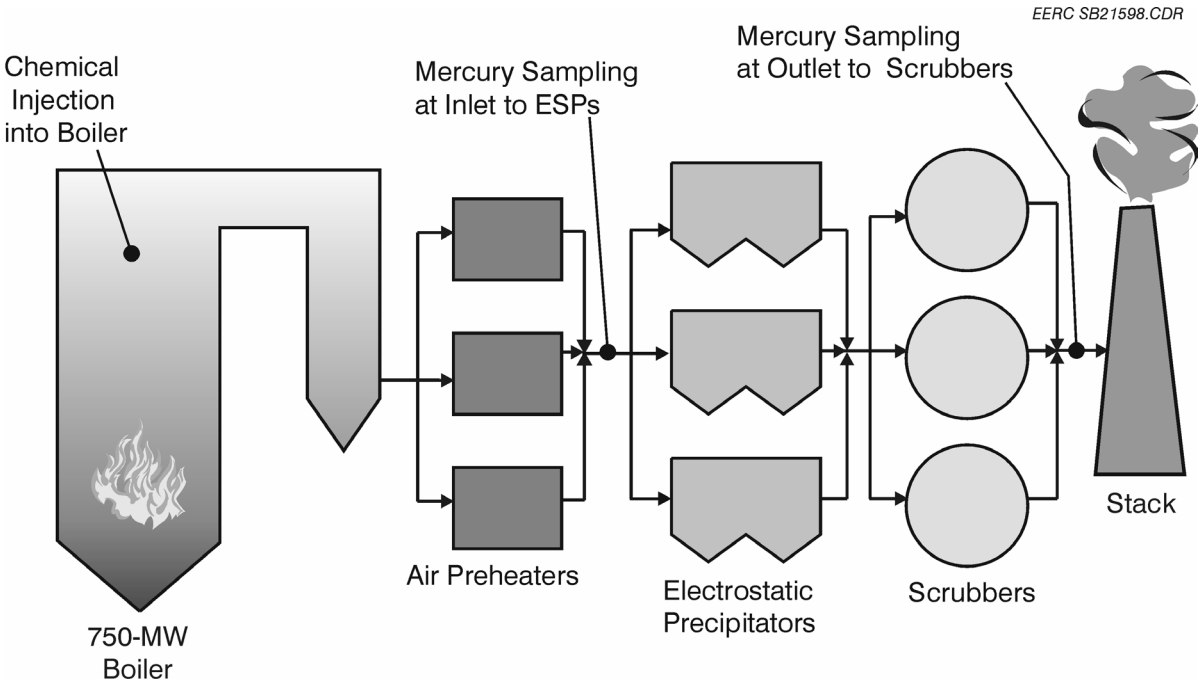


Figure 7. Plant schematic for Monticello Unit 3.

EERC pilot-scale studies (Figure 3) indicate a high potential to oxidize Hg through the addition of 20 to 40 g/hr of salt with the coal in the EERC pilot-scale combustor (750,000 Btu/hr combustor with a feed rate of 90 lb lignite/hr) (20 g/hr NaCl = 0.044 lb NaCl/hr = 0.0005 lb NaCl/lb coal = 3337 lb NaCl/lb Hg and 40 g/hr NaCl = 0.088 lb NaCl/hr = 0.0010 lb NaCl/lb coal = 6667 lb NaCl/lb Hg). In addition, recent testing at a lignite-fired power plant indicated up to 70% Hg oxidation (Figure 4) with 50% capture in a dry scrubber baghouse (8). The data from MRY showed that both the ESP and FGD unit had minimal effect on Hg emissions. The data showed that 87% of the oxidized Hg was removed across the FGD unit (9). If the flue gas Hg^0 were oxidized prior to the scrubber, it is estimated that roughly 90% of the oxidized Hg could be removed across the scrubber. This estimate is based on experience where wet FGD scrubbers are being used to scrub flue gases that contain high levels of oxidized Hg (4). Previous ICR test data have shown that removals of oxidized Hg across wet limestone FGD systems for units firing

Texas lignite have ranged from 65% to 97%; thus total Hg removals ranging from 50% to 80% appear possible across the FGD system at Monticello Unit 3, assuming 70% to 80% Hg oxidation can be achieved through the use of chemical injection technology.

Technical Feasibility and Readiness for Long-Term Field Testing

Oxidation of Hg^0 upstream of wet scrubbers has the potential to significantly improve the capture of Hg in lignite-fired systems equipped with wet scrubbers. Short-term pilot-scale testing at the EERC and field testing supported by EPRI indicate that chemical addition to the combustion zone increases the level of Hg oxidation and promotes Hg capture in downstream scrubbers. These tests included the evaluation of multiple salt types and multiple salt injection rates. The results provided insight as to the ability of different salts to increase Hg oxidation in lignite-derived flue gas and verified that Hg removal for these low-HCl, high-Hg^0 flue gas configurations would be challenging. The results of the previous EPRI and EERC tests as well as tests planned for the summer of 2003 allow determination of which salts may be effective in the short-term parametric test and the longer-term tests, as well as the appropriate ranges of injection rates to evaluate. The DOE test program will thus build on previous results to evaluate long-term performance of successful chemicals as well as possible effects on plant operations. Based on field test results of Hg oxidation and removal potential for Hg^{2+}, overall Hg control across the scrubber is estimated at 61%. However, if the degree of Hg oxidation attained at MRY approaches the level of oxidation in the pilot-scale testing, the level of Hg capture could be as high as 73%, assuming 83% of the Hg is oxidized.

For the MRY testing, the salt material will be introduced through a flange on the lift line below the rotary seal valves on the air side of the point where coal drops from the valve and is introduced into the cyclones. The salt material will be added at a rate up to 1000 ppm in coal,

with a target of 500 ppm for longer-term testing. The high-temperature environment in the cyclone will ensure the vaporization and transformation of Cl to an atomic form.

Tests carried out at Monticello Unit 3 will build upon previous chemical injection tests funded by EPRI, work conducted by the EERC, and results of MRY Unit 2 testing. The initial short-term parametric tests proposed for Monticello Unit 3 will provide confirmation of applicability of the Hg oxidation technology and chemical addition levels for Texas lignite. The subsequent long-term chemical injection tests being proposed will thus focus on evaluation of long-term performance and effects on both plant operations and combustion by-product characteristics for those chemicals that remove the highest levels of total Hg.

Chemical addition to increase Hg oxidation and enhance removal across downstream environmental controls can be carried out using simple equipment, such as liquid pumps and injection lances or solid feeders. Thus capital costs for this technology are very low. In addition, Hg oxidation has been demonstrated with low-cost additive materials that should not affect the characteristics of other combustion by-products, such as fly ash or scrubber solids.

Benefits of Proposed Technology

The Hg in flue gas produced from lignite is in the elemental form and is difficult to remove using conventional APCDs. The technology proposed here will oxidize Hg so that it can be controlled in an existing wet FGD scrubber. The technology consists of adding a chlorine-containing material to the coal. The proposed technology, if successfully demonstrated, will provide a simple and cost-effective means of reducing Hg emissions in low-rank coal-fired power systems with an existing scrubber.

Currently, the fate of Hg in the MRY Unit 2 based on OH data is as follows: Hg removal across the ESP is approximately 10%; Hg removal across the FGD indicates a reduction in

oxidized Hg; average Hg concentration at the stack is 12.5 μg/Nm^3; and the Hg emissions are 95% Hg^0. In addition, the results indicate that up to 87% of the oxidized Hg is removed in the wet FGD scrubber. Oxidizing the Hg through chemical addition has the potential to reduce Hg emissions as much as 73% in the FGD system at MRY. This exceeds the goal of 55% removal stated in the subject solicitation.

Chemical addition has a significant potential for cost savings compared to activated carbon injection (ACI) for Hg control. In order to obtain approximately 55% Hg removal across a wet scrubber, assuming a scrubber removal efficiency of 95% for oxidized Hg, it is necessary to increase the total oxidized portion in lignite-derived flue gas from approximately 25% to 60%. Results from recent pilot and field tests using a reagent salt ("Salt A"; $0.0519/lb) suggest that to increase the flue gas Hg oxidation to 60%, it is necessary to add approximately 9,800,000 lb/yr for a 500-MW boiler. This translates to an annual cost of about $500,000 for the Salt A material. The corresponding Hg removal for a 500-MW boiler with ACI across an ESP translates to a cost of approximately $5,000,000 for the sorbent alone. According to this model, chemical injection may represent only 10% of the cost of carbon injection for similar Hg removals. Other potential salts, such as "Salt B" and "C," are about 4 times the cost of Salt A but still would be 50% lower in cost than activated carbon. In addition, the proposed technology should have no impact on coal combustion by-product salability.

Scientific and Technical Basis and Rationale for Further Research

The flue gas from North Dakota and Texas lignites has routinely been shown to be high in elemental-to-oxidized Hg ratios and is, therefore, less reactive in terms of Hg removal. While both wet and dry scrubbers for SO_2 control have shown the ability to remove roughly 90% of the oxidized Hg, Hg^0 typically remains uncaptured in these systems. Oxidation additives have been

identified that show excellent potential for shifting the ratio of elemental to oxidized Hg from lignite-fired systems so that a majority of the Hg is in the oxidized form. The goal is to facilitate oxidized Hg conversion in lignite systems to allow capture in existing scrubbers. This approach will allow systems equipped with scrubbers to utilize existing equipment for Hg control and avoid the need to incur large capital equipment costs. Past projects support the approach since the potential to increase the proportion of oxidized Hg using a chemical added to the coal has been demonstrated in pilot and short-term field testing. In addition, conventional wet scrubbers have shown the potential to remove roughly 90% of the oxidized Hg.

The proposed work scope will test the ability of oxidation additives to increase Hg capture at two lignite-fired power plants equipped with wet scrubbers. Task 1 will involve testing at the North Dakota lignite-fired MRY Unit 2 to determine the effectiveness for conversion of elemental to oxidized forms and removal of Hg in a wet FGD. The testing at MRY will provide key information on the levels of oxidant addition to oxidize Hg, level of Hg control across the wet scrubber, and potential impacts of salt addition on the fireside performance of the boiler and associated APCDs. Task 2 is aimed at testing at the Texas lignite-fired Monticello power plant at the optimum conditions identified during Task 1 testing at the MRY facility. The focus of the Monticello testing is to determine the impacts of changes in coal characteristics, boiler, and scrubber type on the ability to oxidize and control Hg emissions.

Anticipated Balance of Plant Impacts

Addition of chlorides to the coal to enhance Hg oxidation raises potential concerns in regard to the increased ash deposition and corrosion of boiler and downstream equipment materials. However, these concerns should not be considered significant since the optimal amount of additive required will not exceed the chlorine concentration of most eastern

bituminous coals. The levels in eastern U.S. bituminous coals can be as high as 1000 ppm and over 1200 ppm for Illinois Basin coals.

The potential impact of the technology is increased ash deposition in the economizer, air preheater, and ESP. Currently, the coals contain very low levels of Cl, and increasing the level of chlorine will increase the deposition rate in regions of the boiler at temperatures where the liquid-phase chloride species form. Recent short-term studies at a coal-fired power plant indicated increased pressure drop across the air preheater with salt injection to oxidize Hg (8).

Typically, boiler corrosion concerns involving chlorine can impact furnace waterwalls and stainless superheaters. With regard to furnace wall corrosion, chlorine will only have an impact where reducing conditions exist. Even 1000 ppm (0.1% Cl) in the coal is considered a low level in regard to corrosion, and the effect will be small at normal waterwall temperatures (saturation temperature, <700°F). Central Electricity Generating Board (English electric utility prior to privatization) experience indicates that more than 1000 ppm chlorine in the coal is necessary for any coal ash corrosion effect and more than 1000 ppm has an effect only if other constituents such as substantial S, Na, and K are present with relatively little Ca or Mg to neutralize their effect. In addition, chlorine does not cause coal ash corrosion—it only aggravates it.

Technical Approach

The lignite-based consortium collaborating on this project proposes to test a Hg oxidation technology for controlling Hg emissions at two lignite-fired power plants equipped with wet FGD systems. Description of the test sites and coal types are shown in Table 1. The oxidation technologies have shown good results at the bench-, pilot-, and short-term full-scale levels by the EERC and others. Therefore, it is appropriate to conduct testing at two lignite-fired facilities with different boiler and lignite types to examine Hg removal efficiencies, economics, and BOP

impacts. The technology involves the injection of a chemical additive with the lignite or injection into the furnace to oxidize Hg upstream of a wet FGD system.

Table 1. Description of Test Sites

Plant	Lignite/State and Seam (s)	Boiler Type	Boiler Size, MW	Particulate Control	SO_2 Control
MRY Unit 2	North Dakota/ Kinneman Creek and Hagel	Cyclone	450	ESP SCA* 375	Wet FGD
Monticello Unit 3	Texas/Upper and Lower Wilcox	Pulverized coal wall-fired	750	ESP SCA 900	Wet FGD

* Specific collection area in ft^2/1000 acfm.

Because lignites generally have low chlorine (North Dakota lignites typically 10–20 ppm) and Hg speciation is primarily elemental in the flue gas, an oxidizing additive (chlorine-based) will be used to oxidize Hg. The use of a chlorine-containing salt is desired because of its low cost and demonstrated ability to oxidize Hg. The additive will be added at rates equivalent to 300 to 1000 ppm chlorine in the coal, with a target of less than 500 ppm in the coal for long-term testing. The additive will be introduced with the coal. The high flame temperatures will ensure transformation of Cl to an atomic form. The additive rate will be adjusted to attain a mercury removal target beyond 55%.

The oxidation additives proposed are easily obtained from vendors in quantities needed for the testing. All injection and associated equipment needed to demonstrate the technologies at the two power plants are also readily available.

At the MRY Plant, the overall test structure will consist of the following. After 3–5 days of setup time, 2 weeks of parametric tests will be conducted to confirm baseline data and ensure optimum performance of the technology. This will be followed by up to 8 weeks of longer-term testing using Hg CEMs, which is sufficient for these reasons: 1) previous Hg emission testing at power plants has proven 3–4 weeks to be adequate to determine Hg variability, 2) 8 weeks

allows enough time to reach steady-state operation after technology implementation, and 3) this test duration is believed to be an optimal balance between demonstration of technology effectiveness and project cost. The testing at Monticello will be shorter term than the MRY testing. The goal of the Monticello testing is to determine the impact of lignite type, oxidation type, and firing conditions on Hg oxidation. The Monticello testing will involve initial setup, short-term parametric testing to optimize the chemical injection (two types), and longer-term testing between 10 and 14 days. General project activities are shown in Table 2.

Table 2. General Project Activities

Task	Effort
Project Planning	Develop detailed statement of work and quality assurance/quality control (QA/QC) plan, finalize site agreements, and have project kickoff meeting for each site's project participants
Injection Equipment	Design, procure, set up, and test injection systems
Short-Term Testing	Conduct baseline testing, parametric evaluations, and ensure oxidant optimization. Testing will be conducted with both OH and Hg CEMs
Longer-Term Testing	Conduct Hg CEM testing for approximately 6 weeks (with periodic OH sampling)
Reporting and Project Management	Perform data analysis, project reporting, budget management, presentation development, project review meetings, and final disposition of equipment

Work Plan

Task 1 – Testing at MRY Unit 2. Field testing of Hg oxidation followed by Hg capture in a wet scrubber will be performed at Unit 2 of the MRY Station by the EERC. The unit is equipped with an ESP and scrubber. Figure 5 shows a simplified schematic of MRY Unit 2 along with salt injection locations and the sampling points for flue gas, coal, and ash.

The objectives of the Task 1 are as follows: establish values for baseline Hg speciation and removal, determine the salt addition rate needed to achieve 70% Hg removal, determine the

effect of using salt on Hg speciation and removal, determine the effect of salt injection rate and Hg control effectiveness, prove that 55% removal can be achieved over one 8-week test, quantify Hg emissions variability over an 8-week test period, and determine the impact of salt injection on corrosion and ash deposition.

To meet these objectives and facilitate management and execution of the proposed test plan, the EERC proposes the following two subtasks: Subtask 1.1 – Field Testing of Hg Oxidation and Control and Subtask 1.2 – Data Reduction, Reporting, and Management.

Subtask 1.1 – Field Testing of Hg Oxidation and Control. This subtask will be carried out by the EERC with additional assistance from on-site MRY personnel as needed. ADA.ES will install and set up the oxidant feed system. The task will involve setup and baseline testing, parametric testing, and long-term testing. Setup of equipment and baseline testing will be performed in Weeks 0–2. During the parametric test period in Weeks 2–4, oxidant feed rates will be varied independently to determine optimal rates while achieving predefined Hg reduction levels of 55%, 70%, and maximum percentage reduction based on oxidant injection limits of 300 to 1000 ppm equivalent chlorine in the coal with a target of less than 500 ppm for longer-term testing. Up to three CEMs will be set up: one at the ESP inlet, ESP outlet, and stack outlet. The CEMs will be operational during all parametric testing and the proposed 8-week-long test to ascertain Hg removal efficiency and variability. OH sampling will be performed at the ESP inlet and outlet locations as shown in Figure 5 to fulfill DOE requirements. OH sampling will be performed in triplicate to establish baseline speciation and removal data, during steady-state conditions for predefined parametric parameters, and several times throughout the 8-week-long test.

Testing during Weeks 4–11 will be at a set salt injection rate targeted at a Hg removal efficiency of 50%–70%, with an overall time-average target of 55%, as required by DOE. Note, to account for historical coal variability of approximately 25%, short-term targets must be set higher than 55% in order to achieve an overall average of 55% for the entire test period. During the entire test period, cooled steel probes with coupons will be inserted into the convective pass and air preheater to monitor for corrosion and ash deposition. The coupons will be analyzed to determine if corrosive species are present in sufficient quantities to warrant concerns for long-term application of the chloride material.

Coal samples and process by-products will be collected and analyzed for Hg during the test, including ESP hopper ash and scrubber sludge samples. The purpose is for Hg material balance calculations and to collect samples that will be sent to an outside contractor, as directed by NETL, for additional waste characterization testing. Specifically, three 5-gallon containers will be collected at each sampling location during baseline and all test conditions.

Subtask 1.2 – Data Reduction, Reporting, and Management. The overall project will generate voluminous amounts of data over the parametric and long-term test periods. Data generated and collected will be logged carefully such that the oxidant effectiveness can be accurately assessed relative to both short- and long-term Hg capture/reduction. Data generated throughout the test program will be reduced, interpreted, and summarized to determine overall conclusions related to performance and costs.

Two combined-site team meetings will occur in the planning stages of the project with representatives from all groups participating in the program to coordinate testing activities. In addition, quarterly meetings will be conducted via conference call or on-site to make sure all

participants in the project are informed on progress and direction of the efforts. Final reports will be prepared that will include the results of testing in both MRY and Monticello sites.

Task 2 – Testing at Monticello. Field testing of Hg oxidation followed by Hg capture in a wet scrubber will be performed at Monticello Unit 3 to validate Hg oxidation and removal firing Texas lignite. The objectives of Task 2 are as follows: establish values for baseline Hg speciation and removal, determine the effect of salt injection rate and Hg control effectiveness, prove that 55% removal can be achieved over a 10- to 14-day test, and quantify Hg emission variability. To meet these objectives and facilitate management and execution of the proposed test plan, the project team proposes the following two subtasks: Subtask 2.1 – Field Testing of Hg Oxidation and Control and Subtask 2.2 – Data Reduction, Reporting, and Management.

Subtask 2.1 – Field Testing of Hg Oxidation and Control. This subtask, taking place at Monticello Unit 3, will be carried out by URS and EPRI with additional assistance from on-site Monticello personnel as needed. Oxidant feed rates will be varied independently to determine optimal rates while achieving predefined Hg reduction levels of 55% based on oxidant injection limits of 500 ppm equivalent chlorine in the coal and data collected at MRY Unit 2 testing. Flue gas Hg concentrations will be measured, with and without chemical injection across the ESP wet scrubber configuration.

Short-term parametric tests, conducted to optimize performance, will be followed by longer-term 2-week tests. Up to two chemicals will be chosen based upon predetermined selection criteria and will be evaluated during the short-term parametric tests. Parametric tests will be used to determine the optimal process conditions for each material and to establish the conditions for each long-term test set to last 2 weeks. Results will provide insight to the applicability of the technology to a second lignite and power plant. Data from this program will

be used to perform an economic analysis of the costs associated with full-scale implementation of the chemical oxidation technology.

Coal samples, ESP hopper ash, and scrubber sludge samples will be collected and analyzed for Hg during the test program to both make Hg material balance calculations and to collect samples that will be sent to an outside contractor, as directed by NETL, for additional waste characterization testing. Specifically, three 5-gallon containers will be collected at each sampling location during baseline and all test conditions.

Subtask 2.2 – Data Reduction, Reporting, and Management. This project will generate voluminous amounts of data over the short- and long-term test periods. Data generated and collected will be logged carefully such that the oxidant effectiveness can be accurately assessed relative to both short- and long-term Hg capture/reduction. Data generated throughout the test program will be reduced, interpreted, and summarized to determine overall conclusions related to performance and costs. An economic analysis will be performed using the test data to assess costs for implementing a chemical addition-based system for Hg oxidation and removal for the plant configuration tested.

Deliverables

Reports for this program will be submitted according to the Federal Assistance Reporting Checklist. The reports submitted to DOE and NETL will include technical content relating to both the testing results and the economic analysis of the testing results. The testing plan will describe detailed activities and schedules for each task and will be reviewed by all team members and the host utility before being submitted to the NETL Contracting Officer's Representative (COR) for final review and comment. Work will begin after final acceptance by the COR. Included in the test plan will be a procedure for demobilization and disposal of all test

equipment and expendable material following completion of the project. A QA/QC plan will be developed to ensure the integrity of all data obtained in this program. The QA/QC plan will be reviewed by all team members and by a QA representative from the prime contractor.

The overall project deliverable will be an assessment of the technical aspects of chemical injection for Hg control for plants burning lignite coal with cold-side ESP and wet FGD controls. A draft and final site report summarizing all activities and results obtained during testing at both will be prepared after testing for each site is completed. The site report will include a discussion of the activities performed, the results for samples collected, an evaluation of the Hg removal performance for the chemicals tested, and an evaluation of the waste characterization results for process by-products. In addition, an economic evaluation of the program to assess full-scale implementation costs for the chemical addition Hg removal systems in plants with an ESP wet scrubber combination will be conducted. These analyses will be performed using data collected during this program and will include costs categorized by chemical cost and Hg removal levels. A combined-site final report will be submitted to DOE that includes results, interpretations, and conclusion of the project.

Staffing Plan

The staffing plan for the overall project is shown in Table 3. All individuals listed in the table are available to conduct the proposed project.

Data Collection – QA/QC

To ensure successful projects, the EERC adheres to an organizationwide quality management system (QMS). It is authorized and supported by EERC management to define the requirements and the organizational responsibilities necessary to fulfill governmental and clients' requirements relating to QA/QC, applicable regulations, codes, and protocols. Table 4 outlines

Table 3. Staffing Plan for Project

Personnel Hours by Subtask	Task 1.1	Task 1.2	Task 2.1	Task 2.2	Total
EERC Labor Hours					
Michael Holmes, PM	60	500		72	632
Steven Benson, PI	8	840		84	932
Dennis Laudal, Co-PI	300	200		44	544
Senior Management	152	57		8	217
Research Scientist/Engineer	3048	839		72	3959
Research Support	449	202		13	664
Technology Dev. Mechanic	1300				1300
Technical Support Services	140	280		50	470
Subcontract Labor Support					
ADA.ES					
System Installation and Removal	542				542
URS					
Carl Richardson, PI			304	96	400
Engineer/Scientist			1914	154	2068
Technician/Analyst/Clerical			116	24	140
In-Kind Labor Support					
ADA.ES	138				138
EPRI			40	160	200
Minnkota Power Cooperative	605	250			855
TXU			974	113	1087
Total Staffing Plan	**6742**	**3168**	**3348**	**890**	**14,148**

project QC. Specific details of the QA/QC plan for the actual sampling procedures, sample handling, documentation, and the analysis of the OH samples, coal, and ash are presented in the attachments.

The most important aspect of QA/QC is the expertise of the team conducting research. Both the EERC and URS are highly trained and experienced using the OH sampling method, having conducted hundreds of sampling tests. In fact, the EERC and URS were involved in development and validation of the OH method (www.netl.doe.gov/coalpower/environment/mercury/methods.html). In addition, both organizations are considered experts in the operation of Hg CEMs, which are still considered to be in the developmental phase. The EERC has successfully demonstrated these instruments for 2 weeks or longer at nine different power plants

over the past 3 years. The EERC and URS have actively used these instruments in bench-, pilot-, and full-scale tests for over 7 years.

Table 4. Project Quality Measures

QA/QC Control Measure	PURPOSE/CLARIFICATION
EERC QMS, including *Quality Manual* and quality policy and procedures	Ensure organizationwide compliance with QMS and applicable regulations, codes, and protocols – based on ISO 9000 standards. Authorized and supported by EERC top management.
Project-Independent QA Manager at the EERC (David Brekke)	Assist research managers to plan QA for projects, does reviews and random audits for compliance assurance.
Perform Hg Mass Balance with Values 100% ± 20%	Determine total amount of Hg to be accounted for and determine removal rates: measured at inlet to APCD and stack. Also based on coal Hg and F_d factors.
EERC and URS Expertise in OH Method and Hg CEM Sampling	Understand potential problems that can occur, trouble-shoot, ability to get valid data under difficult conditions.
OH Field and Blank Analysis in On-Site Mobile Laboratory	Determine if contamination exists in sampling conditions and if recovery is complete. Rapid feedback allows immediate action to correct problems in the field.
Hg CEM Calibrations – at least daily. If target not met, may require that additional calibration or maintenance be done and repeat QA/QC check	PS Analytical: sample clean air drawn through carbon trap followed by injecting known Hg standard. This procedure is done 4× to determine scatter (internal QA/QC EERC standard is that $R^2 = 0.999$).
OH Samples Compared to CEM Data	After calibration, two concurrent OH samples taken that should be ±20% of CEM data taken during period.
Chain-of-Custody Procedures	Ensure integrity of samples at all steps, including sample identification, analysis, and storage.
Interim Team Audit: URS to QA/QC One EERC Plant and Vice Versa	Use expertise of team members to ensure consistent quality. Double-check analytical systems.
Team Direction by Consortium and DOE	Ensure that communication issues and problems are addressed to ensure objectives of project are attained.
Quarterly Conference Calls (or as needed)	Ensure effective communications between all team members, address developing issues, resolve problems.
Information Transfer Via ftp Site	Allows efficient transfer of data between team members.
Use ADA.ES Expertise to Provide Setup and Operate Injection Equipment	Ensure QA/QC in delivery system. Uses commercial-grade materials to be analyzed for Hg regularly.

