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March 30, 2012

Ms. Karlene Fine
Executive Director
North Dakota Industrial Commission
State Capitol – 14th Floor
600 East Boulevard Avenue, Department 405
Bismarck, ND 58505-0840

Dear Ms. Fine:

Subject: EERC Proposal No. 2012-0178 Entitled "Demonstration of Multipollutant Reduction Using a Lextran 3-in-1 Wet Scrubber"

The Energy & Environmental Research Center (EERC) of the University of North Dakota is pleased to submit the subject proposal. Enclosed please find an original and one copy of the proposal entitled "Demonstration of Multipollutant Reduction Using a Lextran 3-in-1 Wet Scrubber." Also enclosed is the $100 application fee. The EERC is committed to completing the project as described in this proposal if the Commission makes the requested grant.

If you have any questions, please contact me by telephone at (701) 777-5260 or by e-mail at jalmlie@undeerc.org.

Sincerely,

Jay C. Almlie
Senior Research Manager

Approved by:

Dr. Gerald H. Groenewold, Director
Energy & Environmental Research Center

JCA/kal

Enclosures

EERC
Energy & Environmental Research Center

DEMONSTRATION OF MULTIPOLLUTANT REDUCTION USING A LEXTRAN 3-IN-1 WET SCRUBBER

EERC Proposal No. 2012-0178

Submitted to:

Karlene Fine

North Dakota Industrial Commission
600 East Boulevard Avenue
State Capitol, 14th Floor
Bismarck, ND 58505-0840

Amount of Request: $67,200
Total Amount of Proposed Project: $199,050
Duration of Project: 10 months

Submitted by:

Jay C. Almlie

Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
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Jay C. Almlie, Project Manager

Dr. Gerald H. Groenewold, Director
Energy & Environmental Research Center

March 2012

UND University of North Dakota Grand Forks

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ABSTRACT

Lextran and the Energy & Environmental Research Center (EERC) propose herein to complete the first of two phases of work required to prove the value of the Lextran 3-in-1 technology in lignite-fired utilities. This goal of this first phase is to complete pilot-scale testing at the EERC to demonstrate the technology to Lextran's first North Dakota industrial partner, Great River Energy. Phase I will characterize the performance of Lextran's 3-in-1 technology in low-sulfur lignite flue gases and evaluate the impact on plant operation. Specifically, the test team will evaluate the emission reduction performance on sulfur oxides (SO_x), nitrogen oxides (NO_x), and mercury (Hg) levels in a representative lignite flue gas. The EERC will also seek out additional North Dakota interests to facilitate Phase II field demonstration activities.

The Lextran 3-in-1 technology purports to address three needs: cost-effective hazardous air pollutant removal, no secondary pollution or waste disposal, and recyclable commercially valuable by-products in one single process pass. The Lextran technology may enable the absorption of the following pollutants from flue gases in one single pass:

- SO_x – removal of 99%, unconditional of entrance concentration.
- NO_x – removal of up to 90% of entrance concentration.
- Hg – removal of 98% of elemental and oxidized Hg.

The estimated cost for the 10-month project is $199,050. Of this amount, the EERC requests $67,200 from the North Dakota Industrial Commission, with the remaining amount of $67,200 to be provided by industry in the form of cash and in-kind cost share. The industry cost-share match is anticipated to come from Lextran, Great River Energy, and the EERC. In addition the EERC will seek approval from the U.S. Department of Energy for the remaining $64,650.

DEMONSTRATION OF MULTIPOLLUTANT REDUCTION USING A LEXTRAN 3-IN-1 WET SCRUBBER

PROJECT SUMMARY

Lextran has developed a unique 3-in-1 gas-cleaning technology that uses a Lextran liquid catalyst to simultaneously capture NO_x, SO_x, and mercury within a conventional wet scrubber. The proprietary Lextran catalyst contains an active sulfur–oxygen functional group that will enhance the oxidation reactions of SO_x and NO_x into SO_4 and NO_3 anions. After facilitating the initial oxidation, the Lextran catalyst is released and recycled back into the process. With the addition of ammonia, KOH, or other basic reagents, the captured SO_x and NO_x is reformed into beneficial fertilizer by-products such as ammonium nitrate, ammonium sulfate, potassium sulfate, and potassium nitrate. Regarding Hg and heavy metals, the Lextran catalyst is expected to act as a reagent, forming a very strong complex with the metals while the catalytic properties for the SO_x and NO_x removal are expected to not be affected by the reactions.

Although demonstrated previously for SO_x/NO_x/Hg capture, this technology has not been evaluated in a North Dakota utility plant or in a North Dakota lignite flue gas stream. Considering the fact that the U.S. utility industry is extremely cautious when applying a brand-new technology, the EERC, therefore, proposes a two-phase approach to demonstrate this unique gas-cleaning technology. The focus of this proposal is on Phase I, which will perform pilot-scale combustion tests to evaluate the effectiveness of this 3-in-1 gas-cleaning technology in typical U.S. coal flue gas conditions. Phase II will be a consortium-supported field demonstration, which will be presented in a separate document. The project results from Phase I should provide Lextran with valuable data regarding its technology's performance in capturing SO_2 (sulfur dioxide), NO_x and Hg—data applicable to U.S. utility plants.

The EERC proposes to conduct pilot-scale combustion testing at the EERC to evaluate the performance of the 3-in-1 wet scrubber technology on multipollutant reduction in lignite-fired flue gas conditions. The EERC has an extensive background and expertise in testing and developing pollution control technologies for coal-fired power plants and similar industries. EERC personnel are highly experienced in conducting these types of tests and determining what factors are critical to success. This experience, along with existing pilot test facilities, makes the EERC uniquely qualified to conduct the proposed test program.

Lextran and the EERC envision two phases of work required to prove the value of the Lextran 3-in-1 technology in lignite-fired utilities. The first phase, the phase proposed herein, is to complete pilot-scale testing at the EERC to demonstrate the technology to Lextran's first North Dakota industrial partner, Great River Energy. The overall goal of Phase I is to characterize the performance of Lextran's 3-in-1 technology in low-sulfur lignite flue gases and evaluate the impact on plant operation. Specifically, the test team will evaluate the emission reduction performance on SO_x, NO_x, and Hg levels in a representative flue gas. The EERC will also seek out additional North Dakota interests to facilitate Phase II field demonstration activities.

Phase I will include three tasks. The first task will be to prepare an existing EERC pilot-scale test unit for use with the Lextran technology. The second task will encompass the actual weeklong test effort and data reduction and analysis efforts. The third task will be defined as all management and reporting activities required to adequately complete the project and disseminate results to pertinent North Dakota interests.

It is anticipated that this project would be completed in 10 months, starting with test preparation activities leading to a weeklong test. Data reduction and reporting activities would complete the project. A total project cost of approximately $199,050 is anticipated. Participants with financial vestment would include Lextran, NDIC, DOE, and Great River Energy.

PROJECT DESCRIPTION

The EERC proposes to conduct pilot-scale combustion testing at the EERC to evaluate the performance of the 3-in-1 wet scrubber technology on multipollutant reduction in lignite-fired flue gas conditions. The EERC has an extensive background and expertise in testing and developing pollution control technologies for coal-fired power plants and similar industries. EERC personnel are highly experienced in conducting these types of tests and determining what factors are critical to success. This experience, along with existing pilot test facilities, makes the EERC uniquely qualified to conduct the proposed test program.

Test Goal and Objectives

The overall goal of the project is to characterize the performance of Lextran's 3-in-1 technology on multipollutant removals in North Dakota lignite flue gases, while multipollutants of interest include SO_x, NO_x, HCl, and Hg.

Specific objectives of the proposal are the following:

1. Establish >90% SO_2 removals with Lextran technology across an electrostatic precipitator (ESP)/wet scrubber and a fabric filter (FF)/wet scrubber in a North Dakota lignite flue gas.
2. Establish 60%–90% NO_x removals with Lextran technology across an ESP/wet scrubber and a FF/wet scrubber in a North Dakota lignite flue gas.
3. Quantify removal efficiencies of HCl, and Hg, with Lextran technology across an ESP/wet scrubber and a FF/wet scrubber in a North Dakota lignite flue gas.

4. Characterize SO_3 emissions with Lextran technology across an ESP/wet scrubber and a FF/wet scrubber in a North Dakota lignite flue gas.
5. Determine the optimum operating condition of Lextran's technology for multipollutant capture in a North Dakota lignite flue gas.
6. Compare Lextran's technology with lime-based wet scrubber technology in a North Dakota lignite flue gas.

