GREAT RIVER ENERGY™

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September 30, 2019

Ms. Karlene Fine
Executive Director
North Dakota Industrial Commission
Attn: Lignite Research, Development and Marketing Program
State Capitol
600 East Boulevard Ave. Dept. 405
Bismarck, ND 58505-0840

Dear Ms. Fine,

Great River Energy is pleased to submit an electronic copy and two printed copies of the grant application for the "Preliminary Front End Engineering and Design (pre-FEED) Study for a Full-scale Carbon Dioxide Capture System at Coal Creek Station", North Dakota's largest power plant near Underwood and Washburn, ND.

The enclosed application seeks your support of the research and development efforts for the pre-FEED phase of a carbon dioxide capture system at Coal Creek Station.

The $100 application fee accompanies this letter.

Great River Energy is committed to the completion of this project described in the application. The Lignite Research Council grant support is crucial in confirming the technology to secure the future use of lignite in North Dakota.

Please contact me with any questions at 701-442-7000 or at jbauer@grenergy.com.

Sincerely,

John Bauer

John Bauer

Director, North Dakota Generation

Great River Energy

GREAT RIVER ENERGY™

Application for a Lignite Research Council Grant for:

$4,239,000

September 30, 2019

Principal Investigator:
John Bauer, Director
North Dakota Generation

Great River Energy
Coal Creek Station
2875 3rd St. SW
Underwood, ND 58576

GREATRIVERENERGY.COM

Preliminary Front End Engineering and Design (pre-FEED) Study for a Full-scale Carbon Dioxide Capture System at Coal Creek Station

CCS|2

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ABSTRACT

Objective: Great River Energy is embarking on a long-term project that intends to demonstrate carbon capture and storage at its 1,154 MW lignite Coal Creek Station power plant as an economically feasible means of reducing carbon emissions. The objective of this pre-FEED Study for a Full-Scale Carbon Dioxide Capture System, the Project, is to research and better quantify the costs, benefits, and operational issues of integrating a carbon capture system at Great River Energy's Coal Creek Station. The Project also includes a 3D seismic survey for injecting 200,000 tons of CO_2 from Blue Flint Ethanol into an on-site geologic formation. The Project will leverage learnings from prior carbon capture projects, including those completed by Lignite Research Council (LRC), Great River Energy, the Energy & Environmental Research Center (EERC) and the Electric Power Research Institute (EPRI).

Expected Results: Great River Energy expects the results of this research will provide important insights into overall costs, benefits, and operational issues and opportunities associated with integrating a carbon capture system into Coal Creek Station. While studies such as these are necessarily plant specific due to the unique design and operating aspects of each power plant, the studies will provide valuable insights for all North Dakota lignite coal fired power plants. It is anticipated that the results will provide a clear path towards the next steps in developing the full-scale carbon capture and safe storage system.

Project Duration: Twelve to 14 months from contracts being executed relative to grant approval.

Total Project Cost: Total project cost is $8,478,000 with a grant request for $4,239,000.

Participants: The main participants in the Project are Great River Energy, EERC, EPRI, Bechtel Corporation, Nexant, Inc., Blue Flint Ethanol, and the selected carbon capture process technology supplier (Process Technology Supplier).

PROJECT SUMMARY

Great River Energy requests funding for a preliminary Front End Engineering and Design (pre-FEED) Study for a Full-Scale Carbon Dioxide Capture System at Coal Creek Station (Project). The Project is the initial phase in our Coal Creek Station Carbon Capture and Sequestration Project, CCS|^2, which has a goal of capturing and safely storing, or sequestering, at least 80 percent of the carbon dioxide (CO_2) emissions on an annual basis from Coal Creek Station to extend the economic life of the plant.

The primary components of the Project are:

1. Carbon Capture Island pre-FEED
2. Carbon Capture Integration pre-FEED
3. Flue Gas Characterization
4. Solvent Testing
5. Air Quality Analysis
6. Geologic 3D Seismic Study
7. Economic Feasibility Evaluation

The objectives of the Project are to:

1. Analyze and determine the optimal configuration of a full-scale carbon capture system.
2. Identify and mitigate any potential fatal flaws by developing the design, conducting hazard and safety reviews, flue gas characterization, air quality analysis, and if deemed necessary, solvent testing.
3. Determine the carbon capture island and integration design in sufficient detail to enable capital and operation and maintenance cost estimates at an AACE Class 3 (AACE International, March 6, 2019) accuracy level.
4. Building off previous EERC geologic work, complete a 3D Seismic study which will further characterize the geology below Coal Creek Station and Falkirk Mine, and better determine its suitability for sequestration of carbon dioxide emitted from Coal Creek Station and Blue Flint Ethanol.
5. Evaluate the overall economics of carbon capture at Coal Creek Station.

The Project is essential to ensure the long-term viability of lignite-fired power generation at Coal Creek Station and other North Dakota plants.

PROJECT DESCRIPTION

Great River Energy proposes to complete a pre-FEED of a CO_2 capture system at Coal Creek Station. The combination of components described in this section is referred to as the "Project." The Project is a necessary predecessor in a stage-gate process to more detailed and costly future studies and designs, which typically includes a front-end engineering and design (FEED), and a final design phase. The Project is composed of the following primary components:

1. **Carbon Capture Island pre-FEED**. Great River Energy has identified two carbon capture Process Technology Suppliers with relevant commercial experience. Confidentiality obligations prevent Great River Energy from identifying these suppliers. Document deliverables for the carbon capture island pre-FEED are listed in Appendix A. Great River Energy anticipates selecting the Process Technology Supplier before November 14, 2019.
2. **Carbon Capture Integration pre-FEED.** A critical aspect of any carbon capture strategy is the economic and efficiency impacts to the power plant. Great River Energy conducted prior research in this area through EPRI (EPRI, 2012). Great River Energy proposes to use the same primary team members from that study to assess impacts for current technology and different integration scenarios for the Project. This team includes members of EPRI, Bechtel Corporation and Nexant, Inc. (EPRI Team). Document deliverables for the Carbon Capture Integration pre-FEED are listed in Appendix A. General Electric Company (GE) will conduct an engineering assessment to evaluate the impact of increasing steam extraction from the steam turbine to provide process steam to the carbon capture island. The EPRI Team and the Process Technology Supplier's team will work collaboratively to enable the EPRI Team to prepare a design for

integrating Coal Creek Station with the Carbon Capture Island developed under Project Component 1.