Table 5 overviews the measures for accuracy, precision, and completeness as documented in the OH method (American Society for Testing and Materials D6784-02). The stringent quality rules of the OH method will be exceeded to include two field blank and spikes per week (versus one called for in the method) during the longer-term testing at each sample location per test condition. If the field blank does not meet the criteria listed, the data must be flagged and

corrective action taken to discover the source of the contamination (note: this becomes possible because the EERC and URS will be doing analyses of blanks on-site).

Table 5. Data Quality Objectives for Flue Gas Mercury Analyses by OH Method

Measure	Objective	Approach
Accuracy	<10% of sample value or <10× instrument detection limit	Reagent blanks – analyze one blank per batch of each reagent.
Accuracy	Field blank <25% of sample value	Collect and analyze one field blank at inlet and outlet a day.
Accuracy	Field and laboratory spikes <15% of true value	Collect and analyze one field-spiked sample at inlet.
Precision	<10%	All laboratory samples analyzed in duplicate; every 10th sample analyzed in triplicate.
Completeness	100%	Review any failed or incomplete test and, if necessary, repeat.*

* Whether a test failed or is incomplete will be determined by the sampling manager in consultation with the PI. Any failed or incomplete data that are not considered to cause an invalidation of a test will be flagged.

Travel

Details of the proposed project travel are shown in Table 6 for MRY and Monticello.

Table 6. Project Travel

Purpose	Trips	Origin	Destination	People	Days
EERC Travel					
Quarterly Review Meeting	6	Grand Forks, ND	Bismarck, ND	2	2
Quarterly COR Meeting	3	Grand Forks, ND	Morgantown, WV	2	3
Program Review Meeting	3	Grand Forks, ND	Austin, TX	1	2
Annual Contractor Rev. Meeting	3	Grand Forks, ND	Morgantown, WV	3	3
National Conference	3	Grand Forks, ND	Unspecified, USA	3	4
Corrosion Testing	6	Grand Forks, ND	Center, ND	1	3
Site Visit	1	Grand Forks, ND	Center, ND	2	2
Field Supervision – Pretest	1	Grand Forks, ND	Center, ND	1	5
Field Supervision – Parametric	1	Grand Forks, ND	Center, ND	1	16
Field Supervision – OH Sampling	3	Grand Forks, ND	Center, ND	1	5
Sampling Trip – OH Parametric	1	Grand Forks, ND	Center, ND	5	15
Sampling Trip – OH	3	Grand Forks, ND	Center, ND	5	5
Sampling Trip – CEM	9	Grand Forks, ND	Center, ND	1	8
URS Travel					
Project Planning Meeting	1	Austin, TX	Grand Forks, ND	1	2
Team Meeting	1	Austin, TX	Grand Forks, ND	1	2
Review Meeting at DOE	1	Austin, TX	Morgantown, WV	1	2
Site Setup	1	Austin, TX	Monticello, TX	4	5
Baseline Testing	1	Austin, TX	Monticello, TX	3	5
Parametric Testing	1	Austin, TX	Monticello, TX	3	9
Long-Term Testing (2 weeks)	4	Austin, TX	Monticello, TX	3	9
Site Breakdown	1	Austin, TX	Monticello, TX	4	5
Gas Characterization	1	Austin, TX	Monticello, TX	5	5

Technology Transfer, Commercialization, and Market Penetration Potential

An important part of technology transfer and commercialization is communication of information to the potential market. To accomplish this, after a review procedure, all reports will be made public; presentation of results are being planned for up to three conferences each year; particular for this project is how the regulations will impact utilities firing North Dakota and Texas lignites. All of the North Dakota utilities and TXU in Texas are taking part in this project; therefore, this project will develop a very good understanding of the technology and how well it fits the particular needs of utilities firing lignite. If it is confirmed that the proposed technology will provide Hg control to meet impending regulations and make economic sense, there will be no commercial impediments to adopting the technology quickly. All oxidizing materials are readily available, and the equipment necessary to inject these materials into the facility can be purchased easily from a number of vendors. At the completion of the project, the project team will be available to work with the utilities to implement the technology on a more permanent 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, detailed site-specific test and QA/QC plans will be developed and reviewed by project sponsors to ensure project objectives and time lines are met.

The standards of success for this project will be measured through successful field demonstration of the proposed mercury control technology. The mercury control technology needs to demonstrate technical viability and the potential for economic viability based on the design, process, and test conditions and oxidation additive feed requirements. The technical objective of the technology is to effectively reduce mercury emissions over a long period of time (1 month) by at least 50%. Note, this objective must also be met to fulfill DOE requirements. Higher removal efficiencies are likely obtainable and will be determined during short-term parametric tests. However, during long-term tests, optimum conditions will be selected to meet a 50% or greater reduction while taking into consideration cost of control and implementation of the technology. The economic objective is to reduce mercury emissions using oxidation additive technology with costs on the low end of the estimated range, based on equipment requirements, utilization rates, and required plant modifications. Estimates by EPA range from $5000–$25,000/lb Hg removed, and DOE estimates are from $25,000–$70,000/lb Hg. These long-term field tests should provide the basic performance and cost data needed to estimate cost of control in terms of $/lb Hg removed and the associated balance of plant impacts.

BACKGROUND AND QUALIFICATIONS

Team Qualifications

The project team has extensive experience with all aspects of the clean and efficient utilization of low-rank coals. The project advisory team, DOE, the Mercury Task Force, NDIC, and EPRI, will provide project direction and review during the course of the project. Subcontracts with ADA.ES will provide systems and technology engineering, expertise and, with URS, site management and testing at Monticello. The key participants in the project and their

areas of expertise are listed in Table 7. Organizational profiles, letters of support, and resumes for key personnel are attached.

Table 7. Summary of Expertise of Key Personnel

Name	Organization	Management of DOE Programs	Management of Hg-Related Projects	Air Pollution Control	Hg Sampling and Analysis	QA/QC	Mercury Science	Power Plant Operations	Field Test Experience	Economics – Cost Analysis	Percentage of Time on Project*
Michael Holmes	EERC	X	X	X	X		X	X	X	X	29
Steven Benson	EERC	X	X	X	X		X	X	X		34
Dennis Laudal	EERC		X	X	X	X		X	X		22
Cameron Martin	ADA.ES		X	X	X			X	X	X	8
Stu Libby	Minnkota Power Co.			X				X	X		9
Carl Richardson	URS	X	X	X	X	X	X	X	X		15
Ramsey Chang	EPRI	X	X	X	X	X	X	X	X	X	8
Bob Weimuth	TXU			X				X	X		4

***** Time period used was 15 months for the overall sampling, analysis, and reporting since most of the effort will be conducted over this time period. The overall project length is 3 years.

Team Experience in Related Projects

The team brought together for this research project comprises leaders in the field of emission research and control technologies, especially as they pertain to Hg and lignite coals. Key personnel have participated in government and industry forums to address environmental and regulatory issues related to toxic air pollutants, including Hg.

The EERC. This proposed project builds on over 50 years of research conducted at the EERC on lignite properties and variability; understanding of combustion processes; understanding of the fate of pollutants including Hg, particulate, and acid gases; Hg sampling, measurement, and speciation; development, demonstration, and commercialization of combustion and environmental control systems; conducting field testing and demonstrations; and advanced analysis of materials. The EPA-funded Center for Air Toxic Metals℠ and the Coal Ash Resources Research Consortium℠ at the EERC further the research needs of government

and industry. The EERC has over 13 years of expertise in Hg measurement and control for bench-, pilot-, and full-scale projects. Projects have been conducted specifically on technologies to oxidize and control Hg in flue gases produced from lignitic and subbituminous coals. Research findings from EERC projects have been instrumental to EPA's MACT Working Group and other agencies involved in regulation of air pollution. More information is available on the EERC Web site at www.undeerc.org.

URS Corporation. URS Corporation has more than 25,000 employees who offer a broad range of planning, design, program and construction management, system integration, and operations and maintenance services. URS has long provided consulting, engineering, and testing support for air, ground, and water pollution to federal, state, and local governmental agencies, as well as private clients. With regard specifically to environmental contracts, URS provides environmental planning, consultation, field investigations, engineering, construction, and construction management services to assist with regulatory compliance, enhance operating efficiency, and reduce costs. Further information for URS Corporation can be obtained at www.urscorp.com.

EPRI. EPRI's work covers a wide spectrum of scientific research, technology development, and product applications related to the generation, delivery, marketing, and use of energy. U.S. electric utilities established EPRI as a nonprofit membership corporation to manage a national research program on behalf of its funders, the industry, and society. In forming one of the first industrywide research consortia, electric utilities pioneered the concept of pooling their resources for maximum benefit. Global clients include, among others, regulated gas and electric utilities, competitive power producers, government energy agencies, independent system operators, transmission companies, distribution companies, nuclear licensees, energy service

providers, telecommunication companies, manufacturers, industrial companies, and other energy suppliers. More in-depth information related to EPRI's research can be obtained at www.epri.com.

ADA.ES. ADA.ES is an environmental technology and specialty chemical company that brings 25 years of experience to improve responsible profitability for electric power and industrial companies through proprietary products and systems that mitigate environmental impact while reducing operating costs. It provides air pollution control equipment and consulting services to utility and industrial customers to maximize capacity, increase efficiency, improve operations, and reduce costs. ADA.ES's focus is to work closely with plants to determine the best control strategies. A systemwide approach from combustion zone to by-product management is used to adopt control strategies that provide multipollutant control in an economical manner.

Minnkota Power Cooperative. As a member-owned regional power supplier, Minnkota Power Cooperative, Inc., provides a valuable service to more than 95,000 customers of the associated distribution cooperatives. Since 1940, Minnkota has been generating and transmitting reliable and affordable electric energy for distribution to residents of eastern North Dakota and northwestern Minnesota. Minnkota knows that electric reliability is essential to a high standard of living. In fact, the mission of the cooperative is to assist the associated systems in improving the quality of life of their customers by continuously improving the value of electric energy. Minnkota headquarters are located in Grand Forks, North Dakota, and the primary source of generation is the MRY Station near Center, North Dakota. Minnkota has participated in numerous field tests on Hg measurement and speciation over the past several

years. Further information on Minnkota Power Cooperative, Inc. can be found at www.minnkota.com.

TXU. TXU Energy—a competitive retail electric provider, merchant trader, and electricity producer—has built a 100-year heritage of serving Texans and now also provides electricity and energy-related services across the United States (2.7 million customers). TXU Energy is part of TXU, one of the largest energy companies in the world, selling and/or distributing electricity to 11 million customers worldwide. TXU is a leader in providing energy, protecting the environment, and reducing emissions. TXU Energy's 99%-plus air compliance rate is one of the best in the industry, and it is a proactive leader in air quality through the Climate Challenge Program and voluntary nitrogen oxide emission reductions. TXU is committed to being an innovative leader in the management of environmental issues. As part of its current environmental efforts, TXU Energy is utilizing a variety of methods to reduce or cocontrol the air emissions that contain trace amounts of inorganic mercury. Although there is presently no available technology to eliminate all emissions of inorganic mercury, TXU is working with other organizations to develop methods of mercury emission control.

Facilities and Equipment

The two sites chosen to host the project were selected based on configuration. Each site has committed (letter of commitment is in the appendix) to being part of this project if selected. Both the EERC and URS have facilities equipped to deal with all aspects of the project, including project management, sample analyses, data reduction, reporting, accounting, procurement, and contracting. Both the EERC and URS have previously been awarded DOE contracts and have extensive experience understanding DOE requirements for this type of program.

Specific equipment necessary to conduct this program is either directly available at the EERC or URS or will be purchased or leased. Although additional sampling equipment will be needed to complete the work (as detailed in the equipment list in the budget), to a great extent all sampling equipment is currently available both to execute the OH method and the Hg CEM sampling. Major equipment that will need to the purchased or leased is the injection system for the chemical oxidizing agent. The equipment to inject the chemical will be provided by ADA.ES for the MRY site and by URS for the Monticello site.

VALUE TO NORTH DAKOTA

The project will focus on developing effective mercury control sorbent technologies for conventional power plants firing lignite coals equipped with ESP–wet FGD combinations for emission control. It is anticipated that key information will be delivered to consortium members throughout the duration of the project, with all results and deliverables transferred to project sponsors by the end of the project. Key deliverables that will be realized by participants include:

- Information on mechanisms of mercury transformations and interactions with fly ash, flue gas components, and oxidation additives.
- Results on mercury emissions and reduction potential for the oxidation additive-based technology.
- Performance and cost data to assist in developing an overall compliance strategy. Data available will be directly applicable to coals and plants that are part of this project.
- Collaborative research and interaction between stakeholders with an 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.
- Demonstration of the technology at a power plant. Data generated from 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. This project provides commercial trial of the technology with minimal risk to the lignite industry. Resulting information on costs, installation, performance, and balance of plant impact will allow the utilities to assess the commercial viability of the mercury control technology on North Dakota lignite.

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. 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, help lead to the demand for greater production. Increased lignite production and use in North Dakota will result in more jobs in all lignite-related industries in the state.

MANAGEMENT

Mr. Mike Holmes will be overall project manager (PM) for the Hg control projects. Mr. Holmes will be in charge of coordinating all activities and integration of sampling effort. For the Task 1 effort, the site lead for the MRY Unit 2 large-scale field test will be Dr. Steve Benson. Dr. Benson will be responsible for all field testing activities at MRY Unit 2. Mr. Dennis Laudal will manage and coordinate all sampling and measurement activities at MRY. Mr. Stu Libby

from Minnkota Power will be the on-site plant lead to coordinate field testing with plant operations.

The Task 2 effort at Monticello will be coordinated by URS and EPRI. The site lead for the Monticello testing will be Dr. Carl Richardson. The on-site plant lead is Mr. Bob Weimuth from TXU. The EPRI PM will be Dr. Ramsey Chang. Dr. Richardson and Dr. Chang will coordinate efforts with Mr. Holmes and Dr. Benson to ensure the identification of optimum conditions for oxidant injection and make comparisons of levels of Hg control attained at each site. The project team will work with project sponsors and the Mercury Task Force to ensure communication and reporting to meet DOE and proposed milestones.

The overall organization of the project is illustrated in Figure 8.

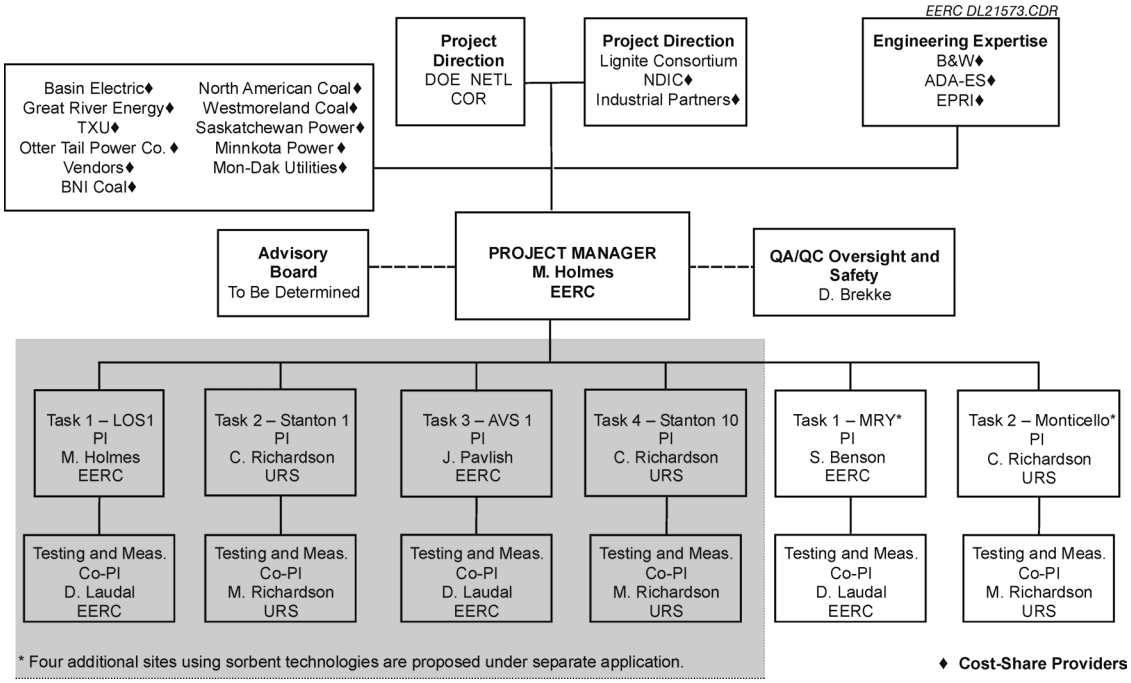
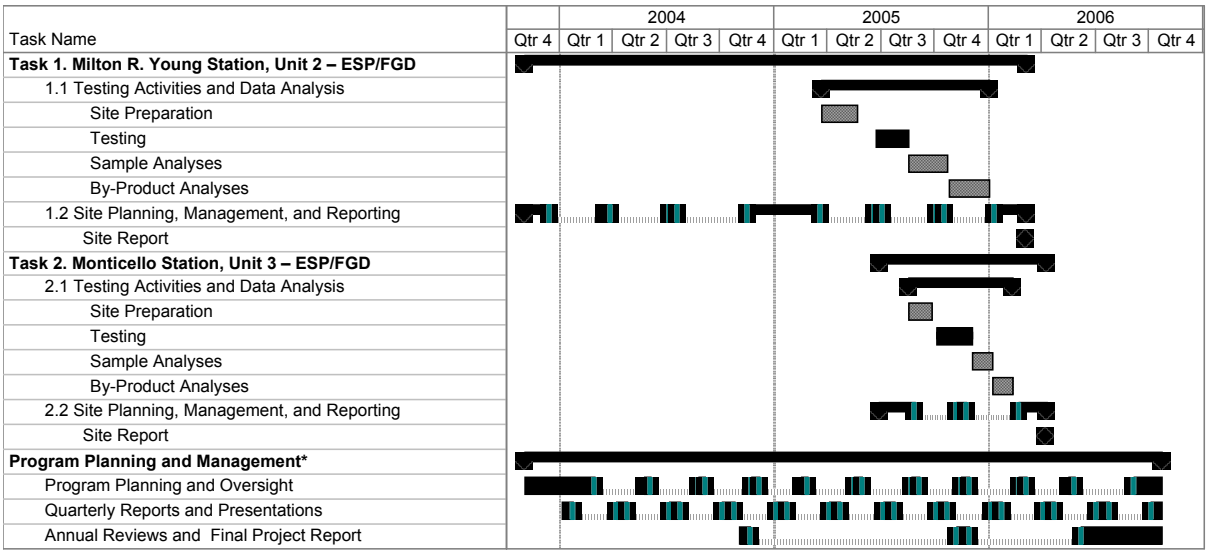


Figure 8. Organizational chart for Hg oxidation and control program.

TIMETABLE

The project will be performed over a 3-year period, October 1, 2003, through September 30, 2006. The overall schedule for the project is shown in the Gantt chart in Figure 9.



* Program planning and management are included in Tasks 1 and 2 but are broken out here to indicate timing of meetings and reporting.

Figure 9. Project schedule.

BUDGET

The work of this project will be performed on a cost-reimbursable basis for $2,150,767. Of that amount, DOE is providing $1,602,195 and the balance of $548,572 will be provided by consortium members. A detailed budget is attached, and a breakdown of cost share is provided in the following section.

MATCHING FUNDS

Funding requested from NDIC is $172,500. Other project partners providing cash and in-kind funding include SaskPower; BNI Coal, Ltd.; Coteau Properties Company; Falkirk Mining Company; Dakota Westmoreland Corporation; Great River Energy; Basin Electric Power Cooperative; Minnkota Power Cooperative; Otter Tail Power Company; Montana-Dakota

Utilities Co.; ADA.ES; EPRI; and TXU. A detailed breakdown of cost share is provided in Table 8. Letters of Support in Appendix A reflect cost share known at the time the project was proposed to DOE. Cash cost-share components have been revised, but updated letters could not be obtained prior to submission of this proposal. Overall cash cost-share remains the same.

Table 8. Cost-Share Table

SOURCE	TYPE		COST SHARE	DOE		TOTAL PROJECT
NDIC	Cash	$	172,500		$	172,500
SaskPower	Cash	$	46,150		$	46,150
BNI	Cash	$	1,092		$	1,092
Coteau	Cash	$	1,092		$	1,092
Falkirk	Cash	$	1,092		$	1,092
Westmoreland	Cash	$	1,092		$	1,092
Great River	Cash	$	2,073		$	2,073
Basin Electric	Cash	$	1,993		$	1,993
Minnkota	Cash $1312; in-kind $65,000 services and materials	$	66,312		$	66,312
Otter Tail	Cash	$	979		$	979
Montana-Dak.	Cash	$	625		$	625
ADA-ES	In-kind – discount of equipment	$	104,500		$	104,500
EPRI	In-kind – services, materials, travel, and overhead	$	71,000		$	71,000
TXU	In-kind – services and material	$	78,072		$	78,072
URS	In-kind – sorbent	$	—		$	—
DOE	Cash	$	—	$1,602,195	$	1,602,195
Total		$	548,572	$1,602,195	$	2,150,767
PERCENT COST SHARE			25.5%	74.5%		100%

TAX LIABILITY

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

REFERENCES

1. U.S. Congress. U.S. Public Law 101-549, U.S. Government Print Office, 1990, 314 p.
2. U.S. EPA. *Mercury Study Report to Congress*; EPA-452/R-97-003; U.S. EPA Office of Air Quality Planning and Standards, U.S. Government Printing Office, Washington, DC, December 1997.
3. U.S. EPA. *A Study of Hazardous Air Pollutant Emissions from Electric Utility Steam Generating Units: Final Report to Congress*; EPA-453/R-98-004a; U.S. EPA Office of Air Quality Planning and Standards, U.S. Government Printing Office, Washington, DC, February 1998.
4. U.S. Environmental Protection Agency. *Information Collection Request*; 1999.
5. Pavlish, J.H.; Holmes, M.J. Mercury Control for Lignite-Fired Power Plants Poses a Challenge. *Center for Air Toxic Metals Newsletter* **2002**, *8* (1), 6.
6. Pavlish, J.H.; Sondreal, E.A.; Mann, M.D.; Olson, E.S.; Galbreath, K.C.; Laudal, D.L.; Benson, S.A. Status Review of Mercury Control Options for Coal-Fired Power Plants. *Fuel Process. Technol.* **2003**, in press.
7. Sjostrom, S.; Richardson, C.; Chang, R. *Evaluation of Mercury Emissions and Control Options for Great River Energy*; Final Report for North Dakota Industrial Commission; June 2001.

8. Chang, R.; Strohfus, M. *The Evaluation of Chemical Additives for Mercury Emission Control at Great River Energy*; Final Report Submitted to the North Dakota Industrial Commission; Jan 2003.
9. Thompson, J.S.; Holmes, M.J.; Laudal, D.L. *Long-Term Monitoring at North Dakota Power Plants*; Final Report; Submitted to the North Dakota Industrial Commission, March 2003.
10. Laudal, D.L.; Pavlish, J.P.; Graves, J.; Stockdil, D. Mercury Mass Balances: A Case Study of Two North Dakota Power Plants. In *Proceedings of the AWMA Mercury in the Environment Specialty Conference*; AWMA VIP91, 1999; pp 340–349.