Test Facility

The major equipment to be used for these tests includes the following:

- Pulverized coal (pc)-fired combustor
- ESP
- Pulse-jet FF
- Modified Lextran wet scrubber
- Sampling equipment

The pilot-scale combustor to be used for the project, known as the particulate test combustor (PTC), is a 550,000-Btu/hr pc-fired unit. A suite of different air pollution control devices, including an ESP, a FF, selective catalytic reduction (SCR), and wet/dry scrubbers, are available for the testing. The wet scrubber is of interest to Lextran and will be modified to accommodate any changes required by Lextran's wet scrubber. Since ESPs and FFs are widely used in U.S. utility plants, both will be used during the pilot-scale testing to evaluate the tolerance of Lextran's technology to particulate matter. A schematic of the combustion facility is shown in Figure 1. The entire system is designed to generate flue gas and fly ash representative of that produced in a full-scale utility boiler. The time–temperature profile of the pilot unit is typical of that of a full-scale system.

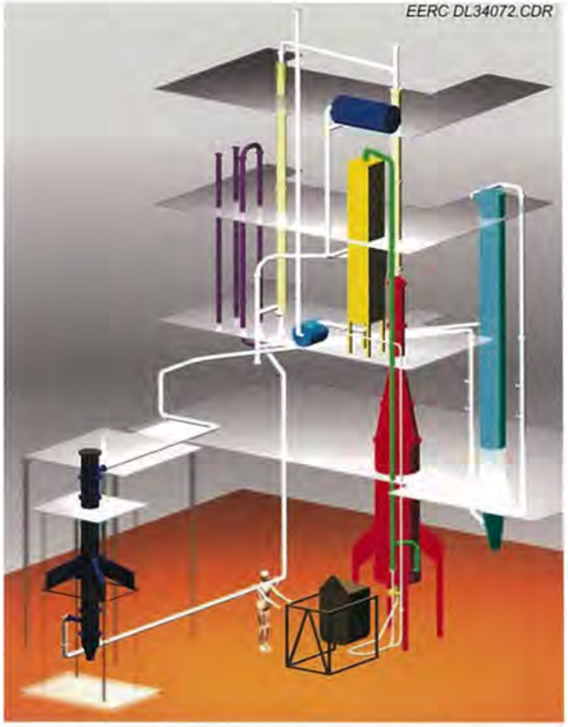


Figure 1. Schematic of the pilot-scale combustion facility.

PTC instrumentation permits system temperatures, pressures, flow rates, flue gas constituent concentrations, and operating data to be monitored continuously and recorded by the unit's data acquisition system. Flue gas samples can be taken and analyzed at a number of locations, including the outlet of the combustor and the inlet and outlet of pollution control devices. After the flue gas passes through sample conditioners to remove the moisture, the standard set of instrumentation allows for analysis of O_2, CO, CO_2, SO_2, and NO_x. NO_x is determined using a pair of Rosemount Analytical NO_x chemiluminescent analyzers. SO_2 is measured using a pair of Ametek Instruments photometric gas analyzers. The remaining gases are measured by a pair of Rosemount Analytical multigas continuous emission monitors. Each of these analyzers is regularly calibrated and maintained to provide accurate flue gas concentration measurements.

For all tests, the flue gas will route through a series heat exchanger followed by a particulate control device, which can be either an ESP or a FF. The ESP (single-wire, tubular) is designed to provide a specific collection area of 125 square feet per 1000 actual cubic feet per minute (acfm) of flue gas at 300°F. Since the flue gas flow rate for the PTC is 200 acfm at 300°F, the gas velocity through the ESP is 5 ft/min. The plate spacing for the unit is 11 in. The FF vessel is a 20-in.-i.d. chamber that is heat-traced and insulated, with the flue gas introduced near the bottom. Three 13-ft by 5-in. FF bags provide an air-to-cloth ratio of 4 ft/min. Each bag is cleaned separately with its own diaphragm pulse valve. In order to quantify differences in pressure drop for different test conditions, the bags are typically cleaned on a time basis. The fly ash-free flue gas is then introduced into the wet scrubber where the Lextran liquid catalyst is circulated to capture $NO_x/SO_x/Hg$.

The unit starts with an 8-hr heatup period on gas and then with steady-state operation firing coal. The unit will be operated by engineers and operators around the clock to ensure stable operation and provide valid measurement. The pilot unit has consistently been shown to produce the expected concentrations of SO_x, NO_x, HCl, Hg, and other trace elements in flue gas based on coal analysis. The resulting partitioning of different air pollutants is proven to be similar to that of full-scale utility boilers that burn the same type of coal.

Scope of Work

Task 1 – Experimental System Setup. With assistance from Lextran, the EERC will modify its existing wet scrubber to accommodate Lextran's 3-in-1 technology. An existing EERC spray wet scrubber will be converted to a packed tower where standard packings will be used for gas absorption. After the unit is modified, the packed tower will be functionally tested to determine the operational parameters required to attain the levels of mass transfer representative of full scale wet scrubber application.

An ozone injection system will be installed upstream of the packed-gas absorption tower for NO oxidation. Ozone will be injected into the flue gas at three different locations to attain residence times varying from 1 second to 3 seconds prior to the packed scrubber. The ozone injection rate will also be parametrically varied to achieve overall 60%–90% NO_x reduction across the combustion system. A filter assembly and a phase separator may also be added to ensure the proper operating conditions. Two additional pumps will be attached to the scrubber for feeding 25% NH_4OH and Lextran's makeup emulsion catalyst, respectively.

Task 2 – Pilot-Scale Experiments. Table 1 lists the test matrix that will be completed during the 1-week pilot-scale combustion experiment.

Test I is designed to evaluate the performance of Lextran's technology in a FF/wet scrubber application. The 25% NH_4OH containing Lextran's emulsion catalyst will be circulated through the packed absorber while the fluid flow rate will be tuned to reach 90% SO_2 reduction across the scrubber. Ozone will be used as NO oxidant and will be injected into the flue gas upstream of the scrubber at three different locations equivalent to residence times of 1 s, 2 s, and 3 s, respectively. The objective is to characterize the effect of residence time on NO oxidation and subsequent capture with a wet scrubber in lignite flue gas. Under each injection location, the ozone injection rate will also be parametrically varied to achieve overall 60%–90% NO_x reduction across the combustion system.

The EERC will measure O_2, CO, CO_2, SO_2, and NO_x at the combustor outlet and Lextran's scrubber outlet during the testing period. Removals of SO_2 and NO_x will be obtained by comparing measured emissions of SO_2 and NO_x at the scrubber outlet with corresponding

Table 1. Test Matrix

Test No.	APCDs[a]	Scrubber Fluid	NO Oxidant	NO Oxidant Injection: Residence Time[b], s	NO Oxidant Injection: Injection Rate[c]	Online Sampling	Wet Chemistry Sampling
I-1	FF/wet scrubber	Lextran emulsion catalyst	O_3	1	TBD[d]	SO_2 NO_x HCl	1 SO_3 at scrubber outlet 1 M29[e] at scrubber inlet 1 M29 at scrubber outlet
I-2	FF/wet scrubber			2	TBD		
I-3	FF/wet scrubber			3	TBD		
II-1	ESP/wet scrubber	Lextran emulsion catalyst	O_3	1	TBD	SO_2 NO_x HCl	1 SO_3 at scrubber outlet 1 M29 at scrubber inlet 1 M29 at scrubber outlet
II-2	ESP/wet scrubber			2	TBD		
II-3	ESP/wet scrubber			3	TBD		
III-1	FF/wet scrubber	Lime slurry	NA	NA	NA	SO_2 NO_x HCl	1 SO_3 at scrubber outlet 1 M29 at scrubber inlet 1 M29 at scrubber outlet
III-2	ESP/wet scrubber		NA	NA	NA		

[a] Air pollution control devices.
[b] The time of O_3 in flue gas prior to reaching the wet scrubber.
[c] The injection rate will be varied with the tentative goal of attaining 60%, 75%, and 90% NO_x reduction across the system, respectively.
[d] To be determined.
[e] U.S. Environmental Protection Agency (EPA) Method 29.

concentrations of SO_2 and NO_x measured at the combustor outlet. As HCl is also regulated by the EPA under the proposed utility MACT (maximum achievable control technology) rule, an online HCl analyzer (Thermo 15C) will be set up at the outlet of the scrubber to monitor HCl emissions. The removals of HCl will be determined by calculating the difference between estimated HCl in flue gas-based chlorine content in coal and measured HCl emissions at the scrubber outlet. SO_3 has been a concern for U.S. utility plants and oxidants such as the O_3 used in the Lextran 3-in-1 scrubber could also induce additional SO_3 formation. Therefore, a condensation sampling will be conducted at the outlet of the Lextran scrubber to characterize SO_3 emission during the test.

Since ESPs and FFs are widely used in North Dakota utility plants, Test 2 will be performed in an ESP/wet scrubber scenario, the purpose of which is to further evaluate the tolerance of Lextran's technology to particulate matter. Detailed test conditions and related sampling activities are listed in Table 1.

