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

April 1, 2011

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. 2011-0209 Entitled "Water Recovery from Lignite Drying"

Enclosed please find an original and one copy of the subject proposal. Also enclosed is the $100 application fee.

The Energy & Environmental Research Center (EERC) of the University of North Dakota is pleased to submit the subject proposal to the North Dakota Industrial Commission Lignite Research, Development and Marketing Program. The proposed cost of the project is estimated at $897,335 The EERC is committed to completing the project as described in this proposal if the North Dakota Industrial Commission makes the requested grant.

If you have any questions regarding this proposal, please contact me by phone at (701) 777-5420 or by e-mail at jziman@undeerc.org.

Sincerely,

Joshua J. Ziman
Research Engineer

Approved by:

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

JJZ/sah

Enclosures

WATER RECOVERY FROM LIGNITE DRYING

EERC Proposal No. 2011-0209

Submitted to:

Karlene Fine

North Dakota Industrial Commission
State Capitol, 14th Floor
600 East Boulevard Avenue, Department 405
Bismarck, ND 58505-0840

Amount of Request: $266,520
Total Amount of Proposed Project: $897,335
Duration of Project: 18 months

Submitted by:

Joshua J. Ziman
Daniel J. Stepan
Robert M. Cowan
Kerryanne M. Leroux
Sheila K. Hanson

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

Northern Great Plains Water Consortium®

Joshua J. Ziman, Project Manager

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

April 1, 2011

TABLE OF CONTENTS

Continued…

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF TABLES

WATER RECOVERY FROM LIGNITE DRYING

ABSTRACT

The goal of the proposed Energy & Environmental Research Center (EERC) project is to demonstrate that water produced during the drying of North Dakota lignite can be economically recovered.

Project partners include Great River Energy (GRE), SPX Cooling Technologies (SPX), the Electric Power Research Institute (EPRI), and the U.S. Department of Energy. The demonstration project will be conducted at GRE's Coal Creek Station using SPX's air-cooled condensation system operating on an exhaust slipstream from GRE's Lignite Fuel Enhancement process. A successful demonstration will produce data and information on the quantity and quality of recovered water and an assessment of the value of the recovered water for use in a variety of cooling and reuse applications across the country and, particularly, in arid regions where water is a critically limiting resource. Demonstrating that the drying of high-moisture North Dakota lignite to produce a low-sulfur, high-Btu fuel and a source of high-quality water will open new markets for North Dakota lignite, particularly in arid regions where power plants rely on hybrid or air cooling.

The project duration is 18 months, which will allow operation of the demonstration facility over an entire year to evaluate water recovery capabilities and identify and address any operating concerns over a full range of extreme seasonal temperature variations.

The total project cost is $897,335 of which $266,520 (28.7% of the total project cost) is requested from the North Dakota Industrial Commission. EPRI has been sent a preproposal, and it is anticipated that EPRI will provide $266,520. The U.S. Department of Energy will provide $308,795 through the EERC's Northern Great Plains Water Consortium®. Other sponsorship includes noncash cost from GRE and SPX for $32,000 and $23,500, respectively.

PROJECT SUMMARY

The goal of the proposed Energy & Environmental Research Center (EERC) project is to demonstrate that water produced during the drying of North Dakota lignite can be economically recovered and to develop baseline data that will provide new marketing strategies for North Dakota lignite. A feasibility study conducted by the EERC's North Great Plains Water Consortium® (NGPWC) predicted that a heat-exchange system cooled by ambient air could be used to recover a significant amount of high-quality water from the exhaust stream from Great River Energy's (GRE's) Lignite Fuel Enhancement (LFE) process. The study found that recovering an average of 30% of the water that is removed from lignite during LFE processing using outside ambient air as a heat-exchange media to condense moisture in the LFE exhaust was technically and economically viable. The study identified a specialty plastic air-to-air heat exchanger manufactured by SPX Cooling Technologies (SPX) designed specifically for water recovery, which could be integrated into the LFE system.

The demonstration project proposed herein will be conducted at GRE's Coal Creek Station using SPX's air-cooled condensation system operating on an exhaust slipstream from GRE's LFE process. Specific project objectives include the following:

- Design the system and fabricate and install an SPX water recovery module at GRE's Coal Creek Station near Underwood, North Dakota
- Validation testing of the SPX module to assess water recovery under a wide range of climate and operating conditions to identify any operational constraints, evaluate and optimize water recovery potential, and assess water quality characteristics

- Assess economic potential considering a range of reuse opportunities in varying climates
- Develop baseline data that will provide new marketing strategies for North Dakota lignite where the water in high-moisture lignite is an asset rather than a liability

A multitask project has been developed in order to satisfy project objectives that will subsequently create additional lignite production activities through the realization of expanded resource opportunities. The pilot demonstration will utilize a single SPX heat-exchange module installed at Coal Creek Station and operated on an exhaust slipstream from one of GRE's 125-tph LFE dryers. Task 1 will include the design and fabrication of a heat-exchange module capable of handling the temperature and humidity conditions of the nearly saturated, warm LFE dryer exhaust and the climatic temperature extremes encountered throughout a year in the North Dakota climate. The heat-exchange module will be transported to Coal Creek Station and connected to the LFE exhaust system. Blowers and system monitoring components will also be installed as a Task 1 activity. The installed system will undergo shakedown and leak testing to ensure proper operation of the unit and control systems. Task 2 will initiate validation testing to assess and optimize water recovery under varying seasonal climate conditions. Grab samples of recovered water will be collected during operation under steady-state conditions at several times throughout the yearlong operating period to assess consistency of condensed water quality under the respective operating conditions. Data and information from Task 2 will be used in Task 3 to conduct an economic assessment and to assess new markets for North Dakota lignite where the recovered water, along with the high-Btu fuel, provides an asset that overcomes the limitations of transporting high-moisture coals to arid regions of the country where water is limited.

Task 4 will include project management and reporting. Semiannual technical progress reports will be prepared and submitted to the North Dakota Industrial Commission (NDIC) Lignite Research Council and all project partners. A final project report will include details of all project activities, present all system operating and water characteristic data, provide data interpretation, and assess economic viability and new market potential for high-Btu lignite and a nontraditional high-quality water supply.

Success of the project will be measured in terms of the demonstrated ability to recover sufficient volumes (30% of total nominal LFE exhaust moisture) of high-quality water for reuse. Providing this nontraditional water supply in arid regions where limited water supply results in a significant derating of power generation and subsequent loss of revenue may result in new market opportunities for North Dakota lignite.

The proposed work is anticipated to be complete within 18 months and have a total estimated cost of $897,335. The EERC is requesting $266,520 from NDIC to be matched with a total of $266,520 from EPRI. Noncash cost share will be provided by SPX in the amount of $23,500 to cover all labor and travel required to design, install, and test the SPX unit. Additional noncash cost share will be provided by GRE in the amount of $32,000, to cover the construction and labor costs for site preparation to install the SPX unit. The EERC will provide $308,795 from the U.S. Department of Energy (DOE)-sponsored NGPWC, contingent upon DOE approval.

PROJECT DESCRIPTION

The goal of the proposed EERC project is to demonstrate that water produced during the drying of North Dakota lignite can be economically recovered and to develop baseline data that will

provide new marketing strategies for North Dakota lignite. The proposed project follows a Phase 1 effort that showed that reclaiming 30% of the water removed during GRE's LFE processing could be economically feasible. Outside ambient air was found to potentially be the most economical media to recover water in the LFE exhaust. The study also identified that the recovered water could be a resource of significant value for utilities, particularly those located in drier climate regions where water supply can limit power generation. The EERC, therefore, proposes to demonstrate the utility of adapting the SPX Air2Air™ heat exchanger to recover water from the LFE exhaust at GRE's Coal Creek Station.

Project Objectives

- Design the system and fabricate and install a pilot-scale SPX heat-exchange module on a slipstream of the exhaust from one of GRE's 125-tph LFE dryers.
- Conduct validation testing of the SPX heat-exchange system, monitor and collect operating as well as performance data to assess performance over a yearlong period of operation under climate and temperature extremes.
- Verify process economics of the water recovery system and assess markets for premium, high-Btu lignite and the water produced.

Task 1 – Design, Fabrication, and Installation of the Water Recovery System.

A project kickoff meeting will be held at Coal Creek Station to finalize project details and identify specific project needs, including the identification of all utilities needed for system operation and data acquisition as well as identifying any necessary permits. Task 1 will then proceed with the design, fabrication, and installation of the SPX heat-exchange module(s). SPX will do the final detailed module design, fabricate a test module, and ship the module to Coal Creek Station. The test module will be designed to accommodate operation on a slipstream of the

exhaust flow from one of GRE's LFE dryers (Figure 1). The module will be fabricated from a plastic material able to withstand the operating temperatures of the LFE exhaust as well as the range of outdoor temperature extremes experienced in North Dakota. The fabricated test module will be transported to Coal Creek Station and connected to the existing LFE exhaust ductwork. SPX will also prepare and provide operating instructions for the test module.

Necessary blowers, ducting, plumbing, and fittings will be purchased, and the data acquisition system will be installed. The data acquisition system will monitor key process parameters including temperature, pressure, humidity, and blower electrical demand as well as condensed water flow rate. Condensed water pH and conductivity will also be continuously monitored.