SUMMARY BUDGET

LARGE-SCALE MERCURY CONTROL TECHNOLOGY TESTING FOR LIGNITE-FIRED
UTILITIES - OXIDATION SYSTEMS FOR WET FGD
US DEPARTMENT OF ENERGY/NDIC
PROPOSED START DATE: 10/01/2003
EERC PROPOSAL #2004-0045

CATEGORY		TOTAL HRS	TOTAL $COST	NDIC SHARE HRS	NDIC SHARE $COST	INDUSTRY SHARE HRS	INDUSTRY SHARE $COST	DOE SHARE HRS	DOE SHARE $COST
TOTAL DIRECT LABOR		8,718	$ 288,929	1,854	$ 59,523	235	$ 9,605	6,629	$ 219,801
FRINGE BENEFITS - % OF DIRECT LABOR	54%		$ 156,021		$ 32,142		$ 5,187		$ 118,692
TOTAL LABOR			$ 444,950		$ 91,665		$ 14,792		$ 338,493
OTHER DIRECT COSTS									
TRAVEL			$ 89,411		$ 2,546		$ 11,515		$ 75,350
COMMUNICATION - PHONES & POSTAGE			$ 2,131		$ 472		$ 157		$ 1,502
OFFICE (PROJECT SPECIFIC SUPPLIES)			$ 3,551		$ 942		$ 314		$ 2,295
REPAIRS			$ 7,700		$ -		$ -		$ 7,700
SUPPLIES			$ 70,550		$ 668		$ 223		$ 69,659
GENERAL (FREIGHT, FOOD, MEMBERSHIPS, ETC.)			$ 9,575		$ 1,296		$ 431		$ 7,848
EQUIPMENT > $5000			$ 33,907		$ -		$ -		$ 33,907
FEES (AND SUBCONTRACTS)			$ 791,009		$ 12,988		$ 9,427		$ 768,594
TOTAL OTHER DIRECT COST			$ 1,007,834		$ 18,912		$ 22,067		$ 966,855
TOTAL DIRECT COST			$ 1,452,784		$ 110,577		$ 36,859		$ 1,305,348
FACILITIES & ADMIN. RATE - % OF MTDC		VAR	$ 379,411		$ 61,923		$ 20,641	VAR	$ 296,847
TOTAL CASH REQUESTED			$ 1,832,195		$ 172,500		$ 57,500		$ 1,602,195
IN-KIND - ADA.ES - EQUIPMENT			$ 104,500						
IN-KIND - MINNKOTA POWER			$ 65,000						
IN-KIND - EPRI - LABOR, EQUIPMENT & OVERHEAD			$ 71,000						
IN-KIND - TXU - MONTICELLO			$ 78,072						
TOTAL IN-KIND			$ 318,572						
TOTAL PROJECT COST			$ 2,150,767						

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

LARGE-SCALE MERCURY CONTROL TECHNOLOGY TESTING FOR LIGNITE-FIRED
UTILITIES - OXIDATION SYSTEMS FOR WET FGD
US DEPARTMENT OF ENERGY/NDIC
PROPOSED START DATE: 10/01/2003
EERC PROPOSAL #2004-0045

			TOTAL		NDIC SHARE		INDUSTRY SHARE		DOE SHARE	
LABOR	LABOR CATEGORY	HRLY RATE	HRS	$COST	HRS	$COST	HRS	$COST	HRS	$COST
HOLMES, M.	PROJECT MANAGER	$ 42.18	632	$ 26,659	110	$ 4,640	37	$ 1,563	485	$ 20,456
BENSON, S.	SITE MANAGER - MR YOUNG	$ 48.02	932	$ 44,754	180	$ 8,644	60	$ 2,880	692	$ 33,230
LAUDAL, D.	PRINCIPAL INVESTIGATOR	$ 43.06	544	$ 23,423	103	$ 4,435	35	$ 1,506	406	$ 17,482
----------	SENIOR MANAGEMENT	$ 48.20	217	$ 10,460	60	$ 2,892	-	$ -	157	$ 7,568
----------	RESEARCH SCIENTIST/ENGINEER	$ 26.94	3,959	$ 106,654	919	$ 24,757	-	$ -	3,040	$ 81,897
----------	RESEARCH TECHNICIAN	$ 18.42	664	$ 12,231	174	$ 3,204	-	$ -	490	$ 9,027
----------	TECHNOLOGY DEV. MECH.	$ 20.79	1,300	$ 27,027	195	$ 4,054	65	$ 1,351	1,040	$ 21,622
----------	TECHNICAL SUPPORT SERVICES	$ 14.62	470	$ 6,872	113	$ 1,652	38	$ 557	319	$ 4,663
			8,718	$ 258,080	1,854	$ 54,278	235	$ 7,857	6,629	$ 195,945
ESCALATION ABOVE CURRENT BASE		VAR		$ 30,849		$ 5,245		$ 1,748		$ 23,856
TOTAL DIRECT LABOR				$ 288,929		$ 59,523		$ 9,605		$ 219,801
FRINGE BENEFITS - % OF DIRECT LABOR		54%		$ 156,021		$ 32,142		$ 5,187		$ 118,692
TOTAL LABOR				$ 444,950		$ 91,665		$ 14,792		$ 338,493
OTHER DIRECT COSTS										
TRAVEL				$ 89,411		$ 2,546		$ 11,515		$ 75,350
COMMUNICATION - PHONES & POSTAGE				$ 2,131		$ 472		$ 157		$ 1,502
OFFICE (PROJECT SPECIFIC SUPPLIES)				$ 3,551		$ 942		$ 314		$ 2,295
REPAIRS				$ 7,700		$ -		$ -		$ 7,700
SUPPLIES				$ 70,550		$ 668		$ 223		$ 69,659
GENERAL (FREIGHT, FOOD, MEMBERSHIPS, ETC.)				$ 9,575		$ 1,296		$ 431		$ 7,848
EQUIPMENT > $5000				$ 33,907		$ -		$ -		$ 33,907
NATURAL MATERIALS ANALYTICAL RES. LAB.				$ 7,080		$ 1,328		$ 442		$ 5,310
FUELS & MATERIALS RESEARCH LAB.				$ 7,778		$ 1,458		$ 486		$ 5,834
ANALYTICAL RESEARCH LAB.				$ 8,535		$ 1,600		$ 533		$ 6,402
COMBUSTION TEST SERVICES				$ 1,968		$ 295		$ 99		$ 1,574
PARTICULATE ANALYSIS				$ 44,214		$ 3,965		$ 6,421		$ 33,828
PROCESS CHEM. & DEV. LAB.				$ 4,371		$ 820		$ 273		$ 3,278
GRAPHICS SUPPORT				$ 14,387		$ 2,572		$ 856		$ 10,959
SHOP & OPERATIONS SUPPORT				$ 2,319		$ 348		$ 116		$ 1,855
SAMPLING TRAILER FEE				$ 4,014		$ 602		$ 201		$ 3,211
SUBCONTRACT - ADA.ES & URS				$ 696,343		$ -		$ -		$ 696,343
TOTAL OTHER DIRECT COST				$ 1,007,834		$ 18,912		$ 22,067		$ 966,855
TOTAL DIRECT COST				$ 1,452,784		$ 110,577		$ 36,859		$ 1,305,348
FACILITIES & ADMIN. RATE - % OF MTDC			VAR	$ 379,411	56.0%	$ 61,923		$ 20,641	VAR	$ 296,847
TOTAL CASH REQUESTED				$ 1,832,195		$ 172,500		$ 57,500		$ 1,602,195
IN-KIND - ADA.ES - EQUIPMENT				$ 104,500						
IN-KIND - MINNKOTA POWER				$ 65,000						
IN-KIND - EPRI - LABOR, EQUIPMENT & OVERHEAD				$ 71,000						
IN-KIND - TXU - MONTICELLO				$ 78,072						
TOTAL IN-KIND				$ 318,572						
TOTAL PROJECT COST				$ 2,150,767						

DETAILED BUDGET - TRAVEL - TASK 1

LARGE-SCALE MERCURY CONTROL TECHNOLOGY TESTING FOR LIGNITE-FIRED
UTILITIES - OXIDATION SYSTEMS FOR WET FGD
EERC PROPOSAL #2004-0045

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	$ 750
Center, ND (Site Visit - Milton R. Young)	$ -	$ 0.31	$ 50	$ 20	$ -	$ -
Bismarck, ND Area	$ -	$ 0.31	$ 50	$ 20	$ -	$ -
Center, ND (Sampling - Milton R. Young)	$ -	$ 0.50	$ 50	$ 20	$ -	$ -
Morgantown, WV (via Pittsburgh, PA)	$ 1,060	$ -	$ 65	$ 38	$ 50	$ -

PURPOSE/DESTINATION	NUMBER OF TRIPS	PEOPLE	LDG DAYS	PD DAYS	AIRFARE	LODGING (LDG)	PER DIEM (PD)	CAR RENTAL	MISC.	REGIST.	TOTAL
National Conference/Unspecified Dest. (USA)	1	3	3	4	$ 4,572	$ 1,125	$ 600	$ 200	$ 240	$ 2,250	$ 8,987
Quarterly Review Mtg/Bismarck, ND Area	2	2	1	2	$ -	$ 200	$ 160	$ -	$ 80	$ -	$ 440
Annual Contractor Rvw Mtg/Morgantown, WV (Pittsburgh, PA)	1	2	2	3	$ 2,120	$ 260	$ 228	$ 100	$ 120	$ -	$ 2,828
Quarterly COR Mtg/Morgantown, WV (Pittsburgh, PA)	1	2	2	3	$ 2,120	$ 260	$ 228	$ 100	$ 120	$ -	$ 2,828
TOTAL ESTIMATED TRAVEL -BUDGET PERIOD ONE											$ 15,083
National Conference/Unspecified Dest. (USA)	1	3	3	4	$ 4,572	$ 1,125	$ 600	$ 200	$ 240	$ 2,250	$ 8,987
Quarterly Review Mtg/Bismarck, ND Area	2	2	1	2	$ -	$ 200	$ 160	$ -	$ 80	$ -	$ 440
Annual Contractor Rvw Mtg/Morgantown, WV (Pittsburgh, PA)	1	2	2	3	$ 2,120	$ 260	$ 228	$ 100	$ 120	$ -	$ 2,828
Quarterly COR Mtg/Morgantown, WV (Pittsburgh, PA)	1	2	2	3	$ 2,120	$ 260	$ 228	$ 100	$ 120	$ -	$ 2,828
Corrosion Testing/Center, ND	6	1	2	3	$ -	$ 600	$ 360	$ -	$ 180	$ -	$ 1,140
Site Visit/Center, ND	1	2	1	2	$ -	$ 100	$ 80	$ -	$ 40	$ -	$ 220
Field Supervision/Center, ND - Pretest	1	1	4	5	$ -	$ 200	$ 100	$ -	$ 50	$ -	$ 350
Field Supervision/Center, ND - Parametric	1	1	15	16	$ -	$ 750	$ 320	$ -	$ 160	$ -	$ 1,230
Field Supervision/Center, ND - OH Sampling	3	1	4	5	$ -	$ 600	$ 300	$ -	$ 150	$ -	$ 1,050
Sampling Trip - Ontario Hydro/Center, ND - Parametric (2 trucks)	1	5	0	1	$ -	$ -	$ 100	$ -	$ 50	$ -	$ 150
Sampling Trip - Ontario Hydro/Center, ND - Parametric	1	5	14	15	$ -	$ 3,500	$ 1,500	$ -	$ 750	$ -	$ 5,750
Sampling Trip - Ontario Hydro/Center, ND	3	5	4	5	$ -	$ 3,000	$ 1,500	$ -	$ 750	$ -	$ 5,250
Sampling Trip - Ontario Hydro/Center, ND - Return (2 trucks)	1	5	0	1	$ -	$ -	$ 100	$ -	$ 50	$ -	$ 150
Sampling Trip - CEM/Center, ND	1	1	7	8	$ -	$ 350	$ 160	$ -	$ 80	$ -	$ 590
Sampling Trip - CEM/Center, ND	6	1	9	10	$ -	$ 2,700	$ 1,200	$ -	$ 600	$ -	$ 4,500
Sampling Trip - CEM/Center, ND	1	1	2	3	$ -	$ 100	$ 60	$ -	$ 30	$ -	$ 190
Sampling Trip - CEM/Center, ND	1	1	3	4	$ -	$ 150	$ 80	$ -	$ 40	$ -	$ 270
TOTAL ESTIMATED TRAVEL -BUDGET PERIOD TWO											$ 35,923
National Conference/Unspecified Dest. (USA)	1	3	3	4	$ 4,572	$ 1,125	$ 600	$ 200	$ 240	$ 2,250	$ 8,987
Quarterly Review Mtg/Bismarck, ND Area	2	2	1	2	$ -	$ 200	$ 160	$ -	$ 80	$ -	$ 440
Annual Contractor Rvw Mtg/Morgantown, WV (Pittsburgh, PA)	1	2	2	3	$ 2,120	$ 260	$ 228	$ 100	$ 120	$ -	$ 2,828
Quarterly COR Mtg/Morgantown, WV (Pittsburgh, PA)	1	2	2	3	$ 2,120	$ 260	$ 228	$ 100	$ 120	$ -	$ 2,828
TOTAL ESTIMATED TRAVEL -BUDGET PERIOD THREE											$ 15,083
TOTAL ESTIMATED TRAVEL - ALL YEARS											$ 66,089

ESTIMATED VEHICLE EXPENSES	/MILE CAR	/MILE SUV/TRK
Bismarck/Center, ND area	$ 0.31	$ 0.50

*Miles include RT and daily miles to and from site: plus # of vehicles	BUDGET PERIOD ONE MILES*	MILEAGE	BUDGET PERIOD TWO MILES*	MILEAGE	BUDGET PERIOD THREE MILES*	MILEAGE
State car - Quarterly Rvw Mtg/Bismarck, ND Area	1440	$ 446	1440	$ 446	1440	$ 446
State car - Corrosion Testing/Center, ND	0	$ -	4920	$ 1,525	0	$ -
State car - Site visit/Center, ND	0	$ -	720	$ 223	0	$ -
State car - Field Supervision/Center, ND (pretest, parametric, OH)	0	$ -	7200	$ 2,232	0	$ -
State car - CEM Sampling Crew/Center, ND	0	$ -	14000	$ 4,340	0	$ -
Truck - Ontario Hydro Sampling crew/Center, ND	0	$ -	7600	$ 3,800	0	$ -
TOTAL ESTIMATED VEHICLE EXPENSES	1440	$ 446	35880	$ 12,566	1440	$ 446

DETAILED BUDGET - TRAVEL - TASK 2

LARGE-SCALE MERCURY CONTROL TECHNOLOGY TESTING FOR LIGNITE-FIRED
UTILITIES - OXIDATION SYSTEMS FOR WET FGD
EERC PROPOSAL #2004-0045

RATES USED TO CALCULATE ESTIMATED TRAVEL EXPENSES

DESTINATION	AIRFARE	LODGING	PER DIEM	CAR RENTAL
Austin, TX	$ 1,400	$ 150	$ 42	$ 50
Morgantown, WV (via Pittsburgh, PA)	$ 1,060	$ 65	$ 38	$ 50

PURPOSE/DESTINATION	NUMBER OF TRIPS	PEOPLE	LDG DAYS	PD DAYS	AIRFARE	LODGING (LDG)	PER DIEM (PD)	CAR RENTAL	MISC.	TOTAL
Program Rvw Mtg/Austin, TX	1	1	1	2	$ 1,400	$ 150	$ 84	$ 100	$ 40	$ 1,774
Annual Contractor Rvw Mtg/Morgantown, WV (Pittsburgh, PA)	1	1	2	3	$ 1,060	$ 130	$ 114	$ 150	$ 60	$ 1,514
TOTAL ESTIMATED TRAVEL -BUDGET PERIOD ONE										$ 3,288
Program Rvw Mtg/Austin, TX	1	1	1	2	$ 1,400	$ 150	$ 84	$ 100	$ 40	$ 1,774
Annual Contractor Rvw Mtg/Morgantown, WV (Pittsburgh, PA)	1	1	2	3	$ 1,060	$ 130	$ 114	$ 150	$ 60	$ 1,514
TOTAL ESTIMATED TRAVEL -BUDGET PERIOD TWO										$ 3,288
Program Rvw Mtg/Austin, TX	1	1	1	2	$ 1,400	$ 150	$ 84	$ 100	$ 40	$ 1,774
Annual Contractor Rvw Mtg/Morgantown, WV (Pittsburgh, PA)	1	1	2	3	$ 1,060	$ 130	$ 114	$ 150	$ 60	$ 1,514
TOTAL ESTIMATED TRAVEL -BUDGET PERIOD THREE										$ 3,288
TOTAL ESTIMATED TRAVEL - ALL YEARS										$ 9,864

DETAILED BUDGET - FEES

LARGE-SCALE MERCURY CONTROL TECHNOLOGY TESTING FOR LIGNITE-FIRED UTILITIES - OXIDATION SYSTEMS FOR WET FGD
EERC PROPOSAL #2004-0045

NATURAL MATERIALS ANALYTICAL RES. LAB.	RATE	#	TOTAL SCOST
MORPHOLOGY (HOURLY)	$126	32	$ 4,032
XRD	$133	2	$ 266
XRFA	$144	14	$ 2,016
SUBTOTAL			$ 6,314
ESCALATION		VAR	$ 766
TOTAL NATURAL MATERIALS ANALYTICAL RES. LAB.			$ 7,080

FUELS & MATERIALS RESEARCH LAB.	RATE	#	SCOST
BTU	$46	8	$ 368
LOSS ON IGNITION (LOI)	$37	80	$ 2,960
MISCELLANEOUS	$64	45	$ 2,880
PROXIMATE ANALYSIS	$52	8	$ 416
SULFUR	$44	8	$ 352
SUBTOTAL			$ 6,976
ESCALATION		VAR	$ 802
TOTAL FUELS & MATERIALS RESEARCH LAB.			$ 7,778

ANALYTICAL RESEARCH LAB.	RATE	#	SCOST
CHLORINE	$42	45	$ 1,890
CVGAA	$32	30	$ 960
FILTERING	$10	30	$ 300
GFAA	$42	40	$ 1,680
IC	$39	9	$ 351
IC PREP	$10	9	$ 90
ICP	$34	40	$ 1,360
MIXED ACID DIGESTION	$34	26	$ 884
SUBTOTAL			$ 7,515
ESCALATION		VAR	$ 1,020
TOTAL ANALYTICAL RESEARCH LAB.			$ 8,535

COMBUSTION TEST SERVICES	RATE	#	SCOST
FIELD TESTING-PREPARATION	$3,529	0.5	$ 1,765
SUBTOTAL			$ 1,765
ESCALATION		VAR	$ 203
TOTAL COMBUSTION TEST SERVICES			$ 1,968

PARTICULATE ANALYSIS	RATE	#	SCOST
EPA METHOD 29/ONTARIO HYDRO	$273	58	$ 15,834
MERCURY CEM (PER DAY)	$96	190	$ 18,240
WET CHEMISTRY SAMPLES	$124	45	$ 5,580
SUBTOTAL			$ 39,654
ESCALATION		VAR	$ 4,560
TOTAL PARTICULATE ANALYSIS			$ 44,214

PROCESS CHEM. & DEV. LAB.	RATE	#	SCOST
PREP/GC/CHN	$49	80	$ 3,920
SUBTOTAL			$ 3,920
ESCALATION		VAR	$ 451
TOTAL PROCESS CHEM. & DEV. LAB.			$ 4,371

GRAPHICS SUPPORT	RATE	#	SCOST
GRAPHICS (HOURLY)	$39	326	$ 12,714
SUBTOTAL			$ 12,714
ESCALATION		VAR	$ 1,673
TOTAL GRAPHICS SUPPORT			$ 14,387

SHOP & OPERATIONS SUPPORT	RATE	#	SCOST
TECHNICAL DEVELOPMENT HOURS	$1.60	1,300	$ 2,080
SUBTOTAL			$ 2,080
ESCALATION		VAR	$ 239
TOTAL SHOP & OPERATIONS SUPPORT			$ 2,319

SAMPLING TRAILER FEE	RATE	#	SCOST
TRAILER FEE (WEEKLY)	$450	8	$ 3,600
SUBTOTAL			$ 3,600
ESCALATION		VAR	$ 414
TOTAL SAMPLING TRAILER FEE			$ 4,014

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. 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.

BUDGET NARRATIVE – URS

The following section details the personnel, travel, equipment, supplies, and cost sharing associated with the TXU Monticello Injection Tests.

PERSONNEL

The following schedule identifies labor rates, hours, and costs per fiscal year of the proposed project. All rates are based on actual rates for the person identified (initials).

	Hourly Rates	FY04	FY05	FY06	Cost
Principal Engineer/Scientist II (GB)	112.32	0.60	6.80	2.60	$1,123.20
Senior Engineer/Scientist II (CR)	90.94	17.60	13.60	282.80	$28,555.16
Engineer/Scientist IV (TM)	65.93	7.20	24.80	366.00	$26,241.76
Engineer/Scientist II (MR)	46.15	1.60	1.60	336.80	$15,691.00
Engineer/Scientist IV (KD)	68.66	2.40	21.60	354.00	$25,953.48
Engineer/Scientist III (JP)	57.98	-	19.20	338.80	$20,755.59
Technician/Analyst VI (CG)	54.57	-	-	58.00	$3,164.83
Technician/Analyst V (RW)	53.57	-	-	58.00	$3,106.81
Engineer/Scientist III (MD)	49.34	-	-	52.00	$2,565.52
ESII TBD	50.02	-	-	52.00	$2,600.98
ESI TBD	42.06	-	-	52.00	$2,187.19
Engineer/Scientist IV (BM)	66.89	-	-	184.00	$12,307.57
Senior Engineer/Scientist I (SY)	77.53	2.00	2.00	16.00	$1,550.59
Engineer/Scientist II (LAH)	49.25	1.60	1.60	12.80	$787.93
Engineer/Scientist I (PG)	39.79	3.60	3.60	28.80	$1,432.36
Secretary/Clerical IV (DA)	41.56	4.00	3.20	16.80	$997.47

TRAVEL

The travel required for testing at TXUs Monticello plant is outlined in the following table. Basis for costs are on previous travel except for perdiem which is based on government rates.

Task No.	Year No.	Trip No.	Purpose of Travel	Origin	Destination	No. Trips	No. Traveler	Duration (Trip (days	Per diem $/day	Per diem Cost	Ground Transportal $/day	Ground Transportal Cost	Airfare $/trip	Airfare Cost	Local Mileag Airport Parki	Total Cost
1	1	1	Project Planning Meeting	Austin, TX	Grand Forks, ND	1	1	2	$85	$170	$72	$144	$1,100	$1,100	$12	$1,426
4	1	2	Site Setup	Austin, TX	Monticello, TX	1	4	5	$135	$2,700	$98	$980	$0	$0	$120	$3,800
4	1	3	Baseline Testing	Austin, TX	Monticello, TX	1	3	5	$135	$2,025	$72	$720	$0	$0	$90	$2,835
5	1	4	Optimization Testing	Austin, TX	Monticello, TX	1	3	9	$135	$3,645	$72	$1,296	$0	$0	$162	$5,103
5	1	5-8	Short-Term Testing	Austin, TX	Monticello, TX	4	3	9	$135	$14,580	$72	$5,184	$0	$0	$648	$20,412
5	1	9	Site Breakdown	Austin, TX	Monticello, TX	1	4	5	$135	$2,700	$98	$980	$0	$0	$120	$3,800
6	1	10	Gas Characterization	Austin, TX	Monticello, TX	1	5	5	$135	$3,375	$72-$98	$850	$0	$0	$150	$4,375
7	1	11	Team Meeting	Austin, TX	Grand Forks, ND	1	1	2	$85	$170	$72	$144	$1,100	$1,100	$12	$1,426
7	1	12	Review Meeting at DOE	Austin, TX	Pittsburgh, PA	1	1	2	$125	$250	$72	$144	$1,100	$1,100	$12	$1,506
																$44,68

EQUIPMENT

The equipment needed for the testing at Stanton Stations Units 1 and 10 is itemized below:

EQUIPMENT		UNIT COST	TOTAL COST BASIS_____
Screwfeeder/Installation	$12000	$12000	vendor quote
Mercury Analyzers (2)	$2500/month	$5000	rental fee

The analyzers will be provided by EPRI at no cost to DOE.

SUPPLIES

The supplies needed for testing at Monticello power plant are itemized on the following page.

SUPPLIES

REAGENTS	**Quantity**	**Size**	**Cost**	**Total Cost**	**Cost Basis**
SnCl2	2	2.5 kg	$278.50	$557.00	catalog
Acetone	2	6-1L	$162.28	$324.56	catalog
KMnO4	2	2.5 kg	$169.10	$338.20	catalog
Tris	1	5 kg	$309.40	$309.40	vendor quote
MeOH	2	4-4L	$93.92	$187.84	catalog
NaOH	3	2.5 kg	$73.40	$220.20	vendor quote
Na2CO3	3	2.5 kg	$90.80	$272.40	vendor quote
HCl	2	4L	$40.29	$80.58	catalog
NaHCO3	4	2.5kg	$49.50	$198.00	vendor quote
Nitric Acid	1	2.5L	$18.86	$18.86	catalog
TOTAL				**$2,507.04**	
TAPE					
Heat Tape	8	4 ftX1/2 in	$41.80	$334.40	prior invoice
Insulating Tape	1	1"X100ft	$12.65	$12.65	catalog
Glas-Col coated Heat Tape	3	1/4" X 10 ft.	$50.53	$151.59	prior invoice
Cloth Electrical Tape	3		$13.25	$39.75	prior invoice
Teflon Tape	12	1/2"	$1.44	$17.28	prior invoice
Teflon Tape	12	3/4"	$2.21	$26.52	prior invoice
FITTINGS					
Ferrules	20	1/4"	$1.57	$31.40	prior invoice
Ferrules	20	3/8"	$2.56	$51.20	prior invoice
Unions	5	1/4" to 1/4"	$15.60	$78.00	prior invoice
Unions	5	3/8" to 3/8"	$15.60	$78.00	prior invoice
Plug	4	1/4"	$12.80	$51.20	prior invoice
Plug	4	3/8"	$22.10	$88.40	prior invoice
Cap	4	1/4"	$12.90	$51.60	prior invoice
Cap	4	3/8"	$26.60	$106.40	prior invoice
Tee	2	1/4"	$40.00	$80.00	prior invoice
Tee	2	3/8"	$50.20	$100.40	prior invoice
TUBING					
FEP Tubing	6	1/4"-25 ft	$23.00	$138.00	prior invoice
FEP Tubing	2	3/8"-25 ft	$35.00	$70.00	prior invoice
PTFE-high temp	8	1/4"-12 ft	$20.00	$160.00	prior invoice
PTFE-high temp	1	3/8"-12 ft	$27.50	$27.50	prior invoice
Stainless Steel	20	1/4"	$1.13	$22.60	prior invoice
JARS/BOTTLES					
Amber Wide Mouth	4	12-950 mL	$31.11	$124.44	catalog
Nalgene Bottles	2	12-65mL	$16.20	$32.40	catalog
Nalgene Bottles	2	12-125mL	$16.34	$32.68	catalog
Nalgene Bottles	2	12-250mL	$24.03	$48.06	catalog
Nalgene Bottles	2	12-500 mL	$37.31	$74.62	catalog
Nalgene Bottles	4	6-1000 mL	$43.15	$172.60	catalog
Field Sampling Jars	4	24-125 mL	$32.30	$129.20	prior invoice
Gloves	1	large	$10.44	$10.44	prior invoice
Gloves	1	x-large	$10.44	$10.44	prior invoice
Gloves	1	medium	$14.47	$14.47	prior invoice
FILTERS					
Cellulose Nitrate Membrane filters-Whatman	1	0.45u, 47mm	$8.55	$8.55	prior invoice
INSULATION					
Vinyl Backed Fiberglass Insulation	2	12 rolls	$36.72	$73.44	prior invoice
Magnehelic (0-10inH2O)	1	1	$57.41	$57.41	prior invoice
TOTAL			**TOTAL**	**$2,505.64**	
TOTAL REAGENTS & PARTS				**$5,012.68**	

CONTRACTUAL

Subcontractors

The subcontractors planned to use for testing at Monticello Station CT&E and a subcontractor for Silo rental. Each subcontractor's total proposed budget is shown below and a description of the work to be performed follows.

	Total
CT&E	$840.00
Silo Rental Subcontractor	$10,000.00

CT&E

CT&E will be providing support to the Monticello tests by analyzing the coal samples obtained with a proximate/ultimate analysis. The selection of CT&E to provide the coal analysis is based on URS' knowledge of CT&E's technical competence as well as having a prior working relationship with this company.

Silo Rental Contractor

A subcontractor has not yet been established to complete the requirements of this task. Costs are based on an engineering estimate. The contractor chosen will be required to deliver a silo and set it up on site. When the testing is completed, the contractor will be required to break down the silo and take it off site.

OTHER DIRECT COSTS

Other direct costs include shipping of the URS and Apogee Scientific, Inc equipment trailers on and off site, shipping of the mercury analyzers on and off site for long term testing, and shipping of the byproducts at each site to a NETL approved contractor for analysis.

Type of Direct Cost	Unit Cost	Cost	Basis
Trailer Shipping	$700-one way	$1400	Prior Invoice
Other Shipping		$1300	Prior Invoice
Salt 1	$1410/day	$19,740	Vendor Quote
Salt 2	$8800/day	$88,000	Vendor Quote

INDIRECT COSTS

This section will be submitted directly from URS to DOE if needed.

COST SHARING

The cost sharing commitment for the TXU Monticello plant testing will be provided from EPRI and TXU. EPRI and TXUs cost share amounts and percentages follow.

TXU Monticello	FY04	FY05	FY06	Total	% Cost Share
TOTAL PROJECT COST				**552843.2**	
EPRI (In-Kind Labor)	8000	24000	8000	40000	3.20
EPRI (In-Kind Travel)	1500	3000	1500	6000	0.48
EPRI (In-Kind Overhead)	200	19650	150	20000	1.60
EPRI (In-Kind Equipment)		500		500	0.04
TXU (In-Kind Labor)		65800		65800	5.26
TXU (In-Kind Materials)		9000		9000	0.72
TXU (In-Kind Travel)		3200		3200	0.26
TOTAL	**9700**	**125150**	**9650**	**144500**	**26**

COST CENTER

Cost Center costs include rental fees associated with the equipment used for gas characterization and rental fees for the mercury-testing trailer and the lab trailer. Itemized costs are shown in the table below.