Flow rate and temperature of flue gas and scrubber fluid will be continuously monitored at both the inlet and outlet of the scrubber during the entire testing period to ensure optimum operating conditions. Pressure drop across the scrubber will be monitored as well. Meanwhile, scrubber fluid will be collected at the inlet and outlet of the scrubber, and respective samples will be analyzed for total sulfur, nitrate, and Hg. Combining analysis results of flue gas and scrubber fluid, a comprehensive evaluation can be conducted to characterize mass transfer of SO_2/NO_x/Hg from bulk gas to scrubber fluid across Lextran's scrubber.

Having completed Tests I and II, the scrubber fluid will be switched to conventional lime-based slurry, while both an ESP and FF will be used as particulate matter control devices, respectively. The purpose of Test III is to obtain a complete set of hazardous air pollutant (HAP) data of SO_x, NO_x, HCl, Hg, across the lime-based wet scrubber and further establish reference removals of multipollutants of SO_2, NO_x, and Hg across a lime-based wet scrubber in a North Dakota lignite flue gas. Flue gas sampling conducted will be similar to that in Tests I and II. The results will be compared with results of Tests I and II.

Task 3 – Project Management and Reporting. Data reduction and reporting activities will begin as soon as the tests are completed. A final technical report will be prepared and delivered to NDIC, Lextran, Great River Energy, and DOE at the end of the project. With agreement from participating partners, the EERC may also reach out to the U.S. utility industry with the testing results and seek sponsorship for the Phase II field demonstration.

Economic and Technological Impacts

The Lextran 3-in-1 technology purports to address three needs: cost-effective HAPs removal, no secondary pollution or waste disposal, and recyclable commercially valuable by-products in one single process pass. The Lextran technology may enable the absorption of the following pollutants from flue gases in one single pass:

- SO_x – removal of 99%, unconditional of entrance concentration.
- NO_x – removal of up to 90% of entrance concentration.
- Hg – removal of 98% of elemental and oxidized Hg.

Lextran projects that the 3-in-1 technology may offer a 50% reduction in operational costs and 40% reduction in capital costs versus traditional flue gas desulfurization facilities. The Lextran 3-in-1 process may introduce a dramatic savings compared with traditional dedicated facilities, which have to be implemented sequentially. Once the investment in an open-spray tower has been made, treating NO_x and Hg are virtually free. Integrating the three processes into one project and structure provides significant cost savings over treating the units separately and optimizes the use of space. Acceptance of the Lextran technology to achieve multipollutant control could help reduce the operating expenses of utilities, create North Dakota-based jobs in order to integrate the technology into existing utility plants, and create North Dakota-based jobs related to the production of salable by-products resulting from this process. The Lextran technology promises to convert the current gypsum-producing wet scrubber process, which amounts to a disposal expense for utilities because of the flooded gypsum market, into a revenue generator for utilities, as this technology produces fertilizer components as a by-product.

Need for Project

North Dakota utilities fired with lignite currently face a difficult NO_x emission control challenge. Traditional SCR technologies do not function adequately with the high-sodium, high-ash lignite fuel. The SCRs tend to blind easily in lignite flue gas, thus negating any potential of the SCR to control NO_x emissions. Despite this challenge, recent actions by EPA have imposed even tighter NO_x control regulations on North Dakota utilities, leaving them in need of advanced NO_x control technologies that do not depend upon dirty-side SCR technologies. Lextran's 3-in-1 technology may provide a viable alternative worth investigation.

STANDARDS OF SUCCESS

Success of this project will be determined by the ability of the Lextran–EERC team to complete a prescribed test matrix and obtain data that validates the claims put forth by Lextran regarding multipollutant control potential of the technology. If the Lextran 3-in-1 technology is able to demonstrate SO_x control equivalent to current flue gas desulfurization technology while simultaneously greatly improving NO_x control and addressing Hg control, the demonstration will be successful and enticing to North Dakota utilities.

BACKGROUND

A variety of environmental concerns, including ground-level ozone, formation of acid rain, acidification of aquatic systems, forest damage, degradation of visibility, and formation of fine particles in the atmosphere, are associated with emissions of SO_2 and NO_x [1, 2]. Hg has recently become another air pollutant that needs to be regulated under the new EPA emission rule.

Extensive research has been performed over the years, and several technologies have been developed specifically for NO_x, SO_2, and Hg, respectively. Wet/dry lime-based scrubber technologies have been in commercial operation. While the technology can reduce SO_2

emissions to meet existing and pending regulations, most of the by-products have become solid waste. These solid wastes present additional disposal concerns, which impose a cost to the utility industry.

Among existing de-NO_x technologies that are commercially available, combustion-based de-NO_x technologies are applicable to North Dakota utility plants but provide less than 50% NO_x reduction with undesirably high levels of unburned carbon and CO. On the other hand, an SCR that can provide ~90% NO_x removal is not applicable to lignite-fired utility plants, mainly because of high contents of alkali and alkaline-earth metal. This leads to excessive blinding in SCR systems, as observed at some North Dakota plants (1). The alkali and alkaline-earth-rich oxides generated from lignite combustion react with flue gas to form sulfates and possibly carbonates, which cause low-temperature deposition, blinding, and plugging problems in SCR systems (2). Activated carbon injection is now considered to be the most appropriate commercially available technology for Hg reduction.

Each individual pollutant has, to date, required a specific control strategy, which imposes significant financial stress to the utility industry. Cost-effective multipollutant control technologies are urgently needed for companies burning lignite to meet both state and federal NO_x control regulations. These technologies also need to be designed with economic sustainability in mind.

Lextran has developed a unique 3-in-1 gas-cleaning technology that uses a Lextran liquid catalyst to simultaneously capture NO_x, SO_x, and Hg within a conventional wet scrubber. The proprietary Lextran catalyst contains an active sulfur–oxygen functional group that will enhance the oxidation reactions of SO_x and NO_x into SO_4 and NO_3 anions. After facilitating the initial oxidation, the Lextran catalyst is released and recycled back into the process. With the addition of ammonia, KOH, or other basic reagents, the captured SO_x and NO_x is reformed into beneficial fertilizer by-products such as ammonium nitrate, ammonium sulfate, potassium sulfate, and potassium nitrate. Regarding Hg and heavy metals, the Lextran catalyst is expected to act as a reagent, forming a very strong complex with the metals while the catalytic properties for the SO_x and NO_x removal are expected to not be affected by the reactions. The process described here is also represented pictorially in Figure 2.

Although demonstrated previously for SO_x/NO_x/Hg capture, this technology has not been evaluated in a U.S. utility plant or in a typical U.S. coal flue gas stream. Considering the fact that the U.S. utility industry is extremely cautious when applying a brand-new technology, the EERC, therefore, proposes a two-phase approach to demonstrate this unique gas-cleaning technology. The focus of this proposal is on Phase I, which will perform pilot-scale combustion tests to evaluate the effectiveness of this 3-in-1 gas-cleaning technology in typical U.S. coal flue

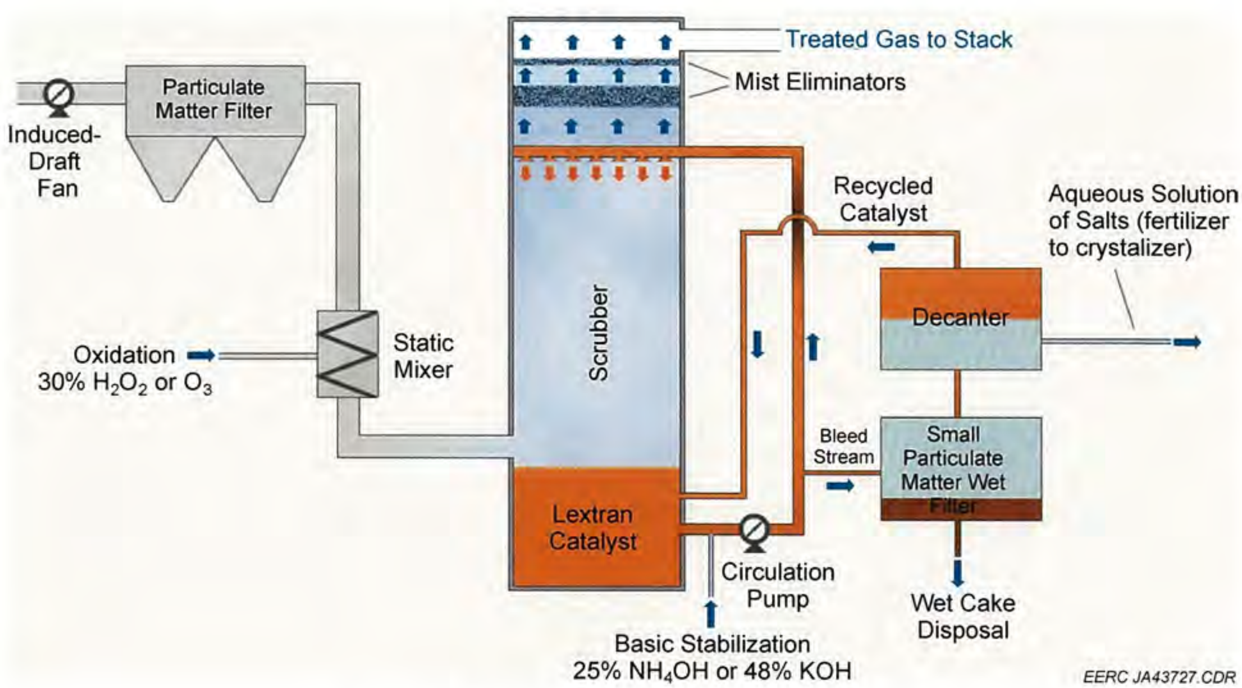


Figure 2. Lextran 3-in-1 process diagram.

gas conditions. Phase II will be a consortium-supported field demonstration, which will be presented in a separate document. The project results from Phase I should provide Lextran with valuable data regarding its technology's performance in capturing SO_2, NO_x, and Hg—data applicable to U.S. utility plants.