3. **Flue Gas Characterization**. A definitive analysis of the flue gas constituents for Coal Creek Station will be performed. Results of the analysis will be used under Project Component 1 to assess the impacts of the power plant's flue gas quality on the design and performance of the carbon capture system. This flue gas analysis is essential to the carbon capture system design and will be conducted by EERC. EERC's proposal is included in Appendix C.
4. **Solvent Testing**. The Project may include solvent testing utilizing the EERC carbon capture pilot system to test a slip stream of flue gas from one of the units at Coal Creek Station. Solvent testing mitigates carbon capture performance risk related to amine emissions, solvent degradation, and energy consumption at the regenerator reboiler. Great River Energy has included the cost and scope of solvent testing within this application. Great River Energy proposes that a final decision to conduct solvent testing be made after the results of the Project Carbon solvent testing become available and after detailed consultation with the selected Process Technology Supplier. EERC's proposal is included in Appendix C.
5. **Air Quality Analysis**. Air quality dispersion modeling will be conducted to ensure the carbon capture system's emissions do not cause a violation of National Ambient Air Quality Standards (NAAQS) for sulfur dioxide, nitrogen oxides and fine particulate. A visibility model will also be run to determine if operation of the carbon capture system would increase regional haze. Modeling results will be used to determine the necessary height of stacks within the carbon capture island, or, if the absorber flue gas is returned to Coal Creek Station's existing stacks, whether stack modifications would be required to avoid NAAQS or haze issues. Barr Engineering will complete the modeling.

6. **3D Seismic Study**. Great River Energy and Blue Flint Ethanol will collaborate to complete a 3D Seismic Study which will better characterize the suitability of geology below Coal Creek Station and Falkirk mine for injection and sequestration of CO_2 from the Blue Flint Ethanol plant and Coal Creek Station into the Deadwood geologic formation. Blue Flint Ethanol is an existing steam partner adjacent to Coal Creek Station. This project component is a predecessor to the ultimate goal of injecting and sequestering CO_2 from Blue Flint Ethanol and Coal Creek Station into the Deadwood formation. Injection of CO_2 from the ethanol plant is an expedient opportunity for actual testing, on a small scale, the viability of using the Deadwood formation for full-scale injection of the CO_2 generated at Coal Creek Station. EERC will assist in coordinating field work and will interpret the data collected from the seismic study. EERC's scope of work and cost estimate are provided in Appendix D.
7. **Economic Feasibility Evaluation**. The capital cost (CAPEX) and operations and maintenance cost (OPEX) estimates developed in the Carbon Capture Island and Integration pre-FEEDs (Components 1 and 2) will be used in conjunction with the findings of Components 3 through 6 to evaluate the overall economic feasibility of carbon capture at Coal Creek Station.

Why the Project is needed:

There is increasing global pressure for a less carbon intensive energy future. Baseload coal fired power plants are critically important for the stability and reliability of the bulk electric system and the economic health and vitality of the upper Midwest. Capturing the carbon emissions and sequestering or using the carbon is essential to maintaining the environmental viability of these power plants, including Coal Creek Station. Tax credit for the storage or use of carbon emissions is provided by 26 United States Code §45Q. Eligibility for the tax credits requires that construction of the carbon capture and use/storage systems must start before

January 1, 2024. The design, construction and integration of amine-based technologies is complicated, time consuming and costly. Accordingly, Great River Energy believes it is imperative to start the design process now to evaluate the best business case to add carbon capture to Coal Creek Station to ensure the plant continues to provide reliable and affordable power for the life of the plant. Even with an aggressive schedule, meeting the requisite construction start date will be challenging.

Project objectives:

The Project has five overall objectives:

1. Analyze and determine the optimal configuration of a full-scale carbon capture system at Coal Creek Station. While the design of a commercial scale carbon capture system has been commercially demonstrated by both Process Technology Suppliers, the application of the technology and the level of integration at any specific power plant is unique and site specific. The carbon capture island design is affected by factors such as fuel source, boiler design, existing air pollution controls, ambient conditions, existing infrastructure (e.g., natural gas pipelines), and availability of cooling water and electric power. Considering these factors and more, the implementation of the carbon capture system can be done in a variety of configurations. Configuration scenarios could involve approaches such as combined heat and power, auxiliary boilers, back pressure turbines for power generation or CO_2 compression, and other options. With each of these approaches, there are tradeoffs between power plant efficiency, power plant output, water consumption, wastewater production, capital, operations and maintenance costs, and CO_2 reduction. The Project will determine the optimal carbon capture system configuration for Coal Creek Station.

2. Identify and mitigate fatal flaws. The Project will identify and mitigate any potential fatal flaws by developing the design, conducting hazard and safety reviews, characterizing flue gas, analyzing air quality impacts, and if deemed necessary, testing the Process Technology Supplier's solvent on Coal Creek Station's flue gas.
3. Determine the carbon capture island and integration designs in sufficient detail to quantify capital and operation and maintenance cost estimates at an AACE Class 3 (AACE International, March 6, 2019) accuracy level, which is within the range of -20% to +30%. According to AACE, a Class 3 estimate is typically prepared to support full project funding requests and becomes the first control estimate against which all costs and resources will be monitored for variations to the budget.
4. Building off previous EERC geologic work, complete a 3D Seismic study which will further characterize the geology below Coal Creek Station and Falkirk Mine, and better determine its suitability for sequestration of CO_2 emitted from Coal Creek Station and Blue Flint Ethanol.
5. Evaluate the economics of carbon capture at Coal Creek Station.