	Number	Unit Cost	Extension
Method 5 Sampling Train	1	$1,375	$1,375
2nd Train	1	$1,210	$1,210
Fyrite sampler	1	$110	$110
Extra Impinger train	1	$220	$220
Balance	1	$100	$100
Radios	1	$50	$50
Subtotal			$3,065
Trailer Rentals			
Hg Trailer	1.25	$375	$469
Lab Trailer	1	$1,160	$1,160
Subtotal			$1,629
TOTAL Site 1 (Task 2)			**$4,694**

Plant Costs for Chemical Injection

April 1, 2003

Installation of Salt Additive:

Installation of Silo	Fluor	12 Man-hours	$40/Hour	$480.00
Install feed piping from silo to conveyor	Fluor	64 Man-hours	$40/Hour	$2,560.00
Miscellaneous Support Material	Ameco			$5,000.00
Insulation	Merrico	24 Man-hours	$23/hour	$552.00
Power	Fluor	32 Man-hours	$40/Hour	$1,280.00
Miscellaneous Conduit (Material)	TXU			$500.00
Fluor Supervision	Fluor	40 Man-hours	$40/Hour	$1,600.00
Technican for I&C Work	TXU	48 Man-hours	$55/Hour	$3,360.00
Craft Support for Checkout/Start-Up	Fluor	8 Man-hours	$50/hour	$400.00
TXU Project Management for Construction	TXU	20 Man-hours	$70/hour	$1,400.00
				$17,132.00

Site Support for Salt Additive:

Ash & Coal Samples :	TXU	14 Samples	$55/hour	$770.00
Plant Data Download (TXU Craft)	TXU	14 Man-hours	$55/hour	$770.00
Reagent Transport	Fluor	24 Man-hours	$40/hour	$960.00
Mobilization Support	Fluor	4 Man-hours	$40/hour	$160.00
TXU Project Management (Total Project)	TXU	96 Man-hours	$70/hour	$6,720.00
				$8,610.00

Demobilization of Salt Additive:

Dismantle piping, air, electirc,etc.	Fluor	50 Man-hours	$40/hour	$2,000.00
Technician for I&C Work	TXU	24 Man-hours	$55/hour	$1,320.00
TXU Project Management	TXU	20 Man-hours	$70/hour	$1,400.00
Crane and Riggers to load skids	Fluor	32 Man-hours	$40/Hour	$1,280.00
				$6,000.00

Chemical Liquid Injection Installation:

Installation of Skid/Tank	Fluor	24 Man-hours	$40/Hour	$960.00
Install piping to MoSES U3 7th Floor	Fluor	120 Man-hours	$40/Hour	$6,600.00
Miscellaneous Support Material	Ameco			$3,000.00
Modify Doors for Injection Probes	Merrico	32 Man-hours	$55/hour	$1,280.00
Power	Fluor	16 Man-hours	$40/Hour	$640.00
Miscellaneous Conduit (Material)	TXU			$500.00
Fluor Supervision	Fluor	40 Man-hours	$40/Hour	$1,600.00
Technican for I&C Work	TXU	24 Man-hours	$55/Hour	$1,320.00
Craft Support for Checkout/Start-Up	Fluor	8 Man-hours	$50/hour	$400.00
TXU Project Management for Construction	TXU	20 Man-hours	$70/hour	$1,400.00
				$17,700.00

Site Support for Liquid Additive:

Ash & Coal Samples :	TXU	14 Samples	$55/hour	$770.00
Plant Data Download (TXU Craft)	TXU	14 Man-hours	$55/Hhour	$770.00
Reagent Transport	Fluor	22 Man-hours	$40/hour	$880.00
Mobilization Support	Fluor	4 Man-hours	$40/hour	$160.00
				$1,810.00

Demobilization of Liquid Additive:

Dismantle piping, air, electirc,etc.	Fluor	50 Man-hours	$40/hour	$2,000.00
Technician for I&C Work	TXU	24 Man-hours	$55/hour	$1,320.00
TXU Project Management	TXU	20 Man-hours	$70/hour	$1,400.00
Crane and Riggers to load skids	Fluor	32 Man-hours	$40/Hour	$1,280.00
				$6,000.00

Project Management:

DOE Kickoff Meeting (Pittsburgh, Pa)	TXU	24 Man-hours	$70/hour	$1,680.00
(Misc. Cost for travel)	TXU			$1,600.00
Test Plan Review	TXU	21 Man-hours	$70/hour	$1,470.00
Monticello Kick-off Meeting	TXU	20 Man-hours	$70/hour	$1,470.00
Plant Safety Review	TXU	24 Man-hours	$50/Hour	$1,320.00
DOE Conference Attendence (Pittsburgh, Pa)	TXU	24 Man-hours	$70/hour	$1,680.00
	TXU			$1,600.00
On site Coordination (Covered Above)				
Project Management (Covered Above)				
Other Administration Support	TXU			$10,000.00
				$20,820.00

Total: $78,072.00

DOE RFP No. DE-PS26-03NT41718
URS Proposal No. 104584.25400101

URS - MONTICELLO

Cost Proposal for "Evaluation of Chemical Addition for Mercury Control in Lignite-Derived Flue Gas"

24-Mar-03

		Design and Testing		Planning, Mgmt.& Report		FY04	FY05	FY06
	Rates	Units	Cost ($)	Units	Cost ($)			
DIRECT LABOR								
Principal Engineer/Scientist II (GB)	112.32	8.00	898.56	2.00	224.64	$ 56.16	$ 1,067.04	$ -
Senior Engineer/Scientist II (CR)	90.94	304.00	27,645.76	96.00	8,730.24	$ 1,418.66	$ 34,193.44	$ 763.90
Engineer/Scientist IV (TM)	65.93	444.00	29,274.72	40.00	2,637.36	$ 421.98	$ 31,252.74	$ 237.36
Engineer/Scientist II (MR)	46.15	324.00	14,952.60	16.00	738.40	$ 73.84	$ 15,506.40	$ 110.76
Engineer/Scientist IV (KD)	68.66	354.00	24,305.64	24.00	1,647.84	$ 164.78	$ 25,541.52	$ 247.18
Engineer/Scientist III (JP)	57.98	444.00	25,741.57	-	-	$ -	$ 25,741.57	$ -
Engineer/Scientist III (LR)	53.88	-	-	-	-	$ -	$ -	$ -
Technician/Analyst VI (CG)	54.57	58.00	3,164.83	-	-	$ -	$ 3,164.83	$ -
Technician/Analyst V (RW)	53.57	58.00	3,106.81	-	-	$ -	$ 3,106.81	$ -
Engineer/Scientist III (MD)	49.34	52.00	2,565.52	-	-	$ -	$ 2,565.52	$ -
ESII TBD	50.02	52.00	2,600.98	-	-	$ -	$ 2,600.98	$ -
ESI TBD	42.06	52.00	2,187.19	-	-	$ -	$ 2,187.19	$ -
Engineer/Scientist IV (BM)	66.89	184.00	12,307.57	-	-	$ -	$ 12,307.57	$ -
Senior Engineer/Scientist I (SY)	77.53	-	-	20.00	1,550.59	$ 155.06	$ 1,162.94	$ 232.59
Engineer/Scientist II (LAH)	49.25	-	-	16.00	787.93	$ 78.79	$ 590.95	$ 118.19
Engineer/Scientist I (PG)	39.79	-	-	36.00	1,432.36	$ 143.24	$ 1,074.27	$ 214.85
Secretary/Clerical IV (DA)	41.56	-	-	24.00	997.47	$ 149.62	$ 748.10	$ 99.75
Loaded Labor		2,334.00	148,751.76	274.00	18,746.83	$ 2,662.13	$ 162,811.88	$ 2,024.57
Escalation		0.15	-	0.06	87.74	$ 15.86	$ 65.80	$ 6.07
		0.30	264.97	0.12	143.98	$ 23.85	$ 372.96	$ 12.15
		0.45	12,990.20	0.18	1,208.03	$ 156.24	$ 13,896.22	$ 145.77
Total Loaded Labor			162,006.93		20,186.58	$ 2,858.08	$ 177,146.87	$ 2,188.56
						$ -	$ -	$ -
						$ -	$ -	$ -
TRAVEL						$ -	$ -	$ -
Days Subsistence - Monticello, TX	135.00	215.00	29,025.00	-	-	$ -	$ 29,025.00	$ -
Airline Flight - Grand Forks	1,100.00	-	-	2.00	2,200.00	$ 385.00	$ 1,650.00	$ 165.00
Airline Flight - Pittsburgh	1,100.00	-	-	1.00	1,100.00	$ 110.00	$ 825.00	$ 165.00
per diem - Grand Forks, ND	85.00	-	-	4.00	340.00	$ 59.50	$ 255.00	$ 25.50
per diem - Pittsburgh	125.00	-	-	2.00	250.00	$ 25.00	$ 187.50	$ 37.50
Days Van Rental	98.00	25.00	2,450.00	-	-	$ -	$ 2,450.00	$ -
Days Car Rental	72.00	105.00	7,560.00	6.00	432.00	$ 64.80	$ 7,884.00	$ 43.20
(See Attached sheet for details)								
Total Unloaded Travel			39,035.00		4,322.00	$ 644.30	$ 42,276.50	$ 436.20
OTHER COSTS						$ -	$ -	$ -
Supplies (Rate = $/month)	2000	1.50	3,000.00	-	-	$ -	$ 3,000.00	$ -
Materials (screwfeeder/installation)		-	12,000.00	-	-	$ -	$ 12,000.00	$ -
Reagents (Rate = $/month)	2000	1.50	3,000.00	-	-	$ -	$ 3,000.00	$ -
Shipping/other	100	12.00	1,200.00	1.00	100.00	$ 10.00	$ 1,275.00	$ 15.00
Trailer Shipping ($/mile)	1.75	800.00	1,400.00	-	-	$ -	$ 1,400.00	$ -
Total Unloaded ODC			20,600.00		100.00	$ 10.00	$ 20,675.00	$ 15.00
						$ -	$ -	$ -
URS Direct Costs			221,641.93		24,608.58	$ 3,512.38	$ 240,098.37	$ 2,639.76
G&A (ODC & Travel)			11,614.04		1,289.49	$ 184.05	$ 12,581.15	$ 138.32
Fee @ 10.0 %			23,325.60		2,589.81	$ 369.64	$ 25,267.95	$ 277.81
TOTAL URS LOADED DIRECT COSTS			256,581.57		28,487.88	$ 4,066.07	$ 277,947.48	$ 3,055.90

DOE RFP No. DE-PS26-03NT41718
URS Proposal No. 104584.25400101

URS - MONTICELLO

Cost Proposal for "Evaluation of Chemical Addition for Mercury Control in Lignite-Derived Flue Gas"

24-Mar-03

			Design and Testing		Planning, Mgmt.& Report		FY04	FY05	FY06
		Rates	Units	Cost ($)	Units	Cost ($)			
SUBCONTRACTS/CONSULTANTS							$ -	$ -	$ -
Silo Rental		-	-	10,000.00	-	-	$ -	$ 10,000.00	$ -
CT&E		140.00	6.00	840.00	-	-	$ -	$ 840.00	$ -
Unloaded Subcontracts			-	10,840.00	-	-	$ -	$ 10,840.00	$ -
							$ -	$ -	$ -
MATERIAL/SUPPLIES							$ -	$ -	$ -
Satl 1 (0.05 wt%)/day - 800 MW	1	1,410.00	14.00	19,740.00	-	-	$ -	$ 19,740.00	$ -
Salt 2 (0.05 wt%)/day - 400 MW	1	8,800.00	10.00	88,000.00	-	-	$ -	$ 88,000.00	$ -
Unloaded Materials				107,740.00		-	$ -	$ 107,740.00	$ -
							$ -	$ -	$ -
COST CENTER							$ -	$ -	$ -
Trailer Rental-Hg trailer	#	375.00	1.25	468.75	-	-	$ -	$ 468.75	$ -
Trailer Rental-lab trailer	#	1,160.00	1.00	1,160.00	-	-	$ -	$ 1,160.00	$ -
Equipment Rental	#	100.00	-	3,065.00	-	-	$ -	$ 3,065.00	$ -
Total Cost Center Costs				4,693.75		-	$ -	$ 4,693.75	$ -
							$ -	$ -	$ -
							$ -	$ -	$ -
Total Indirect Costs (SUB+MAT+Cost Center)				123,273.75		-	$ -	$ 123,273.75	$ -
							$ -	$ -	$ -
							$ -	$ -	$ -
Total Estimated Cost				379,855.32		28,487.88	$ 4,066.07	$ 401,221.23	$ 3,055.90
							$ -	$ -	$ -
Total Estimated Cost + Fee				**379,855.32**		**28,487.88**	$ 4,066.07	$ 401,221.23	$ 3,055.90
							$ -	$ -	$ -
COST SHARE							$ -	$ -	$ -
EPRI (In-Kind)	46,000.00			0.00		46,000.00	$ 5,980.00	$ 34,500.00	$ 5,520.00
EPRI (In-Kind Equipment	5,000.00			5,000.00		0.00	$ -	$ 5,000.00	$ -
Utility (In-Kind)	78,000.00			78,000.00		0.00	$ -	$ 78,000.00	$ -
EPRI (Overhead)	20,000.00			18,604.71		1,395.29	$ 199.15	$ 19,651.18	$ 149.67
EPRI / TC Cash	-			0.00		0.00	$ -	$ -	$ -
DOE Cost Share (Balance)				379,855.32		28,487.88	$ 4,066.07	$ 401,221.23	$ 3,055.90

ADA-ES, LLC

8100 SouthPark Way, Unit B
Littleton, Colorado 80120
Fax: 303.734.0330
303.734.1727

March 27, 2003

Mr. John H. Pavlish
Senior Research Manager
University of North Dakota
Energy and Environmental Research Center
P.O. Box 9018
Grand Forks, ND 58202

Dear Mr. Pavlish,

This letter is written to express our support of your proposal to the Department of Energy under Solicitation No. DE-PS26-03NT41718 and to confirm our commitment to participate in the proposed project. The described work compliments our ongoing efforts to provide mercury control equipment and services to the coal-fired power generation industry. We feel that the effort has merit in furthering the understanding of ramifications and costs of mercury control systems. The results of the testing will be of interest to power companies, regulators, DOE and the many organizations that support this industry.

ADA-ES will commit to participate in the project by providing one additive injection system for the proposed work at the Milton R. Young plant and one Powdered Activated Carbon injection system for the proposed projects at the Leland Olds and Antelope Valley plants. We will provide the equipment as well as experienced and qualified personnel in the manner outlined in the proposal. Our scope of work is backed up by our written quotation dated March 27, 2003. The quoted price is discounted by approximately 30%, which constitutes our cost share to the effort. The invoices for our portion of the work will show the full price for the services and equipment, our cost share amount, and the net amount due after cost share. Barring any unexpected events, we expect to hold the quoted price firm through 2004. The specific terms and conditions will be subject to a definitive subcontract between UNDEERC and ADA-ES should UNDEERC be awarded a cooperative agreement from the DOE.

ADA-ES shares your enthusiasm and we look forward to working with you and the DOE in this interesting and needed effort.

Sincerely,

Richard J. Schlager
Vice President

An Earth Sciences Company

ADA-ES, LLC

8100 SouthPark Way, Unit B
Littleton, Colorado 80120
Fax: 303.734.0330
303.734.1727

March 27, 2003

Mr. John H. Pavlish
Senior Research Manager
Energy & Environmental Research Center
P.O. Box 9018
Grand Forks, ND 58202

RE: Pricing for Injection Systems

Dear John:

ADA-ES is pleased to provide budget pricing for reagent injection systems, installation, start-up and transport services, and Powdered Activated Carbon (PAC) reagent to EERC for use in the DOE/NETL Phase II mercury program. These budget estimates will be in effect through 2004.

ADA-ES, along with our strategic partner Norit Americas, Inc., will provide transportable reagent injection systems to be used at multiple full-scale utility plant sites.

EQUIPMENT

One system for injecting powdered activated carbon into the flue gas ductwork upstream of air pollution control devices. The system will hold the contents of one 45,000 lb tanker truck and be capable of feeding 50 – 1000 lbs/hr PAC. The system will be transportable from one plant to the next with minimal installation labor.

One system for injecting EERC's additive into the boiler or boiler air system. This system will be almost identical to the PAC injection system, with the exception of the structural design to accommodate the denser additive and the modifications to the fluidizing system for the physical properties of the additive that are expected to be different from PAC. The system will hold the contents of one 45,000 lb tanker truck and be capable of feeding 100 – 2000 lbs/hr additive with a bulk density of 80 lb/cu. Ft. The system will be transportable from one plant to the next with minimal installation labor.

A technical proposal describing the equipment and an example flow diagram are attached.

INSTALLATION START-UP AND TEAR DOWN

ADA-ES will provide labor and materials to install and make operational the two injection systems and then tear them down and make ready for shipment.

ADA-ES will install the ~~system(s) and make operational~~. This includes:

1. A site pre- visit to scope out layout issues and assess the site, determine power and air sources etc.
2. Mechanical and electrical installation of the system(s) (Assuming non-union labor rates of $45/hr mechanics and $60/hr electricians)
3. Supervision by ADA-ES/Norit engineer
4. Start up and operational check out of the entire system before handing it over to EERC along with operator training.
5. Crane rental to erect silo and set bin filter.
6. Travel and living expenses

At the conclusion of the testing at each site ADA-ES will dismantle the system(s) and make ready for shipping to the next site: This includes:

1. Mechanical and electrical labor to dismantle and pack and load equipment onto trucks. (Assuming non-union labor rates of $45/hr mechanics and $60/hr electricians)
2. Supervision by ADA-ES/Norit engineer
3. Crane ~~rental~~ remove silo(s) and vent filter(s).
4. Travel and living expenses

PRICING

All prices presented herein are budgetary.

Equipment – Purchase Option

The purchase price for each system (PAC and additive) is:

Norit Americas/ADA-ES commercial price	$275,000
Norit/ADA-ES cost share	$82,500
Discounted price to DOE/NETL program	$192,500

Equipment - Lease option* (per system)

Norit Americas/ADA-ES standard commercial lease rate	$21,414/Month
Norit/Americas/ADA-ES cost share	$6,425/Month
Discounted Lease Rate for DOE/NETL Program	$14,989/Month

*exact terms and conditions of lease to be negotiated at contract in order to conform with DOE/NETL requirements.

Expendable Equipment and Supplies

Equipment and supplies designed for each plant site that may not be able to be re-used at subsequent sites include reagent conveying hose, fittings and injection lances.

Expendable Equipment and supplies	$ 5,000/plant site one system $ 10,000/plant site two systems

Shipping

The price to ship the silo and all other equipment from Marshall, TX to North Dakota is:

Shipping, initial delivery	$ 5,500/ injection system
Subsequent shipping	Variable depending on locations

Installation and Start Up Services

Materials, equipment and labor to install injections systems and make operational. These prices are budgetary (+/- 30%) only. Plant locations, drawings and technical information is required to develop more accurate costs.

One system $75,000
ADA-ES will use discounted labor rates and discounted indirect charges as a cost share contribution. The cost for installation and start up services after the discounts is $60,000.

Equipment Removal Services

Materials, equipment and labor to tear down, pack up and load systems onto trucks for shipping. These prices are budgetary (+/- 30%) only. Plant locations, drawings and technical information are required to develop more accurate costs.

One system $32,000/plant site
ADA-ES will use discounted labor rates and discounted indirect charges as a cost share contribution. The cost for installation and start up services after the discounts is $25,000

Activated Carbon Reagent

Darco FGD Powdered Activated Carbon Reagent (all prices FOB Marshall, TX, shipping prices will vary). There is no cost share discount for the shipping charges.

ADA-ES/Norit Commercial Price	$0.42/lb
Cost Share	$0.12/lb
Discounted Price to DOE	$0.30/lb

We hope the information herein meets your needs for your DOE proposal. If you need clarification or more information please don't hesitate to call:

Sincerely,

Cameron E. Martin
Director of Engineering

cc: MDD, CJB, JFW, RJS, TJS
cc: R. Thomas, D. Hall Norit-Americas

Enclosure: P03-1005 Attachments

ADA Environmental Solutions, LLC 8100 SouthPark Way, B-2, Littleton, Colorado 80120

APPENDIX A

RESUMES OF KEY PERSONNEL, ORGANIZATIONAL PROFILES, AND LETTERS OF SUPPORT

MICHAEL J. HOLMES
Senior Research Advisor
Energy & Environmental Research Center (EERC)
University of North Dakota (UND)
PO Box 9018, Grand Forks, North Dakota 58202-9018 USA
Phone (701) 777-5000 Fax (701) 777-5181
E-Mail: mholmes@undeerc.org

Principal Areas of Expertise

Mr. Holmes' principal areas of interest and expertise include emissions control (air toxics, SO_2, NO_x, H_2S, and particulate), fuel processing for production of syngas and feed gas for fuel cells, and process development and economics for advanced energy systems. He has had project management responsibilities on several large-scale projects. Some examples include the end of Phase II and all of Phase III of the Advanced Emissions Control Development Program (multimillion dollar program focused on mercury control); a program to demonstrate the feasibility of vitrifying low-level radioactive wastes in a slagging combustion system; and several programs for development of spraying systems (dry scrubbing, wet scrubbing, duct injection technology, oil lighters, and heavy oil burners). Mr. Holmes has also had process engineering responsibilities in these and other energy and environmental related projects, as well as experience on multiple commercial contracts in the areas of dry scrubbing, wet scrubbing, and natural gas processing.

Qualifications

M.S., Chemical Engineering, University of North Dakota, 1986.
B.S., Chemistry and Mathematics, Mayville State University, 1984.

Professional Experience

2001 – Senior Research Advisor, EERC, UND. Mr. Holmes is involved in research in a range of areas, including emissions control, fuel utilization, process development, and process economic evaluations. Specific duties include marketing and managing research projects and programs, providing group management and leadership, preparing proposals, interacting with industry and government organizations, designing and overseeing effective experiments as a principal investigator, researching the literature, interpreting data, writing reports and papers, presenting project results to clients, and presenting papers at conferences.

1986 – 2001 Process Development Engineer (Principal Research Engineer), McDermott Technology, Inc., Alliance, Ohio.

Publications and Presentations

- Holmes, M.J.; Benson, S.A. Mercury Measurement and Control I and II. Abstract Presented at the 2002 Energy Generation Conference, Bismarck, ND, Jan 23–24, 2002.

- Holmes, M.J.; Pavlish, J.H.; Miller, S.J.; Dunham, G.E. Sorbent Development for Control of Mercury Emissions from Utility Power Plants. Presented at the 95th Air & Waste Management Association 2002 Annual Conference & Exhibition, Baltimore, MD, June 23–27, 2002.

- Nolan, P.S.; Farthing, G.A.; Yurchison, D.M.; Holmes, M.J. Development of Mercury Emissions Control Technologies for the Power Industry. Presented at the EPRI–DOE–EPA Combined Utility Air Pollutant Control Symposium, Atlanta, GA, Aug 16–20, 1999, Paper No. BR-1685.

- Farthing, G.A.; Holmes, M.J. Mercury Emissions Control Strategies for Coal-Fired Power Plants. Presented at the International Technical Conference on Coal Utilization and Fuel Systems, Clearwater, FL, March 1998.

- Holmes, M.J.; Bailey, R.T.; Farthing, G.A.; Madden, D.A. Mercury Emissions Control Strategies for Coal-Fired Power Plants. Presented at the 1998 American–Japanese International Flame Research Committee, Maui, HI, Oct 1998.

- Holmes, M.J.; Farthing, G.A.; Madden, D.A. Advanced Emissions Control Development Program. Presented at the Advanced Coal-Based Power and Environmental Systems '98 Conference, Morgantown, WV, July 21–23, 1998, RDTPA98-12.

- Madden, D.A.; Holmes, M.J. Limestone Injection: Mercury Control for Unscrubbed Coal-Fired Systems. In Proceedings of the Power-Gen International '98 Conference, Orlando, FL, Dec 9–11, 1998.

- Evans, A.P.; Redinger, K.W.; Holmes, M.J. Advanced Emissions Control Development Program: Mercury Control. Presented at the Advanced Coal-Based Power and Environmental Systems '97 Conference, Pittsburgh, PA, July 22–24, 1997.

- Holmes, M.J.; Redinger, K.E.; Evans, A.P. Control of Mercury in Conventional Flue Gas Emissions Control Systems. Presented at the Managing Hazardous Air Pollutants 4th International Conference, Washington, DC, Nov 12–14, 1997.

DR. STEVEN A. BENSON
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University of North Dakota (UND)
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Phone (701) 777-5000 Fax (701) 777-5181
E-Mail: sbenson@undeerc.org

Principal Areas of Expertise

Management of complex multidisciplinary programs focused on solving energy production and environmental problems. Program areas include the development of 1) methodologies to minimize the effects of inorganic components on the performance of combustion/gasification and air pollution control systems; 2) the fate, behavior, and control of air toxic substances in combustion and gasification systems; 3) advanced analytical techniques to determine the chemical and physical transformations of inorganic species in combustion gases; 4) computer-based codes to predict the effects of coal quality on system performance; 5) advanced materials for coal-based power systems; and 6) training programs designed to improve the global quality of life through energy and environmental research activities.

Qualifications

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

Professional Experience

1999 – Senior Research Manager/Advisor, EERC, UND. Responsible for the direction of projects and programs on the impact of inorganic species on the performance of combustion and associated environmental control systems. Specific areas of focus include advanced methods of materials analysis, and application of computer models to energy and environmental issues.

1994 – 1999 Associate Director for Research, EERC, UND.
1986 – 1994 Senior Research Manager, Fuels and Materials Science, EERC, UND.
1989 – 1991 Assistant Professor (part-time), Depart. of Geology and Geological Eng., UND.
1984 – 1986 Graduate Research Assistant, Fuel Science Program, Department of Materials Science and Engineering, the Pennsylvania State University.
1983 – 1984 Research Supervisor, Distribution of Inorganics and Geochemistry, Coal Science Division, UND Energy Research Center.
1977 – 1983 Research Chemist, U.S. Department of Energy (DOE) Grand Forks Energy Technology Center.

Professional Memberships

- The Combustion Institute
- ASME Research Committee on Corrosion and Deposits from Combustion Gases
- American Chemical Society, Fuel Division Chair-Elect
- American Chemical Society, Member, Committee on Environmental Improvement

Books/Special Issues

- *Air Quality: Mercury, Trace Elements, and Particulate Matter*, Special Issue of *Fuel Process. Technol.*; Elsevier Science Publishers: Amsterdam, 2000; Vol 65−66, 511 p.

Publications and Presentations

- Benson, S.A.; Erickson, T.A.; Jensen, R.R.; Laumb, J.D. Transformations Model for Predicting Size and Composition of Ash During Coal Combustion. *Prepr. Pap.—Am. Chem. Soc., Div. Fuel Chem.* **2002**, *46* (1).