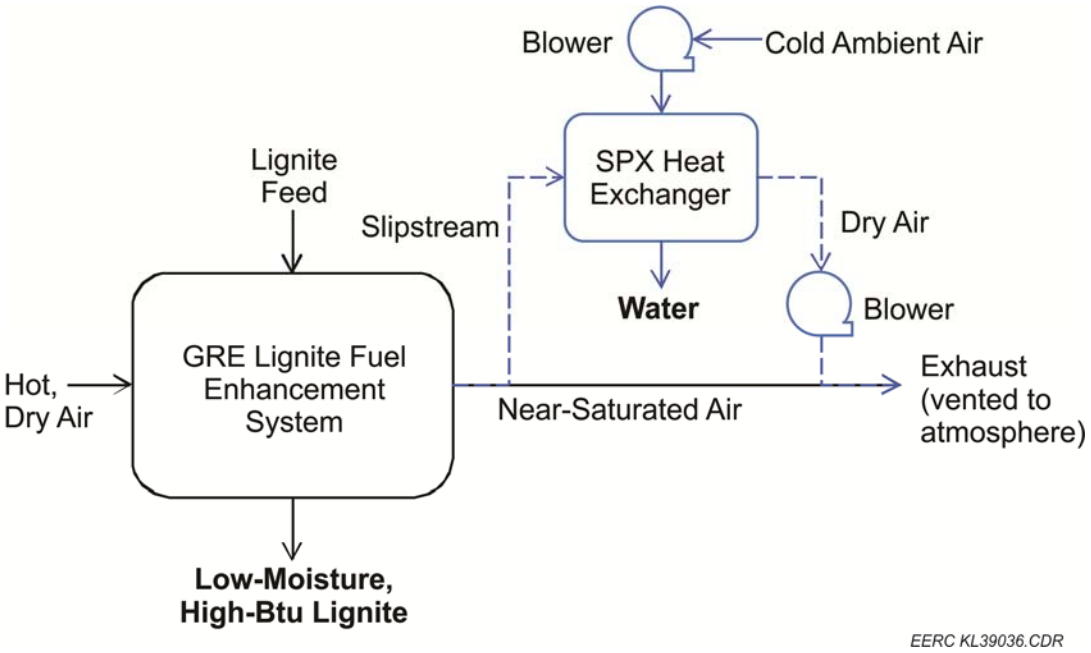

Figure 1. EERC-proposed water recovery system.

Installation of the water recovery system will be performed by licensed contractors hired by GRE. Because of specific site-safety guidelines, these contractors have already been approved to work at GRE facilities. EERC project personnel will be available during the system installation process and will ensure proper operation of the data acquisition and control system. It is anticipated that Task 1 will be completed within the first 3 months of the project as shown in the timetable section. The timetable illustrates the suggested time line for the proposed work, which is anticipated to be complete within 18 months.

Task 2 – Water Recovery System Testing. The installed SPX heat-exchange system will undergo shakedown testing to ensure proper operation and to confirm that adjustments to system operation, as well as data downloads, can be performed remotely. Once the water recovery system has undergone successful shakedown, it will be operated continuously for a period of 1 year. Operating conditions will be adjusted and monitored in order to determine optimal operating conditions over a range of LFE exhaust loading rates and at several different climate conditions. In addition to the continuous data collection, condensed water samples will be collected, preserved accordingly, and submitted to a certified commercial laboratory to provide a detailed chemical characterization. Samples will be collected during steady-state operation during periods of extreme hot and cold operation as well as average annual temperature conditions. We envision up to six separate sampling events to assess water quality. Each sample will consist of a composite of several grab samples collected at regular predetermined intervals. Table 1 lists the parameters to be analyzed for each sampling event. These data will be used to verify anticipated water quality and to develop any treatment strategies needed to satisfy reuse water quality requirements.

Table 1. Condensed Water Characterization Analyses

Parameter
pH
Alkalinity, as $CaCO_3$
Hardness
Calcium
Magnesium
Manganese
Sodium
Sulfate
Nitrate + Nitrite
Chloride
Fluoride
Cyanide
Total Organic Carbon
Inorganic Carbon
Ammonia
Total Kjehldahl Nitrogen
Conductivity
Total Suspended Solids
Total Dissolved Solids
Total Volatile Dissolved Solids
Total Solids
Priority Pollutant Metals

Task 3 – Economic Evaluation and Market Assessment. Economic data generated during the proposed demonstration will be compared to the Phase 1 findings. Capital, operating, and maintenance costs will be projected for a full-scale system, then compared to potential revenue streams (the value of a high-Btu North Dakota lignite and a high-quality water source). The market assessment will utilize the economic data and assess new markets for transporting and utilizing lignite as a premium product – a high-Btu fuel as well as a source of high-quality water.

An engineering economic evaluation will be performed to determine the cost-effectiveness of recovering water from GRE's LFE process. Expenses such as installed capital costs, observed operating costs, maintenance costs, and blower electrical demand, along with estimated

transportation costs for the raw lignite to identified markets where water is a key limiting factor in power generation, will be compiled. The value of the condensed water will be based on quality and quantity of water recovered and compared to the cost and availability of water in several regions of the country. The value of North Dakota lignite as a premium product, supplying both a high-Btu fuel and a source of high-quality water, will be analyzed by comparing regional coal pricing as well as regional water values, respectively.

The value of the condensed water will be proportional to the level of treatment that would be required for reuse. We anticipate, based on the operating conditions of the LFE process, that the condensed water will be of a high quality suitable for direct use as cooling tower makeup or for direct use in hybrid-cooled generation scenarios. However, reuse as boiler makeup, for example, would require additional treatment for demineralization, which would ultimately reduce the value of the water because of the cost incurred for treatment.

The economic analysis will be presented as an annual cash flow, with applicable financing. Potential revenue or increased profit from water recovery will be used to pay back the financing costs. A payback of 10 years or less will be regarded as economical. Sensitivity analyses will be conducted for all costs including economies of scale for a full commercial-scale water recovery system to be integrated into the GRE LFE system.

The market assessment will address the potential for North Dakota lignite as both an enhanced fuel and water source. The market feasibility of two topics will be reviewed: 1) the potential for LFE systems with water recovery on-site and 2) uses for water recovered at the Underwood site. The added value of water recovery presents new market opportunities from regional and national end users of coal and other fuels, particularly for geographic areas where water supplies are limited or constrained. Potential end users will be identified, interviewed, and

evaluated based upon their technical suitability and interest in licensing the LFE process at their site.

The water generated and captured through drying of North Dakota lignite could provide a benefit, not just as a supplemental water source for use in lignite-fired power plants, but possibly as a much-needed water source for the oil and gas industry in the western part of the state. In North Dakota's Bakken play, water is used in the oil field to pressurize and fracture oil-bearing formations to increase permeability and enhance the flow and recovery of oil. The volume of water required to hydraulically fracture one well ranges from 10,000 to 95,250 barrels (bbl) (0.5 to 4 million gallons), depending on the number of stages in the fracture. Multistage fractures, which require more water than single-stage fractures, are increasingly being employed in the Bakken Formation because they generate fractures more effectively.

Relatively low total dissolved solids and bacteria-free water are required for hydraulic fracturing. Currently, the freshwater comes from glacial and bedrock aquifer systems, surface waters, and municipal supplies. However, most available water supplies are already being utilized, and there are ongoing issues with respect to accessing Lake Sakakawea water resources as a result of an ongoing environmental impact study by the U.S. Army Corps of Engineers. Water supplies for use in hydraulic fracturing are in very short supply, and any additional freshwater resources in the western part of the state would be of great interest to the oil industry. Again, any potential users will be identified, interviewed, and evaluated based upon their technical suitability and interest in access to an additional water supply.

Task 4 – Management and Reporting. The EERC will be responsible for overall project management and coordination of project activities. The EERC project manager will be

responsible for routine communication among the respective project participants and for ensuring that the project is conducted in a timely manner and within budget.

In addition to routine communication between the EERC, GRE, SPX, NDIC, EPRI, and DOE, the project manager will be responsible for the preparation and submission of all required project reports, including the semiannual technical project report to NDIC and a final technical project report to all participants. The final report will provide details of all project testing and present test data and an interpretation of those data. In the final report, a detailed economic and market assessment will also be provided along with recommendations for expanding the utilization of North Dakota lignite.

STANDARDS OF SUCCESS

Technical success of the proposed project will be judged by the ability to economically produce a significant quantity of high-quality water from the LFE system exhaust. A target goal of recovering an average of 30% of the water contained in the LFE exhaust on an annual basis will be deemed successful. Quality goals will include the production of a water that has the potential to be directly used without the need for additional treatment. Economic success will be a favorable economic analysis that considers the capital, operating, maintenance, and transportation costs to selected market segments where water is a key limiting factor in power generation. Secondary success standards include the ability to document continuous operation of the SPX heat-exchange water recovery system throughout the testing period. Project success will also be measured by the ability to identify and document new and economically viable markets for premium lignite resources.

A successful test program will meet all of the deliverables and milestones listed in the timetable section in a timely manner. Project sponsors will be notified of the completion of each deliverable and milestone as tasks are completed.

BACKGROUND

Increased Water Demand in the United States

In the United States, 85% of thermoelectric power generation utilizes closed-loop cooling. Fossil fuel-fired thermoelectric power generation uses 135,000 million gallons of water each day, accounting for 28% of all freshwater withdrawals in the nation. Coal, the most abundant fossil fuel, currently accounts for 52% of U.S. electricity generation, and each kWh generated from coal requires withdrawal of 25 gallons of water, (Solley et al., 1995; Goldstein and Smith, 2002). Water use is projected to increase because total electrical demand in the United States is expected to increase 30% by 2035. This will lead to a projected water demand increase of about 60 billion gallons a day to provide cooling for coal-powered electricity generation. The largest portion of the increase in electrical use is in the service and residential sectors, resulting from population growth, and continued population shifts to warmer regions with greater cooling requirements (Kenny et al., 2009; Energy Information Administration, 2010).