QUALIFICATIONS

The EERC team has extensive knowledge of reduction mechanisms of NO_x, SO_2, Hg, and other HAPs. As summarized in Table 2, EERC researchers routinely perform pilot-scale experiments to characterize NO_x reduction with overfire air and SCR technology, SO_2 reduction with dry/wet scrubber and dry sorbent injection, and Hg and other trace metal reduction with activated carbon and chemical additives. The EERC has also actively pursued multipollutant reduction technologies. EERC researchers have investigated NO oxidation mechanisms using H_2O_2 and/or chlorite compounds with subsequent capture by scrubbers. The EERC has developed a robust understanding of physical/chemical constraints in NO oxidation in postcombustion flue gas. The EERC has also previously investigated mercury capture enhancement technology across a wet flue gas desulfurization system (3). The EERC also holds a patent on multipollutant reduction (4).

This extensive base of experience will facilitate the implementation of the Lextran technology in the proposed pilot-scale combustion study.

VALUE TO NORTH DAKOTA

North Dakota utilities are confronted with mounting regulatory pressures from EPA and others to further limit NO_x emissions from lignite-fired boilers. North Dakota utilities have repeatedly argued that traditional SCR technologies do not work well with North Dakota lignite flue gases

Table 2. A Small Sample of EERC Synergistic Research Activities for Project Team

Relevance	Project	Report Date
NO_x Control	Impact of Lignite Properties on Powerspan's NO_x Oxidation System	2/08
NO_x Control	CEPS[a] Testing of Elk Land Holdings' Coals to Compare NO_x and SO_2 Emission Performance	2/08
NO_x Control	Long-Kiln NO_x Reduction Study	9/08
Multipollutant Control	Assessment of Illinois Basin Coal Pretreatment for Mercury and NO_x Reduction in a Circulating Fluidized-Bed Combustor	8/11
Multipollutant Control	Reduction of Acid Gases of HCl, SO_2, and NO_x using Sorbent in Low-Sulfur Coal Flue Gases	2/12
NO_x Control	SCR Catalyst Performance in Flue Gases Derived from Subbituminous and Lignite Coals	2005
Multipollutant Control	Pilot-Scale Study of Mercury Capture Enhancement Across Wet FGD[b] Systems	
Multipollutant Control	Multifunctional Abatement of Air Pollutants in Flue Gas	
SO_3 Control	Evaluation of Aerosol Emissions Downstream of an Ammonia-Based SO_2 Scrubber (evaluation of a wet ESP for reducing SO_3 aerosol emissions)	6/02
Multipollutant Control	Evaluation of Sorbents for SO_2 Control, Mercury Control, and Ash Fouling	3/05
Multipollutant Control	CTF[c] Testing of Additives for SO_2, NO_x, and Hg Reduction	1/09

[a] Conversion and environmental process simulator.
[b] Flue gas desulfurization.
[c] Combustion test facility.

because of the high ash levels and high sodium levels in the coal. The high levels of ash and sodium tend to quickly and permanently blind the SCR catalyst. Despite these logical arguments, EPA pressures continue.

North Dakota utilities are now confronted with both near-term and long-term targets for NO_x reduction. NO_x reduction is of immediate concern to regulatory agencies, but forward-looking utilities are anticipating further pressures in the 2018 timeframe. Thus, proactive North Dakota utilities are considering research and development of "over-the-horizon" types of advanced multipollutant control technologies that can help them economically and simultaneously address SO_x, NO_x, particulate matter, and Hg emissions years in the future.

This project is one avenue of pursuit of these types of "over-the-horizon" projects. Successful demonstration of this technology could pave the way for its rapid commercialization and could achieve economic and emission control performance benefits for North Dakota utilities. Great River Energy could be an early adopter of this technology, if proven successful. An economical multipollutant control technology such as that offered by Lextran could enable Great River Energy and other utilities to continue utilization of the vast North Dakota lignite resource in the face of mounting regulatory pressures. In fact, advanced multipollutant technologies could eventually increase demand for this low-rank fuel, thus creating new jobs and increased revenues for North Dakota interests.

With NDIC funding, data developed during the course of this project will be made available to other North Dakota utilities interested in this pathway for multipollutant control.

MANAGEMENT

Mr. Jay Almlie will be responsible for overall project management. Dr. Ye Zhuang will serve as principal investigator. Mr. Michael Holmes will serve as a project advisor.

Jay C. Almlie is a Senior Research Manager in Environmental Technologies at the EERC, where he is involved in mercury control in coal-derived flue gases, emission control for diesel systems, flue gas filter media development, industrial-scale hydrogen generation systems, and natural gas/natural gas liquids technology development. Mr. Almlie's principal areas of interest and expertise include particle capture in ESPs, data acquisition and control systems, thermal control systems, and hydrogen generation systems. He has authored and coauthored several professional publications.

Dr. Ye Zhuang is a Research Manager at the EERC, where he develops and manages various research projects focused on air toxic metals, emission control technologies, biomass utilization, and technical and economic evaluation of various emission control systems. Dr. Zhuang's principal areas of interest and expertise include air pollution control with an emphasis on particulate, SO_3, CO_2, and Hg emissions. He has authored or coauthored numerous professional publications.

Mr. Michael J. Holmes is a Deputy Associate Director for Research at the EERC, where he currently oversees fossil energy research areas. Mr. Holmes' principal areas of interest and expertise include emission control; fuel processing; production of syngas for coproduction of hydrogen, power, fuels, and chemicals; and process development and economics for advanced energy systems. Mr. Holmes has extensive experience in the development of emission control technologies, including particulate control, SO_2, NO_x, trace metals, and CO_2.

Figure 3 provides an overview of the project management structure. Resumes for key personnel can be found in Appendix A.

TIMETABLE

The proposed work will begin in earnest after receiving approval from NDIC and DOE. The testing will occur as soon as contract and project logistics allow. A summary of the proposed timetable is shown in Figure 4.

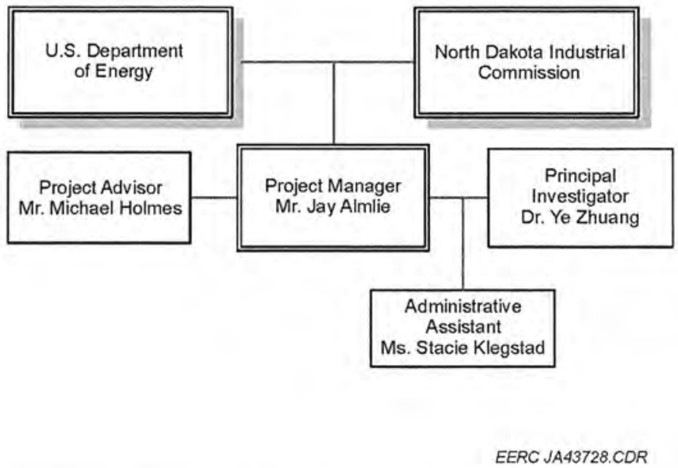


Figure 3. Overview of management structure.

Figure 4. Project timetable.

BUDGET

The total budget for the proposed scope of work is $199,050. This budget is shown in Table 3.

NDIC cofunding is being sought to significantly leverage limited funding available from Lextran, DOE, and various North Dakota utilities for a forward-looking project such as that being proposed. If NDIC funding at the level suggested in the budget summary is not available or is not granted, the EERC will not continue to pursue the project. All partners suggested in the budget must invest if this project is to proceed. The scope of work cannot be scaled back to achieve a lower budget target.