- Benson, S.A.; McCollor, D.P.; Eylands, K.E.; Laumb, J.D.; Jensen, R.R. Characterization of Particulate Matter with Computer-Controlled Scanning Electron Microscopy. In *Environmental Challenges and Greenhouse Gas Control for Fossil Fuel Utilization in the 21st Century*; Plenum Press: New York, 2002; pp 29−42.

- Holmes, M.J.; Benson, S.A. Mercury Measurement and Control I and II. Abstract Presented at the 2002 Energy Generation Conference, Bismarck, ND, Jan 23−24, 2002.

- Pavlish, J.P.; Sondreal, E.A.; Mann, M.D.; Olson, E.S.; Galbreath, K.C.; Laudal, D.L.; Benson, S.A. A Status Review of Mercury Control Options for Coal-Fired Power Plants. Submitted to Special Mercury Issue of *Fuel Process. Technol*. **2002**.

- Crocker, C.R.; Erjavec, J.; Nyberg, C.M.; Jensen, R.R.; Benson, S.A. Fish Consumption Survey: Minnesota and North Dakota, USA. Abstract in *Proceedings of the 6th International Conference on Mercury as a Global Pollutant*; Minamata, Japan, Oct 15−19, 2001; Section HE-60; p 255.

- Laumb, J.D.; Benson, S.A.; Olson, E.S.; Dunham, G.E. Characterization of Coal-Derived Mercury Sorbents. Presented at the 26th International Technical Conference on Coal Utilization and Fuels Systems, Clearwater, FL, March 5−8, 2001.

- Pavlish, J.H.; Olson, E.S.; Benson, S.A.; Laumb, J.D. Understanding Mercury−Sorbent Interactions. Abstract in *Proceedings of the 6th International Conference on Mercury as a Global Pollutant*; Minamata, Japan, Oct 15−19, 2001.

- Olson, E.S.; Miller, S.J.; Sharma, R.K.; Dunham, G.E.; Benson, S.A. Catalytic Effects of Carbon Sorbents for Mercury Capture. *J. Hazard. Mater.* **2000**, *74*, 61−79.

- Sondreal, E.A.; Benson, S.A.; Pavlish, J.H. Status of Research on Air Quality: Mercury, Trace Elements, and Particulate Matter. In *Air Quality: Mercury, Trace Elements, and Particulate Matter*, Special Issue of *Fuel Process. Technol.* **2000**, *65−66*, 5−19.

- Benson, S.A.; Miller, S.J.; Olson, E.S. Chemistry of Mercury Control in Combustion Systems. *Prepr. Pap.—Am. Chem. Soc., Div. Environ. Chem.* **1998**, *38* (2), 163.

DENNIS L. LAUDAL
Senior Research Advisor
Energy & Environmental Research Center (EERC)
University of North Dakota (UND)
PO Box 9018, Grand Forks, North Dakota 58202-9018 USA
Phone (701) 777-5000 Fax (701) 777-5181
E-Mail: dlaudal@undeerc.org

Principal Areas of Expertise

Mr. Laudal's principal areas of expertise include mercury measurement and control. Mr. Laudal is considered a leading expert on continuous emission monitors for mercury. Other areas of expertise include particulate characterization and control, control measurements of SO_x/NO_x and air toxics, fluidized-bed combustion, and preparation and analysis of combustion fuels.

Qualifications

M.S., Chemical Engineering, University of North Dakota, 1984.
B.A., Chemistry and Biology, Concordia College, 1974.

ASTM Methods Development and Validation

One of principal authors of American Society for Testing and Materials 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)" and was the project manager for the pilot and field validation of the method.

Professional Experience

2001 – Senior Research Advisor, EERC, UND. Mr. Laudal's primary responsibility is program development and management of EERC's, mercury control and measurement programs. For the past 9 years, he has been directly responsible for large, multipartner projects at the bench-, pilot-, and field-scale level, including development of project quality control and quality assurance plans, project oversight, research analysis, and reporting, as well as developing work plans and budgets for future projects.

1982 –2001 Research Manager/Engineer, Gas Cleanup Technologies, EERC, UND. Mr. Laudal's responsibilities include the direct supervision of personnel involved in flue gas cleanup research programs at the EERC as well as planning, implementation, supervision, and reporting of research projects involving field- and pilot-scale studies. For the past 8 years, Mr. Laudal has directed mercury research programs at the EERC. Previous work included pilot-scale pc-fired combustor testing, catalytic fabric filtration research and computer-aided data analysis and equipment design.

1977 – 1982 Technical Project Officer, Coal Preparation and Analysis Laboratory. U.S. Department of Energy, Grand Forks Energy Technology Center. Analyses included ultimate, proximate, ash fusion, surface area, and Btu value. Research work on various environmental projects included leaching characterization of fly

ashes and sludges, utilization studies, operation and maintenance of pilot plant equipment.

Publications and Presentations

- Pavlish, J.P.; Sondreal, E.A.; Mann, M.D.; Olson, E.S.; Galbreath, K.C.; Laudal, D.L.; Benson, S.A. A Status Review of Mercury Control Options for Coal-Fired Power Plants. Submitted to Special Mercury Issue of *Fuel Process. Technol*. **2003**.
- Laudal, D.L.; Thompson, J.S.; Pavlish, J.H.; Brickett, L.A.; Chu, P. Use of Continuous Mercury Monitors at Coal-Fired Utilities. *In Proceedings of the Air Quality III Conference: Mercury, Trace Elements, and Particulate Matter;* Arlington, VA, Sept 9–12, 2002; Energy & Environmental Research Center: Grand Forks, ND, 2002.
- Laudal, D.L.; Thompson, J.S.; Pavlish, J.H.; Brickett, L.A.; Chu, P.; Srivastava, R.K; Lee, C.W.; Kilgroe, J. Evaluation of Mercury Speciation at Power Plants Using SCR and SNCR NO_x Control Technologies. *In Proceedings of the Air Quality III Conference: Mercury, Trace Elements, and Particulate Matter;* Arlington, VA, Sept 9–12, 2002; Energy & Environmental Research Center: Grand Forks, ND, 2002.
- Laudal, D.L.; Thompson, J.S.; Pavlish, J.H.; Brickett, L.; Chu, P.; Srivastava, R.K.; Lee, C.W.; Kilgroe, J. *Selective Catalytic Reduction Mercury Field Sampling Project;* Final Report for U.S. Department of Energy Cooperative Agreement No. DE-FC26-98FT40321, U.S. Environmental Protection Agency Cooperative Agreement No. 92935301, and EPRI Contract No. EP-P5248/C2595; Energy & Environmental Research Center: Grand Forks, ND, 2002.
- Laudal, D.L.; French, N.B.; Roberson, R.L. State of the Art of Continuous Mercury Monitors for Coal-Fired Systems. Abstract in *Proceedings of the 6th International Conference on Mercury as a Global Pollutant*; Minamata, Japan, Oct 15–19, 2001; Section AN-15; p 76.
- Laudal, D.L.; Pavlish, J.H.;Galbreath, K.C.; Thompson, J.S.; Weber, G.F.; Sondreal, E.A. *Pilot-Scale Evaluation of the Impact of Selective Catalytic Reduction for NO_x on Mercury Speciation*; Final Report for U.S. Environmental Protection Agency Cooperative Agreement No. R-828323091; EERC Publication 2001-EERC-12-03; Energy & Environmental Research Center: Grand Forks, ND, Dec 2001.
- Laudal, D.L.; Brown, T.D.; Nott, B.R. Effects of Flue Gas Consitituents on Mercury Speciation. In *Air Quality: Mercury, Trace Elements, and Particulate Matter*; Special Issue of *Fuel Process. Technol.* **2000**, *65–66*, 157–165.
- Laudal, D.L. *Field Validation of the Ontario Hydro Mercury Speciation Sampling Method at Site E-29*; Final Report for U.S. Department of Energy Contract No. DE-FC21-93MC30098; EERC Publication 99-EERC-07-02, Energy & Environmental Research Center: Grand Forks, ND, July 1999.
- Hassett, D.J.; Pflughoeft-Hassett, D.F.; Laudal, D.L.; Pavlish, J.H. Mercury Release from Coal Combustion By-Products to the Environment. In *Proceedings of the 1999 International Ash Utilization Symposium*; Lexington, KY, Oct 18–20, 1999.
- Laudal, D.L.; Behrens, G.; Chu, P.; Brown, T.D. Field Validation of the Ontario Hydro Mercury Speciation Method. Presented at the Electric Utilities Environmental Conference, Tucson, AZ, Jan 11–13, 1999.
- Laudal, D.L; Kurz, M.D.; Sorensen, J.A.; Bolles, B.A.; Gunderson, L.L. *Mercury Formation and Fate*; Final Report for EPRI Purchase Order No. WO9002-23, Cooperative Power

Association Purchase Order No. PO2002350-000, Minnkota Power Cooperative Purchase Order No. PO 97-4630, U.S. Department of Energy Contract No. DE-FC21-93MC30098, and Industrial Commission of North Dakota Purchase Order No. FY98-XXVIII-79; EERC Publication 99-EERC-01-02, Energy & Environmental Research Center: Grand Forks, ND, Jan 1999.

- Benson, S.A.; Miller, S.J.; Laudal, D.L.; Galbreath, K.C. An Overview of Mercury Studies at the Energy & Environmental Research Center. In *Proceedings of the 15th Annual International Pittsburgh Coal Conference*; Pittsburgh, PA, Sept 14–18, 1998.
- Laudal, D.L.; Brown, T.D.; Nott, B.R.; Heidt, M.K. Evaluation of Flue Gas Mercury Speciation Methods. Presented at the CEM'98 Conference, Teddington, Middlesex, UK, April 22–24, 1998.
- Laudal, D.L.; Heidt, M.K. *Evaluation of Flue Gas Mercury Speciation Method*; Final Report for EPRI No. 108988; U.S. Department of Energy Contract No. DE-FC21-93MC30098; Energy & Environmental Research Center: Grand Forks, ND, Nov 1997.
- Laudal, D.L.; Galbreath, D.C.; Heidt, M.K. *A State-of-the-Art Review of Flue Gas Mercury Speciation Methods*; Report for EPRI and the U.S. Department of Energy; EPRI Report No. TR-107080, Oct 1997.
- Laudal, D.L.; Heidt, M.K.; Galbreath, K.C. A Comprehensive Evaluation of Flue Gas Mercury Speciation Methods. Presented at the Advanced Coal-Based Power and Environmental Systems '97 Conference, July 22–24, 1997.
- Laudal, D.L.; Nott, B.; Brown, T.D.; Robertson, R. Mercury Speciation Methods for Utility Flue Gas. *Fresenius' J. Anal. Chem.* **1997**, *359*, 397–400.
- Laudal, D.L.; Galbreath, K.C.; Zygarlicke, C.J. Experimental Investigation of Mercury Speciation in Coal Combustion Flue Gases. In *Book of Abstracts for the 4th International Conference on Mercury as a Global Pollutant*; Ebinghaus, R.; Petersen, G.; von Tumpling, U., Eds.; Hamburg, Germany, Aug 4–8, 1996.
- Miller, S.J.; Laudal, D.L.; Chang, R.; Bergman, P.D. Investigation of Mercury Control in Baghouses with Sorbents. Presented at the 12th Annual International Pittsburgh Coal Conference, Pittsburgh, PA, Sept 12–15, 1995.
- Miller, S.J.; Laudal, D.L.; Dunham, G.E. Evaluation of Activated Carbon for Control of Mercury from Coal-Fired Boilers. Presented at the Eleventh Annual Preparation, Utilization and Environmental Control Contractors' Conference, Pittsburgh, PA, July 12–14, 1995.
- Young, B.C.; Miller, S.J.; Laudal, D.L. Carbon Sorption of Trace Mercury Species. In *Proceedings of the 11th Annual International Pittsburgh Coal Conference*; Pittsburgh, PA, Sept 12–16, 1994; Chiang, S.H., Ed.; Vol. 1, pp 575–580.

DAVID W. BREKKE
Quality Assurance Manager
Energy & Environmental Research Center (EERC)
University of North Dakota (UND)
PO Box 9018, Grand Forks, North Dakota 58202-9018 USA
Phone (701) 777-5000 Fax (701) 777-5181
E-Mail: dbrekke@undeerc.org

Principal Areas of Expertise

Mr. Brekke's principal areas of interest and expertise include quality assurance systems, combustion and gasification ash formation and deposition, geology, mineralogy, environmental geology, and analytical techniques applied to geologic and material science problems.

Qualifications

M.A., Geology, University of North Dakota, 1979.
B.S., Earth Science and Geography, North Dakota State University, 1973.

Professional Experience

1997 – Quality Assurance Manager, EERC, UND. Mr. Brekke's primary responsibilities include developing, implementing, and maintaining an organizationwide quality assurance/quality control (QA/QC) program in which he provides QA/QC assistance to project managers, principal investigators, and laboratory managers and serves as the EERC representative on quality matters.

1989 – 1997 Research Manager, EERC, UND. Mr. Brekke's responsibilities included planning, implementation, supervision, and reporting of research projects involving combustion and gasification ash formation and deposition. Other responsibilities included managing and presenting short courses relating to ash behavior and trace metals; and performing research using scanning electron microscope/microprobe analysis, image analysis, and computer data evaluation techniques.

1982 – 1989 Geologist, North Dakota Geological Survey. Mr. Brekke's responsibilities included research and participation in projects involving the geology, mineralogy, petrology, and geochemistry of rocks and minerals in North Dakota. He also administered the subsurface minerals, underground injection control, and geothermal energy regulatory programs.

1979 – 1982 Geologist, Natural Materials Analytical Laboratory, Mining and Mineral Resources Research Institute, School of Engineering and Mines, UND.

Professional Memberships

- American Society for Quality, Corporate Representative
- Sigma Xi
- North Dakota Academy of Science

Selected Publications and Presentations

- Brekke, D.W. *Task 37 – Ash Deposition Course*; Final Report for U.S. Department of Energy Contract No. DE-FC21-93MC30098; EERC Publication 98-EERC-12-01; Energy & Environmental Research Center: Grand Forks, ND, Dec 1998.

- Brekke, D.W. *Slagging Short Course*; Final Report for Institute of International Education Contract No. AEP-0015-Q-00-5021-00 D.O. No. 1; EERC Publication 97-EERC-04-03; Energy & Environmental Research Center: Grand Forks, ND, April 1997.

- Brekke, D.W.; Zygarlicke, C.J.; Gunderson, J.R.; Erickson, T.A. Coal Ash Behavior and Deposition. Short course presented to the Indonesia Energy Technology Laboratory and U.S. Department of Energy Albany Research Center, Pittsburgh, PA, Jan 27-31, 1997.

- Pavlish, J.H.; Brekke, D.W.; Miller, S.J.; Zygarlicke, C.J.; Erickson, T.A. Trace Metals in Industrial Applications. Short course presented to Northern States Power Company, Minneapolis, MN, Sept 20, 1996.

- Brekke, D.W.; Botros, P.E.; Erickson, T.A.; Mudd, M.J. Comparison of Hazardous Air Pollutants from Advanced and Conventional Power Systems. In *Proceedings of the 12th Annual International Pittsburgh Coal Conference*; Pittsburgh, PA, Sept 12–15; 1995; pp 1003–1010.

- Erickson, T.A.; Brekke, D.W. *Assessment of Hazardous Air Pollutants for Advanced Power Systems*; Final Topical Report; EERC Publication 95-EERC-12-03; Energy & Environmental Research Center: Grand Forks, ND, Dec 1995.

- McCarthy, G.J.; Butler, R.D.; Brekke, D.W.; Adamek, S.D.; Parks, J.A.; Foster, H.J.; Šolc, J. Mineralogical Transformations and Microstructure after Disposal of Cementitious Advanced Coal Technology By-Products. In *Proceedings of the Materials Research Society*; Materials Research Society, 1995; Vol. 370, pp 179–190.

- O'Leary, E.M.; Brekke, D.W. *Incorporation of the Results from the Assessment of Toxic Emissions into the Center for Air Toxic Metals Database*; Report for Subtask 2.3 – Review and Assessment of the Results from the Comprehensive Characterization of Toxic Emissions from Coal-Fired Power Plants for U.S. Department of Energy Cooperative Agreement No. DE-FC21-93MC30097; EERC Publication 95-EERC-06-06; Energy & Environmental Research Center: Grand Forks, ND, June 1995.

INDUSTRIAL COMMISSION OF NORTH DAKOTA

The Industrial Commission of North Dakota was created by the legislature in 1919 to conduct and/or manage, on behalf of the state of North Dakota, certain utilities, industries, enterprises, and business projects established by state law. The members of the Commission are the Governor, the Attorney General, and the Commissioner of Agriculture of the State. The Building Authority, Bank of North Dakota, Geological Survey, North Dakota Housing Finance Agency, Municipal Bond Bank, State Mill and Elevator Association, Student Loan Trust, Oil and Gas Division, and Lignite Research, Development, & Marketing Program (LRP) are all under the auspices of the Industrial Commission. LRP is a multimillion dollar state–industry partnership focused on the near-term, practical research and development projects that provide the opportunity to preserve and enhance development of North Dakota's abundant lignite resources. Over 18,000 jobs, $1.3 billion in business volume, and $60 million in tax revenue are generated by the lignite industry for North Dakota each year. LRP provides grants to assist research and development; preserve and enhance jobs and production; ensure economic growth, stability, and opportunity; maintain a stable and competitive tax base; and market coal-based electricity.

Further information on the Industrial Commission can be found at its Web site at www.state.nd.us/ndic/.

HARVEY NESS
Director of Lignite Research, Development and Marketing Program
Lignite Energy Council
Bismarck, North Dakota

Harvey Ness has 27 years of experience in energy research and development (R&D). At present, he is the Director of the Lignite Research, Development, and Marketing Program for the Lignite Energy Council in Bismarck, North Dakota. He has a B.S. and an M.S. degree in Chemistry, graduating from the University of North Dakota in 1972.

Mr. Ness spent 26 years working for the U.S. Department of Energy (DOE). He began his career in energy research with the Bureau of Mines in Grand Forks, North Dakota. He also worked for DOE's National Energy Technology Laboratory in Morgantown, West Virginia, and Pittsburgh, Pennsylvania, retiring in December 2000.

While with the federal government, he was responsible for implementation of a coal-based R&D program for power generation technology and advanced environmental concepts. He was responsible for overseeing the implementation of RD&D programs supporting the development and commercialization of coal-based high-efficiency power generation and pollutant control concepts. These technologies include gasification and combustion systems and environmental control systems for advanced and conventional power generation stations. Duties included participation in defining and planning programmatic goals and objectives and formulation and implementation of new contract initiatives. As a manager, he provided technical oversight and guidance to professional staff members.

OVERVIEW OF EPRI

EPRI is the world leader in developing science and technology solutions for all segments of the global energy industry. With more than 25 years of proven success, the company serves about 1000 energy-related organizations in 40 countries. EPRI's work covers a wide spectrum of scientific research, technology development, and product applications related to the generation, delivery, marketing, and use of energy.

U.S. electric utilities established EPRI as a nonprofit membership corporation to manage a national research program on behalf of its funders, the industry, and society. In forming one of the first industry-wide research consortia, electric utilities pioneered the concept of pooling their resources for maximum benefit. Today, in response to the changing energy marketplace, EPRI has supplemented its large-scale collaborative program with small-scale collaborative and customized projects for diverse clients throughout the world.

Global clients include, among others, regulated gas and electric utilities, competitive power producers, government energy agencies, independent system operators, transmission companies, distribution companies, nuclear licensees, energy services providers, telecommunications companies, manufacturers, industrial companies, and other energy suppliers.

More in-depth information related to EPRI's research can be obtained at www.epri.com.

Relevant Corporate Experience

The assembled project team possesses extensive experience with the measurement and control of mercury from coal-fired flue gas. EPRI has funded a great deal of research in mercury control over the past decade resulting in a number of licensed technologies. URS has actively participated in mercury-related research for over 10 years. They have carried out projects ranging from lab R&D to full-scale control demonstrations for a variety of clients. URS has operated a lab dedicated to evaluating mercury control from coal-fired flue gas for over 10 years. URS has experience operating test equipment used for mercury control evaluations ranging from small slipstream tests to full-scale demonstrations. URS maintains an inventory of mercury SCEMs used to measure speciated mercury at over 25 coal-fired plants.

A Cooperative Agreement is also being conducted where URS, EPRI, Apogee, We Energies, Midwestern Generation-EME, Williams Bio-Energy, Illinois Corn Growers Association, Physical Sciences Inc., Illinois State Geological Survey, and ADA Environmental Solutions are studying the effectiveness of multiple carbon-based and other chemicals that show promise in removing more than 90% of mercury from the flue gas of coal-fired power plants and that cost 40% to 75% less than commercial sorbents. DOE is providing 71% of the financial support for the $780,654 Cooperative Agreement. Pilot-scale evaluations are being conducted at two power plants.

URS Group. Dr. Carl Richardson will be the URS Project Manager for the proposed effort at TXU's Monticello power plant. He will be responsible for the successful and timely execution of the project and will lead the project planning and management/reporting tasks. Dr. Richardson has a Ph.D. in physical chemistry and has worked for URS for the past 12 years as a process chemist and project manager in the areas of SO_2 and mercury control for coal-fired utilities. He

has managed a number of EPRI-sponsored mercury control projects ranging from bench-scale programs evaluating novel sorbents to slipstream and full-scale evaluations at coal-fired power plants. He is the principal investigator on a DOE/NETL-sponsored pilot project to evaluate catalytic oxidation of elemental mercury for enhanced removal in FGD scrubbers.

EPRI. EPRI is providing a large portion of the cofunding for this project and will comanage the URS effort. Dr. Ramsey Chang will be EPRI's Project Manager for this project. Dr. Chang is the manager of Air Pollution Control in the Generation Group at EPRI. He is responsible for assessing and developing particulate, NO_x, SO, and air toxics control technologies for power plant emissions. Dr.Chang is one of the inventors of the MerCAP™ concept. In the last 6 years, Dr. Chang has investigated air toxics and mercury control processes including fundamental studies, bench and pilot-scale work, novel concept development and engineering economic analysis.

Dr. Chang received his B.Sc. in Chemical Engineering from Lehigh University in 1971 and his M.S. and Ph.D. degrees, also in Chemical Engineering, from Stanford University in 1972 and 1975, respectively. He has authored over two hundred reports, papers, and book chapters and is a holder of six patents in air pollution control technology.

EPRI has been investigating mercury emissions and control since 1990 and has spent over $50 million in R&D to develop mercury measurement methods, characterize mercury emissions from power plants, assess the health effects and risks of the mercury emitted, and develop options to reduce mercury emissions. Ten mercury control patents have been issued or are pending.

Relevant Project Experience for URS Group

URS Group (formally as Radian International) has over 30 years of experience conducting research, development, process evaluation, troubleshooting, design and construction projects

related to pollution control on coal-fired utility power plants. Radian was perhaps best known for FGD work, but also has considerable experience with particulated control, NO_x control, plume opacity, and air toxics (including mercury). This section summarizes some of that experience, with a particular focus on mercury measurement and control technology. Many projects have been conducted with URS serving as a contractor to EPRI. This illustrates the long-standing, successful relationship between URS and EPRI, and points towards the expected success of the proposed teaming arrangement for this project. Key projects are briefly described below.

Sorbent Injection for Mercury (EPRI). URS Corporation has conducted laboratory and field tests for EPRI for over 10 years to develop and evaluate the ability of sorbents to remove mercury from coal-fired utility flue gas. Work activities have included bench-scale tests to investigate the ability of various sorbents to remove mercury from simulated flue gas. Additional lab tests were conducted to investigate the stability of mercury adsorbed to sorbents and combustion by-products under various conditions, including tests to regenerate sorbents and recover the mercury. Field tests have been conducted at over ten full-scale utility sites to determine sorbent performance in real flue gas. Data from this work are being used in conjunction with a theoretical model to estimate mercury removal performance by the sorbent injection process and the associated costs.

Mercury Oxidation Technologies. URS has experience with testing and developing mercury oxidation technologies for enhancing removal in wet or dry scrubbers. With EPRI cofunding, URS developed a catalytic oxidation process under the DOE Mega-PRDA program (DE-AC22-95PC95260). Bench- and pilot-scale tests were performed to develop a process to oxidize mercury in different coal-fired flue gases to a form that is removed in wet scrubbers. URS is currently testing this process at pilot scale under a cooperative agreement project with DOE (DE-

FC26-01NT41185) to evaluate the long-term performance of mercury oxidation catalysts. In addition, URS has performed full-scale testing of chemical addition processes to enhance mercury removal across wet and dry scrubbers. Funded by EPRI and EPRI-member utilities, chemical additives were injected directly into boilers firing ND lignite or PRB coal. The effect of chemical type and injection rates on flue gas mercury speciation and scrubber removal was determined.

Evaluation of Full-Scale Chemical Injection for Mercury Removal in Wet and Dry Scrubbers (EPRI). A program was carried out to investigate full-scale injection of chemical additives to the boilers of two coal-fired power plants. A URS team evaluated the effect of chemical addition on the oxidation of mercury in flue gas, the fate of mercury across the flue gas path, and the effects on plant operations. The test team designed and fabricated the injection system used for adding chemical solutions directly to a boiler and used semi-continuous mercury analyzers to evaluate the effects on mercury speciation and removal across environmental control devices.

ICR Mercury Testing at Limestone Station and Seymour Station (Reliant Energy and the Lower Colorado River Authority). In two separate projects, URS served as the testing and reporting contractor for two utilities that were selected for flue gas testing in the recent EPA Mercury ICR initiative. For each site, URS prepared a QA/QC plan that was approved by EPA, then conducted flue gas mercury measurements upstream and downstream of the plants' wet FGD systems using the draft Ontario Hydro method. Coal and fly ash samples were also collected and analyzed for mercury content. The results of this testing were documented in reports for each site, which were submitted to and have been approved by the U.S. EPA.

Formal Evaluation of EPA Draft Method 29 and Comparison with Other Source Sampling Methods (EPRI and U.S. Environmental Protection Agency). URS, in conjunction with other test contractors, conducted a methods evaluation including a comparison of methods for measuring mercury in flue gas from power plants and conducting a Method 301 validation for Method 29 for measuring trace metals. The Method 301 validation protocol involved development of an extensive QA/QC plan to fulfill the methods validation requirements. Simultaneous samples were collected for five different methods on eight consecutive sampling days. Sources of variability in the Method 29 sample method were evaluated using analysis of variance (ANOVA) techniques. URS staff was responsible for coordination of sampling activities, final data evaluation, and preparation of the final report.

PISCES—Field Chemical Emissions Monitoring [FCEM] (EPRI). Under contract to EPRI, URS conducted a project to characterize inorganic and organic chemical substances identified as potential HAPs that are of direct concern to the utility industry (including mercury). The power systems and environmental control systems selected for characterization represented a significant fraction of conventional coal-, oil-, and gas-fired generating capacity in the United States.