Project methodology:

The project methodology breaks the Project into 13 logical Tasks to collect information and data that supports the Project objectives outlined above**.** The Tasks are the building blocks of the Project execution plan, and essentially provide a high-level Work Breakdown Structure for the Project. The completion of each Task represents a Major Milestone of the Project. The Tasks are scheduled in the Timetable provided below. The costs to perform the Tasks are provided in the Budget provided below.

Task 1: Project management

This Task includes all work elements required to contract, maintain, manage and report

on activities in accordance with the Project schedule. It also includes the necessary activities to ensure planning and execution of the Project with all project participants.

Task 2: Base power plant data review, pre-FEED basis and kick-off meeting

Part 2.A: Data review

The EPRI Team will review the data from the previous 2012 study (EPRI, 2012) compile and issue a list of updated information required from Great River Energy to undertake the new carbon capture integration pre-FEED. Information required will include:

- Energy and material balances for the current plant condition
- Current plot diagrams showing space available
- Existing equipment specification sheets (including any recent steam turbine upgrades and performance of lignite drying equipment)
- Site data and conditions
- Available utilities
- Operating data
- Current environmental requirements

Part 2.B: Data supply

Great River Energy will work closely with the EPRI Team to clarify all aspects of the existing Coal Creek Station design and performance. This will require engagement with the steam turbine manufacturer, GE, to help understand steam extraction options and implications.

Part 2.C: Draft pre-FEED design basis

Upon receiving the required documents and information from Great River Energy, a pre-FEED basis will be drafted with missing data and inconsistencies identified. Any limitations on other utility systems that are needed by the carbon capture system, both utility supply and waste or utility discharge, (e.g. cooling water or raw river water, and wastewater) will also be considered at this point. This Task will also include coordination with the Process Technology

Supplier to discuss its carbon capture system design and startup/shutdown/bypass/turn-down operating philosophy.

Part 2.D: Kick-off meeting at Coal Creek Station

Project team participants will visit Coal Creek Station for a kick-off meeting with Great River Energy to review the draft pre-FEED basis, to resolve any missing or inconsistent data, to clarify carbon capture system operating philosophies, to discuss proposed tie-in arrangements, and to agree on other critical design/operating/maintenance criteria. A final pre-FEED basis will be issued for Great River Energy approval following the kick-off meeting.

A preliminary configuration options screening will also take place during the kick-off meeting. This will be a joint Great River Energy, EPRI Team and Process Technology Supplier brainstorming session. It will essentially look ahead at Task 4 based on the experience and judgement of the collective team, coupled with the results of EPRI's previous study at Coal Creek Station and Great River Energy's recently completed Concept Design activities.

Task 3: Develop base power plant model & compare to current performance

Bechtel will update its previous 2012 Gate Cycle model (EPRI, 2012) for the existing plant, and compare the model performance (output, heat rate) against documented performance provided by Great River Energy. The model will incorporate the equipment design data received in Task 2. Bechtel will then determine the maximum steam and power extraction limits for the existing power plant based on recommendations from the steam turbine manufacturer.

Task 4: System analysis of integration and retrofit options

Using the base power plant model and extraction limits from Task 3, the EPRI Team will work with the selected Process Technology Supplier to determine the optimum integration of the carbon capture system into the power plant. The most practical level of CO_2 capture efficiency

based on site-specific constraints will be considered, as well as the potential to make use of the cold winter temperatures in North Dakota to improve the level of annual average CO_2 capture.

Several options for supplying steam and electric power to the carbon capture island may be considered, such as:

- Adding a package boiler to provide the carbon capture system with the required steam, including an option for steam turbine driven CO_2 compressors.
- Extracting steam from the existing Coal Creek steam turbine and using a back-pressure steam turbine to minimize the performance impact.
- Modifying the existing steam turbine to allow for specific stream extraction for the carbon capture system.
- Use of a gas turbine and heat recovery steam generator to supply steam and power to the carbon capture system.

In addition, any potential benefits of integrating the carbon capture system waste heat into Coal Creek Station's heating requirements will be investigated. The ability of the carbon capture system to accommodate fast shutdowns of steam from Coal Creek Station, in order to maximize export power, will also be examined.

Results from this Task will be reviewed and recommendations for the optimal source of process steam and electric power to the carbon capture system will be made to Great River Energy.

Task 5: Complete the carbon capture island design

This Task, to be completed by the selected Process Technology Supplier, involves defining power plant interfaces with the carbon capture system, and completing the carbon capture island pre-FEED. Document deliverables are identified in Appendix A.

Task 6: Complete the carbon capture integration design

The EPRI Team will define the retrofit modifications, additional facilities and balance of plant equipment required to integrate the carbon capture island into the power plant. Specific areas to be addressed will include:

- Coal Creek Station flue gas desulphurization system (upgrade if necessary)
- Direct contact cooler for carbon capture system (if necessary)
- Tie into existing flue
- Ducting run to carbon capture system
- Return from carbon capture system to existing stack
- Plume buoyancy
- Fan/blower requirements
- Steam supply system, pipe work, valving
- Turndown
- Carbon capture system cooling tower design supply
- Overall water balance
- Single-line diagrams

Working with the Process Technology Supplier, the EPRI team will complete the pre-FEED layout of the power plant interfaces with the carbon capture system, including additional facilities for utility supplies. A plan will be developed for coordinating the implementation of the carbon capture system integration during scheduled plant outages.

Using the Gate Cycle model established in Task 3 and carbon capture system design requirements provided by the Process Technology Supplier, the EPRI Team will develop the overall power plant and utility system heat and material balances to assess overall power plant performance (output and heat rate) following the carbon capture system installation. Document deliverables are identified in Appendix A. EPRI's proposal is included as Appendix B.

Task 7: Estimate capital and operating & maintenance (O&M) costs

Task 7 will be completed by the EPRI Team and the Process Technology Supplier for their respective design scopes. The EPRI Team will develop cost estimates for all power plant modifications. The Process Technology Supplier will develop cost estimates for the carbon capture island. Cost estimates will be AACE estimate Class 3.