Water is becoming a critical limiting factor where population growth is competing for the water needs of electrical generation in arid areas. This has led to a dramatic increase in the value of water. The value of water for power generation in arid areas can be equated to the revenue lost from derating or shutdown during temporary periods of shortage or draught, reducing power available to commercial and residential customers. The water value has been determined to range from an average of $6/1000 gallons, if considering only municipal expenses for supply, to

$150/1000 gallons when equating water to lost electrical generation during water restrictions (Goldstein and Smith, 2002).

The resulting increase in value of water for electricity generation in dry climates could create a niche market for North Dakota lignite, a low-sulfur, relatively high-moisture coal. One of the key limiting factors in transportation of high-moisture lignite – the high moisture content – can be an attribute where that water has sufficient value. Lignite drying processes, such as GRE's LFE process, can be used to provide a low-sulfur, high-Btu fuel, and cost-effective recovery and reuse of that moisture could result in little or no power plant derating. The North Dakota lignite could be marketed as providing two commodities, premium lignite fuel and a source of water.

The recovered water also has significant value for a variety of other industrial uses, including use as makeup water for hydraulic fracturing in the Bakken oil play in North Dakota. In North Dakota's Bakken play, water is used in the oil field to pressurize and fracture oil-bearing formations to increase permeability and enhance the flow and recovery of oil. The volume of water required to hydraulically fracture one well ranges from 10,000 to 95,250 bbl (0.5 to 4 million gallons), depending on the number of stages in the fracture. Multistage fractures, which require more water than single-stage fractures, are increasingly being employed in the Bakken Formation because they generate fractures more effectively. Relatively low total dissolved solids and bacteria-free water are required for hydraulic fracturing. Limited available supplies of freshwater are creating a high demand for freshwater in oil production. The water recovered from the drying of North Dakota lignite may provide a viable opportunity for use in the oil field.

Great River Energy's Lignite Fuel Enhancement System

GRE developed the LFE lignite drying system to produce a lower-moisture fuel to improve coal-fired power generation efficiency as well as reduce emissions. GRE conducted extensive testing of the LFE system, drying North Dakota Freedom Mine lignite from 38% to 28% moisture, which resulted in up to 5% greater power plant efficiency, lower coal feed rates, and lower emissions for the given electrical load (Ness and Bullinger, 2005). The LFE process, illustrated in Figure 2, has been fully deployed at GRE's Coal Creek Station. The LFE system uses relatively low-temperature waste heat to warm water and air, which drives a bubbling fluidized-bed coal dryer to remove moisture from the lignite. The hot-water loop is closed and recycled. The 120°F, near-saturated exhaust air from the dryer is directed through a baghouse to remove particulates before it is vented to the atmosphere. The moisture in the vented exhaust is likely to be high-quality water suitable for use as cooling water makeup or as a boiler feed water with minimal treatment.

SPX Cooling Technologies Heat Exchanger

SPX has patented a polyvinyl chloride (PVC)-based heat exchanger called the Air2Air. It was designed to be used in cooling towers for water recovery and for plume abatement as part of the ClearSky system. The ClearSky system, shown in Figure 3, utilizes the Air2Air heat exchanger modules (shown as black squares) mounted above the cooling tower packing. By using the PVC heat exchanger modules in series in the tower plenum, ambient air condenses much of the moisture before it exits the tower, thereby reducing the amount of water vapor that is vented to the atmosphere that would result in a visible condensation plume. The Air2Air heat exchanger cools the air to saturation, causing the water vapor to condense and drier air to be discharged.

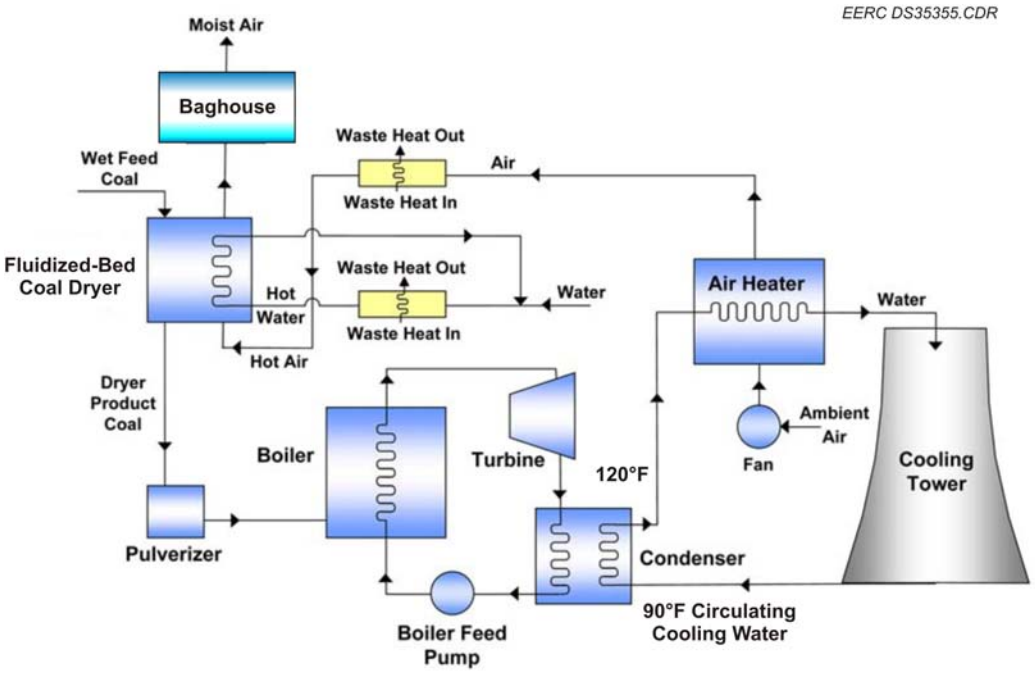

Figure 2. GRE LFE system.

Figure 3. Schematic of SPX ClearSky system with the Air2Air mounted above the cooling tower packing.

Utilization of SPX heat exchangers for water recovery from the moist air generated from coal drying is thus a logical extension of its designed application.

QUALIFICATIONS

Project Team

The EERC project team has extensive experience in energy processing and water systems. Mr. Joshua Ziman, Research Engineer, will be responsible for overall project management. Mr. Ziman will report directly to Mr. Daniel Stepan, Senior Research Manager and Program Coordinator for the EERC's Northern Great Plains Water Consortium, who will oversee all project activities. Dr. Robert Cowan, Ms. Kerryanne Leroux, and Dr. Sheila Hanson will serve as co-principal investigators to the proposed project. Resumes for these individuals can be found in Appendix A.

Project Manager. *Joshua J. Ziman, Research Engineer:* Mr. Ziman holds a B.S. degree in Chemical Engineering. His expertise includes process engineering, equipment diagnosis, and construction methods. Mr. Ziman also has experience in water treatment, emerging contaminants in drinking water, and anaerobic digestion. Prior to his position at the EERC, Mr. Ziman worked for Archer Daniels Midland, assisting in the management of capital expansion projects.

Technical Advisor. *Daniel J. Stepan, Senior Research Manager:* Mr. Stepan is a Senior Research Manager in the Water Management Center at the EERC, where his current responsibilities include coordination of the Northern Great Plains Water Consortium and management of multidisciplinary wastewater treatment and remediation research projects. Current research activities include treatment and reuse of oil field waters, enhanced anaerobic treatment of dairy manure, biomass gasification wastewater treatment, water resource

assessments for power generation, and assessment and treatment of nontraditional water supplies.

Technical Support.. *Robert M. Cowan, Research Engineer:* Dr. Cowan holds a Ph.D. degree in Civil (Environmental) Engineering, an M.S. degree in Chemical (Biochemical) Engineering, and a B.S. degree in Chemical Engineering. His work focuses on addressing the issue of global climate change through carbon capture and storage (CCS), including developing novel capture technologies, designing equipment and conducting experiments, and assisting with the development of programs to minimize and treat water used or produced during CCS activities. Dr. Cowan's principal areas of interest and expertise include separations science, industrial wastewater treatment, air pollution control, carbon dioxide capture, and bioremediation.

Kerryanne M. Leroux, Research Engineer: Ms. Leroux holds M.S. and B.S. degrees in Chemical Engineering. Ms. Leroux has extensive experience in energy processes. She has performed data, statistical, and economic analyses as well as feasibility studies for numerous technologies such as gasification, cogeneration facilities, alternative energy, and other high-value products. Ms. Leroux has also provided technical support for water management efforts, including water/wastewater treatment and mitigation, through method and technology assessment, process data analyses, and statistical interpretation. Current efforts include process designing and testing for pilot- and demonstration-scale systems.

Sheila K. Hanson, Marketing Research Manager: Dr. Hanson holds a Ph.D. and an M.S. in Research Methodologies, a B.A. in Psychology and German, and a B.B.A. in Marketing, all from the University of North Dakota. Her principal areas of interest and expertise include business development of energy conversion systems and renewable energy, commercialization and marketing of high-tech products, economic and technical feasibility studies, university–industry

relations, technology transfer, and marketing of higher education. Prior to her position at the EERC, she served as the Marketing Director at the University of North Dakota Center for Innovation, a technology incubator, and Marketing Research Director for Simmons Advertising.

EERC

The EERC is one of the world's major energy and environmental research organizations, providing access to an array of multidisciplined engineers and scientists. Since its founding in 1951, the EERC has conducted research, testing, and evaluation of fuels, combustion and gasification technologies, emission control technologies, ash use and disposal, analytical methods, groundwater impacts, cofiring technologies, and advanced environmental control systems.

Expertise. All EERC projects have resulted in valuable information used by various federal, state, and municipal agencies and industrial clients to pursue financing, present projects for management or legislative review, negotiate rates with utilities, or provide public outreach. The EERC is a nonprofit organization that seeks the best solution for the client. The EERC is not affiliated with any specific corporation or required to promote technologies under development at the EERC. Examples of EERC reports are available upon request.