MATCHING FUNDS

The total cost of the project is $199,050. The amount requested from the NDIC is $67,200. Matching funds in the form of cash will be provided as follows: DOE = $64,650 and Great River

Table 3. Budget by Tasks, US$

Project Associated Expense	NDIC's Share	EERC DOE Share	Industry Sponsor's Share	Total Project
Labor	$63,288	$45,400	$17,406	$126,094
Travel	–	$5,296	–	$5,296
Supplies	$3,591	$5,780	$6,162	$15,533
Communication	$171	$429	$160	$760
Printing & Duplicating	$150	$405	$208	$763
Food – Partner Meetings	–	–	$800	$800
Fuels & Materials Research Lab	–	–	$1,230	$1,230
Analytical Research Lab	–	$1,839	$5,174	$7,013
Combustion Test Services	–	–	$15,805	$15,805
Particulate Analysis	–	$786	$5,483	$6,269
Fuel Prep and Maintenance	–	–	$1,478	$1,478
Graphics Support	–	$1,715	–	$1,715
Shop & Operations Support	–	–	$2,294	$2,294
Freight	–	$3,000	–	$3,000
Noncash Cost Share	–	–	$11,000	$11,000
Total Project Cost	$67,200	$64,650	$67,200	$199,050

Energy = $25,000. A combination of cash and in-kind matching funds totaling $42,200 will be provided by Lextran. Further budget justification can be found in Appendix B. Letters of commitment can be found in Appendix C.

TAX LIABILITY

The EERC does not have an outstanding tax liability owed to the state of North Dakota or any of its political subdivisions.

CONFIDENTIAL INFORMATION

There is no confidential information contained in this proposal.

REFERENCES

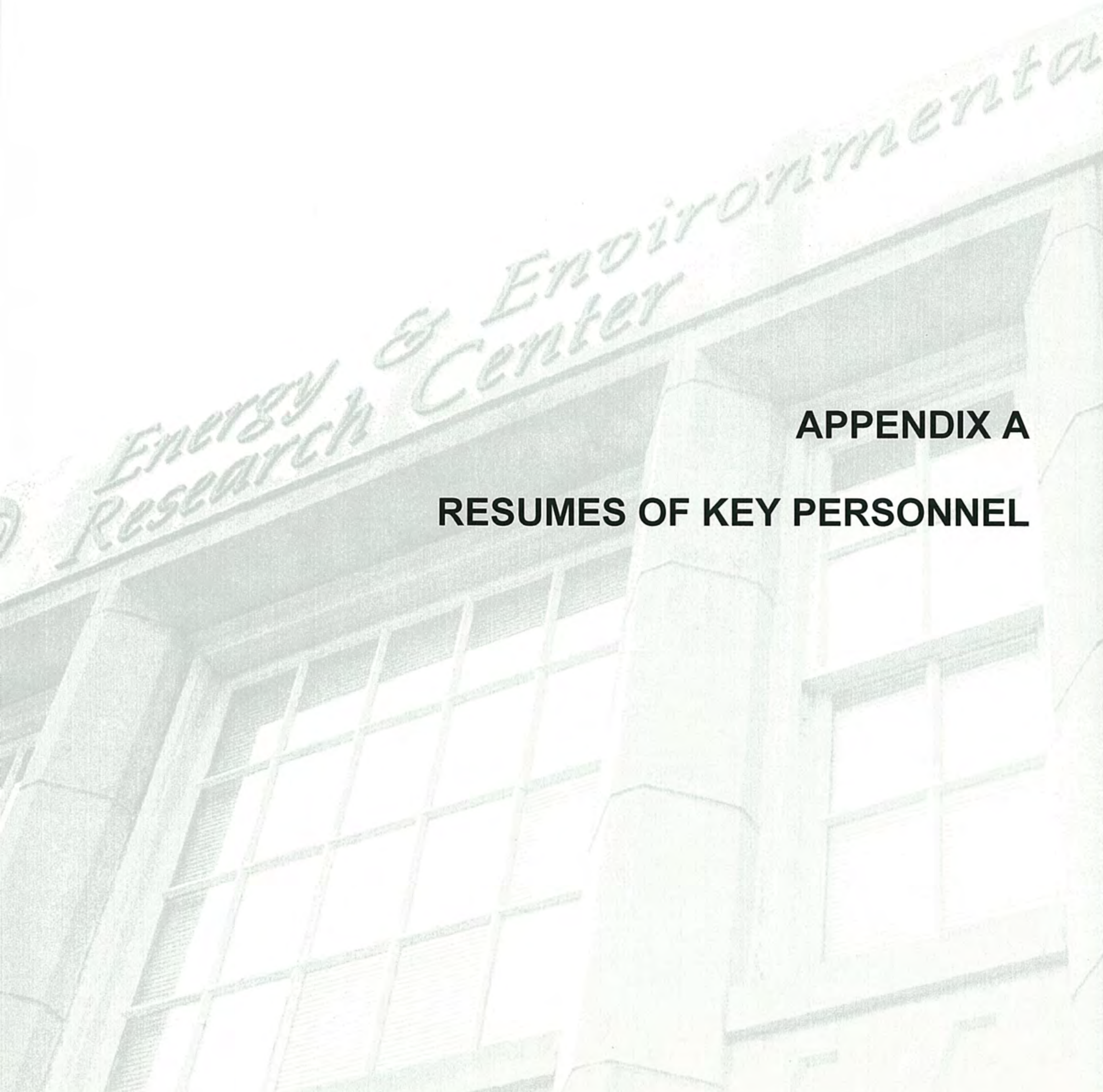
1. Srivastava, R.K.; Hall, R.E.; Khan, S.; Culligan, K.; Lani, B.W. Nitrogen Oxides Emission Control Options for Coal-Fired Electric Utility Boilers. *J. Air & Waste Manage. Assoc.* **2005**, *55*, 1367–1388.

2. Benson, S.A.; Laumb, J.D.; Crocker, C.R.; Pavlish, J.H. SCR Catalyst Performance in Flue Gases Derived from Subbituminous and Lignite Coals. *Fuel Process. Technol.* **2005**, *86*, 577–613.

3. Martin, C.L.; Zhuang, Y.; Pavlish, J.H.; Botha, F. Pilot-Scale Study of Mercury Capture Enhancement Across Wet FGD Systems. In *Proceedings of Air Quality VII: An International Conference on Carbon Management, Mercury, Trace Substances, SO_x, NO_x, and Particulate Matter*; Arlington, VA, Oct 26–29, 2009.

4. Holmes, M.J.; Pavlish, J.H.; Zhuang, Y.; Benson, S.A.; Olson, E.S.; Laumb, J.D. Multifunctional Abatement of Air Pollutants in Flue Gas. U.S. Patent 7628969 B2, 2009.

EERC
Energy & Environmental Research Center



APPENDIX A

RESUMES OF KEY PERSONNEL

JAY C. ALMLIE
Senior Research Manager
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5260, Fax: (701) 777-5181, E-Mail: jalmlie@undeerc.org

Principal Areas of Expertise
Mr. Almlie's principal areas of interest and expertise include hydrogen production technologies, particle capture in electrostatic precipitators, mercury control technologies, thermal control systems, water-processing systems, and environmental control and life support systems.

Qualifications
B.S., Mechanical Engineering, and B.S., Engineering Management, University of North Dakota, 1995. Proficient in the use of LabView, AutoCad, Autodesk Inventor, MS Excel, MS Project, MathCAD, Rockwell Software RSLogix, and RSView Studio.

Professional Experience
2009–Present: Senior Research Manager, Environmental Technologies, EERC, UND. Mr. Almlie's responsibilities include supervision and direction of a diverse group of approximately 30 researchers focused on emission control technology development and hydrogen generation technology development. Mr. Almlie is responsible for technical, managerial, and business development aspects of this work. Mr. Almlie has managed several successful multimillion-dollar projects during his tenure in this position.

2006–2009: Research Manager, Environmental Technologies, EERC, UND. Mr. Almlie's responsibilities included supervising a team of researchers focused on mercury emission control, particulate matter emission control, and hydrogen production. Mr. Almlie was also involved technically in projects in each of these areas.

2001–2006: Research Engineer, Environmental Technologies, EERC, UND. Mr. Almlie's responsibilities included projects involving mercury control, particulate matter emission control, and emission control for diesel systems.

2000–2001: Lead Mechanical Engineer, Water Systems, International Space Station Habitability Outfitting, and Deputy Project Manager, International Space Station Galley, Lockheed Martin Space Operations Company, Houston, Texas. Mr. Almlie's responsibilities included supervision of the Galley Potable Water System and Waste and Hygiene Compartment Crew Hygiene System design teams, development of system architecture and component specs, design of water system engineering development units, and thermal and fluid mechanics analysis and testing on water systems. He was also responsible for customer interfacing, team integration, project direction and cost/schedule estimates for both projects, including planning and analyzing project performance, monitoring progress, and developing "to-completion" cost estimates within an earned value system.