Task 8: Flue gas characterization

Task 8 will be carried out by EERC. This Task involves identifying critical contaminants in the flue gas stream, primarily aerosols. Existing flue gas from one of Coal Creek Station's two

units will be sampled. Sampling will include the use of a scanning mobility particle sizer (SMPS), a Dekati particle impactor sampler, and a Fourier transform infrared (FTIR) analyzer. With these methods, the characterization of aerosols, presence of SO_3, and any other constituents observed will be reported. Further details related to Task 8 are provided in Appendix C.

Task 9: Solvent testing

Task 9 will also be carried out by EERC. This Task involves characterizing solvent degradation, amine emissions, and regeneration energy efficiency. Solvent testing is conducted using EERC's portable CO_2 capture system, which will be assembled on-site at Coal Creek Station. On-site solvent testing will be a 3-month (12-week) program. Testing will be conducted utilizing a liquid solvent selected and provided by Great River Energy. The capture system will be monitored 24 hours per day by EERC personnel. Periodic sampling of aerosols will be conducted on the outlet of the system to determine the increase or reduction in emissions exiting the CO_2 capture system. To facilitate this testing, Great River Energy will provide installation equipment (e.g., forklifts) and make plant modifications needed to integrate the system into Coal Creek Station, including a system shelter, power, cooling water and demineralized water. Further details related to Task 9 are provided in Appendix C.

Task 10: Air quality analysis

Barr Engineering (Barr) will complete the air quality analysis. Barr has previously developed air quality models of Coal Creek Station's stacks and plant layout. Those models will be modified to include the carbon capture island configuration. The modified models will be run using emissions rates as provided by the carbon capture technology vender and EPRI. Modeling iterations will be completed with all of Coal Creek Station's flue gas emitted through stacks within the carbon capture island to determine the stack heights necessary to ensure the emissions do not cause a violation of any National Ambient Air Quality Standards (NAAQS) and to assess any impacts on visibility within Class I areas. If the Project team believes it may be

economically beneficial to route the carbon capture island exhaust back to Coal Creek Station's existing stack, modeling iterations will also be run in this configuration.

Task 11: 3D seismic study

Great River Energy and Blue Flint Ethanol have been collaborating on geologic studies necessary to design, engineer, construct and permit a CO_2 injection and sequestration system on properties owned primarily by Great River Energy and Falkirk Mine. Preliminary desktop studies have identified the Deadwood geologic formation, which lies approximately 8,000 feet below the properties, as the likeliest, best opportunity for storage of approximately nine million tons of CO_2 emissions per year from Coal Creek Station and Blue Flint Ethanol. In addition to the desktop analyses, Great River Energy and Blue Flint Ethanol have conducted 2D seismic testing. The logical next step is to conduct 3D seismic testing.

The 3D seismic study will cover sufficient surface area to model the Deadwood formation's ability to receive and store approximately 200,000 tons of CO_2 per year. The results of the study will yield key characteristics of the Deadwood formation within close proximity of Coal Creek Station. Future 3D work would be required to characterize the full extent of the areas necessary for receiving the CO_2 from Coal Creek Station.

Carbon capture and sequestration work at Blue Flint Ethanol affords a unique opportunity for Great River Energy to expeditiously develop and implement small-scale carbon injection into the Deadwood formation due to the favorable economics of carbon capture on an ethanol plant. Carbon capture on ethanol plants is relatively inexpensive because the fermentation process produces a relatively pure stream of CO_2, the capture technology is mature and relatively inexpensive, and renewable fuel programs (e.g. California's low-carbon fuel standard) offer revenues in addition to the §45Q tax credits to enhance the Project's economics. Given the economic and technical advantages, the capture and safe storage of

carbon is much more achievable for ethanol than it is for a lignite-fired power plant and can proceed at an expedited schedule.

Advancing the storage of CO_2 in geologic formations on a smaller scale will help to facilitate the larger scale injection of CO_2 from Coal Creek Station. The ability to get the necessary permits and inject CO_2 on a faster pace will help to familiarize the local communities and governments with the technology, and ideally would produce actual injection and monitoring data as we move forward into full-scale carbon capture and storage for Coal Creek Station.

Great River Energy and Blue Flint Ethanol are presently working to identify and contract service companies with availability to manage the 3D field work, data collection, and data analysis. EERC will conduct the data interpretation. EERC's scope of work and cost estimate are provided in Appendix D.

Task 12: Economic feasibility evaluation

The CAPEX and OPEX data from Task 7, informed by Tasks 8 through 11, will be used to estimate revenue requirements to implement Carbon Capture at Coal Creek Station and compare that with tax and other incentives to assess the overall economics.

Task 13: Reporting

Great River Energy will provide periodic reports and the final report to the North Dakota Industrial Commission as described in the Management section below. The final report by Great River Energy will provide a project summary that will integrate the findings of reports provided by the other project participants as described below:

- The Process Technology Supplier will provide a final report on the carbon capture system design. Document deliverables identified in Appendix A through D will be included as appendices to the technology provider final report.
- EPRI will provide a final report on the carbon capture system integration into the power plant. Document deliverables per Appendix A will be included as appendices in EPRI's final report.
- EERC will provide a final report on the flue gas characterization and, if deemed necessary, the solvent testing.

- Barr Engineering Company will provide a final report on the air quality analysis.
- EERC will provide a final interpretive report from the 3D Seismic Study.

Facilities, resources, and techniques to be used and their availability and capability:

Please see the above Task descriptions, which address these points. Great River Energy is not expecting equipment purchases to be required for completion of the Project.

Anticipated results:

Great River Energy anticipates that the results of this project will provide a clear path towards the next stages in developing a full-scale carbon capture and storage system at Coal Creek Station as follows:

- Informed by the 3D seismic study performed in this project, a Phase 2 geologic investigation will be performed.
- Informed by the pre-FEED designs for the carbon capture system and its integration developed in this project, FEED studies will be conducted.
- Informed by the flue gas characterization, solvent testing (if deemed necessary) and air quality analysis completed in this project, a permitting plan will be developed and implemented. This work also informs the FEED for the carbon capture system.