Dr. Ramsay Chang is Manager, Air Emissions Control at EPRI, Palo Alto, California. He is responsible for assessing and developing particulate, NO_x, SO_x, and air toxics control technologies for power plant emissions. In the last 9 years, Dr. Chang has been investigating air toxics and mercury control processes including fundamental studies, bench and pilot-scale work, novel concept development and engineering economic analysis. He has also managed the development of advanced particulate collection technologies and novel NO_x SCR systems.

Before joining EPRI in 1987, Dr. Chang was with Acurex Corporation for eight years. He was Section Leader and Program Manager in the Energy Department, where he headed the hot gas cleanup group managing and developing business in high temperature particulate and fuel nitrogen control.

Dr. Chang received his B.Sc. in Chemical Engineering from Lehigh University in 1971, and his M.S. and Ph.D. degrees, also in Chemical Engineering, from Stanford University in 1972 and 1975, respectively. He is a member of the American Institute of Chemical Engineers. He has authored over two hundred reports, papers, and book chapters and is a holder of 8 patents in air pollution control technology.

URS CORPORATION
San Francisco, CA

URS Corporation (NYSE: URS) is a publicly held organization of more than 25,000 employees that offers a broad range of planning, design, program and construction management, system integration, and operations and maintenance services. URS business areas include air, surface, and rail transportation design; hazardous waste services; water and wastewater services; facilities management; and a broad range of design and environmental projects for industrial and power clients.

URS' annual revenues total approximately $3 billion. Of these revenues, approximately 46% are for the U.S. federal government, 20% are for state and local governments, and 34% are for industrial and multinational clients.

URS environmental projects include environmental planning, consulting, field investigations, engineering, construction, and construction management services to assist with regulatory compliance, enhance operating efficiency, and reduce costs.

The URS office in Austin, Texas, was formerly the home office of Radian International LLC, an engineering and environmental services company that was acquired by URS in 1999. Radian, and now URS, has been recognized as a leader in flue gas desulfurization process engineering and chemistry for over 30 years. Since the promulgation of the 1990 Clean Air Act Amendments, URS staff in the Austin office have been conducting research and development related to the measurement and control of mercury in flue gases from coal firing. Projects have included development of mercury manual and semicontinuous measurement techniques, field measurements of flue gas mercury concentrations and speciation, and development of novel mercury sorbents and elemental mercury oxidation catalysts. These projects have been conducted in URS Austin bench-scale laboratories and at dozens of full-scale power plants.

Further information for URS Corporation can be obtained at its Web site at http://www.urscorp.com/.

CARL F. RICHARDSON
Senior Scientist
URS Corporation
Austin, Texas

Education

Ph.D., 1991, Physical Chemistry, State University of New York at Buffalo, Buffalo, NY.
B.S., 1985, Chemistry, Gannon University, Erie, PA.

Positions

Team Leader, Air Toxics/SO_3 Control, URS Corporation, Austin , TX, 1999-present.
Senior Scientist, Radian International LLC, Austin, TX, 1998-present.
Staff Scientist, Radian International LLC, Austin, TX, 1991-1998.

Work Experience

As a Senior Scientist at URS, Dr. Richardson is actively involved in the development of processes to remove air toxics from industrial gas streams. Work over the past eight years has focused on the removal of mercury from utility flue gas using duct injection and chemical oxidation methods. He has managed a number of EPRI-sponsored mercury control projects ranging from bench scale programs evaluating novel sorbents to slipstream and full-scale evaluations at coal-fired power plants. He is the principal investigator on a DOE/NETL-sponsored pilot project to evaluate catalytic oxidation of elemental mercury for enhanced removal in FGD scrubbers.

Dr. Richardson has performed various studies investigating analytical methods for measuring and speciating mercury in flue gas. Work has led to the development of a semi-continuous mercury monitor for EPRI which has subsequently been used in a number of test programs at over twenty power plants. Dr. Richardson has provided quality control support for field determinations of mercury using speciating methods such as the Ontario Hydro Method.

Experience with Mercury Control Development for Coal-Generated Flue Gases

- Dr. Richardson managed a program for EPRI evaluating full scale injection of chemical additives to the boilers of two coal-fired power plants. A URS team evaluated the effect of chemical addition on the oxidation of mercury in flue gas, the fate of mercury across the flue gas path, and the effects on plant operations. The test team designed and fabricated the injection system used for adding chemical solutions directly to a boiler.
- Dr. Richardson has managed a number of field test projects for EPRI evaluating the performance of various mercury control processes in actual flue gas. Testing has been performed at over ten North American power plants using slipstream test devices and semi-continuous mercury analyzers to evaluate various sorbent and oxidation technologies. Test

objectives generally include determining the most cost effective controls for a given site or flue gas type.

- Dr. Richardson managed a two year EPRI project evaluating the effects of NO_x-control processes on the mercury reactions in flue gas. Tests were carried out at several power plants firing a variety of fuels to determine how different NO_x controls affect mercury speciation. Testing included long term tests to evaluate mercury oxidation across SCR catalysts in cluding a six-month pilot investigation at a PRB-fired plant.
- Dr. Richardson is the Principle Investigator on a DOE/NETL-sponsored pilot project to evaluate catalytic oxidation of elemental mercury for enhanced removal in FGD scrubbers. This project is part of a multi-phase program co-funded by EPRI and DOE to develop a process for enhancing mercury removal across wet absorbers. Work has included a combination of bench-scale, slipstream, and pilot scale testing to identify promising catalyst materials and determine optimal process conditions.
- Dr. Richardson has been the Project Manager of a multi-year EPRI-funded laboratory and field program developing novel sorbent materials for mercury removal from flue gas. Several bench scale experimental setups and test protocol have been developed to study the adsorption of mercury by commercial and novel sorbents. Dr. Richardson has worked with a team of EPRI contractors to evaluate a large number of sorbents derived from a variety of materials. Tests have evaluated the effects of various process parameters and different flue gas types on sorbent performance.
- Dr. Richardson has managed projects focused on screening sorbent materials for use in pilot- and full-scale sorbent injection projects funded by DOE/NETL. URS, as a sub-contractor to ADA-ES and Apogee Scientific, has performed laboratory screening tests of sorbents as well as slipstream screening tests in actual flue gas at a number of coal-fired power plants to select sorbents for testing at larger scale.

Other Utility Mercury-Related Experience

- Dr. Richardson has managed and co-managed a number of mercury emission evaluations for U.S. coal fired utilities. Projects involve measurements using semi-continuous mercury analyzers and manual gas sampling methods to characterize plant mercury emissions and the fate of mercury across various environmental control devices. Testing has included balance of plant measurements and tests to evaluate the effects of various plant operational parameters on mercury emissions.
- As part of a $1.2M DOE air toxics assessment program, Dr. Richardson investigated ways to detect and speciate mercury, on a semi-continuous basis, in the flue gas of a coal gasifier. An on-site laboratory was constructed to measure the flue gas of a coal gasivication process. Various classical and novel sampling and analytical methods were evaluated in attempts to improve detection limits as well as to provide mercury mass-balance information at different gasifier process locations.

BABCOCK & WILCOX
Barberton, OH

The Babcock & Wilcox Company (B&W) is a leading worldwide energy services company. B&W manufactures steam-generating equipment, environmental equipment, and products for the U.S. government. It also provides engineering and construction services for industrial, utility, and hydrocarbon processing facilities.

For over 135 years, B&W has been supplying innovative solutions to meet the world's growing energy needs. The B&W team comprises more than 10,800 employees globally who provide planning, engineering, procurement, construction, field engineering, equipment upgrades and retrofits, environmental control equipment, and technical training seminars to more than 800 utilities and industries in over 90 countries.

B&W provides integrated solutions to produce steam for power generation needs and environmental equipment to a variety of markets, including electric utilities, industrial, pulp and paper, nuclear power, environmental, and construction. Supported by a strong research and development program, B&W constantly seeks better, more efficient technologies for these markets.

B&W environmental equipment is designed to meet today's stringent environmental requirements while increasing plant performance, reducing operating and maintenance costs, and improving reliability and safety. B&W is continually developing new technologies and design enhancements, which are integrated into both existing and new units. Its environmental product line was significantly enhanced when its subsidiary, Diamond Power Specialty Company, acquired Joy Environmental Technologies in 1995. Environmental services include investigative testing, performance testing and operating improvements, condition assessment, and by-product marketing.

Specific environmental expertise at B&W pertains to flue gas desulfurization systems (wet and dry), electrostatic precipitators, selective catalytic and noncatalytic reduction systems for NO_x control, low-NO_x burners, sorbent injection systems, condensing heat exchangers, limestone injection multistage burners, limestone injection with dry scrubbing, SNRB (SO_x–NO_x–Rox Box) integrated cleanup systems, multicyclone collectors, acid mist precipitators, pulse-flow baghouses, and carbon injection systems for toxics control.

Further details about B&W can be obtained at http://www.babcock.com.

Resume of **RONALD J. TRISCORI**, Operations Division, Barberton, Ohio.

EDUCATION

Purdue University, West Lafayette, Indiana, B.S.M.E.

PROFESSIONAL EXPERIENCE:

Feb. 2002 – Present BABCOCK & WILCOX

Jul. 1999 – Dec. 2001 LURGI PSI, Sales Manager, Gas Cleaning

Function was overall sales and marketing of Lurgi gas cleaning technologies to the non-ferrous metallurgical industry, incinerator industry, and chemical industry in the United States. This included business development, proposal management, and project negotiations. During this time frame, Lurgi PSI was able to develop several projects in the hazardous incinerator industry and is presently executing these projects. An aftermarket program was begun and Lurgi was quite successful in rebuilding several existing projects and developing a support system to the customer base that would provide parts and service and provide Lurgi PSI with a source of revenue.

Oct. 1996 – Jul. 1999 LURGI CORPORATION, Vice President

Responsibility was market development of Lurgi technologies into the US market with regards to gas cleaning to the process industries. We were successful in providing imported technologies to the non-ferrous metallurgical industry, cement industry, and the chemical industry. Due to this success, when this office was closed, I was relocated to Lurgi PSI in Memphis, Tennessee where we would be able to sell and execute entire gas cleaning projects in the United States.

Aug. 1994 - Oct. 1996 BELCO TECHNOLOGIES, INC., Vice President, Dry Systems

Responsibility was the overall management of Belco's dry technologies. These included electrostatic precipitators, dry scrubbers, fabric filters, and development of the wet precipitator product line that was licensed from ND/Japan. Responsibility was to operate this unit as an individual profit center and be responsible for profitability within Belco's overall structure.

Feb. 1980 - Mar. 1994 JOY ENVIRONMENTAL TECHNOLOGIES, INC., Manager, Particulate Systems, Aug. 1992 - Mar. 1994

Responsibility was to size equipment, provide technical information to Joy's Pre-Contract Department to prepare proposals, review project estimates and to support Joy's internal and external sales groups in project development and negotiations.

Pre-Contract Engineering, Nov. 1991 - Aug. 1992

On November 1991, a new organization was put in place at Joy that broke proposal preparation, estimating, and the pre-contract engineering functions apart. Pre-contract engineering responsibilities were equipment selection, overall engineering inputs required for proposal preparation, and to support sales and marketing in technical presentations and customer negotiations.

Director Sales & Marketing, Sept. 1988 - Nov. 1991, Particulate Systems

Responsibility was an overall sales and marketing inputs for particulate systems which included sizing, proposal preparation, support of the field sales organization, and direct project negotiations.

Product Manager, June 1985 - Sept. 1988, Electrostatic Precipitators

As product manager for electrostatic precipitators. Responsibility for sizing equipment, make technical presentations, train the rep organization, and do direct selling on certain key projects. Over this time frame, Joy did receive orders for precipitator business once again after a long absence from the marketplace due to emphasis on dry scrubbing.

Product Director, Sept. 1980 - June 1985

While in this position, all Product Managers reported directly to the Product Director. During this period, we had Product Managers for precipitators, fabric filters, Dry FGD, and standard products. Responsibility during this was to train young personnel and insure that prior to the proposal release that a risk analysis was provided to management and that the technical and commercial inputs fit our general business plan.

Product Director, Particulate, Feb. 1980 - Sept. 1980

Function was to bring Joy back into the world of utility electrostatic precipitators through a licensee agreement they had just concluded with BSH. However, in the early 80's most the utility work revolved around dry FGD and fabric filters. After establishing a new "program" for management proposal review, it was decided to make this position over all Joy technologies.

June 1977 - Jan. 1980 FLAKT, INC., Product Manager, Sept. 1979 – Jan. 1980 all products except FGD)

Position was to oversee the direct sales of the electrostatic precipitator product line, fabric filter product line, and the ash handling product lines. The position was to interface with the application engineers to determine correct sizing and layouts required by the individual project. I was to participate with the field sales force in both technical and commercial negotiations and market development of new Flack technologies.

Product Manager, June 1977 - Sept. 1979, Electrostatic Precipitators

Responsibility was to head up the precipitator product line and make it a viable product in the US market. During my time at Flakt, we moved from being successful on half million dollar projects to twenty-five million dollar projects with this product line with a minimum of personnel.

Nov. 1973 - June 1977 AMERICAN AIR FILTER, Engineered Systems department, Louisville, Kentucky

Positions: Sales Supervisor, (Jan. '77 - June '77) Incinerator and Utility Markets, (Jan. '74 - Dec. '76) Rock Products and Incinerator Market, (Nov. '73 - Dec. '76) Pulp and Paper Market.

Responsibility was to direct sales strategy to individual market segments. To direct and assist branch offices in inquiry development, participate in advertising and promotional programs, and somewhat direct product section as to how special customer requirements would be handled in proposal preparation. Also responsible for terms and conditions and turn over project management for project execution.

June 1965 - Nov. 1973 AMERICAN STANDARD, INC., Industrial Products Division, ($20 Million Annual Sales), Detroit, Michigan MFR.

Positions: (Nov. '72 - Nov. '73) Regional Manager, (April '70 - Nov. '72) Branch Manager, (Feb. '66 - April '70) Sales Engineer, (Oct. '64 - Feb. '66) Application Engineer, (June '64 - Oct. '64) Trainee.

Function was to direct the Eastern Region which had six direct offices and eight representative offices in all sales efforts. Had responsibly for sales volume, pricing, application, direct office budgets and key customer contacts.

PUBLICATIONS:

R.J. Triscori, H.W. Spencer, “ESP as a Back-end Cleaning Equipment for Dry FGD”. Presented at Dry FGD Utility Seminar, Minneapolis, Minnesota, 1982.

R.J. Triscori, H.W. Spencer, “The Precipitator as an Option for Dry FGD”. Presented at Conference on Electrostatic Precipitator Technology for Coal-Fired Power Plants, Nashville, Tennessee, 1982.

R.J. Triscori, H.F. Krigmont, H.W. Spencer III, Y. Chen, “Current Status of ESP on Dry FGD Systems”.

R.J. Triscori, Y. Chen, “Electrostatic Precipitators in Dry FGD Applications”. Presented at Second International Conference on Electrostatic Precipitation, Japan, 1984.

R.J. Triscori, H.V. Krigmont, “Laboratory and Full-Scale Characteristics of ESP with Rigid Mast Electrodes”. Presented at Fifth Symposium on the Transfer and Utilization of Particulate Control Technology, Kansas City, Kansas, 1984.

PATENTS:

U.S. Patent 4,571,330, Feb 18, 1986, Flue Gas Desulfurization.

Resume of **GEORGE A. FARTHING, JR.**, Advisory Engineer, Babcock and Wilcox Company, Babcock and Wilcox Research Center, Alliance, Ohio

EDUCATION

B.S.Ch.E. Carnegie Mellon University, 1970
M.S.Ch.E. Carnegie Mellon University, 1976

PROFESSIONAL EXPERIENCE

(2003-Present) BABCOCK AND WILCOX COMPANY, BABCOCK AND WILCOX RESEARCH CENTER, ADVISORY ENGINEER

NOTE: On 1/1/03 Mr. Farthing transferred from McDermott Technology, Inc., to The Babcock & Wilcox Company.

Program development and project management responsibilities related to the technical needs of the Babcock & Wilcox Company. Areas of responsibility include innovative processes for the control of SO_x, NO_x, CO_2, particulate, air toxics (especially mercury), and solid waste/byproduct emissions from large-scale steam generation systems, and the application of these processes to proof-of-concept and commercial plants.

(2001 - 2002) McDERMOTT TECHNOLOGY, INC., ALLIANCE RESEARCH CENTER, TECHNICAL MANAGER, FUEL PROCESSORS SECTION

Project management and program development responsibilities related to the Company's initiative in the areas of fuel cells and fuel processing. Current activities are focused on technical and business development issues related to the commercialization of distillate fuel processors for both proton exchange membrane and solid oxide fuel cell applications.

(2000 - 2001) McDERMOTT TECHNOLOGY, INC., ALLIANCE RESEARCH CENTER, TECHNICAL MANAGER, COMBUSTION PROCESSES AND PROGRAM DEVELOPMENT SECTION

Program development and project management responsibilities related primarily to the needs of the Babcock & Wilcox operating unit. Programs of interest included innovative processes for the control of SO_x, NO_x, CO_2, particulate, air toxics (especially mercury), and solid waste/byproduct emissions from large-scale steam generation systems, and the application of these processes to proof-of-concept and commercial plants.

(1997 - 2000) McDERMOTT TECHNOLOGY, INC., ALLIANCE RESEARCH CENTER, MANAGER, EMISSIONS CONTROL SECTION

Management responsibilities for a section dedicated to the support of the Babcock & Wilcox Company's environmental equipment product line. A major focus of the Section's work was the development of innovative processes for the control of SO_x, NO_x, CO_2, particulate, air toxics (especially mercury), and solid waste/byproduct emissions from large-scale steam generation systems, and the application of those processes to proof-of-concept and commercial plants.

PROFESSIONAL EXPERIENCE (CONTINUED)

(1994-1997) McDERMOTT TECHNOLOGY, INC., ALLIANCE RESEARCH CENTER, MANAGER, ADVANCED EMISSIONS CONTROL SECTION

NOTE: On 7/1/97 The Contract Research Division and the Research and Development Division of The Babcock & Wilcox Company became McDermott Technology, Inc.

Management responsibilities for a section dedicated to the development of innovative processes for the control of SO_x, NO_x, CO_2, particulate, air toxics, and solid waste/byproduct emissions from large-scale steam generation systems, and the application of these processes to proof-of-concept and commercial plants. Was personally involved in the establishment and management of the Advanced Emissions Control Development Program. This project added wet scrubbing, fabric filter, and electrostatic precipitator test capabilities to the Clean Environment Development Facility, and took a proactive approach to the control of mercury emissions from coal-fired power plants.

(1990 - 1994) BABCOCK & WILCOX COMPANY, ALLIANCE RESEARCH CENTER, GROUP SUPERVISOR, CHEMICAL ENGINEERING SECTION

Supervisory responsibilities for a group of engineers primarily executing projects under the U.S. DOE's Clean Coal Technology Program. Projects generally comprised the development of innovative processes for the control of SO_x, NO_x, particulate, and solid waste/byproduct emissions from large-scale steam generation systems, and the application of these processes to proof-of-concept and commercial plants.

(1987 - 1990) ENERGY & ENVIRONMENTAL RESEARCH CORPORATION, DIRECTOR, PROCESS DESIGN

Project management and coordination responsibilities related to the application of emerging technologies to proof-of-concept and commercial systems. Process design responsibility for full-scale demonstrations of gas reburning and upper furnace sorbent injection (GR-SI) systems at two coal-fired utility plants. Lead an evaluation of options for the utilization of a coke byproduct for an industrial client. Technical areas of specialization included combustion system design and safety, boiler thermal performance, GR-SI and electrostatic precipitator performance, and the interpretation of computer and physical modeling results.

(1986 - 1987) BABCOCK & WILCOX COMPANY, BARBERTON, OH, DESIGN SPECIALIST, ATMOSPHERIC FLUIDIZED BED DEVELOPMENT

Contributed to the design of the company's first commercial fluidized bed boilers. Responsibilities included the interpretation of pilot-scale and commercial-scale data, performance prediction, and first-of-a-kind (FOAK) testing. Participated in the start-up and initial shakedown work on a wood-fired circulating fluidized bed boiler in West Enfield, ME.

(1984 - 1986) BABCOCK & WILCOX COMPANY, ALLIANCE RESEARCH CENTER, SENIOR RESEARCH ENGINEER, SLURRY FUELS SECTION

Directed a program to develop a commercial firing system (burner, atomizer, and fuel supply system) for coal-water fuels. The work resulted in a patented CWF burner. Principal investigator for an Electric Power Research Institute contract to demonstrate utility-scale CWF firing systems. Participated in CWF conversions at several industrial installations, including the conversion of a B&W Stirling Avenue plant boiler. Traveled extensively, both in the U.S. and overseas, to present and discuss technical findings.

ADA-ES, LLC
Littleton, Colorado

Established in 1996, ADA-ES, LLC, is a specialty chemical and environmental engineering and technology company with internationally recognized experts in air pollution control equipment.

The ADA-ES team has more than 25 years of experience developing and implementing pollution control technology specifically for coal-burning power plants and has been contracted by U.S. government agencies to work with utility companies to create technologies that will help power plants meet environmental standards and new coal-burning regulations.

ADA-ES personnel have been involved with mercury control for coal-fired power plants for over a decade. ADA-ES experience ranges from managing early sorbent injection technology development projects for EPRI to control mercury using pilot-scale equipment to currently managing the Nation's largest full-scale mercury control demonstration project. The company recently provided guidance to EPA's Office of Air Quality Planning and Standards related to carbon injection-based mercury control systems for EPA's Air Pollution Control Cost Manual.

ADA-ES currently has a staff of 18.

RELEVANT EXPERIENCE - ADA-ES

Toxecon Retrofit for Mercury and Multipollutant Control on Three 90-MW Coal-Fired Boilers
U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL), Pittsburgh, Pennsylvania
ADA-ES is managing this $50M project that was awarded to We Energies under the DOE NETL Clean Coal Power Initiative program. Activated carbon and other sorbents will be injected upstream of a single new TOXECON fabric filter retrofit downstream of the ESPs on three boilers. The project also includes a system to recover the collected mercury from the waste solids. In addition to program management, ADA-ES will provide activated carbon injection (ACI) technology and carbon sorbents and continuous mercury emissions monitoring and testing.

Long-Term Operation of a COHPAC System for Removing Mercury from Coal-Fired Flue Gas
DOE NETL, Pittsburgh, Pennsylvania
ADA-ES is conducting a yearlong program to evaluate the performance and impacts of ACI technology upstream of a COHPAC fabric filter. Mercury removal performance will be monitored over a range of coals and operating conditions. The impacts of ACI on long-term fabric filter operations and performance will be determined including the evaluation of alternate fabrics.

Field Test Program to Develop Comprehensive Design, Operating, and Cost Data for Mercury Control Systems on Nonscrubbed Coal-Fired Boilers
DOE NETL, Pittsburgh, Pennsylvania
ADA-ES began work on this Cooperative Agreement with DOE in October 2000 to demonstrate full-scale mercury control systems at four coal-fired power plants. Power-generating companies that are providing sites to conduct the work are PG&E National Energy Group, Wisconsin Electric Power Company, and Alabama Power Company. During the 3-year, $6.8 million project integrated control systems were installed and tested. ADA-ES is responsible for managing the

project including engineering, testing, economic analysis, and information dissemination functions.

Impact of Multipollution Controls on the Performance of Particulate Control Equipment
EPRI, Palo Alto, California
ADA-ES recently completed an evaluation of how NO_x, SO_x, and mercury control systems will impact the effectiveness of particulate control equipment.

Investigation and Demonstration of Dry Carbon-Based Sorbent Injection for Mercury Control
Public Service Company of Colorado, Denver, Colorado
Under subcontract to the Public Service Company of Colorado, ADA personnel fabricated a pilot-scale (600-cfm) particle control system that could be configured as a pulse-jet baghouse, a reverse-gas baghouse, or an electrostatic precipitator. The system was used to evaluate the effectiveness of carbon-based sorbents for removing mercury from a slipstream of flue gas.

Sorbent Injection for Flue Gas Mercury Control
EPRI, Palo Alto, California
ADA-ES personnel evaluated the use of sorbent injection technology to remove mercury from coal-fired power plant flue gas. The pilot-scale (5000-cfm) testing involved the use of the EPRI-patented COHPAC system.

MICHAEL D. DURHAM
President, Project Specialist
ADA-ES, LLC
Littleton, Colorado

Ph.D. – Environmental Engineering

Dr. Durham is the President of ADA Environmental Solutions, L.L.C., a company he founded in 1996 to commercialize environmental technologies to help utilities solve particulate-control problems that result from switching to low-sulfur Western coals. The technology that formed the basis of ADA-ES was originally developed under funding provided by DOE through SBIR and PRDA contracts. Dr. Durham is currently the Manager of DOE/NETL Cooperative Agreement No. DE-FC26-00NT41005, under which mercury control systems are being evaluated at four full-scale coal-fired electric generating facilities.

Dr. Durham has been involved in the measurement and control of air pollution from utility and industrial sources for the past 24 years. Prior to ADA-ES, he was the founder and Executive Vice President of ADA Technologies, Inc. from 1985 to 1996. He has presented and published over 120 papers and has been awarded seven patents. Dr. Durham helped organize the 2000 AWMA conference "Mercury, Toxics Release Inventory, and Air Toxics" and was Chairman of the Mercury Track. He led the technical program organizing committee for the joint EPRI/EPA/DOE/ICAC conference "Mercury Emissions: Fate, Effects, and Control" held in 2001. Dr. Durham is the Chairman of the A&WMA Emission Control Division, and was recently appointed to the National Coal Council by Secretary of Energy Spencer Abraham.

C. JEAN BUSTARD
Executive Vice President, Project Specialist
ADA-ES, LLC
Littleton, Colorado

M.A. – Physics

Ms. Bustard is Executive Vice President of ADA Environmental Solutions, L.L.C. She has been involved in the measurement and control of air pollution from utility and industrial sources for the past 18 years. Ms. Bustard helped to organize and co-chaired the EPRI Fabric Filter Workshop held in 2000 and co-chaired the 2001 Reinhold ESP and Fabric Filter Roundtable. She managed some of the early EPRI sorbent injection projects to control mercury using pilot-scale equipment, and is currently responsible for the installation and evaluation of full-scale mercury control equipment at four coal-fired utilities. Her background includes sorbent injection for SOx control, developing COHPAC technology, particle control, and pulse-jet baghouses.

CAMERON E. MARTIN
Project Specialist
ADA-ES, LLC
Littleton, Colorado

B.Sc. – Environmental Science

Mr. Martin has twenty years of experience in process engineering, evaluation and troubleshooting of air pollution control technologies, including ESPs, fabric filters, flue gas conditioning, dry sorbent injection for SO_2 control, and combustion modifications for NO_X control. He joined ADA after six years at Raytheon Engineers & Constructors as a Senior Air Pollution Control Engineer.