1995–2000: Mechanical Engineer, Hernandez Engineering, Inc. Mr. Almlie's responsibilities included involvement in several projects:

- Lead mechanical engineer for a potential Space Shuttle thermal control system upgrade, including performing thermal design, analysis, and test functions and serving as project manager for the $1 million research project. This was one of 10 projects identified by the National Research Council as leading contenders to extend the life of the Space Shuttle fleet.
- Lead mechanical engineer for water recovery systems, including performing mechanical system design and analysis functions; designing, testing, and analyzing a potable water tank/radiation protection system for a crew habitat vehicle; and performing project management functions.
- Test engineer for the International Space Station Active Thermal Control System (ATCS), including conducting fluid line, fluid flow balance, and thermal/vacuum testing on ISS Active Thermal Control components and participating in Analysis and Integration Team activities to ensure ISS Thermal Control System function on-orbit.

1994–1995: Research Assistant, School of Engineering and Mines, UND. Mr. Almlie's responsibilities included computational fluid mechanics model generation for combustion applications using Fluent software.

Summer 1994: Engineering Intern, Orbital Sciences Corporation, Inc., Dulles, Virginia. Mr. Almlie's responsibilities included performing launch vehicle dynamic separation analyses, designing payload separation system components, performing multiple stress/strain analyses on payload carrier structures using COSMOS/M finite element analysis software.

1993–1994: Teaching Assistant, School of Engineering and Mines, UND. Mr. Almlie's responsibilities included assisting with thermodynamics, heat and mass transfer, and fluid mechanics courses.

1991–1993: Mechanical Engineering Cooperative Education Program Participant, Eagle Engineering, Inc., Houston, Texas. Mr. Almlie's responsibilities included authoring a satellite ground tracking code, coauthoring a separation simulation code, serving as a company representative on launch vehicle mission status reviews, and performing payload fairing separation analysis for the Pegasus rocket.

Publications and Presentations

Has coauthored several professional publications.

DR. YE ZHUANG
Research Manager
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5236, Fax: (701) 777-5181, E-Mail: yzhuang@undeerc.org

Principal Areas of Expertise
Dr. Zhuang's principal areas of interest and expertise include air pollution control with an emphasis on particulate, SO_3, CO_2, and mercury emissions. Dr. Zhuang's other research interests include biomass utilization and green energy production.

Qualifications
Ph.D., Environmental Engineering and Science, University of Cincinnati, 2000.
M.S., Mechanical Engineering, Beijing Polytechnic University, 1995.
B.E., Mechanical Engineering, Beijing Polytechnic University, 1992.

Professional Experience
2010–Present: Research Manager, EERC, UND. Dr. Zhuang's responsibilities include developing and managing various research projects focused on air toxic metals, emission control technologies, biomass utilization, and technical and economic evaluation of various emission control systems.

2000–2010: Research Engineer, EERC, UND. Dr. Zhuang's responsibilities included environmental emission control, equipment design and fabrication, proposal and technical report and paper preparation, presenting research, and interacting with industry and government organizations.

1996–2000: Teaching/Research Assistant, University of Cincinnati. Dr. Zhuang's responsibilities included investigating trace heavy metal formation mechanisms in combustion, applying vapor-phase sorbent technology to emission control, characterizing and improving electrostatic precipitator performance, and performing kinetic studies on the fate of Hg in a combustion environment.

1995–1996: Research Associate, Beijing Polytechnic University, China. Dr. Zhuang's responsibilities included developing liquid jet impingement technology for microelectronic cooling, investigating enhanced heat transfer by magnetic fluid, and characterizing heat transfer and fluid mechanics in heating and ventilation systems.

1994–1995: Project Manager, National Environmental Protection Agency, China. Dr. Zhuang's responsibilities included a World Bank project to assess an innovative refrigeration technology for an ozone-depleting substance.

1993–1995: Student Assistant, Global Environmental Facility, China. Dr. Zhuang's responsibilities included assessing a control technology for greenhouse gas emission in China and stipulating energy plan incorporation of environmental consideration in China.

1992–1994: Graduate Research Assistant, Beijing Polytechnic University, China. Dr. Zhuang's responsibilities included developing a jet impingement technology for microelectronics cooling.

Professional Memberships
American Association of Aerosol Research

Publications and Presentations
Has authored or coauthored numerous publications.

MICHAEL J. HOLMES
Deputy Associate Director for Research
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5276, Fax: (701) 777-5181, E-Mail: mholmes@undeerc.org

Principal Areas of Expertise
Mr. Holmes's principal areas of interest and expertise include fuel processing for production of syngas for coproduction of hydrogen, fuels, and chemicals with electricity in gasification systems and process development and economics for advanced energy systems and emission control (air toxics, SO_2, NO_x, H_2S, and particulate technologies). He has managed numerous large-scale projects in these areas. Mr. Holmes is the program manager of the National Center for Hydrogen Technology at the EERC and is working under agreement with the U.S. Department of Energy National Energy Technology Laboratory and over 85 partners to develop a broad range of technologies required to advance the opportunity for a hydrogen economy. In addition, Mr. Holmes is currently serving as a board member for the National Hydrogen Association Board of Directors (an executive committee member) and the Mountain States Hydrogen Business Council.

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

Professional Experience
2005–Present: Deputy Associate Director for Research, EERC, UND. Mr. Holmes currently oversees fossil energy research areas at the EERC, including coproduction of hydrogen, fuels, and chemicals with electricity in gasification systems, advanced energy systems, and emission control technology projects involving mercury, SO_2, NO_x, H_2S, and particulate.

2001–2004: Senior Research Advisor, EERC, UND. Mr. Holmes was involved in research in a range of areas, including emission control, fuel utilization, process development, and process economic evaluations. Specific duties included 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. Mr. Holmes' responsibilities included project management and process research and development for projects involving advanced energy systems, environmental processing, combustion systems, fuel processing, and development of new process measurement techniques. He also served as Project Manager and Process Engineer for projects involving evaluation of air toxic emissions from coal-fired power plants; development of low-cost solutions for air toxic control focused on mercury emissions; development of wet and dry scrubber technologies; demonstration of low-level radioactive liquid waste remediation; in-duct spray drying development; development of improved oil lighter burners; limestone injection multistaged burning; the ESO_x process; the SO_x–NO_x–Rox Box™ process; and the limestone injection dry-scrubbing process.

Professional Memberships

Fuel Cell and Hydrogen Energy Association
- Board of Directors, 2011

National Hydrogen Association
- Board Member, 2004–2011
- Executive Committee Member, 2009–2010
- Cochair of Hydrogen from Coal Group, 2008–2010

Subbituminous Energy Coalition
- Board Member, 2003–2008

Mountain States Hydrogen Business Council
- Board Member, 2009–2010

Tau Beta Pi

Patents

Holmes, M.J.; Pavlish, J.H.; Olson, E.S.; Zhuang, Y. High Energy Dissociation for Mercury Control Systems. U.S. Patent 7615101 B2, 2009.

Holmes, M.J.; Pavlish, J.H.; Zhuang, Y.; Benson, S.A.; Olson, E.S.; Laumb, J.D. Multifunctional Abatement of Air Pollutants in Flue Gas. U.S. Patent 7628969 B2, 2009.

Olson, E.S.; Holmes, M.J.; Pavlish, J.H. Sorbents for the Oxidation and Removal of Mercury. U.S. Patent Application 2005-209163, Aug 22, 2005.

Olson, E.; Holmes, M.; Pavlish, J. Process for Regenerating a Spent Sorbent. International Patent Application PCT/US2004/012828, April 23, 2004.

Madden, D.A.; Holmes, M.J. Alkaline Sorbent Injection for Mercury Control. U.S. Patent 6,528,030 B2, Nov 16, 2001.

Madden, D.A.; Holmes, M.J.; Alkaline Sorbent Injection for Mercury Control. U.S. Patent 6,372,187 B1, Dec 7, 1998.

Holmes, M.J.; Eckhart, C.F.; Kudlac, G.A.; Bailey, R.T. Gas Stabilized Reburning for NO_X Control. U.S. Patent 5,890,442, Jan 23, 1996.

Holmes, M.J. Three-Fluid Atomizer. U.S. Patent 5,484,107, May 13, 1994.

Bailey, R.T.; Holmes, M.J. Low-Pressure Loss/Reduced Deposition Atomizer. U.S. Patent 5,129,583, March 21, 1991.