Environmental and economic impacts of the project while it is underway:

Completion of the Project, as scoped in this application, will have minimal environmental or economic impacts. The Project is an engineering analysis with limited on-site work to characterize existing flue gas conditions, characterize emissions from the carbon capture island if solvent testing is conducted, and complete a 3D seismic survey. The 3D Seismic activities are regulated by the North Dakota Industrial Commission Department of Mineral Resources. A Geophysical Exploration Permit must be issued prior to commencing any field activities

pursuant to NDAC 43-02-12-05 and NDAC 43-02-12-06. The permit ensures proper notifications have occurred and exploration will be conducted in a manner that will not cause damage to land, water, or infrastructure.

Furthermore, there will be no major capital expenditures at Coal Creek Station, nor will there be any significant labor influx to complete the work.

Ultimate technological and economic impacts:

The Project will advance amine-based carbon capture from lignite coal fired power plants. Unlike air emissions controls for sulfur dioxide, nitrogen oxides and particulate matter, there are only two technologies commercially demonstrated in North America for reducing CO_2 emissions, both are amine-based systems.

Lignite coal is a critical resource for North Dakota's economy. The potential of future carbon legislation and/or regulations could significantly impact the ability for coal to contribute to North Dakota's economy and the livelihood of people working in the industry. The Lignite Energy Council reports that the North Dakota lignite industry is responsible for about 14,000 jobs in the state and $5.7 billion in economic activity. [https://lignite.com/coal-strong/benefits-of-north-dakotas-homegrown-lignite-coal/] Given global efforts to constrain and reduce the use of fossil fuels such as lignite coal, it is prudent for those in the lignite industry to aggressively pursue further research and development of technologies to mitigate emissions from the use of lignite.

The reformed §45Q tax credits under the FUTURE Act create opportunities for improving the economics of carbon capture and utilization or storage. §48A also provides tax credits for qualifying advanced coal projects.

STANDARDS OF SUCCESS

The Coal Creek Station Carbon Capture & Sequestration (CCS|^2) team was chartered in March of 2019 to explore and evaluate options for Carbon Capture and Sequestration in order to extend the productive and economic life of our 1,154-MW North Dakota lignite-fired Coal Creek Station. The proposed pre-FEED study is a critical component to move CCS|^2 forward. The Project success will be achieved by:

- Developing a high-level process engineering and site layout design for the carbon capture system and for the integration of Coal Creek Station to supply flue gas (CO_2), power and other utilities.
- Evaluating and identifying the most cost-effective solution(s) for supplying flue gas, steam, power and other utilities necessary for the carbon capture and compression facility.
- Extending (maintaining) the environmental and commercial viability of Coal Creek Station.

BACKGROUND

The seminal work for this Project is the 2012 EPRI study (EPRI, 2012). The EPRI study was shy of a pre-FEED level design and was based on a generic amine system and some simplifying assumptions that provided a conceptual cost and design for full carbon capture at Coal Creek Station. Great River Energy was thoroughly impressed with that project's team (EPRI, Bechtel and Nexant) and their work product, so much so, that Great River Energy will retain these same organizations to complete the Carbon Capture Integration pre-FEED component. Their scope on the Project will primarily be on the integration side; however, their

recent work on other carbon capture projects will benefit the Carbon Capture Island pre-FEED component as well.

The first task of the CCS|^2 Core Team was to engage carbon capture Process Technology Suppliers. Great River Energy received conceptual designs and indicative cost estimates from two international Process Technology Suppliers that have commercial carbon capture system currently operating on the globe. These designs and cost estimates were consistent with the results of the 2012 EPRI study, which validated the credibility of the EPRI team and the Process Technology Suppliers. Great River Energy anticipates selecting the specific Process Technology Supplier for the pre-FEED before November 14, 2019.

QUALIFICATIONS

The proposed Project Team includes world-wide leaders in carbon capture and sequestration. The two Process Technology Suppliers being considered are responsible for the only two commercial, utility-scale carbon capture systems in the world and together represent the majority of captured CO_2 in the world. The EPRI Team has been engaged in CO_2 capture and storage projects for decades and has evaluated more the 140 different post-combustion technologies, including extensive studies that have examined the technical and economic feasibility of amine-based post-combustion systems on coal fired power plants. The EERC team is comprised of internationally recognized experts in the areas of carbon sequestration. It has evaluated and tested numerous amine solvents for carbon capture and has recently completed pilot solvent testing as part of Project Carbon. Due to its leadership and work on the Plains CO_2 Reduction Partnership, EERC is likely the most knowledgeable organization on carbon sequestration in North Dakota.

Resumes for key Project team members are included in Appendix E.

VALUE TO NORTH DAKOTA

Carbon capture research, development, and commercial deployment is crucial to achieve lower carbon-intensive power generation. The $3 billion North Dakota lignite industry's future depends on the deployment of carbon capture technology on the state's existing lignite power generating fleet. North Dakota is already a national leader in "all-of-the-above" energy production, carbon capture and sequestration is the next step in ensuring the future use of the 800-year supply of lignite resources in producing reliable and affordable power. This Project is valuable to North Dakota because it seeks to identify the technology that can economically reduce the carbon intensity of lignite power generation. Appendix F contains letters of support from entities that understand the value of the Project and the importance of it to ensuring the continued contribution of lignite to North Dakota.

In addition to being an essential and economic baseload facility for over forty years, Coal Creek Station, the mine and adjacent ethanol plant along with two Spiritwood facilities provide thousands of direct and indirect jobs that are the backbone to many communities throughout North Dakota. Carbon capture and sequestration will help retain these jobs plus create new direct and indirect jobs, which create a significant economic impact for the rural communities, counties and the state of North Dakota.

Great River Energy has made a number of efficiency changes over the years to reduce the carbon intensity of the energy generated at Coal Creek Station including the addition of DryFining™. Carbon capture would be another significant step towards meeting the market demands for energy with lower carbon intensity. It is imperative to look at technologies that have the potential to work, both economically and technologically, at Coal Creek Station.