Mr. Martin has developed detailed specifications and conducted bid evaluations for electric utility clients for ESPs, Fabric Filters and Flue Gas Conditioning systems. He actively participated in the development of system wide strategies for utility clients to meet the 1990 Clean Air Act Amendments. He conducted technical and economic comparisons of a wide variety of fuel switching, control technology, and allowance trading options to determine the best and most economic means of achieving SO_2 and NO_X reduction goals station by station and systemwide.

MINNKOTA POWER COOPERATIVE, INC.
Grand Forks, North Dakota

As a member-owned regional power supplier, Minnkota Power Cooperative, Inc., provides a valuable service to more than 95,000 customers of the associated distribution cooperatives. Since 1940, Minnkota has been generating and transmitting reliable and affordable electric energy for distribution to residents of eastern North Dakota and northwestern Minnesota.

Minnkota's employees, past and present, know that electric reliability is essential to a high standard of living. In fact, the mission of the cooperative is to assist the associated systems in improving the quality of life of their customers by continuously improving the value of electric energy.

A low wholesale power rate and dependable, round-the-clock service help ensure the ongoing success of this mission statement. Minnkota headquarters are located in Grand Forks, North Dakota, and the primary source of generation is the Milton R. Young Station near Center, North Dakota. Minnkota's name is derived from the two states in which it operates, an area that encompasses approximately 35,000 square miles.

Reliability has been a cornerstone of Minnkota's foundation since the cooperative was formed more than 60 years ago. Today, Minnkota continues a long-standing tradition of providing the best energy value in the region, adequately and reliably.

Further information on Minnkota Power Cooperative, Inc., can be found at its Web site at http://www.minnkota.com/.

BIOGRAPHICAL SKETCH OF:

STUART M. LIBBY

WORK EXPERIENCE

MINNKOTA POWER COOPERATIVE, INC. - Center, North Dakota ● 1970 - Present

Plant Manager - Operations - (2/98 - Present)

Provide overall direction, supervision, and resource planning for operations to include technical support services. Develop and communicate goals and objectives to include future planning. Establish and coordinate generation schedules.

Operations Superintendent - (8/79 – 1/98)

Provide overall supervision, coordination, budgeting, and work direction for the operations and coal handling groups for a two unit, 700 MWe combined capacity lignite-fired electric generating station.

- ♦ increased station availability and production by development and implementation of a boiler flue gas temperature control program.
- ♦ station consistently ranks in the top ten for lowest production costs in the nation, on a five year rolling basis, as reported by the Utility Data Institute.
- ♦ serve on labor agreement negotiating committee.
- ♦ co-authored and presented papers on boiler operation.

Assistant Operations Supervisor - (7/78 - 7/79)

Assisted the operations supervisor in overall direction of the operations of the station with emphasis on the flue gas scrubber system.

- ♦ served as leader and contractor liaison for start-up of flue gas scrubber system.
- ♦ participated in modifying scrubber which improved availability and efficiency.

Shift Supervisor - (7/76 - 6/78)

Supervised and directed all phases of plant operation for the duration of assigned shift while maintaining generation on schedule.

- ♦ participated in commissioning of a 439 MWe generating unit.

Station Operator - (3/73 - 6/76)

Responsible for the operation of the unit for the duration of my assigned shift to include directing the activities of all operations personnel on duty.

- ♦ participated in the development of a state-wide training program for power plant operators.
- ♦ served on labor agreement negotiating committee as a union member.

Assistant Station Operator & Equipment Operator I - (3/70 - 2/73)

Assist the station operator in control board operation and monitored the operation of plant equipment outside the control room.

- ♦ contributed to one of the industries most successful start-ups of a 235 MWe lignite fired electrical generating facility.

NORTHERN STATES POWER COMPANY - Grand Forks, North Dakota ● 1966 - 1970

Fireman - Auxiliary Operator - (11/66 - 2/70)

Responsible for the operation of multiple coal-fired steam-generators, turbine-generators, and associated auxiliary equipment during my assigned shift.

EDUCATION:

UNIVERSITY OF MARY – Bismarck, North Dakota

Bachelor of Science Degree ▪ Major: Business Administration – Minor: Management Information Systems

BASIN ELECTRIC POWER COOPERATIVE
Bismarck, North Dakota

Basin Electric Power Cooperative is a consumer-owned regional wholesale electric power supply cooperative. It operates electricity-generating plants for its 124-member-system cooperatives in nine states, serving the more than 1.7 million people that own Basin Electric. Basin Electric has its headquarters in Bismarck, North Dakota.

Basin Electric operates 3373 megawatts (MW) of electric generating capacity. The cooperative owns 2420 MW of this capacity. It operates the other 953 MW for participants in the Missouri Basin Power Project.

Basin Electric and its subsidiaries are in businesses primarily connected to energy supply, but they also provide other services difficult to obtain in rural areas. Its two major subsidiaries are described below. Basin Electric and its subsidiaries employed 1768 people in 2002.

Major subsidiaries:

Dakota Gasification Company (DGC) is a for-profit subsidiary that produces synthetic natural gas, fertilizers, and other products from the gasification of lignite coal.

Dakota Coal Company is a for-profit subsidiary that provides financing for and markets the lignite production from the Freedom Mine near Beulah, North Dakota. It also has a subsidiary that mines and sells limestone and a division that processes the limestone into lime for sale.

Additional information can be obtained at its Web site at http://www.basinelectric.com.

Robert L. Eriksen is the Environmental Compliance Administrator at Basin Electric Power Cooperative. Bob received a B.S. degree in Chemical Engineering from the University of North Dakota in 1974. He has been employed with Basin Electric in the environmental field since June of 1974.

Bob's experience includes pollution control technology, environmental monitoring and reporting systems, permitting facilities, and tracking environmental legislation and regulations regarding air, water, and waste. He was instrumental in the pilot testing and development of spray dryer flue gas desulfurization in the 1970's that led to the application of spray dry FGD in the electric utility industry. He has authored or co-authored several technical publications and presentations on FGD, air dispersion modeling, and mercury controls.

He is married and has two children. His community activities include Boy Scouts, the Great American Bike Race for Cerebral Palsy, deacon and treasurer for his church, treasurer for the Magical Moments Playground project, and supporting his children's activities.

TXU ENERGY

TXU Energy: TXU Energy—a competitive retail electric provider, merchant trader, and electricity producer—has built a 100-year heritage of serving Texans and now also provides electricity and energy-related services across the United States (2.7 million customers). TXU Energy is part of TXU, one of the largest energy companies in the world, selling and/or distributing electricity to 11 million customers worldwide. TXU is a leader in providing energy, protecting the environment, and reducing emissions. TXU Energy's 99%-plus air compliance rate is one of the best in the industry, and they are a proactive leader in air quality through the Climate Challenge Program and voluntary nitrogen oxide emission reductions. TXU is committed to being an innovative leader in the management of environmental issues. As part of its current environmental efforts, TXU Energy is utilizing a variety of methods to reduce or co-control the air emissions that contain trace amounts of inorganic mercury. Although there is presently no available technology to eliminate all emissions of inorganic mercury, TXU is working with other organizations to develop methods of mercury emissions control. Further information on TXU Energy can be found at its Web site at www.txucorp.com.

Michael E. Montgomery
TXU Energy
Monticello Plant Support Superintendent

Education: BSME from Mississippi State University, 1982

Current Responsibilities: I currently hold the position of Support Superintendent at TXU Energy's Monticello Plant. My responsibilities include the direction of the plant's technical staff as required to meet the TXU and Monticello's needs for the safe, efficient, and reliable production of electricity. My team consists of the plant's Engineering Team, I&C Team, Environmental Team, Lab Team, and Conditioned Based Maintenance Team. My team's base annual budget is $2+M/ year. The team is also responsible for the development, design, and implementation of special projects and capital improvement projects not included in the annual budget listed above.

Career Background: I have worked with the TXU system since 1982. During that time, one of my positions was as a Project Engineer. I have worked on a wide range of projects such as Low NO_x retrofits on 2 units at the Monticello Plant (including SOFA ducts and dampers), optimization of CO emissions, installation of Operating Ponds, scrubber and chimney rebuilds, and the design and construction of bottom ash dewatering bins.

I have had the opportunity of working as a Support Supervisor directly supervising a crew of craft mechanics and electricians to support Monticello's generation goals. I also worked as a Production Supervisor directly supervising a crew of craft operators who operated the coal handling facility at Monticello.

Robert W. Wiemuth Jr.

Project Manager

TXU Energy

Mr. Wiemuth has been employed by TXU Energy since receiving his Bachelor of Science degree in Electrical Engineering from Texas A&M University in 1973.

Since joining TXU Energy, Mr. Wiemuth has been involved in many business groups of the electric utility. For the last 17 years, he has provided engineering support for the TXU Energy fossil power plant fleet. He has a background based in the CEM software area and has recently completed a project to upgrade of the CEM data gathering and reporting software system. He has supported development of TXU Energy's plan for NO_x reduction and provides impact analysis of pending environmental regulatory changes. He managed the mercury characterization test conducted in 2002 at Monticello Unit 3.

URS

Mr. Michael Holmes
Energy & Environmental Research Center
PO Box 9018
Grand Forks, ND 58202

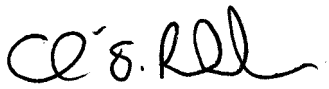
Subject: URS support of DOE NETL Mercury Control Solicitation DE-PS26-03NT41718-3

Dear Mike,

This letter is to confirm URS Group's intention to participate in a cooperative agreement project being proposed by a team led by the Energy & Environmental Research Center to the Department of Energy under the solicitation number listed above. The proposed project for evaluating sorbent injection for mercury control in lignite-derived flue gas is being submitted under Area of Interest 3, "Field Testing of Non-Sorbent Based Concepts for Increasing the Oxidation of Elemental Mercury for Removal in Downstream Air Pollution Control Equipment".

In support of the proposed EERC test program, URS will conduct tests at TXU Energy's lignite-fired Monticello Steam Electric Station to evaluate the effect of adding chemical reagents to the Unit 3 boiler on mercury removal across downstream control devices. The tests at Monticello will evaluate two different chemical reagents, to be determined based on the results of planned EERC and EPRI tests, for periods of two weeks each. URS has performed similar full-scale tests for EPRI at two power plants in the past and plan to demonstrate the technology at least one plant for later this year. The 2003 tests will provide valuable input to be used to design the tests outlined in this proposal.

URS believes that the approach being proposed by EERC will provide valuable information to the power industry regarding the cost and performance of chemical addition technology for mercury control in lignite-derived flue gas. We look forward to carrying out this collaborative effort with EERC and its assembled team.



Carl F. Richardson, Ph.D.
Project Manager
URS Group

URS Group
P.O. Box 201088
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Tel: 512.454.4797
Fax: 512.454.8807
www.urscorp.com

ADA-ES, LLC

8100 SouthPark Way, Unit B
Littleton, Colorado 80120
Fax: 303.734.0330
303.734.1727

March 27, 2003

Mr. John H. Pavlish
Senior Research Manager
University of North Dakota
Energy and Environmental Research Center
P.O. Box 9018
Grand Forks, ND 58202

Dear Mr. Pavlish,

This letter is written to express our support of your proposal to the Department of Energy under Solicitation No. DE-PS26-03NT41718 and to confirm our commitment to participate in the proposed project. The described work compliments our ongoing efforts to provide mercury control equipment and services to the coal-fired power generation industry. We feel that the effort has merit in furthering the understanding of ramifications and costs of mercury control systems. The results of the testing will be of interest to power companies, regulators, DOE and the many organizations that support this industry.

ADA-ES will commit to participate in the project by providing one additive injection system for the proposed work at the Milton R. Young plant and one Powdered Activated Carbon injection system for the proposed projects at the Leland Olds and Antelope Valley plants. We will provide the equipment as well as experienced and qualified personnel in the manner outlined in the proposal. Our scope of work is backed up by our written quotation dated March 27, 2003. The quoted price is discounted by approximately 30%, which constitutes our cost share to the effort. The invoices for our portion of the work will show the full price for the services and equipment, our cost share amount, and the net amount due after cost share. Barring any unexpected events, we expect to hold the quoted price firm through 2004. The specific terms and conditions will be subject to a definitive subcontract between UNDEERC and ADA-ES should UNDEERC be awarded a cooperative agreement from the DOE.

ADA-ES shares your enthusiasm and we look forward to working with you and the DOE in this interesting and needed effort.

Sincerely,

Richard J. Schlager
Vice President

An Earth Sciences Company
An Earth Sciences Company

ADA-ES, LLC

8100 SouthPark Way, Unit B
Littleton, Colorado 80120
Fax: 303.734.0330
303.734.1727

March 27, 2003

Mr. John H. Pavlish
Senior Research Manager
Energy & Environmental Research Center
P.O. Box 9018
Grand Forks, ND 58202

RE: Pricing for Injection Systems

Dear John:

ADA-ES is pleased to provide budget pricing for reagent injection systems, installation, start-up and transport services, and Powdered Activated Carbon (PAC) reagent to EERC for use in the DOE/NETL Phase II mercury program. These budget estimates will be in effect through 2004.

ADA-ES, along with our strategic partner Norit Americas, Inc., will provide transportable reagent injection systems to be used at multiple full-scale utility plant sites.

EQUIPMENT

One system for injecting powdered activated carbon into the flue gas ductwork upstream of air pollution control devices. The system will hold the contents of one 45,000 lb tanker truck and be capable of feeding 50 – 1000 lbs/hr PAC. The system will be transportable from one plant to the next with minimal installation labor.

One system for injecting EERC's additive into the boiler or boiler air system. This system will be almost identical to the PAC injection system, with the exception of the structural design to accommodate the denser additive and the modifications to the fluidizing system for the physical properties of the additive that are expected to be different from PAC. The system will hold the contents of one 45,000 lb tanker truck and be capable of feeding 100 – 2000 lbs/hr additive with a bulk density of 80 lb/cu. Ft. The system will be transportable from one plant to the next with minimal installation labor.

A technical proposal describing the equipment and an example flow diagram are attached.

INSTALLATION START-UP AND TEAR DOWN

ADA-ES will provide labor and materials to install and make operational the two injection systems and then tear them down and make ready for shipment.

ADA-ES will install the ~~system(s) and make operational~~. This includes:

1. A site pre- visit to scope out layout issues and assess the site, determine power and air sources etc.
2. Mechanical and electrical installation of the system(s) (Assuming non-union labor rates of $45/hr mechanics and $60/hr electricians)
3. Supervision by ADA-ES/Norit engineer
4. Start up and operational check out of the entire system before handing it over to EERC along with operator training.
5. Crane rental to erect silo and set bin filter.
6. Travel and living expenses

At the conclusion of the testing at each site ADA-ES will dismantle the system(s) and make ready for shipping to the next site: This includes:

1. Mechanical and electrical labor to dismantle and pack and load equipment onto trucks. (Assuming non-union labor rates of $45/hr mechanics and $60/hr electricians)
2. Supervision by ADA-ES/Norit engineer
3. Crane ~~rental~~ remove silo(s) and vent filter(s).
4. Travel and living expenses

PRICING

All prices presented herein are budgetary.

Equipment – Purchase Option

The purchase price for each system (PAC and additive) is:

Norit Americas/ADA-ES commercial price	$275,000
Norit/ADA-ES cost share	$82,500
Discounted price to DOE/NETL program	$192,500

Equipment - Lease option* (per system)

Norit Americas/ADA-ES standard commercial lease rate	$21,414/Month
Norit/Americas/ADA-ES cost share	$6,425/Month
Discounted Lease Rate for DOE/NETL Program	$14,989/Month

*exact terms and conditions of lease to be negotiated at contract in order to conform with DOE/NETL requirements.

Expendable Equipment and Supplies

Equipment and supplies designed for each plant site that may not be able to be re-used at subsequent sites include reagent conveying hose, fittings and injection lances.

Expendable Equipment and supplies	$ 5,000/plant site one system $ 10,000/plant site two systems

Shipping

The price to ship the silo and all other equipment from Marshall, TX to North Dakota is:

Shipping, initial delivery	$ 5,500/ injection system
Subsequent shipping	Variable depending on locations

Installation and Start Up Services

Materials, equipment and labor to install injections systems and make operational. These prices are budgetary (+/- 30%) only. Plant locations, drawings and technical information is required to develop more accurate costs.

One system $75,000
ADA-ES will use discounted labor rates and discounted indirect charges as a cost share contribution. The cost for installation and start up services after the discounts is $60,000.

Equipment Removal Services

Materials, equipment and labor to tear down, pack up and load systems onto trucks for shipping. These prices are budgetary (+/- 30%) only. Plant locations, drawings and technical information are required to develop more accurate costs.

One system $32,000/plant site
ADA-ES will use discounted labor rates and discounted indirect charges as a cost share contribution. The cost for installation and start up services after the discounts is $25,000

Activated Carbon Reagent

Darco FGD Powdered Activated Carbon Reagent (all prices FOB Marshall, TX, shipping prices will vary). There is no cost share discount for the shipping charges.

ADA-ES/Norit Commercial Price	$0.42/lb
Cost Share	$0.12/lb
Discounted Price to DOE	$0.30/lb

We hope the information herein meets your needs for your DOE proposal. If you need clarification or more information please don't hesitate to call:

Sincerely,

Cameron E. Martin
Director of Engineering

cc: MDD, CJB, JFW, RJS, TJS
cc: R. Thomas, D. Hall Norit-Americas

Enclosure: P03-1005 Attachments

INDUSTRIAL COMMISSION OF NORTH DAKOTA

LIGNITE RESEARCH, DEVELOPMENT AND MARKETING PROGRAM

Governor,
John Hoeven
Attorney General,
Wayne Stenehjem
Agriculture Commissioner,
Roger Johnson

March 27, 2003

Mr. Michael Holmes
Senior Research Manager
Energy & Environmental Research Center
P. O. Box 9018
Grand Forks, ND 58202-9018

Subject: Letter of Interest and Financial Commitment

Dear Mr Holmes:

This letter is in response to your request for participation in the proposed Energy & Environmental Research Center project entitled "Large-Scale Mercury Control Technology Testing for Lignite-Fired Utilities – Oxidation Systems for Wet FGD," a proposal submitted under DOE Solicitation No. DE-PS26-03NT41718, "Large- Scale Mercury Control Technology Field Testing Program."

The North Dakota Lignite Research, Development and Marketing Program (Program) is committed to the development and commercialization of advanced environmental control technologies for the power generation industry. The development of innovative technical approaches addressing mercury emissions capture technology is a critical need for lignite-fired power plants.

This letter of support and potential funding of $150,000 from the North Dakota Program is subject to submission of a proposal by the Energy & Environmental Research Center at the University of North Dakota. North Dakota funding is also subject to submission of a proposal that meets Program guidelines, a funding recommendation by the Lignite Research Council and approval by the North Dakota Industrial Commission.

Environmental issues, particularly elemental mercury emissions from lignite combustion, are priorities for the North Dakota Program. Funding guidelines require matching industrial funds and activities that preserve and enhance the use of North Dakota lignite.

Sincerely,

Harvey M. Ness
Director and Technical Advisor, Lignite Research, Development and Marketing Program

cc: Karlene Fine, Executive Director and Secretary, North Dakota Industrial Commission
John W. Dwyer, Chairman, Lignite Research Council

LIGNITE RESEARCH COUNCIL

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(701) 258-7117 (701) 258-2755 FAX

INDUSTRIAL COMMISSION OF NORTH DAKOTA

Karlene Fine
Executive Director & Secretary
kfine@state.nd.us
600 E. Blvd., State Capitol
Bismarck, N.D. 58505

(701) 328-3722 (701) 328-2820 FAX

The attached budget includes $78,072 of in-kind cost share from TXU. Based on a change in commitment from EPRI it was determined this amount will now be included as cash cost share. Since this change was made so late during proposal preparation there was insufficient time to make the corresponding changes in EERC budgets. The change reduces in-kind and increases cash cost share. Total cost share remains unchanged as does the work scope and technical effort. The changes will be addressed as stated at time of award.

ELECTRIFY THE WORLD

EPRI

April 2, 2003

Mr. Mike Holmes
Senior Research Advisor
Energy & Environmental Research Center
PO Box 9018
Grand Forks, ND 58202

Dear Mike:

Subject: Letter of Interest and Financial Commitment for Field-Testing Activities Proposed by the EERC to the U.S. Department of Energy's (DOE) Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program"

I am pleased to submit this letter of support and interest to participate in the field-testing activities that are described in Energy & Environmental Research Center (EERC) proposal being submitted under DOE Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program." The proposal being submitted to address the mercury control needs of the lignite industry is entitled "Large-Scale Mercury Control Technology Testing for Lignite-Fired Utilities – Oxidation Systems for Wet FGD."

EPRI has a particular interest in this program because some of our key members operate multiple units firing North Dakota and Texas lignites. We have a critical need to identify mercury control options for lignite-fired units equipped with an electrostatic precipitator and wet scrubber-based SO_2 control technologies. Based on our current understanding and existing data, mercury emission control in units firing lignite and other western coals with these configurations will prove to be more challenging and require higher costs in comparison to that for other coals. The approaches proposed allow the lignite industry to test whether these low-capital-cost mercury control technologies are feasible options that can be considered for meeting future regulations.

EPRI, together with its partners GRE and TXU Energy, is pleased to offer support to the proposed program in the form of cash cost share valued at $86000, In addition, EPRI is pleased to offer labor, travel expense, materials, and equipment in support of the proposed tests as in-kind cost share valued at $71,000. We hope that DOE gives careful consideration to this program, as there is a significant need for field data applicable to low-rank coals, especially North Dakota lignite. Again, we express our support and look forward to working with DOE and the EERC on this project.

Sincerely,

George R. Offen
Area Manager
Air Emissions and By Product Management
EPRI

cc: Mark Strohfus, GRE
Cliff Clark, TXU Energy

Bob Wiemuth, TXU Energy
Ramsay Chang, EPRI

215 South Cascade Street
PO Box 496
Fergus Falls, Minnesota 56538-0496
218 739-8200
www.otpco.com (web site)

March 27, 2003

OTTER TAIL POWER COMPANY

Mr. John Pavlish
Senior Research Manager
Energy & Environmental Research Center
PO Box 9018
Grand Forks, ND 58202

Dear Mr. Pavlish:

Subject: Letter of Interest and Financial Commitment for Field-Testing Activities Proposed by the EERC to the U.S. Department of Energy's (DOE) Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program" (Oxidation Systems for Wet FGD).

As Manager of Environmental Services for Otter Tail Power Company, I am pleased to submit this letter of support and interest to participate in the field-testing activities that are described in Energy & Environmental Research Center (EERC) proposals being submitted under DOE Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program." This proposal is being submitted to address the mercury control needs of the lignite industry are entitled "Large-Scale Mercury Control Technology Testing for Lignite-Fired Utilities – Oxidation Systems for Wet FGD."

Otter Tail Power Company has a particular interest in this program because we own and operate a unit firing lignite. We have a critical need to identify mercury control options for our lignite-fired unit currently equipped with combined dry scrubber and reverse-air fabric filter equipment. In addition, in preparation for the possibility of multi-pollutant control legislation (e.g., Clear Skies Initiative), mercury control options are needed for both wet and dry scrubber-based SO_2 control technologies. Based on our current understanding and existing data, mercury emission control in units firing lignite and other western coals with these configurations will prove to be more challenging and require higher costs in comparison to that for other coals. The approaches proposed allow the lignite industry to test whether these low-capital-cost mercury control technologies are feasible options that can be considered for meeting future regulations.

Otter Tail Power Company is pleased to offer support to the proposed program in the form of cash cost share valued at $3,780 for the Oxidation Systems for Wet FGD proposal. It is understood that Otter Tail Power Company funding for this project will provide cost share to federal funding from DOE; therefore, Otter Tail Power Company hereby certifies that our

cost-share funding will be comprised of nonfederal dollars and will not be used as federal match on any other project.

We hope that DOE gives careful consideration to this program, as there is a significant need for field data applicable to lignite coal. Again, we express our support and look forward to working with DOE and the EERC on this project.

Sincerely,

Terry Graumann
Manager, Environmental Services

BASIN ELECTRIC POWER COOPERATIVE

1717 EAST INTERSTATE AVENUE
BISMARCK, NORTH DAKOTA 58503-0564
PHONE 701-223-0441
FAX: 701/224-5336

March 27, 2003

Mr. Mike Holmes
Senior Research Advisor
Energy & Environmental Research Center
PO Box 9018
Grand Forks, ND 58202

Dear Mr. Holmes:

Subject: Letter of Interest and Financial Commitment for Field-Testing Activities Proposed by the EERC to the U.S. Department of Energy's (DOE) Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program"

As Senior Vice President of Generation of Basin Electric Power Cooperative (BEPC), I am pleased to submit this letter of support and interest to participate in the field-testing activities that are described in Energy & Environmental Research Center (EERC) proposals being submitted under DOE Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program." The two proposals being submitted to address the mercury control needs of the lignite industry are entitled "Large-Scale Mercury Control Technology Testing for Lignite-Fired Utilities – Sorbent Injection Technologies" and "Large-Scale Mercury Control Technology Testing for Lignite-Fired Utilities – Oxidation Systems for Wet FGD."

Basin Electric has a particular interest in this program because we own and operate multiple units firing lignite. We have a critical need to identify mercury control options for our lignite-fired units equipped with an electrostatic precipitator for particulate control, as well as for our units currently equipped with combined dry scrubber and reverse-air fabric filter equipment. In addition, in preparation for the possibility of multipollutant control legislation (e.g., Clear Skies Initiative), mercury control options are needed for both wet and dry scrubber-based SO_2 control technologies. Based on our current understanding and existing data, mercury emission control in units firing lignite and other western coals with these configurations will prove to be more challenging and require higher costs in comparison to that for other coals. The approaches proposed allow the lignite industry to test whether these low-capital-cost mercury control technologies are feasible options that can be considered for meeting future regulations.

Basin Electric is pleased to offer support to the proposed program in the form of cash cost share valued at $33,380, which includes $25,680 for the Sorbent Injection Technology proposal and $7,700 for the Oxidation Systems for Wet FGD proposal. It is understood that Basin Electric's funding for this project will provide cost share to federal funding from DOE; therefore, Basin Electric hereby certifies that our cost-share funding will be comprised of nonfederal dollars and will not be used as federal match on any other project.

The Leland Olds Station is pleased to offer labor, travel expense, and materials in support of the proposed tests as in-kind cost share valued at $70,000. It is understood that Basin Electric's in-kind services for this project will provide cost share to federal funding from the U.S. Department of Energy, therefore Basin Electric hereby certifies that our in-kind contribution of $70,000 will be comprised of nonfederal dollars.