Coal Utilization Technologies Center. The EERC has been involved in research and development of clean coal technologies for over 50 years and is the world's leading research and development center for coal, with special emphasis on low-rank coal. Coal research at the EERC pursues a scientific understanding of the physical, chemical, and mineralogical nature of coal and its associated earth materials as the foundation for predictively engineering coal conversion and power systems. EERC research, development, demonstration, and commercialization programs are designed to embrace all aspects of energy-from-coal technologies from cradle to grave,

beginning with fundamental resource characterization and ending with waste utilization or disposal in mined land reclamation settings.

Water Management Center. Water is the world's most precious resource. In order to ensure sufficient quantities of quality water for public use and future development of industry and agriculture, intelligent use and management of water resources are required. The EERC has a long history of water management research. Today, it is a recognized expert on a host of water conservation and contamination issues and has an expanding number of water management initiatives.

Personnel, Facilities, and Equipment. Since its founding in 1951, the EERC has conducted research, testing, and evaluation of fuels, combustion and gasification technologies, emission control technologies, ash use and disposal, analytical methods, groundwater, waste-to-energy systems, and advanced environmental control systems.

The EERC has specific experience in the design, procurement, fabrication, installation, and testing of conventional and advanced process development systems. Over 345 scientists, engineers, technicians, and support staff are available at the EERC to address current problems and assess future needs. The research staff is equipped with state-of-the-art analytical and engineering facilities. The EERC houses 245,000 square feet of laboratories, technology demonstration facilities, and offices and is located on the southeast corner of the University of North Dakota campus. Laboratory- and pilot-scale equipment is available for evaluating new fuels and assessing new emission control technologies. Analytical techniques and instrumentation are available for the characterization of solid, liquid, and gaseous materials. Thus the EERC can provide a total-system assessment of a wide variety of energy, environmental, and mineral resource research topics.

Capabilities. The EERC has established working relationships with over 1120 clients in 51 countries and all 50 states, including federal and state agencies, universities, coal companies, utilities, research and development firms, equipment vendors, architecture and engineering firms, chemical companies, and agricultural product companies. The EERC emphasizes true working partnerships among private industry, government agencies, academic institutions, and the research community.

The EERC also fosters cooperation among industry, government, and the local communities. The EERC has well-established working relationships with numerous private and public entities throughout the United States. These relationships involve contracts with individual entities as well as contracts involving groups of entities participating in cooperative multiclient projects. Thus the EERC is committed to a partnership team approach for energy and environmental technologies.

VALUE TO NORTH DAKOTA

The goal of this project is to demonstrate the technical and economic viability of recovering water produced during the drying of North Dakota lignite and to assess new market opportunities for the resulting premium lignite fuel and a valuable source of high-quality water. The commercialization of the proposed application is likely near-term as both the SPX module and the GRE LFE are commercial technologies. The process requires testing and validation to garner interest and promote the benefits for national marketing. The long-term advantages of the proposed project will be increased opportunity and growth in the lignite industry.

The proposed project would also assist in the economical and environmental sustainability of current and future electrical energy infrastructure while expanding the marketability of North

Dakota lignite. Technology that reduces net water consumption while maintaining existing coal-fired power plants is of national interest (Goldstein and Smith, 2002). Recovery of this valuable resource is essential as demand for electricity increases, especially for utilities located in drier climate regions where water supply can limit power generation.

Dissemination of project results will educate the public and private sector on the opportunities for water conservation from North Dakota lignite, spurring interest in both commercializing the proposed technology and increasing North Dakota lignite exports. The long-term effects of commercialization of the proposed technology will not only secure but enhance the current lignite market, preserving as well as creating jobs in the industry of coal to electricity.

MANAGEMENT

The EERC will be responsible for managing and overseeing the project, ensuring that all project goals and deliverables are met. A time line is presented in the timetable section that provides a detailed schedule for each of the tasks, containing several milestones such as installation, shakedown, and completion of water sampling and economic and market assessments. Several decision points are also listed, including final part selection, minimum condensation of 1 gpm and up to an average of 30% of the partial LFE exhaust stream, evaluation of water sampling events as planned, and sufficient availability of operating costs to conduct the economic assessment. Project sponsors will be notified of the completion of each deliverable and milestone as tasks are completed.

Once the project is initiated, monthly or as-needed conference calls will be held with project sponsors and team members to review the project status. A comprehensive final report

will be issued to all project sponsors at the conclusion of the project detailing results, and project findings will be presented at a national conference.

TIMETABLE

Figure 4 illustrates the suggested time line for the proposed work, which is anticipated to be complete within 18 months.

BUDGET

The total project budget is $897,335. The EERC is requesting $266,520 from NDIC to be matched with $266,520 from EPRI, as was sent to them in a preproposal, and noncash cost share from GRE, in the amount of $32,000, and SPX, in the amount of $23,500. The EERC will provide $308,795 from the DOE-sponsored NGPWC, contingent upon DOE approval. A detailed budget and budget notes are included in Appendix B. Equipment costs are approximately $105,000 to purchase blowers, which will be used to control the airflow into the heat exchanger and to force the air to reenter the main pipe. Travel expenses for the EERC include a kickoff meeting, project review meetings, presentation at a national conference, and site visits to Underwood, North Dakota, and are also included in the budget estimate.

MATCHING FUNDS

The EERC is matching the requested $266,520 from NDIC with noncash cost share from SPX in the amount of $23,500 to cover all labor and travel required to design, install, and test the SPX unit. GRE will also be providing noncash cost share in the amount of $32,000 to cover labor

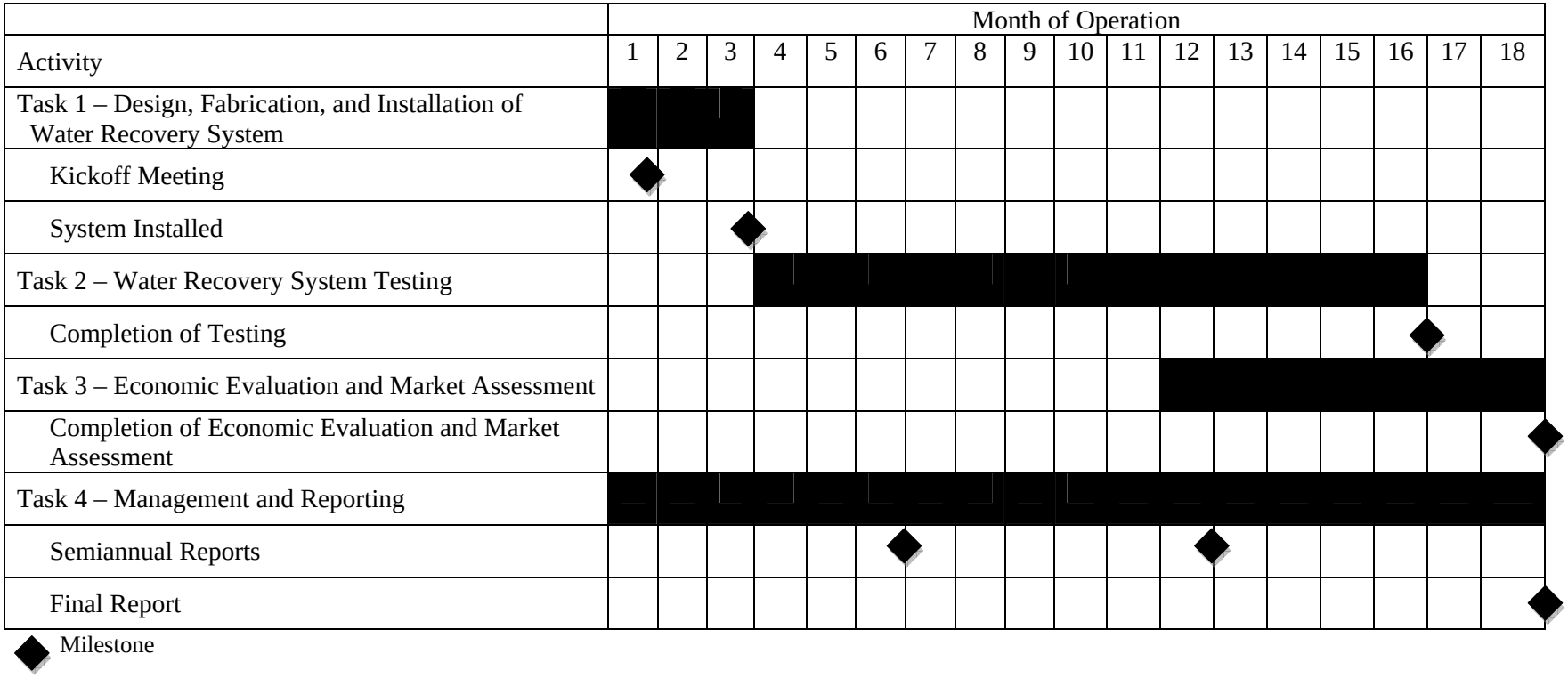

Figure 4. Estimated timetable for the EERC demonstration of water recovery from the drying of North Dakota lignite.

costs for site preparation to install the SPX unit. A preproposal has been submitted to the EPRI, and it is anticipated that EPRI will contribute $266,520 to the project. The EERC will provide $308,795 from the DOE-sponsored NGPWC, contingent upon DOE approval. 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

This proposal does not contain confidential information.

Patents and Rights to Technical Data

The manufacture of each product used in the EERC maintains existing intellectual property. All parties involved will have use of the data generated.

REFERENCES

Energy Information Administration. Annual Energy Outlook 2010: with Projections to 2035; Washington, DC, 2010.