MANAGEMENT

In general, Great River Energy has a management structure that involves our Members, our Board of Directors, and Great River Energy Executive Management.

For this Project, a CCS|^2 Sponsor team of Great River Energy Executive Management members has been formed. This Sponsor team will provide guidance and direction on the Project. Communications with the Sponsor team will be ongoing throughout the Project and will be formalized by monthly reports and quarterly meetings.

The CCS|^2 Sponsors have directed that a cross functional CCS|^2 Core Team be formed to monitor and direct the Project progress. The make-up of the CCS|^2 Core Team is indicated in Figure 1. The CCS|^2 Core Team will be led by Principal Investigator John Bauer and Project Director David Farnsworth, with the assistance of Project Manager Vince Herda. The CCS|^2 Core Team will direct the efforts of external Project participants such as EPRI, EERC, and the Process Technology Supplier. The CCS|^2 Core Team will meet monthly.

The overall Project organization, including external Project participants is shown in Figure 2. As indicated, the overall project will be managed by Great River Energy's Principal Investigator, Project Director, and Project Manager. Also as indicated, each external Project participant will have a project manager to direct the execution of their scope. In doing so, each external Project participant will develop and maintain a detailed project scope of work, schedule and budget. A high-level scope of work for EPRI is provided in Appendix B, and for EERC in Appendix C and D. External project managers will provide monthly project updates to their scope of work, schedule and budget. Scope of work changes will be managed by a formal change order process. Schedules will be based upon the critical path method (CPM). Budgets will be updated to reflect authorized budget, actual expenditures, percent complete (earned value) and forecasted cost at completion (FCAC).

The building blocks of the Project execution plan (PEP) are the Tasks discussed above (see Project methodology). These Tasks essentially provide a high-level work breakdown structure (WBS) for the Project. The completion of each Task represents a major milestone of the Project. A high-level schedule for these Tasks is provided in the Timetable discussion below. The costs to perform the Tasks are provided in the Budget provided below. Again, each external project manager will provide a detailed scope of work (based upon the Task descriptions given above), a detailed schedule (based upon the Timetable provided below) and a detailed budget (based upon the Budget provided below).

Great River Energy's project manager will control the project scope via a formalized change order process and will maintain an overall project budget and schedule. Great River Energy's project manager will provide project updates to the LRC as required by the contract with the NDIC and as otherwise requested by the LRC.

Figure 1. CCS|² Core Team

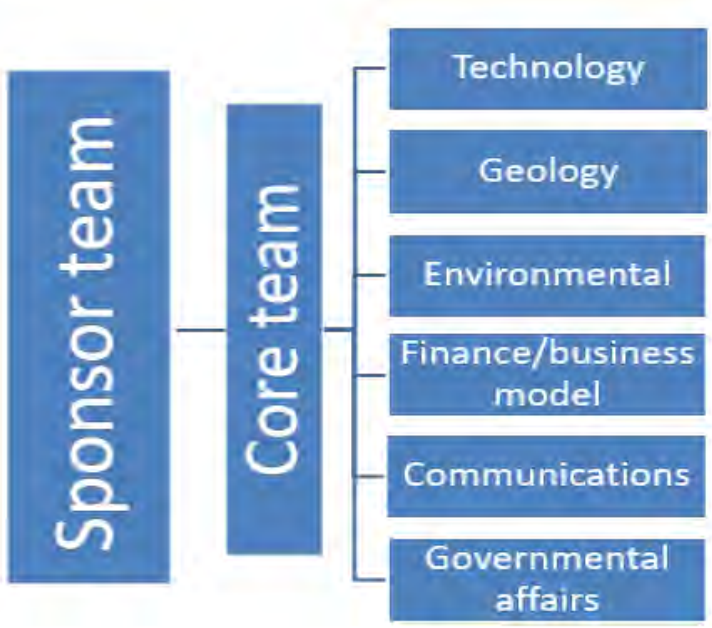
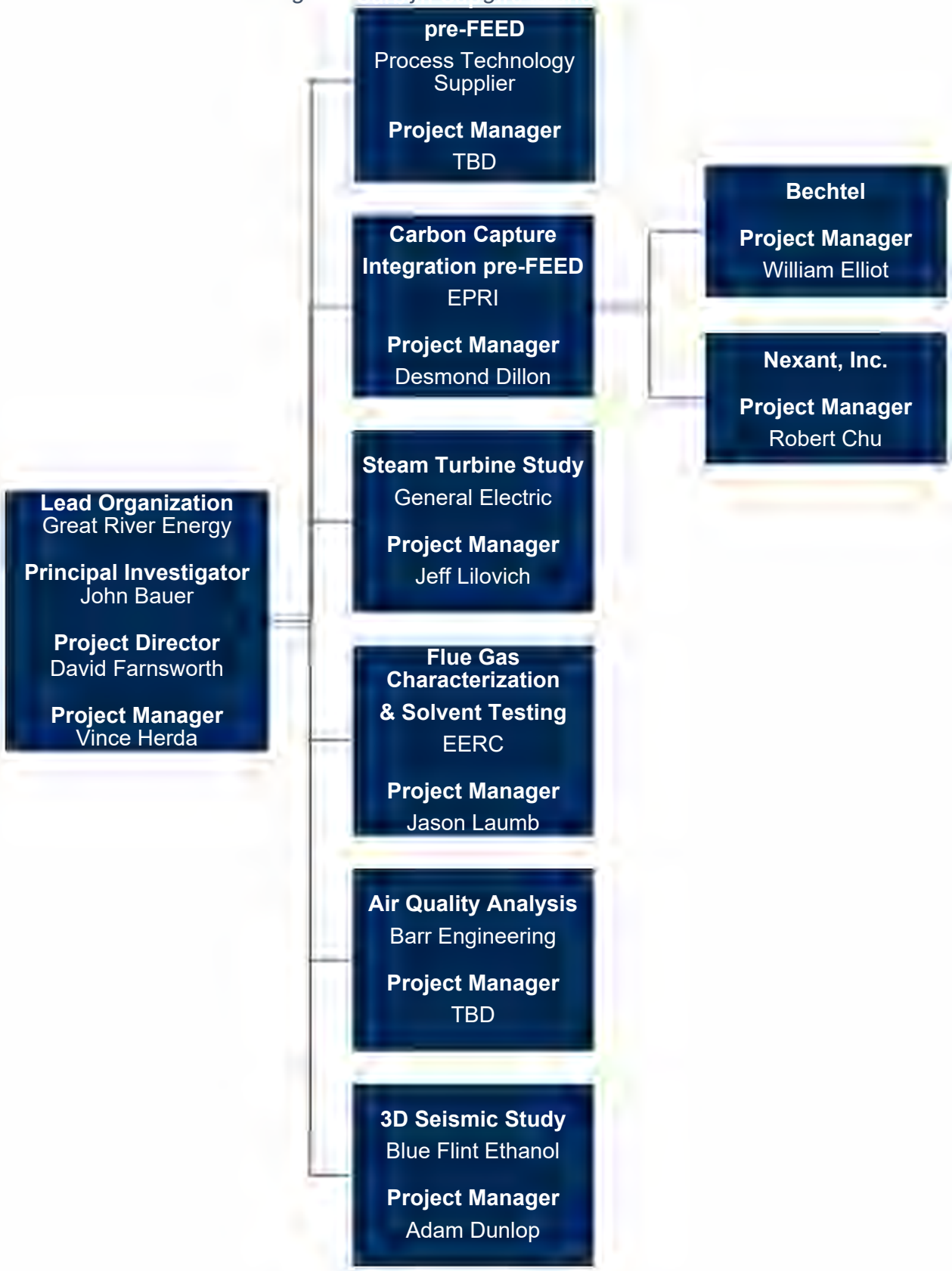