The Antelope Valley Station is pleased to offer labor, travel expense, and materials in support of the proposed tests as in-kind cost share valued at $68,000. It is understood that Basin Electric's in-kind services for this project will provide cost share to federal funding from the U.S. Department of Energy, therefore Basin Electric hereby certifies that our in-kind contribution of $68,000 will be comprised of nonfederal dollars.

Additionally, we understand that all in-kind cost share must be allowable under Federal guidelines outlined for commercial organizations. Specific guidelines that will be followed are the Federal Acquisition Regulations (FAR) part 31.2 (Cost Principles for Commercial Organizations) and FAR part 42.7 (Indirect Cost Rates), which prescribe policies and procedures for establishing indirect cost rates.

Bob Eriksen, Basin Electric's Environmental Compliance Administrator, is serving as project manager for our large-scale mercury test programs. Please coordinate these test programs with Bob at (701) 355-5654 or beriksen@bepc.com.

We hope that DOE gives careful consideration to this program, as there is a significant need for field data applicable to low-rank coals, especially North Dakota lignite. Again, we express our support and look forward to working with DOE and the EERC on this project.

Sincerely,

Wayne Backman

Wayne Backman

Rle
Enclosure
cc: John Hendrikson, EERC
John Pavlish, EERC
Steve Benson, EERC
Curt Melland, Leland Olds Station
John Jacobs, Antelope Valley Station
Bob Eriksen, Project Manager

GREAT RIVER
ENERGY®

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March 28, 2003

Mr. Mike Holmes
Senior Research Advisor
Energy & Environmental Research Center
PO Box 9018
Grand Forks, ND 58202

Dear Mr. Holmes:

Subject: Letter of Interest and Financial Commitment for Field-Testing Activities Proposed by the EERC to the U.S. Department of Energy's (DOE) Solicitation No. DE-PS26-03NT41718, "Large-Scale Mercury Control Technology Testing for Lignite-Fired Utilities – Oxidation Systems for Wet FGD"

Great River Energy is pleased to submit this letter of support and interest to participate in the field-testing activities described in the Energy & Environmental Research Center (EERC) proposal being submitted under DOE Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program." The proposal being submitted to address the mercury control needs of the lignite industry are entitled**"Large-Scale Mercury Control Technology Testing for Lignite-Fired Utilities – Oxidation Systems for Wet FGD."**

Great River Energy has a particular interest in this program because we operate multiple units firing North Dakota lignite. We have a critical need to identify mercury control options for lignite-fired units equipped with an electrostatic precipitator and wet scrubber for particulate and sulfur oxides control. Based on our current understanding and existing data, mercury emission control in units firing lignite and other western coals with these configurations will prove to be more challenging and require higher costs in comparison to that for other coals. The approaches proposed allow the lignite industry to test whether these low-capital-cost mercury control technologies are feasible options that can be considered for meeting future regulations.

Great River Energy, in conjunction with EPRI, is pleased to offer support to the proposed program in the form of cash cost share through EPRI's tailored collaboration program valued at $8,010 for the Oxidation Systems for Wet FGD proposal.

We hope that DOE gives careful consideration to this program, as there is a significant need for field data applicable to low-rank coals, especially North Dakota and Texas lignites. Again, we express our support and look forward to working with DOE and the EERC on this project.

Sincerely,

GREAT RIVER ENERGY

Mary Jo Roth
Manager, Environmental Services

MS/bn

c: Ramsay Chang, EPRI

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LOI-$Commit 3-28-03 OxSys-WetFGD.doc

MONTANA-DAKOTA
UTILITIES CO.
A Division of MDU Resources Group, Inc.

400 North Fourth Street
Bismarck, ND 58501
(701) 222-7900

March 27, 2003

Mr. John Pavlish
Senior Research Manager
Energy & Environmental Research Center
PO Box 9018
Grand Forks, ND 58202

Dear Mr. Pavlish:

Subject: Letter of Interest and Financial Commitment for Field-Testing Activities Proposed by the EERC to the U.S. Department of Energy's (DOE) Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program" (Oxidation Systems for Wet FGD).

As the Power Production Manager for Montana-Dakota Utilities Co., I am pleased to submit this letter of support and interest to participate in the field-testing activities that are described in Energy & Environmental Research Center (EERC) proposals being submitted under DOE Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program." This proposal is being submitted to address the mercury control needs of the lignite industry and is titled *Large-Scale Mercury Control Technology Testing for Lignite-Fired Utilities – Oxidation Systems for Wet FGD.*

Montana-Dakota has a particular interest in this program because we own and operate multiple units firing lignite. We have a critical need to identify mercury control options for our lignite-fired units equipped with an electrostatic precipitator for particulate control. In addition, in preparation for the possibility of multipollutant control legislation (e.g., Clear Skies Initiative), mercury control options are needed for both wet and dry scrubber-based SO_2 control technologies. Based on our current understanding and existing data, mercury emission control in units firing lignite and other western coals with these configurations will prove to be more challenging and be more costly in comparison to that for other coals. The approaches proposed allow the lignite industry to test whether these low-capital-cost mercury control technologies are feasible options that can be considered for meeting future regulations.

Montana-Dakota is pleased to offer support to the proposed program in the form of cash cost share valued at $2,410, for the *Oxidation Systems for Wet FGD* proposal. It is understood that Montana-Dakota's funding for this project will provide cost share to federal funding from DOE; therefore, Montana-Dakota hereby certifies that our cost-share funding will be comprised of nonfederal dollars and will not be used as federal match on any other project.

We hope that DOE gives careful consideration to this program, as there is a significant need for field data applicable to lignite coal. Again, we express our support and look forward to working with DOE and the EERC on this project.

Sincerely,

Gary Gress
Power Production Manager

SaskPower

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

March 27, 2003

Mr. John Pavlish
Senior Research Manager
Energy & Environmental Research Center
P. O. Box 9018
Grand Forks, ND USA
58202

Dear Mr. Pavlish:

Subject: **Letter of Interest and Financial Commitment for Project Entitled "Mercury Control Technologies for Electric Utilities Burning Lignite Coal – Phase II, Field Testing of Slip-stream Technology at Poplar River Power Station" and for Field Testing Activities Proposed by the EERC to the US DOE Solicitation No. DE-PS26-03N41718, "Large Scale Mercury Control Technology Field Testing Program"**

Based on the encouraging results seen to date in Phase I the project entitled "Mercury Control Technologies for Electric Utilities Burning Lignite Coal", SaskPower would like to express its sincere interest in participating in Phase II of this project involving field testing of slip-stream technology at SaskPower's Poplar River Power Station.

This Phase is currently being formulated by SaskPower, ALSTOM Canada, Inc. and the Energy & Environmental Research Center (EERC). On March 5, 2003 SaskPower made a submission for funding to Sustainable Technology Development Canada in which we indicated that we were prepared to contribute $1,600,000 Cdn. in financial and in-kind resources to this project.

Much of the SaskPower contribution would be allocated to the installation of suitable slip-stream technology in time for data collection in the spring of 2004. In addition, SaskPower could contribute an equitable amount for the performance of the test work and data analysis. SaskPower is very interested in seeing this Phase of the project move forward and welcomes the involvement of EERC and other consortium partners as

outlined in previous correspondence and at the Project review meeting of February 25, 2003. SaskPower is currently in the process of designing a scaled-up version of the most suitable mercury control technology based on the results of Phase I of the project. A final decision on the technology design is planned by the end of this month so that it will be ready for test work early next year.

SaskPower is interested in exploring as many mercury-control options as practical. Consequently, we feel it would be very valuable to participate in the field test project involving six U.S. lignite-fired sites that EERC is proposing to the US DOE Solicitation No. DE-PS26-03N41718, "Large Scale Mercury Control Technology Field Testing Program". SaskPower is prepared to contribute up to US $200,000 to this project depending on the implementation of the Phase II project, the final scope of the US DOE project and the award of funds from US DOE for the latter project.

SaskPower is quite anxious that all this work proceeds. We hope that the EERC is successful in securing funding from other consortium sponsors for the Phase II project and that the US DOE decides to support the work proposed by the EERC for the full scale field work at the six U.S. lignite-fired sites. We look forward to working with the EERC, the US DOE and other consortium members on these worthwhile projects.

Yours sincerely

Garner Mitchell
Vice-President, Power Production

GM/dgc

c: Steve Benson, EERC
John Hendrikson, EERC
Mike Holmes, EERC
Rick Patrick, PERA, 6C
Dave Smith, Operations Support, Power Production, 2901 Powerhouse Drive
Max Ball, Engineering Services, 9SE
Bob Stobbs, Operations Support, Power Production, 2901 Powerhouse Drive
John Lebersback, Operations Support, Power Production, 2901 Powerhouse Drive
Robert Stedwill, PERA, 6NE

MICHAEL J. HUMMEL
President & General Manager

BNI COAL®

PHONE (701) 222-8828
FAX (701) 222-1547

March 28, 2003

Mr. Michael Holmes
Senior Research Advisor
Energy & Environmental Research Center
PO Box 9018
Grand Forks, ND 58202

Dear Mr. Holmes:

Subject: Letter of Interest and Financial Commitment for Field-Testing Activities Proposed by the EERC to the U.S. Department of Energy's (DOE) Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program" (Oxidation Systems for Wet FGD).

As President & General Manager of BNI Coal, Ltd., I am pleased to submit this letter of support and interest to participate in the field-testing activities that are described in Energy & Environmental Research Center (EERC) proposals being submitted under DOE Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program." This proposal is being submitted to address the mercury control needs of the lignite industry and is entitled "Large-Scale Mercury Control Technology Testing for Lignite-Fired Utilities – Oxidation Systems for Wet FGD."

BNI Coal, Ltd. has a particular interest in this program because we supply lignite coal to the Milton R. Young Electrical Generating Stations. We have a critical need to identify mercury control options for the lignite-fired units we supply. In addition, in preparation for the possibility of multipollutant control legislation (e.g., Clear Skies Initiative), mercury control options are needed for both wet and dry scrubber-based SO_2 control technologies. Based on our current understanding and existing data, mercury emission control in units firing lignite and other western coals with these configurations will prove to be more challenging and require higher costs in comparison to that for other coals. The approaches proposed allow the lignite industry to test whether these low-capital-cost mercury control technologies are feasible options that can be considered for meeting future regulations.

BNI Coal Ltd. is pleased to offer support to the proposed program in the form of cash cost share valued at $4,220, for the Oxidation Systems for Wet FGD proposal. It is understood that the funding provided by BNI Coal, Ltd. for this project will provide cost share to federal funding from DOE; therefore, BNI Coal, Ltd. hereby certifies that our cost-share funding will be comprised of nonfederal dollars and will not be used as federal match on any other project.

We hope that DOE gives careful consideration to this program, as there is a significant need for field data applicable to lignite coal. Again, we express our support and look forward to working with DOE and the EERC on this project.

Sincerely,

MJ Hummel

BNI COAL, LTD.
1637 BURNT BOAT DRIVE • P.O. BOX 897 • BISMARCK, ND 58503

THE FALKIRK MINING COMPANY

A SUBSIDIARY OF THE NORTH AMERICAN COAL CORPORATION
P.O. BOX 1087
UNDERWOOD, NORTH DAKOTA • (701) 442-5751

DAN W. SWETICH
PRESIDENT

March 27, 2003

Mr. John Pavlish
Senior Research Manager
Energy & Environmental Research Center
P.O. Box 9018
Grand Forks, ND 58202

Dear Mr. Pavlish:

Subject: **Letter of Interest and Financial Commitment for Field-Testing Activities Proposed by the EERC to the U.S. Department of Energy's (DOE) Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program" (Oxidation Systems for Wet FGD)**

As President of The Falkirk Mining Company (Falkirk), I am pleased to submit this letter of support and interest to participate in the field-testing activities that are described in Energy & Environmental Research Center (EERC) proposals being submitted under DOE Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program". This proposal is being submitted to address the mercury control needs of the lignite industry entitled "Large-Scale Mercury Control Technology Testing for Lignite-Fired Utilities – Oxidation Systems for Wet FGD".

Falkirk has a particular interest in this program because we own and operate a mining facility that supplies units firing lignite. Our customer has a critical need to identify mercury control options for their lignite-fired units equipped with an electrostatic precipitator for particulate control as well as for their units currently equipped with combined dry scrubber and reverse-air fabric filter equipment. In addition, in preparation for the possibility of multi-pollutant control legislation (e.g., Clear Skies Initiative), mercury control options are needed for both wet and dry scrubber-based SO_2 control technologies. Based on our current understanding and existing data, mercury emission control in units firing lignite and other western coals with these configurations will prove to be more challenging and require higher costs in comparison to that for other coals. The approaches proposed allow the lignite industry to test whether these low-capital-cost mercury control technologies are feasible options that can be considered for meeting future regulations.

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Falkirk is pleased to offer support to the proposed program in the form of cash cost share valued at $4,220 for the Oxidation Systems for Wet FGD proposal. It is understood that Falkirk funding for this project will provide cost share to Federal funding from DOE; therefore, Falkirk hereby certifies that our cost-share funding will be comprised of non-Federal dollars and will not be used as Federal match on any other project.

We hope that DOE gives careful consideration to this program as there is a significant need for field data applicable to lignite coal. Again, we express our support and look forward to working with DOE and the EERC on this project.

Sincerely,

THE FALKIRK MINING COMPANY

Dan W. Swetich
President

COTEAU
THE COTEAU PROPERTIES COMPANY
A SUBSIDIARY OF THE NORTH AMERICAN COAL CORPORATION

FREEDOM MINE
204 County Road 15
Beulah, ND 58523-9475
(701) 873-2281 • Fax (701) 873-2579

Marc M. Schulz
President

March 31, 2003

Mr. John Pavlish
Senior Research Manager
Energy & Environmental Research Center
P.O. Box 9018
Grand Forks, ND 58202

Subject: Letter of Interest and Financial Commitment for Field-Testing Activities Proposed by the EERC to the U.S. Department of Energy's (DOE) Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program" (Oxidation Systems for Wet FGD)

Dear Mr. Pavlish:

As President of The Coteau Properties Company (Coteau), I am pleased to submit this letter of support and interest to participate in the field-testing activities that are described in Energy & Environmental Research Center (EERC) proposals being submitted under DOE Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program". This proposal is being submitted to address the mercury control needs of the lignite industry entitled "Large-Scale Mercury Control Technology Testing for Lignite-Fired Utilities – Oxidation Systems for Wet FGD".

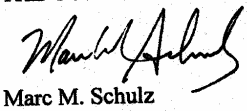
Coteau has a particular interest in this program because we own and operate a mining facility that supplies multiple units firing lignite. Our customers have a critical need to identify mercury control options for their lignite-fired units equipped with an electrostatic precipitator for particulate control as well as for their units currently equipped with combined dry scrubber and reverse-air fabric filter equipment. In addition, in preparation for the possibility of multi-pollutant control legislation (e.g., Clear Skies Initiative), mercury control options are needed for both wet and dry scrubber-based SO_2 control technologies. Based on our current understanding and existing data, mercury emission control in units firing lignite and other western coals with these configurations will prove to be more challenging and require higher costs in comparison to that for other coals. The approaches proposed allow the lignite industry to test whether these low-capital-cost mercury control technologies are feasible options that can be considered for meeting future regulations.

Coteau is pleased to offer support to the proposed program in the form of cash cost share valued at $4,220 for the Oxidation Systems for Wet FGD proposal. It is understood that Coteau funding for this project will provide cost share to Federal funding from DOE; therefore, Coteau hereby certifies that our cost-share funding will be comprised of non-Federal dollars and will not be used as Federal match on any other project.

We hope that DOE gives careful consideration to this program as there is a significant need for field data applicable to lignite coal. Again, we express our support and look forward to working with DOE and the EERC on this project.

Sincerely,

THE COTEAU PROPERTIES COMPANY



Marc M. Schulz
President

MMS:lr

April 3, 2003

Mr. Michael Holmes
Senior Research Manager
Energy & Environmental Research Center
P.O. Box 9018
Grand Forks, ND 58202

Dear Mr. Holmes:

Subject: Letter of Interest and Financial Commitment for Field-Testing Activities Proposed by the EERC to the U.S. Department of Energy's (DOE) Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program" (Oxidation Systems for Wet FGD).

As an authorized representative of Dakota Westmoreland Corporation, I am pleased to submit this letter of support and interest to participate in the field-testing activities that are described in Energy & Environmental Research Center (EERC) proposals being submitted under DOE Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program." This proposal is being submitted to address the mercury control needs of the lignite industry are entitled "Large-Scale Mercury Control Technology Testing for Lignite-Fired Utilities – Oxidation Systems for Wet FGD."

Dakota Westmoreland Corporation has a particular interest in this program because we own and operate the Beulah Mine located south of Beulah, ND. We have a critical need to identify mercury control options for our customers lignite-fired units equipped with an electrostatic precipitator for particulate control, as well as for our units currently equipped with combined dry scrubber and reverse-air fabric filter equipment. In addition, in preparation for the possibility of multipollutant control legislation (e.g., Clear Skies Initiative), mercury control options are needed for both wet and dry scrubber-based SO_2 control technologies. Based on our current understanding and existing data, mercury emission control in units firing lignite and other western coals with these configurations will prove to be more challenging and require higher costs in comparison to that for other coals. The approaches proposed allow the lignite industry to test whether these low-capital-cost mercury control technologies are feasible options that can be considered for meeting future regulations.

Dakota Westmoreland Corporation is pleased to offer support to the proposed program in the form of cash cost share valued at $4,220.00 for the Oxidation Systems for Wet FGD proposal. It is understood that funding for this project will provide cost share to federal funding from DOE; therefore, Dakota Westmoreland Corporation hereby certifies that our cost-share funding will be comprised of nonfederal dollars and will not be used as federal match on any other project.

We hope that DOE gives careful consideration to this program, as there is a significant need for field data applicable to lignite coal. Again, we express our support and look forward to working with DOE and the EERC on this project.

Sincerely,

Douglas J. Davison
Dakota Westmoreland Corporation
Highway 49 S.
P.O. Box 39
Beulah, ND 58523-0039

Minnkota Power
MPC COOPERATIVE, INC.
Your Touchstone Energy® Partner

1822 Mill Road • P.O. Box 13200 • Grand Forks, ND 58208-3200 • Phone (701) 795-4000

March 27, 2003

Mr. Mike Holmes
Senior Research Advisor
Energy & Environmental Research Center
PO Box 9018
Grand Forks, ND 58202

Subject: Letter of Interest and Financial Commitment for Field-Testing Activities Proposed by the EERC to the U.S. Department of Energy's (DOE) Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program" (Oxidation Systems for Wet FGD).

Dear Mr. Holmes:

This letter is to indicate Minnkota Power Cooperative, Inc.'s support and interest to participate in the field-testing activities that are described in the Energy & Environmental Research Center (EERC) proposals being submitted under DOE Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program." This proposal is being submitted to address the mercury control needs of the lignite industry and is entitled "Large-Scale Mercury Control Technology Testing for Lignite-Fired Utilities – Oxidation Systems for Wet FGD."

Minnkota Power Cooperative, Inc has a particular interest in this program because we own and operate multiple units firing lignite. We have a critical need to identify mercury control options for our lignite-fired unit equipped with an electrostatic precipitator for particulate control and a wet scrubber for SO_2 control, along with a unit that has an electrostatic precipitator for particulate control only at this time. In addition, in preparation for the possibility of multipollutant control legislation (e.g., Clear Skies Initiative), mercury control options are needed for both wet and dry scrubber-based SO_2 control technologies. Based on our current understanding and existing data, mercury emission control in units firing lignite and other western coals with these configurations will prove to be more challenging and require higher costs in comparison to that for other coals. The approaches proposed allow the lignite industry to test whether these low-capital-cost mercury control technologies are feasible options that can be considered for meeting future regulations.

Minnkota Power Cooperative, Inc. is pleased to offer support to the proposed program in the form of cash cost share valued at $5,070, for the Oxidation Systems for Wet FGD proposal. It is understood that Minnkota Power Cooperative, Inc. funding for

this project will provide cost share to federal funding from DOE; therefore, Minnkota Power Cooperative, Inc. hereby certifies that our cost-share funding will be comprised of nonfederal dollars and will not be used as a federal match on any other project.

We hope that DOE gives careful consideration to this program, as there is a significant need for field data applicable to lignite coal. Again, we express our support and look forward to working with the DOE and the EERC on this project.

Sincerely,

MINNKOTA POWER COOPERATIVE, INC.

Luther Kvernen

Luther Kvernen
Vice President - Generation

Cc: John Hendrikson, EERC
Harvey Ness, Lignite Energy Council
Karen Thingelstad, Minnkota Power Cooperative, Inc.

Minnkota Power
MPC COOPERATIVE, INC.
Your Touchstone Energy® Partner

1822 Mill Road • P.O. Box 13200 • Grand Forks, ND 58208-3200 • Phone (701) 795-4000

March 27, 2003

Mr. Mike Holmes
Senior Research Advisor
Energy & Environmental Research Center
PO Box 9018
Grand Forks, ND 58202

Subject: Letter of Interest and Financial Commitment for Field Testing Activities Proposed by the EERC to the U.S. Department of Energy's (DOE) Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program." (In-Kind Cost Share for Oxidation Systems for Wet FGD)

Dear Mr. Holmes:

This letter is to indicate Minnkota Power Cooperative, Inc.'s support and interest to participate in the field testing activities that are described in the Energy & Environmental Research Center (EERC) proposal entitled "Large-Scale Mercury Control Technology Testing for Lignite-Fired Utilities – Oxidation Systems for Wet FGD" which is being submitted under the U.S. Department of Energy's (DOE) Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program."

Milton R. Young Unit #2 is of particular interest in this project because it is equipped with an ESP and wet scrubber. Based on our current understanding, this configuration requires oxidation of elemental mercury upstream of the ESP and wet scrubber in order to control mercury. The goal is to test an oxidation technology that can economically and effectively control mercury emissions. The approach proposed allows MRY Unit #2 to test whether a low capital cost mercury control technology targeted to meet moderate mercury reductions is feasible, an option that Minnkota would invest in to meet future regulations. To support this project, Minnkota agrees to provide plant access to the entire project team for testing purposes as defined in the proposal. This would include site access to all organizations described in the proposal, DOE, and any other third party contractor that EERC or DOE feel is appropriate to assess the technology being tested, or to further the goals of the overall DOE mercury program.

Minnkota Power Cooperative is pleased to offer labor, travel expense, and materials in support of the proposed tests as in-kind cost share valued up to $65,000. It is understood that Minnkota's in-kind services for this project will provide cost share to federal funding from the U.S. Department of Energy, therefore Minnkota hereby certifies that our in-kind contribution of up to $65,000 will be comprised of nonfederal dollars.

Additionally, we understand that all in-kind cost share must be allowable under Federal guidelines outlined for commercial organizations. Specific guidelines that will be followed are the Federal Acquisition Regulations (FAR) part 31.2 (Cost Principles for Commercial Organizations) and FAR part 42.7 (Indirect Cost Rates), which prescribe policies and procedures for establishing indirect cost rates.

We hope that the DOE gives careful consideration to this project, as there is a significant need for field data that is applicable to low-rank coals, especially ND lignite. Again, we express our support, and look forward to working with the DOE and EERC on this project.

Sincerely,

MINNKOTA POWER COOPERATIVE, INC.

Luther Kvernen

Luther Kvernen
Vice President-Generation

cc: John Hendrikson, EERC
Harvey Ness, Lignite Energy Council
Karen Thingelstad, Minnkota Power Cooperative, Inc

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April 4, 2003

Mr. Mike Holmes
Senior Research Advisor
Energy & Environmental Research Center
P.O. Box 9018
Grand Forks, ND 58202

RE: Host Site Agreement for EERC Project Under Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program"

Dear Mr. Holmes:

Minnkota Power Cooperative, Inc. supports this proposed effort and, if awarded, commits to act as host site at our Milton R. Young Station for the duration of this project. In addition, Minnkota Power Cooperative, Inc. agrees to provide staff in support of the testing and collection of samples under this work. It is understood that DOE/NETL will be granted the same access to the facility that the applicant is given for the duration of the project. In addition, with prior notice, parties representing DOE or EPA will be given plant access for specific periods of time for QA/QC purposes, verification of results, and/or testing as outlined in the solicitation.

Stuart Libby, Minnkota Power Cooperative, Inc.'s Plant Manager-Operations, is serving as project manager for our large-scale mercury test programs. Please coordinate these test programs with Stuart at 701/794-7215 or slibby@minnkota.com.

Again, we express our support and look forward to working with DOE and the EERC on this project.

Sincerely,

MINNKOTA POWER COOPERATIVE, INC.

John T. Graves

John T. Graves, P.E.
Environmental Manager

c: Luther Kvernen
Stuart Libby
Kevin Thomas

TXU Energy
1601 Bryan, 16th Floor
Dallas, TX 75201
Tele: 214-812-8574
Fax: 214-812-3620
e-mail: skopeni1@txu.com

Steve Kopenitz
Vice President
Lignite Plant Operations

April 4, 2003

Mr. Mike Holmes
Senior Research Advisor
Energy & Environmental Research Center
PO Box 9018
Grand Forks, ND 58202

Dear Mr. Holmes:

Subject: Letter of Interest and Financial Commitment for Field-Testing Activities Proposed by the EERC to the U.S. Department of Energy's (DOE) Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program"

TXU Energy is pleased to submit this letter of support and interest to participate in the field-testing activities that are described in Energy & Environmental Research Center (EERC) proposals being submitted under DOE Solicitation No. DE-PS26-03NT41718, "Large Scale Mercury Control Technology Field Testing Program." The proposal being submitted to address the mercury control needs of the lignite industry are entitled "Large-Scale Mercury Control Technology Testing for Lignite-Fired Utilities – Oxidation Systems for Wet FGD."

TXU Energy has a particular interest in this program because we operate multiple units firing Texas lignite. Our Monticello Steam Electric Station offers an ideal location for testing a Texas lignite-fired plant equipped with an ESP and wet flue gas desulphurization (FGD) system (Unit 3). TXU Energy continues to work with EPRI to evaluate potential mercury control strategies and we believe that the flue gas oxidation approaches described in this proposal provides a promising approach for enhancing removal across an existing wet scrubber.

TXU Energy supports this proposed effort and, if awarded, commits to act as host site for the duration of this project. In addition, TXU Energy agrees to provide staff in support of the testing and collection of samples under this work. It is understood that DOE/NETL will be granted the same access to the facility that the applicant is given for the duration of the project. In addition, with prior notice, parties representing DOE or EPA will be given plant access for specific periods of time for QA/QC purposes, verification of results, and/or testing as outlined in the solicitation. The site will be accessible to the project team during the period of the testing. We shall also work with EPRI to meet the cash cost share requirements as detailed in EPRI's commitment letter. We share your enthusiasm for this project and look forward to working together with the project team and DOE to evaluating this mercury control approach.

Sincerely,

Steve Kopenitz

cc: Ramsay Chang, EPRI