Goldstein, R; Smith, W. Water & Sustainability (Volume 3): U.S. Water Consumption for Power Production – The Next Half Century. Electric Power Research Institute, Palo Alto, CA, March 2002.

Kenny, J.F.; Barber, N.L.; Hutson, S.S.; Linsey, K.S.; Lovelace, J.K.; Maupin, M.A. *Estimated Use of Water in the United States in 2005*; U.S. Geological Survey Circular 1344, 2009, 52 p.

Ness, M.; Bullinger, C. Pre-Drying the Lignite to GRE's Coal Creek Station. Presented at the Technical Conference on Coal Utilization and Fuel System, Clearwater, FL, May 2005.

Solley, W.B.; Pierce, R.R.; Perlmen, H.A. Estimated Use of Water in the United States. U.S. Geological Survey, 1995.

APPENDIX A

RESUMES OF KEY PERSONNEL

JOSHUA J. ZIMAN
Research Engineer
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) 777-5420, Fax: (701) 777-5181, E-Mail: jziman@undeerc.org

Principal Areas of Expertise

Mr. Ziman's principal areas of interest and expertise include process engineering, equipment diagnosis, construction methods, and emerging contaminants.

Qualifications

B.S., Chemical Engineering, South Dakota School of Mines and Technology, 2007.

Professional Experience

2008–Present: Research Engineer, EERC, UND. Mr. Ziman's work focuses on a variety of issues related to energy and water sustainability. Specific responsibilities include review and interpretation of technical literature and data, preparation of technical reports and journal articles, presentations at national and international meetings and to clients, and preparation of proposals to government and commercial entities.

2007–2008: Production Assistant, Archer Daniels Midland, Lincoln, Nebraska. Mr. Ziman's responsibilities included assisting with daily plant operations, performing lockout/tagout, filing confined space and hot work permits, directing equipment repair, solving production problems, supervising employees, dealing with employee performance issues, submitting plans, requesting capital for a $72,000 project, and implementing a $5.3 million project.

2006: Engineering Intern, Archer Daniels Midland, Velva, North Dakota. Mr. Ziman's responsibilities included assisting project engineers, performing equipment analysis, sizing equipment, and project supervision.

2005–2007: Research Assistant, Innovative Materials, Rapid City, South Dakota. Mr. Ziman's responsibilities included operating a scanning electron microscope, measuring particle-size distribution, using Daisy Lab data acquisition software, using a high-speed camera, revamping experimental procedures, rebuilding lab equipment, and contributing to technical presentations and reports.

DANIEL J. STEPAN
Senior Research Manager
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, ND 58202-9018 USA
Phone (701) 777-5247, Fax (701) 777-5181, E-mail: dstepan@undeerc.org

Principal Areas of Expertise

Mr. Stepan's principal areas of interest and expertise include industrial wastewater treatment, groundwater and soil remediation, and pilot- and bench-scale treatability testing.

Education

M.E., Sanitary Engineering/Water Resource Management, University of North Dakota, 1988.
B.S., Civil Engineering, University of North Dakota, 1985.

Professional Experience

1999–Present: Senior Research Manager, Water Resource Management and Wastewater Treatment, EERC, UND. Mr. Stepan is in the Water Management Center at the EERC, where his current responsibilities include coordination of the Northern Great Plains Water Consortium and management of multidisciplinary wastewater treatment and remediation research projects. Current research activities include treatment and reuse of oil field waters, enhanced anaerobic treatment of dairy manure, biomass gasification wastewater treatment, water resource assessments for power generation, and assessment and treatment of nontraditional water supplies.

1993–1999: Research Manager, Remediation, EERC, UND. Mr. Stepan's responsibilities included evaluation of thermal, chemical, and physical remediation technologies for the removal of mercury from soils and the development and field demonstration of remediation technologies, including soil vapor extraction, bioventing, and ex situ groundwater remediation to address subsurface contamination at natural gas processing facilities.

1988–1992: Research Engineer/Project Manager, EERC, UND. Mr. Stepan was responsible for the overall technical direction of wastewater treatability testing programs. As a Principal Investigator, he was responsible for design, construction, operation, data handling and data reduction, and reporting for bench- and pilot-scale treatability test programs involving coal processing wastewaters. Treatability program operations and processes included solvent extraction, steam stripping, conventional activated sludge, two-stage activated sludge, coupled nitrification/ denitrification activated sludge, rotating biological contactors, cooling towers, wet air oxidation, activated carbon adsorption, ion exchange, ultrafiltration, ozonation, and chemical precipitation.

1987–1988: Engineering Technician, Energy and Mineral Research Center, UND.

1985–1987: Graduate Research Assistant, Department of Civil Engineering, UND. Mr. Stepan was responsible for construction, maintenance, and data reduction for bench-scale activated sludge systems.

1980–1983: Quality Control Technician (summers), Superwood Corporation, Duluth, Minnesota.

1974–1978: U.S. Navy. Aviation jet engine maintenance technician and test cell operator, both ashore and aboard the USS Nimitz. Honorably discharged as Second Class Petty Officer.

Professional Memberships
American Society of Civil Engineers
American Water Works Association
Water Environment Federation

Publications and Presentations
Has authored or coauthored numerous publications.

DR. ROBERT M. COWAN
Research Engineer
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) 777-5396, Fax: (701) 777-5181, E-Mail: rcowan@undeerc.org

Principal Areas of Expertise

Dr. Cowan's principal areas of interest and expertise include separations science, industrial wastewater treatment, air pollution control, carbon dioxide capture, and bioremediation.

Qualifications

Ph.D., Civil (Environmental) Engineering, State University of New York at Buffalo, 1994. Dissertation: Effect of Interspecies Interactions on Population Dynamics in a Chemostat as Related to Bacterial Supplementation Processes.
M.S. (departmental honors), Chemical (Biochemical) Engineering, State University of New York at Buffalo, 1987.Thesis: Separating Lactic Acid from Fermentation Media Using Liquid Membrane Emulsions.
B.S. (graduated with distinction), Chemical Engineering, State University of New York at Buffalo, 1984.

Professional Experience

2010–Present: Research Engineer, EERC, UND. Dr. Cowan's work focuses on addressing the issue of global climate change through carbon capture and storage (CCS), including developing novel capture technologies, designing equipment and conducting experiments, and assisting with the development of programs to minimize and treat water used or produced during CCS activities. Current projects include Carbon Dioxide Capture Technology Review, Anaerobic Digestion of Feedlot Waste, and Water Use and Water Quality Impacts of Carbon Dioxide Capture.

2006–2009: Laboratory Director and Senior Scientist, Carbozyme, Inc., Monmouth Junction, New Jersey. Dr. Cowan's responsibilities included managing all aspects of CO_2 capture technology research and development to include writing monthly progress reports and task milestone reports on a $7,500,000 U.S. Department of Energy (DOE)-funded project; managing a scientific and technical team of four Ph.D. engineers, one M.S. professional engineer, and two technicians; developing enzyme immobilization methods for carbonic anhydrase; developing methods for testing immobilized enzyme performance; developing data analysis procedures for quantifying component and system performance which included analysis of flux, permeance, stoichiometry, and kinetics, as well as electrical power requirements for electrodialysis; designing experimental apparatus and experiments for study of all aspects of CO_2 capture; directing the progress of modeling efforts; designing, constructing, and operating prototype CO_2 capture devices; developing and writing research grant proposals; and performing technical liaison functions between company, subcontractors, and vendors.

2008: Lecturer, Environmental Engineering, Civil and Environmental Engineering, Princeton University. Dr. Cowan taught an upper-level engineering class, CEE 303 – Introduction to Environmental Engineering.

2005–2006: Process Specialist, EnviTreat, LLC., Springdale, Alasaka. Dr. Cowan's responsibilities included consulting to industries, municipalities, and engineering firms on industrial wastewater treatability; assessing the stoichiometry and kinetics of biodegradation of industrial wastewater; evaluating wastewater treatability and toxicity; recommendation of process improvements based on results of laboratory testing; developing methods for and performing regression analysis of respirometric data; developing proposals and quotes for laboratory and process analysis services; designing respirometry experiments and data analysis methods; and providing training on the use of respirometers.

2001–2006: Independent Consultant, RMC Environmental, Dayton, New Jersey. Dr. Cowan's responsibilities included consulting to industry and testing laboratories on wastewater treatment and respirometry. Clients included RespirTek, Inc., Biloxi, Mississippi; ELAN Chemicals, Newark, NJ; Mitsubishi Chemical Company, Japan; OLI Systems, Inc., Morris Plains, New Jersey; and Challenge Environmental Laboratories, Fayetteville, Arizonza.

2001–2003: Senior Research Scientist and Laboratory Director, Sapient's Institute, Monmouth Junction, New Jersey. Dr. Cowan's responsibilities included developing technology for the capture and sequestration of carbon dioxide from air, flue gas, and natural gas; researching water treatment and water recycling technology for the National Aeronautics and Space Administration (NASA); managing research program to develop capture and sequestration technology using enzyme-based contained liquid membrane reactor for use in advanced life support and in CO_2 capture from air; and developing and writing successful grant proposals for the NASA and DOE.

1994–2001: Assistant Professor of Environmental Engineering, Department of Environmental Sciences, Rutgers University. Dr. Cowan's responsibilities included managing a large research group with over $1,500,000 in sponsored research; research and training in the areas of bioremediation, industrial wastewater treatment, solid waste management, and air pollution control; conducting biological treatment and toxicity studies of refinery wastewaters experiencing shock loads of Monoethanolamine biodegradation studies on methyl tertiary-butyl ether, other fuel oxygenates, and gasoline components, and degradation of ethylene and ammonia in air treatment biofilters and composting; implementing major changes in both the Environmental Engineering and the Environmental Sciences curricula; designing, developing, and teaching two new laboratory courses and three new lecture courses; leading multidisciplinary Waste Processing and Resource Recovery research team of the New Jersey–NASA Specialized Center of Research and Training for Bioregenerative Life Support, a 5-year multi-investigator project funded by NASA; and collaborating with faculty from departments of Chemical and Biochemical Engineering, Biochemistry, and Microbiology on a multidisciplinary Defense Advanced Research Projects Agency project.