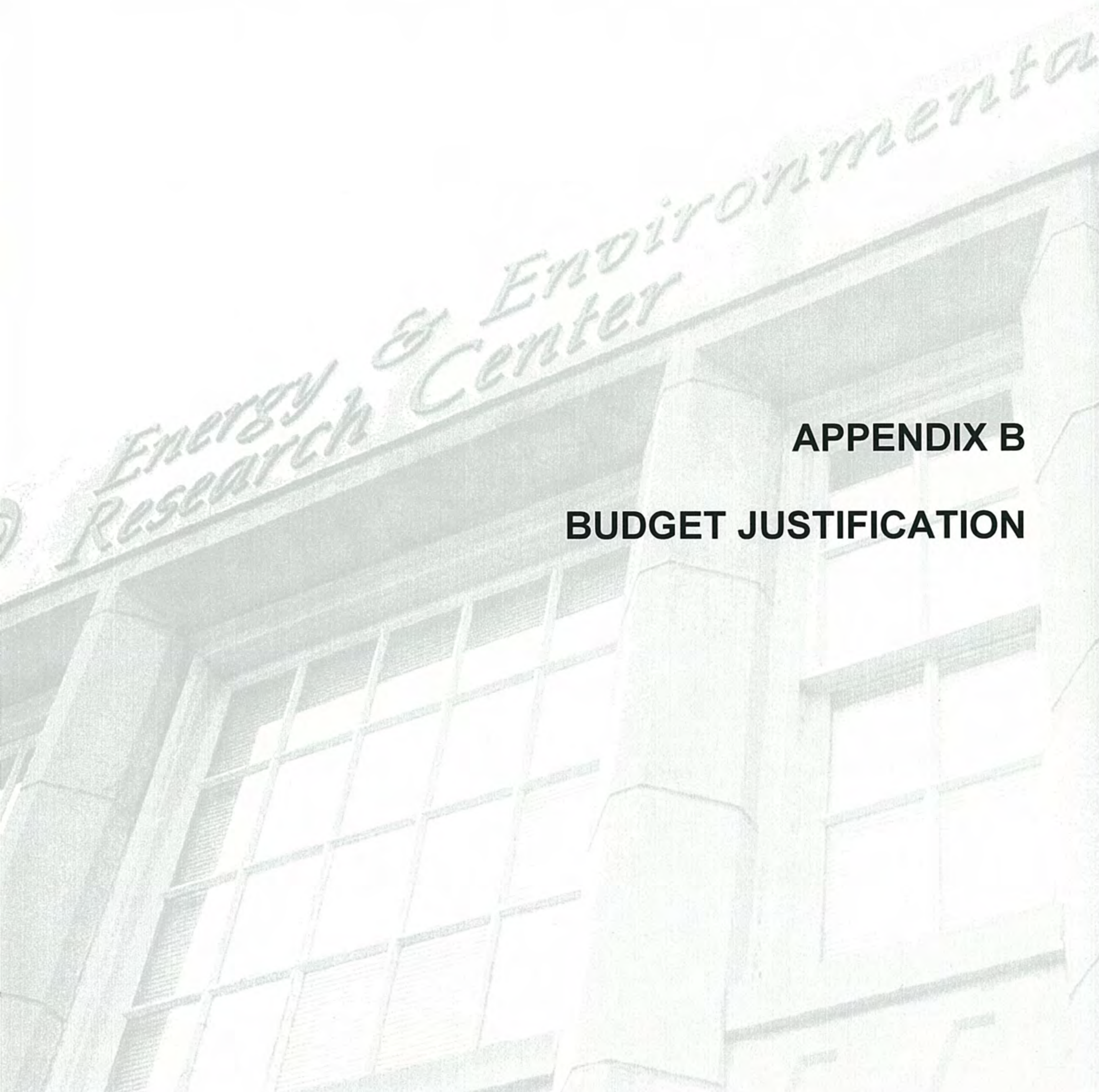
Awards

Lignite Energy Council Distinguished Service Award, Government Action Program (Regulatory), 2005.

Lignite Energy Council Distinguished Service Award, Research and Development, 2003.

Publications and Presentations

Has authored or coauthored more than 120 publications and presentations.



APPENDIX B

BUDGET JUSTIFICATION

BUDGET JUSTIFICATION

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, and other agreements. Although the EERC is not affiliated with any one academic department, university faculty may participate in a project, depending on the scope of work and expertise required to perform the project.

INTELLECTUAL PROPERTY

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

BUDGET INFORMATION

The proposed work will be done on a cost-reimbursable basis. The distribution of costs between budget categories (labor, travel, supplies, equipment, etc.) is for planning purposes only. The project manager may, as dictated by the needs of the work, incur costs in accordance with Office of Management and Budget (OMB) Circular A-21 found at www.whitehouse.gov/omb/circulars. If the Scope of Work (by task, if applicable) encompasses research activities which may be funded by one or more sponsors, then allowable project costs may be allocated at the Scope of Work or task level, as appropriate, to any or all of the funding sources. Financial reporting will be at the total-agreement level.

The cost of this project is based on a specific start date indicated at the top of the EERC budget. Any delay in the start of this project may result in a budget increase. Budget category descriptions presented below are for informational purposes; some categories may not appear in the budget.

Labor: Estimated labor includes direct salaries and fringe benefits. Salary estimates are based on the scope of work and prior experience on projects of similar scope. Salary costs incurred are based on direct hourly effort on the project. Fringe benefits consist of two components which are budgeted as 55% of direct labor. The first component is a fixed percentage approved annually by the UND cognizant audit agency, the Department of Health and Human Services. This portion of the rate covers vacation, holiday, and sick leave (VSL) and is applied to direct labor for permanent staff eligible for VSL benefits. Only the actual approved rate will be charged to the project. The second component is estimated on the basis of historical data and is charged as actual expenses for items such as health, life, and unemployment insurance; social security; worker's compensation; and UND retirement contributions. The following table represents a breakdown by labor category and hours for technical staff for the proposed effort.

Labor Categories	Labor hr
Research Scientists/Engineers	678
Research Technicians	66
Senior Management	43
Technology Dev. Mechanics	272
Technical Support Services	123
	1182

Travel: Travel is estimated on the basis of UND travel policies which can be found at www.und.edu/dept/accounts/policiesandprocedures.html. Estimates include General Services Administration (GSA) daily meal rates. Travel may include site visits, field work, meetings, and conference participation as indicated by the scope of work and/or budget.

Equipment: If equipment (value of $5000 or more) is budgeted, it is discussed in the text of the proposal.

Supplies: Supply and material estimates are based on prior experience and may include chemicals, gases, glassware, nuts, bolts, and piping. Computer supplies may include data storage, paper, memory, software, and toner cartridges. Maps, sample containers, minor equipment (value less than $5000), signage, and safety supplies may be necessary as well as other organizational materials such as subscriptions, books, and reference materials. General purpose office supplies (pencils, pens, paper clips, staples, Post-it notes, etc.) are included in the facilities and administrative cost.

Subcontracts/Subrecipients: Not applicable.

Professional Fees/Services (consultants): Not applicable.

Other Direct Costs

Communications: Telephone, cell phone, and fax line charges are generally included in the facilities and administrative cost. Direct project costs may include line charges at remote locations, long-distance telephone, postage, and other data or document transportation costs.

Printing and Duplicating: Photocopy estimates are based on prior experience with similar projects. Page rates for various photocopiers are established annually by the university's duplicating center.

Food: 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.

Operating Fees and Services – EERC Recharge Centers, Outside Labs, Freight: EERC recharge center rates for laboratory, analytical, graphics, and shop/operation fees are established and approved at the beginning of the university's fiscal year.

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

Graphics fees are based on an established per hour rate for production of such items as report figures, posters, and/or PowerPoint images for presentations, maps, schematics, Web site design, professional brochures, and photographs.

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

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

Facilities and Administrative Cost: The facilities and administrative rate of 50% (indirect cost rate) included in this proposal is approved by the Department of Health and Human Services. Facilities and administrative cost is calculated on modified total direct costs (MTDC). MTDC is defined as total direct costs less individual capital expenditures, such as equipment or software costing $5000 or more with a useful life of greater than one year, as well as subawards in excess of the first $25,000 for each award. The facilities and administrative rate has been applied to each line item presented in the budget table.