Figure 2. Project Organizational Chart



TIMETABLE

The Timetable for the Project is shown in Figure 3. Contract negotiations between Great River Energy and the other project participants will begin shortly after grant approval. Project implementation will begin in early January 2020. Target dates for the various Tasks outlined in the Project methodology section above are shown. Final reports from project participants will be completed by the end of 2020. The dates for interim reports will be in accordance with Great River Energy's contract with NDIC. The Project final report will be submitted by Great River Energy to NDIC not later than January 31, 2021, unless a later date is approved by NDIC.

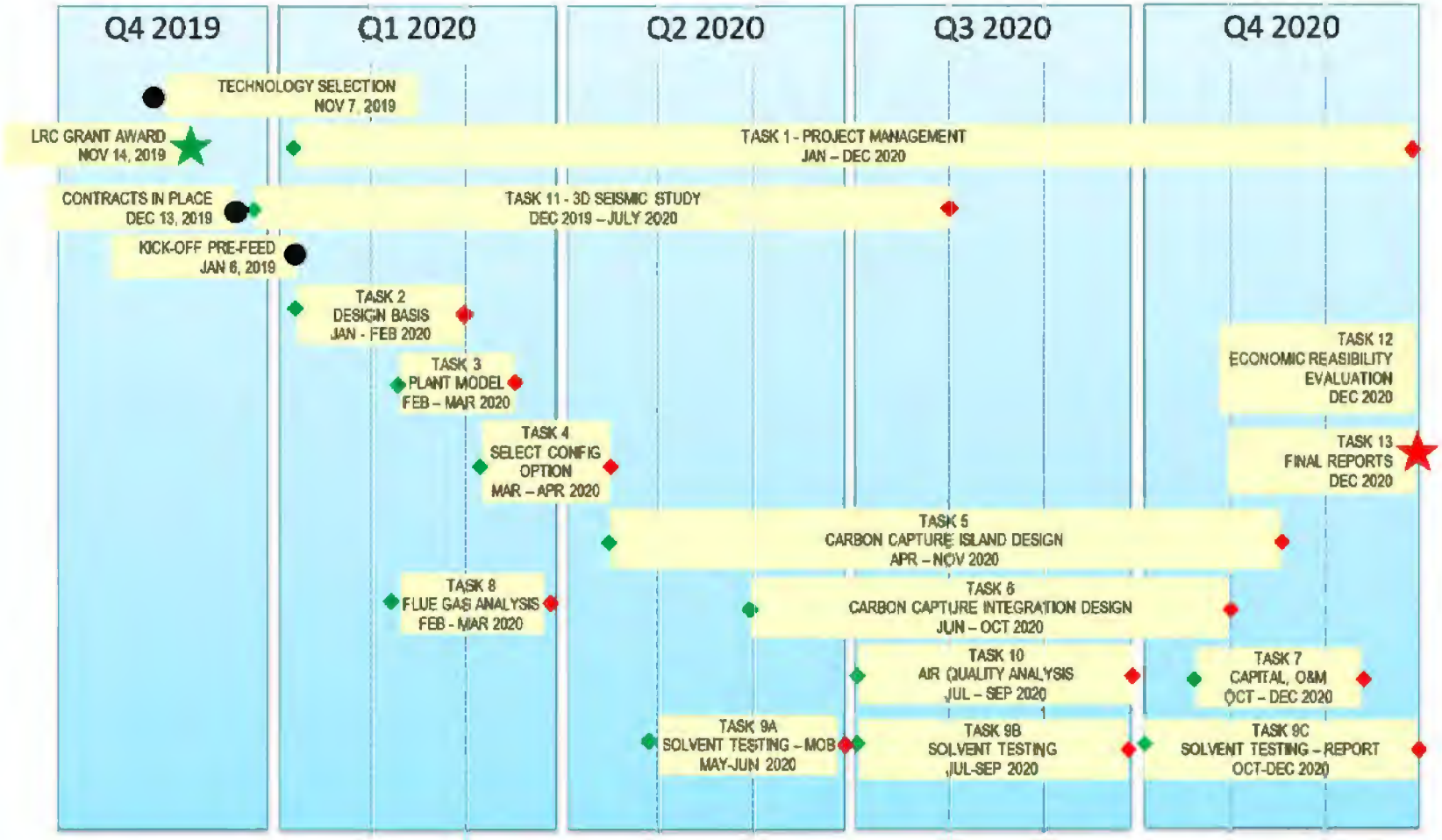


Figure 3. Project Timetable

BUDGET

The estimated cost is $8,478,000, as shown in Table 1. As discussed above in the Management section, the project execution plan (PEP) is based upon defined Tasks. The relationship between these Tasks and the project expenses are shown in Table 1. This application requests an NDIC grant of $4,239,000 (50 percent). As discussed above, solvent testing is included in the budget, but may it may be removed from the Project scope and budget depending on the results of Project Carbon, and discussions with the Process Technology Supplier.