Professional Registration
Engineer In Training certification, South Carolina

Professional Memberships
American Chemical Society
Water Environment Federation
American Institute of Chemical Engineers

Publications and Presentations
Has coauthored several technical publications.

KERRYANNE M. LEROUX
Research Engineer
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) 777-5013, Fax: (701) 777-5181, E-Mail: kleroux@undeerc.org

Principal Areas of Expertise

Ms. Leroux's principal areas of interest and expertise include renewable and alternative energy and chemicals market evaluation, technical feasibility, process design, pilot- and demonstration-scale testing, and economic analysis.

Qualifications

M.S., Chemical Engineering, University of North Dakota, 2001.
B.S., Chemical Engineering, University of North Dakota, 1999.

Professional Experience

2001–Present: Research Engineer, EERC, UND. Ms. Leroux has performed data, statistical, market, and economic analyses as well as feasibility studies for numerous renewable energy technologies, including wind hybrid systems, demonstration-scale gasification, fuel cells, energy storage, biomass cogeneration and combined heat and power facilities, Fischer–Tropsch fuels, pyrolysis, biodiesel, ethanol, hydrogen, and cellulosic chemicals and fuel with the Center for Biomass Utilization®, , the National Alternative Fuels Laboratory®, and the Plains Organization for Wind Energy Resources®. She has provided support for water management efforts through method and technology assessment, process data analyses, and statistical interpretation with the Fernald Silo Waste-Processing and Waffle® projects and the Red River Water Management Consortium. Ms. Leroux's responsibilities include serving as a principal investigator or project manager on assigned tasks; providing project support and guidance and regularly assessing activities and progress; effectively reporting results and conclusions of research activities to clients through technical reports, publications, papers, posters, and personal communication as contractually required; and collecting, reducing, analyzing, and interpreting data and ensuring quality control of personal work.

1999–2001: Graduate Research/Education, Department of Chemical Engineering, UND. Ms. Leroux's work on two-phase flow models for low-pressure systems continued scarce research of pressure gradient models for various regimes, including a deriving model and writing a simulation program for annular flow, and identified parameters for significance of liquid vaporization and acceleration. She also revised an air/water simulation program for hydrogen pressure drop, accommodating National Aeronautics and Space Administration's interest, and altered parameters within a model applicable to all flow regimes for gradient estimation particular to stratified flow. In addition, she designed experiments for an industrial setting and performed statistical analysis of collected data.

Publications and Presentations

Has coauthored numerous professional publications.

DR. SHEILA K. HANSON
Marketing 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) 777-5185, Fax: (701) 777-5181, E-Mail: shanson@undeerc.org

Principal Areas of Expertise

Dr. Hanson's principal areas of interest and expertise include technical program outreach, marketing research, technology commercialization, and business planning.

Qualifications

Ph.D., Research Methodologies with a cognate in Business Administration, UND, 2000.
Dissertation: Alumni Characteristics that Predict Donating and Promoting to Alma Mater.
M.S., Research Methodologies, UND, 1992.
B.A., Psychology and German, UND, 1990.
B.B.A., Marketing, UND, 1988.

Professional Experience

2001–Present: Marketing Research Manager, EERC, UND. Dr. Hanson's responsibilities include conducting marketing research for a variety of industry and government organizations, providing market information for interdisciplinary teams of scientists and engineers, and assisting senior management with marketing tasks.

2000–2007: Assistant Professor, Department of Marketing, UND. Dr. Hanson taught Marketing Research, Advertising, and Marketing Foundations.

1998–1999: Lecturer, Department of Marketing, UND. Dr. Hanson taught Principles of Marketing.

1997–2001: Marketing Director, Center for Innovation, UND. Dr. Hanson's responsibilities included managing the research, analysis, and writing of commercial evaluations and marketing assessments of energy-related technologies for a U.S. Department of Energy grant and researching and writing economic and marketing feasibility studies, business plans, and marketing plans for clients for a variety of products and technologies.

1997–1998: Instructor, Department of Educational Foundations and Research, UND. Dr. Hanson taught Statistical Methods.

1996–Present: Consulting Services. Dr. Hanson has provided focus group, survey research, market planning, and media planning consultation for a broad range of clients, including the Grand Forks Region Economic Development Corporation, Grand Forks Chamber of Commerce, health care facilities, banks, and retail organizations.

1992–1997: Marketing Research Director, Simmons Advertising, Grand Forks, North Dakota. Dr. Hanson's responsibilities included conducting market reviews, focus groups, and survey research for a wide variety of clients, including electric utilities, fast food, banking, and health care facilities; using account planning to develop creative themes for advertising campaigns; and researching, planning, and managing marketing and communications plans and budgets for clients.

1992–1997: Media Buyer. Dr. Hanson's responsibilities included performing qualitative and quantitative media analysis and evaluation, evaluating media opportunities and trends, and measuring the effectiveness of media campaigns using Media Management Plus software.

Professional Memberships
American Academy of Advertising
Association for Consumer Research
Academy of Management
American Marketing Association
American Advertising Federation

Publications and Presentations
Has authored and coauthored numerous professional publications.

APPENDIX B

BUDGET AND BUDGET NOTES

WATER RECOVERY FROM LIGNITE DRYING
NDIC
PROPOSED PROJECT START DATE: 9/1/11
EERC PROPOSAL #2011-0209

BUDGET

CATEGORY			PROJECT TOTAL		NDIC SHARE		EPRI SHARE		SPX NON-CASH SHARE		GRE NON-CASH SHARE		FEDERAL SHARE	
LABOR		Rate	Hrs	Cost	Hrs	Cost	Hrs	Cost	Hrs	Cost	Hrs	Cost	Hrs	Cost
Ziman, J.	Project Manager	$ 29.49	1,080	$ 31,849	435	$ 12,828	315	$ 9,290	-	$ -	-	$ -	330	$ 9,731
Leroux, K.	Co-Principal Investigator	$ 33.40	760	$ 25,384	310	$ 10,354	190	$ 6,346	-	$ -	-	$ -	260	$ 8,684
Cowan, R.	Co-Principal Investigator	$ 46.80	600	$ 28,080	220	$ 10,296	180	$ 8,424	-	$ -	-	$ -	200	$ 9,360
Hanson, S.	Co-Principal Investigator	$ 40.65	240	$ 9,756	85	$ 3,456	85	$ 3,456	-	$ -	-	$ -	70	$ 2,844
Stepan, D.	Project Advisor	$ 60.70	400	$ 24,280	175	$ 10,623	115	$ 6,981	-	$ -	-	$ -	110	$ 6,676
----------	Senior Management	$ 74.19	184	$ 13,651	48	$ 3,561	-	$ -	-	$ -	-	$ -	136	$ 10,090
----------	Research Scientists/Engineers	$ 39.47	1,247	$ 49,219	681	$ 26,880	309	$ 12,196	-	$ -	-	$ -	257	$ 10,143
----------	Research Technicians	$ 25.94	310	$ 8,041	65	$ 1,686	-	$ -	-	$ -	-	$ -	245	$ 6,355
----------	Technology Dev. Mechanics	$ 30.94	320	$ 9,901	320	$ 9,901	-	$ -	-	$ -	-	$ -	-	$ -
----------	Undergrad-Res.	$ 10.61	520	$ 5,518	185	$ 1,964	235	$ 2,494	-	$ -	-	$ -	100	$ 1,060
----------	Technical Support Services	$ 21.50	184	$ 3,957	65	$ 1,398	26	$ 559	-	$ -	-	$ -	93	$ 2,000
				$ 209,636		$ 92,947		$ 49,746		$ -		$ -		$ 66,943
Escalation Above Base			7%	$ 14,675		$ 6,506		$ 3,482		$ -		$ -		$ 4,687
TOTAL DIRECT HRS/SALARIES			5,845	$ 224,311	2,589	$ 99,453	1,455	$ 53,228	-	$ -	-	$ -	1,801	$ 71,630
Fringe Benefits - % of Direct Labor - Staff		55.0%		$ 120,124		$ 53,543		$ 27,808		$ -		$ -		$ 38,773
Fringe Benefits - % of Direct Labor - Undergrad. Research		1.0%		$ 59		$ 21		$ 27		$ -		$ -		$ 11
TOTAL FRINGE BENEFITS				$ 120,183		$ 53,564		$ 27,835		$ -		$ -		$ 38,784
TOTAL LABOR				$ 344,494		$ 153,017		$ 81,063		$ -		$ -		$ 110,414
TRAVEL				$ 14,740		$ 4,976		$ -		$ -		$ -		$ 9,764
EQUIPMENT > $5000				$ 105,000		$ -		$ -		$ -		$ -		$ 105,000
SUPPLIES				$ 19,085		$ 6,868		$ 2,192		$ -		$ -		$ 10,025
SUBCONTRACTOR – WESTCON INC. (INSTALL SYSTEM AT SITE)				$ 100,000		$ -		$ 100,000		$ -		$ -		$ -
COMMUNICATION - LONG DISTANCE & POSTAGE				$ 795		$ 115		$ 125		$ -		$ -		$ 555
PRINTING & DUPLICATING				$ 750		$ 115		$ 125		$ -		$ -		$ 510
FOOD				$ 450		$ 450		$ -		$ -		$ -		$ -
OPERATING FEES & SVCS														
Natural Materials Analytical Res. Lab.				$ 1,034		$ -		$ 1,034		$ -		$ -		$ -
Fuels & Materials Research Lab.				$ 2,607		$ -		$ 2,607		$ -		$ -		$ -
Analytical Research Lab.				$ 6,452		$ -		$ 6,452		$ -		$ -		$ -
Graphics Support				$ 2,696		$ 500		$ 500		$ -		$ -		$ 1,696
Shop & Operations Support				$ 534		$ 534		$ -		$ -		$ -		$ -
Outside Lab.				$ 3,500		$ -		$ 601		$ -		$ -		$ 2,899
TOTAL DIRECT COST				$ 602,137		$ 166,575		$ 194,699		$ -		$ -		$ 240,863
NON-CASH COST SHARE – SPX COOLING TECHNOLOGIES				$ 23,500		$ -		$ -		$ 23,500		$ -		$ -
NON-CASH COST SHARE – GREAT RIVER ENERGY				$ 32,000		$ -		$ -		$ -		$ 32,000		$ -
FACILITIES & ADMIN. RATE - % OF MTDC			VAR	$ 239,698	60%	$ 99,945	60%	$ 71,821	60%	$ -	60%	$ -	49%	$ 67,932
TOTAL PROJECT COST - US DOLLARS				$ 897,335		$ 266,520		$ 266,520		$ 23,500		$ 32,000		$ 308,795

Due to limitations within the University's accounting system, bolded budget line items represent how the University proposes, reports and accounts for expenses. Supplementary budget information, if provided, is for proposal evaluation.