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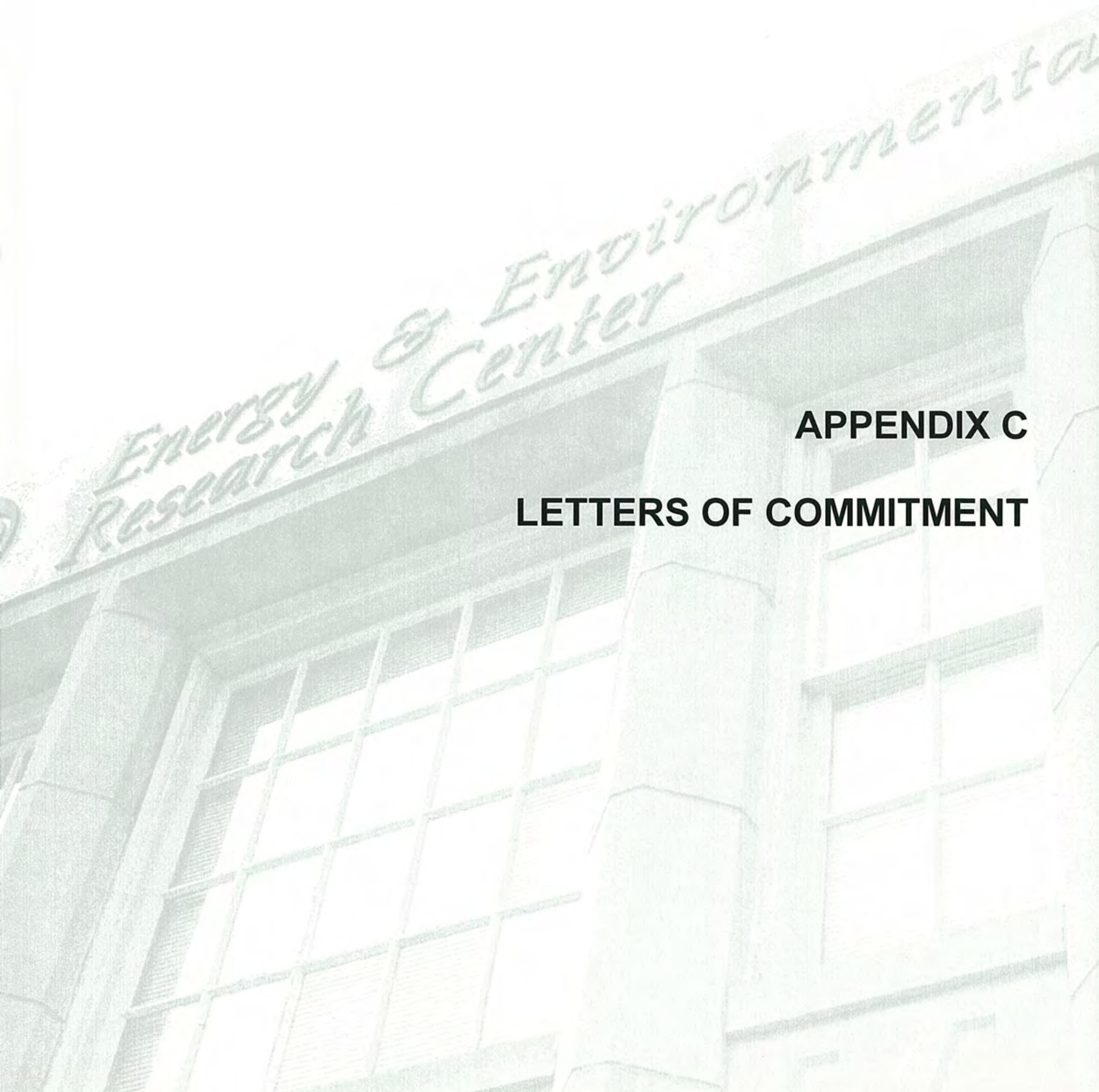

APPENDIX C

LETTERS OF COMMITMENT

EERC®
Energy & Environmental Research Center
UNIVERSITY OF NORTH DAKOTA
15 North 23rd Street — Stop 9018 / Grand Forks, ND 58202-9018 / Phone: (701) 777-5000 Fax: 777-5181
Web Site: www.undeerc.org

March 30, 2012

Ms. Karlene Fine
Executive Director
North Dakota Industrial Commission
600 East Boulevard Avenue, Department 405
State Capitol, 14th Floor
Bismarck, ND 58505-0840

Dear Ms. Fine:

Subject: Cost Share for EERC Proposal No 2012-0178 Entitled "Demonstration of Multipollutant Reduction Using a Lextran 3-in-1 Wet Scrubber"

The Energy & Environmental Research Center (EERC) is conducting complementary research and development efforts under a multimillion-dollar 5-year cooperative agreement with the U.S. Department of Energy (DOE) entitled "Joint Program on Research and Development for Fossil Energy-Related Resources." Through this joint program, nonfederal entities can team with the EERC and DOE in projects that address the goals and objectives of DOE's Office of Fossil Energy.

The proposed project to the North Dakota Industrial Commission (NDIC), entitled "Demonstration of Multipollutant Reduction Using a Lextran 3-in-1 Wet Scrubber," is a viable candidate for funding under this program. Therefore, the EERC intends to secure $64,650 of cash cost share for the proposed project thorough its cooperative agreement with DOE, providing NDIC commits $67,200 in cash cost share and $67,200 is secured from other industry participants.

Once the EERC has commitment from all nonfederal partners to the project, the EERC will submit a proposal to DOE for its concurrence. Initiation of the proposed work is contingent upon the execution of a mutually negotiated agreement or modification to an existing agreement between the EERC and each of the project sponsors.

If you have any questions, please contact me by phone at (701) 777-5157 or by e-mail at jharju@undeerc.org.

Sincerely,

for John A. Harju
Associate Director for Research

JAH/kal

GREAT RIVER
ENERGY®

Bismarck Office • 1611 East Century Avenue • Suite 200 • Bismarck, North Dakota 58503 • 701-250-2165 • Fax 701-255-5405

February 28, 2012

Mr. Jay Almlie
Senior Research Manager
Energy & Environmental Research Center
15 North 23rd Street
Mail Stop 9018
Grand Forks, ND 58202-9018

Subject: EERC to DOE Joint Venture Program, "Demonstration of Multipollutant Reduction Using a Lextran 3-in-1 Wet Scrubber"

Dear Mr. Almlie:

This letter is in support of EERC's request for Great River Energy's (GRE's) participation in the subject DOE Joint Venture proposal entitled "Demonstration of Multipollutant Reduction Using a Lextran 3-in-1 Wet Scrubber". GRE is prepared to commit up to $25,000 in funding for 2012 to complete the scope of work detailed in the proposal named above. It is respectfully requested that the DOE approve cost share funding through the Joint Venture program at the EERC. The GRE funding is subject to appropriate cost share funds being made available from DOE through the EERC, appropriate cost share funds being made available from the North Dakota Industrial Commission through its Lignite Research Council, and appropriate cost share funds being made available from Lextran, Ltd..

GRE has a long and successful history of working with DOE and other U.S. government agencies to advance the state-of-the-art in emissions control technology. In view of the significant advantages of the proposed effort to the energy security and economic competitiveness of our nation, we request that DOE gives careful consideration to this project. Again, we express our interest and support of the proposed project and look forward to working with DOE and the EERC.

Sincerely,

John Weeda
North Dakota Director

Great River Energy

LEXTRAN
Flue Gas Solutions

21 February 2012

Mr. Jay Almlie
Senior Research Manager
Energy & Environmental Research Center
15 North 23rd Street
Mail Stop 9018
Grand Forks, ND 58202-9018

Subject: EERC to NDIC-Lignite Research Council Proposal Entitled "Demonstration of Multipollutant Reduction Using a Lextran 3-in-1 Wet Scrubber"

Dear Mr. Almlie:

This letter is in support of EERC's request for Lextran's participation in the subject NDIC-LRC proposal entitled "Demonstration of Multipollutant Reduction Using a Lextran 3-in-1 Wet Scrubber". Lextran is prepared to commit up to $25,000 in funding for 2012 to complete the scope of work detailed in the proposal named above. It is respectfully requested that NDIC approve cost share funding through the Lignite Research Council. The Lextran funding is subject to appropriate cost share funds being made available from NDIC-LRC, appropriate cost share funds being made available from the U.S. Department of Energy through its Joint Venture program at the EERC, and appropriate cost share funds being made available from Lextran's development partner, Great River Energy.

Lextran has developed a unique 3-in-1 gas-cleaning technology that uses a Lextran liquid catalyst to simultaneously capture NO_x, SO_x, and mercury within a conventional wet scrubber. The proprietary Lextran catalyst contains an active sulfur-oxygen functional group that will enhance the oxidation reactions of SO_x and NO_x into SO_4 and NO_3 anions. With the addition of ammonia, KOH, or other basic reagents, the captured SO_x and NO_x is reformed into beneficial fertilizer by-products such as ammonium nitrate, ammonium sulfate, potassium sulfate, and potassium nitrate.

Lextran eagerly anticipates a successful program with DOE, NDIC, GRE, and other entities to provide a cutting-edge multi-pollutant control technology. In view of the significant economic impacts, specifically with regard to many mature lignite-fired small boilers that are at shutdown risk due to the new EPA regulations, potential for job creation, and in-state agricultural product production, we request that NDIC gives careful consideration to this project. Again, we express our interest and support of the proposed project and look forward to working with NDIC and the EERC.

Sincerely,

Yuval Davidor, Ph.D.
CEO

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