WATER RECOVERY FROM LIGNITE DRYING
EERC PROPOSAL #2011-0209

BUDGET - TRAVEL

ASSEMBLY & SHAKEDOWN – UNDERWOOD, ND				**AIRFARE**	**PER DIEM**			**CAR**		
				RND TRP	**HOTEL**	**MEALS**	**MISC**	**RENTAL**	**MILEAGE**	
NAME	**# DAYS**	**# NIGHTS**	**# MILES**	$ 900	$ 75	$ 25	$ 10	$ 30	$ 0.62	**TOTAL**
Person 1 - Assembly & Shakedown	7	6	270	$ -	$ 450	$ 175	$ 70	$ -	$ 167	$ 862
Person 2 - Assembly & Shakedown	7	6	-	$ -	$ 450	$ 175	$ 70	$ -	$ -	$ 695
Person 3 - Assembly	5	4	270	$ -	$ 300	$ 125	$ 50	$ -	$ 167	$ 642
Person 4 - Assembly	5	4	-	$ -	$ 300	$ 125	$ 50	$ -	$ -	$ 475
Total - Assembly & Shakedown										$ 2,674

TESTING - UNDERWOOD, ND				**AIRFARE**	**PER DIEM**			**CAR**		
				RND TRP	**HOTEL**	**MEALS**	**MISC**	**RENTAL**	**MILEAGE**	
NAME	**# DAYS**	**# NIGHTS**	**# MILES**	$ 900	$ 75	$ 25	$ 10	$ 30	$ 0.62	**TOTAL**
Person 1 - Test 1	3	2	270	$ -	$ 150	$ 75	$ 30	$ -	$ 167	$ 422
Person 2 - Test 1	3	2	-	$ -	$ 150	$ 75	$ 30	$ -	$ -	$ 255
Person 1 - Test 2	3	2	270	$ -	$ 150	$ 75	$ 30	$ -	$ 167	$ 422
Person 2 - Test 2	3	2	-	$ -	$ 150	$ 75	$ 30	$ -	$ -	$ 255
Person 1 - Test 3	3	2	270	$ -	$ 150	$ 75	$ 30	$ -	$ 167	$ 422
Person 2 - Test 3	3	2	-	$ -	$ 150	$ 75	$ 30	$ -	$ -	$ 255
Person 1 - Test 4	3	2	270	$ -	$ 150	$ 75	$ 30	$ -	$ 167	$ 422
Person 2 - Test 4	3	2	-	$ -	$ 150	$ 75	$ 30	$ -	$ -	$ 255
Person 1 - Test 5	3	2	270	$ -	$ 150	$ 75	$ 30	$ -	$ 167	$ 422
Person 2 - Test 5	3	2	-	$ -	$ 150	$ 75	$ 30	$ -	$ -	$ 255
Person 1 - Test 6	3	2	270	$ -	$ 150	$ 75	$ 30	$ -	$ 167	$ 422
Person 2 - Test 6	3	2	-	$ -	$ 150	$ 75	$ 30	$ -	$ -	$ 255
Total - Sampling										$ 4,062

MEETINGS – BISMARCK, ND				**AIRFARE**	**PER DIEM**			**CAR**			
				RND TRP	**HOTEL**	**MEALS**	**MISC**	**RENTAL**	**MILEAGE**	**REGISTR.**	
NAME – PURPOSE	**# DAYS**	**# NIGHTS**	**# MILES**	$ 900	$ 75	$ 25	$ 10	$ 30	$ 0.62	$ 575	**TOTAL**
Person 1 - Kick-off Meeting	2	1	270	$ -	$ 75	$ 50	$ 20	$ -	$ 167	$ -	$ 312
Person 2 - Kick-off Meeting	2	1	-	$ -	$ 75	$ 50	$ 20	$ -	$ -	$ -	$ 145
Person 1 - Project Review Meeting	2	1	270	$ -	$ 75	$ 50	$ 20	$ -	$ 167	$ -	$ 312
Person 2 - Project Review Meeting	2	1	-	$ -	$ 75	$ 50	$ 20	$ -	$ -	$ -	$ 145
Total - Meetings											$ 914

DOE REVIEW MEETING – MORGANTOWN, WV				**AIRFARE**	**PER DIEM**			**CAR**			
				RND TRP	**HOTEL**	**MEALS**	**MISC**	**RENTAL**	**MILEAGE**	**REGISTR.**	
NAME – PURPOSE	**# DAYS**	**# NIGHTS**	**# MILES**	$ 1,100	$ 150	$ 46	$ 20	$ 75	$ 0.62	$ 575	**TOTAL**
Person 1 - DOE Review Meeting	2	1	-	$ 1,100	$ 150	$ 92	$ 40	$ 150	$ -	$ -	$ 1,532
Total - DOE Review Meeting											$ 1,532

CONFERENCES				**AIRFARE**	**PER DIEM**			**CAR**			
				RND TRP	**HOTEL**	**MEALS**	**MISC**	**RENTAL**	**MILEAGE**	**REGISTR.**	
NAME – PURPOSE	**# DAYS**	**# NIGHTS**	**# MILES**	$ 900	$ 200	$ 71	$ 20	$ 85	$ 0.62	$ 575	**TOTAL**
Person 1 - Conference	4	3	-	$ 900	$ 600	$ 284	$ 80	$ 340	$ -	$ 575	$ 2,779
Person 2 - Conference	4	3	-	$ 900	$ 600	$ 284	$ 80	$ 340	$ -	$ 575	$ 2,779
Total - Conferences											$ 5,558

TOTAL ESTIMATED TRAVEL $ 14,740

WATER RECOVERY FROM LIGNITE DRYING
EERC PROPOSAL #2011-0209

DETAILED BUDGET - EQUIPMENT

Other Equipment	
Blowers (2)	$ 105,000
	$ 105,000
Total Equipment	$ 105,000

WATER RECOVERY FROM LIGNITE DRYING
EERC PROPOSAL #2011-0209

DETAILED BUDGET - EERC RECHARGE CENTERS

		TASK ONE		TASK TWO		TASK FOUR		TOTAL	
Natural Materials Analytical Res. Lab.	Rate	#	$Cost	#	$Cost	#	$Cost	#	$Cost
XRFA	$161	-	$ -	6	$ 966	-	$ -	6	$ 966
Subtotal			$ -		$ 966		$ -		$ 966
Escalation		7%	$ -	7%	$ 68	7%	$ -	7%	$ 68
Total Natural Materials Analytical Res. Lab.			$ -		$ 1,034		$ -		$ 1,034
Fuels & Materials Research Lab.	Rate	#	$Cost	#	$Cost	#	$Cost	#	$Cost
BTU	$75	-	$ -	6	$ 450	-	$ -	6	$ 450
Proximate Ultimate	$260	-	$ -	6	$ 1,560	-	$ -	6	$ 1,560
Sulfur	$71	-	$ -	6	$ 426	-	$ -	6	$ 426
Subtotal			$ -		$ 2,436		$ -		$ 2,436
Escalation		7%	$ -	7%	$ 171	7%	$ -	7%	$ 171
Total Fuels & Materials Research Lab.			$ -		$ 2,607		$ -		$ 2,607
Analytical Research Lab.	Rate	#	$Cost	#	$Cost	#	$Cost	#	$Cost
Alkalinity	$27	-	$ -	6	$ 162	-	$ -	6	$ 162
BOD	$51	-	$ -	6	$ 306	-	$ -	6	$ 306
Chlorine	$55	-	$ -	6	$ 330	-	$ -	6	$ 330
COD	$16	-	$ -	6	$ 96	-	$ -	6	$ 96
Conductivity	$10	-	$ -	6	$ 60	-	$ -	6	$ 60
IC	$43	-	$ -	60	$ 2,580	-	$ -	60	$ 2,580
IC Prep	$15	-	$ -	6	$ 90	-	$ -	6	$ 90
Miscellaneous (Sample)	$53	-	$ -	6	$ 318	-	$ -	6	$ 318
pH	$16	-	$ -	6	$ 96	-	$ -	6	$ 96
Phenols-Total + Dist	$89	-	$ -	6	$ 534	-	$ -	6	$ 534
Sulfide	$52	-	$ -	6	$ 312	-	$ -	6	$ 312
TDS	$23	-	$ -	6	$ 138	-	$ -	6	$ 138
TKN	$60	-	$ -	6	$ 360	-	$ -	6	$ 360
TOC	$36	-	$ -	6	$ 216	-	$ -	6	$ 216
TS	$30	-	$ -	6	$ 180	-	$ -	6	$ 180
TSS	$9	-	$ -	6	$ 54	-	$ -	6	$ 54
TVS	$33	-	$ -	6	$ 198	-	$ -	6	$ 198
Subtotal			$ -		$ 6,030		$ -		$ 6,030
Escalation		7%	$ -	7%	$ 422	7%	$ -	7%	$ 422
Total Analytical Research Lab.			$ -		$ 6,452		$ -		$ 6,452
Graphics Support	Rate	#	$Cost	#	$Cost	#	$Cost	#	$Cost
Graphics (hourly)	$63	-	$ -	-	$ -	40	$ 2,520	40	$ 2,520
Subtotal			$ -		$ -		$ 2,520		$ 2,520
Escalation		7%	$ -	7%	$ -	7%	$ 176	7%	$ 176
Total Graphics Support			$ -		$ -		$ 2,696		$ 2,696
Shop & Operations Support	Rate	#	$Cost	#	$Cost	#	$Cost	#	$Cost
Technical Development Hours	$1.56	200	$ 312	120	$ 187	-	$ -	320	$ 499
Subtotal			$ 312		$ 187		$ -		$ 499
Escalation		7%	$ 22	7%	$ 13	7%	$ -	7%	$ 35
Total Shop & Operations Support			$ 334		$ 200		$ -		$ 534

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, 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.

Escalation of labor and EERC recharge center rates is incorporated into the budget when a project's duration extends beyond the current fiscal year. Escalation is calculated by prorating an average annual increase over the anticipated life of the project.

The 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.

Salaries: The EERC employs administrative staff to provide required services for various direct and indirect support functions. Salary estimates are based on the scope of work and prior experience on projects of similar scope. 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. Salary costs incurred are based on direct hourly effort on the project. Faculty who work on this project will be paid an amount over their normal base salary, creating an overload which is subject to limitation in accordance with university policy. Costs for general support services such as contracts and intellectual property, accounting, human resources, purchasing, shipping/receiving, and clerical support of these functions are included in the EERC facilities and administrative cost rate.

Fringe Benefits: Fringe benefits consist of two components which are budgeted as a percentage 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.

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 and/or identified more specifically in the accompanying budget detail.

Supplies – Professional, Information Technology, and Miscellaneous: 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 and Postage: 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: 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.

Professional Development: Fees 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 by the research team.

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: Facilities and administrative (F&A) 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 F&A rate for nonfederal sponsors is 60%. This rate is based on costs that are not included in the federally approved rate, such as administrative costs that exceed the 26% federal cap and depreciation/use allowance on buildings and equipment purchased with federal dollars.

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

April 1, 2011

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: Cost Share for EERC Proposal No. 2011-0209; Entitled "Water Recovery from Lignite Drying"

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 on projects that address the goals and objectives of DOE's Office of Fossil Energy.

The proposed project to the North Dakota Industrial Commission (NDIC) Lignite Research Program entitled "Water Recovery from Lignite Drying" is a viable candidate for funding under this program. Therefore, the EERC intends to secure $308,795 of cash cost share for the proposed project through its Cooperative Agreement with DOE provided that NDIC and the Electric Power Research Institute each commit $266,520 of cash cost share and SPX Cooling Technologies and Great River Energy commit noncash cost share of $23,500 and $32,000, respectively.

Once the EERC has received formal commitment from the nonfederal partners for the project, the EERC will seek concurrence from DOE. Initiation of the proposed work is contingent upon the execution of mutually negotiated agreements or modifications to existing agreements between the EERC and all participating project partners. If you have any questions, please contact me by phone at (701) 777-5215 or by e-mail jhendrikson@undeerc.org.

Sincerely,

John G. Hendrikson
Associate Director for Business and Operations

JGH/sah

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

BRYAN HANNEGAN, Ph.D.
Vice President
Environment and Renewables

March 30, 2011

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

Subject: Letter of Support - University of North Dakota Energy and Environmental Research Center's (EERC)'s proposal of "Recovery of Water from the Drying of North Dakota Lignite"

Dear Dr. Ziman:

EPRI is pleased to submit this letter in support of the University of North Dakota Energy & Environmental Research Center's (EERC's) proposed project entitled "Recovery of Water from the Drying of North Dakota Lignite," a proposal submitted to the North Dakota Industrial Commission's Lignite Research Council. We believe that this proposal is consistent with EPRI's interests and vision of generating electric power economically within the constraints of future water demands.

EPRI is a nonprofit corporation organized under the laws of the District of Columbia Nonprofit Corporation Act and recognized as a tax exempt organization under Section 501(c)(3) of the U.S. Internal Revenue Code of 1986, as amended, and whose mission is to conduct research and development in energy and related fields for the benefit of the public. EPRI supports the proposed project in furtherance of its public purpose mission.

EPRI has long recognized the need to reduce water demands for cooling power generating facilities while preserving cycle efficiency. The EERC water capture from coal drying concept is a technology that EPRI believes can address this issue. This new technology has the potential to economically replace a significant portion of the water needs of a typical coal-fired power plant, reducing the need to develop higher cost water sources and protecting existing surface and groundwater sources for other priority uses..

If the project is selected, EPRI is prepared to support the program by providing technical assistance and project guidance. EPRI will work with EERC, as we have in many other successful projects, to assist the team in assuring that the project meets the highest technical standards for success. Mr. Kent Zammit (Senior Program Manager for Water and Ecosystems – Environment Sector) would serve as an advisor for the project to assist EERC with project objectives relative to utility applications.

3420 Hillview Avenue, Palo Alto, CA 94304-1338 USA • 650.855.2459 • Fax 650.855.1042 • bhannegan@epri.com

Please note that any potential support assumes successful negotiation among the parties of a final project plan and mutually acceptable contractual arrangements. Such support would also be subject to both the availability of sufficient North Dakota Industrial Commission's Lignite Research Council and EERC funds at the time of award and to EPRI's continued interest in the project as ultimately structured. For the avoidance of doubt, this letter may not be construed by EERC, North Dakota Industrial Commission's Lignite Research Council, EPRI or any third party as creating legally binding obligations.

We are looking forward to working with you in this project. We urge the North Dakota Industrial Commission's Lignite Research Council to give strong consideration to this proposal.

Sincerely,

Bryan Hannegan, Ph.D.
Vice President, Environment and Renewables

SPX
COOLING TECHNOLOGIES

Mr. Joshua Ziman
Research Engineer
Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, North Dakota 58202 - 9018

September 23, 2010

Dear Mr. Ziman,

Subject: SPX Commitment to the EERC Water Recovery from Lignite Drying Project

SPX Cooling Technologies is an industry leading, full-line, full-service cooling tower and air-cooled condenser manufacturer. The companies that formed SPX Cooling Technologies were founded more than 100 years ago and have more than 250 global patents in the power generation, industrial, refrigeration, and HVAC markets. With more than 150 offices, subsidiaries, and partners worldwide, SPX has the global reach and local services necessary to deliver solutions for our customers. We are committed to the goal of continually improving quality, service, and value for our customers by exploring innovative processes as well as applications that affect all aspects of our products.

SPX Cooling Technologies would like to express its support for the University of North Dakota Energy & Environmental Research Center's (EERC's) proposed project entitled "Water Recovery from Lignite Drying Project," a proposal submitted by the EERC's Water Management Center to the North Dakota Industrial Commission's Lignite Research Council. SPX believes this project has significant potential advantages for our customers, if proven in application.

SPX Cooling Technologies intends to support the proposed program in the form of cash equivalent for the total amount of $23,500. As shown in the following table, SPX Cooling Technologies will provide functional water recovery heat exchange media, engineering support for use of this technology, installation support, and operational advice. The cash equivalent is contingent upon the successful execution of an appropriate research contract. It is understood that SPX Cooling Technologies funding for this project will provide cash equivalent to be leveraged with funding from the North Dakota Industrial Commission's Lignite Research Council. A brief estimation of our commitment is as follows:

Design	40 hrs @ $100 /hr	$4,000
Module	discounted value	$3,000
Construction/ Installation	40 hrs @ $100 /hr	$4,000
Shakedown	80 hrs @ $100 /hr	$8,000
Travel	3 trips @ $1500 /trip	$4,500
Total Value to Project		$23,500

Respectfully,

Kenneth P. Mortensen
SPX Cooling Technologies
7401 West 129th Street
Overland Park, Kansas 66213

W: 913-664-7723
C: 913-706-7635
ken.mortensen@spx.com

CC: Glenn Brenneke
Doug Bougher
Eric Rasmussen

RDclearskyheatxcoaldehonidundeercltrsupport091310.doc

GREAT RIVER
ENERGY®

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

September 22, 2010

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

Subject: GRE Commitment to the EERC Water Recovery from Lignite Drying Project

Dear Mr. Ziman:

Great River Energy would like to express its support for the University of North Dakota's Energy & Environmental Research Center's (EERC's) proposed project entitled "Water Recovery from Lignite Drying Project," a proposal submitted by the EERC's Water Management Center to the North Dakota Industrial Commission's Lignite Research Council. Great River Energy will provide the necessary access to our Coal Creek Station to conduct this project.

GRE intends to support the proposed program in the form of in kind support equivalent for the total amount of $32,000. GRE will provide oversee component installation and a portion of project operation. The in kind equivalent is contingent upon the successful execution of an appropriate research contract. It is understood that GRE funding for this project will provide in kind equivalent to be leveraged with funding from the North Dakota Industrial Commission's Lignite Research Council.

Sincerely,

Charlie Bullinger