Table 1. Project Budget

Project Expense	Tasks Included	Amount	NDIC Share	GRE Share
Carbon capture island	2, 4, 5, 7	$1,800,000	$1,800,000	$0
Integration engineering	2, 3, 4, 6, 7	$870,000	$0	$870,000
Steam turbine impacts	3	$120,000	$0	$120,000
Flue gas analysis	8	$168,000	$39,000	$129,000
Solvent testing	9	$2,880,000	$1,440,000	$1,440,000
Dispersion modeling	10	$120,000	$0	$120,000
3-D Seismic Study	11	$1,920,000	$960,000	$960,000
Consulting fees	2,	$50,000	$0	$50,000
Eligible business expenses	2,	$150,000	$0	$150,000
GRE In-Kind & PM	1, 12, 13	$400,000	$0	$400,000
Total		$8,478,000	$4,239,000	$4,239,000
Cost share %			50%	50%

MATCHING FUNDS

Great River Energy's funding match obligation is $4,239,000. Great River Energy expects North American Coal Corporation to contribute to the Project as well as the Process Technology Supplier if solvent testing is deemed necessary.

TAX LIABILITY

Great River Energy has no outstanding tax liabilities owed to the state of North Dakota or any of its political subdivisions. A notarized affidavit of this fact is included in Appendix G.

CONFIDENTIAL INFORMATION

This application includes no confidential information.

APPENDICES

Appendix A: Great River Energy Carbon Capture at Coal Creek Station Document Deliverables

Appendix B: EPRI Statement of Work for a Post Combustion CO_2 Capture Integration Pre-FEED for Great River Energy's Coal Creek Station

Appendix C: EERC Flue Gas Characterization and Solvent Testing

Appendix D: EERC 3D Seismic Study

Appendix E: Resumes

Appendix F: Letters of Support

Appendix G: Affidavit of No Tax Liability

Appendix H: References

APPENDIX A

GREAT RIVER ENERGY CARBON CAPTURE AT COAL CREEK STATION DOCUMENT DELIVERABLES

Great River Energy
Carbon Capture at Coal Creek Station
Document Deliverables

Deliverable	GRE	PCC Pre-FEED	Integration Pre-FEED
PROJECT ENGINEERING / MANAGEMENT			
Project Economics	X		
Risk Management Plan	X		
Communications Plan	X		
Design Basis Document	Input	X	X
Project Schedule	X	X	X
Capital Cost Estimate		X	X
O&M Cost Estimate		X	X
Cost Forecasts		Monthly	Monthly
HAZOP/PHA/Operations Safety Review (Hazards Identification)		X	
PROCESS			
Process Symbols, Std Details, Numbering, General Notes		X	X
Studies or Evaluations (Configuration Options Screening)		X	X
Feedstock Specifications (Flue Gas Analysis)	X		
Chemicals Specifications		X	
Water Quality Specifications (River Water, Demin Water)	X	X	
Wastewater Quality Specifications		X	
Product Specifications (CO2)		X	
Process Description		X	X
Process Control Description		X	X
Process Flow Diagrams		X	X
Material Balance Diagram		X	X
Heat Balance Diagram		X	X
Utility Summary		X	?
Stream Property Tables		X	X
Safety/Shutdown System Design		X	X
Hazardous Area Classification Drawing		X	
Material Safety Data Sheets (MSDS)		X	
METALLURGICAL			
Piping & Vessel Materials Specifications		X	X
ENVIRONMENTAL			
Regulatory Review & Report	X		
Env Permit & License Plans	X		
Water Permit Review	X	Input	
Air Permit Review	X	Input	
Waste Permit Review	X	Input	
Use Permit Review	X		
MECHANICAL			
Piping & Instrumentation Diagram (P&ID)		X	X
Line List / Line Designation Tables		X	X
Tie-in Lists		X	X
Equipment List		X	X
Specialty Items Index		X	X

Great River Energy
Carbon Capture at Coal Creek Station
Document Deliverables

Deliverable	GRE	PCC Pre-FEED	Integration Pre-FEED
General Arrangement Drawings		X	X
Preliminary Piping Routing Plans, Underground (Nominal Diameter >3")		X	X
Preliminary Piping Routing Plans, Above Ground (Nominal Diameter > 3")		X	X
ELECTRICAL			
Electrical Symbols, Std Details, Numbering, General Notes		X	X
Transformer Sizing		X	X
Single Line Diagrams		X	X
Electrical Equipment Location Plans		X	X
Preliminary Electrical Bus Duct Routing Plan		X	X
Raceway Layout Drawings - Above Ground		X	X
Duct Bank Layout Drawings - Below Ground		X	X
Substation & HV Distribution Drawings			X
INSTRUMENTATION & CONTROLS			
Controls Architecture (Block Diagram)		X	
FIRE PROTECTION			
Fire Protection Requirements Document		X	
Fire Protection System Description		X	
Fire Detection System Description		X	
GEOTECHNICAL			
Soil Sampling Specification	X		
Soil Sampling Report	X		
CIVIL/STRUCTURAL			
Clearing and Grubbing Drawing			
Grading & Drainage Plans		X	
Road and Paving Plans		X	
Curbing and Containment Drawings			
Ladders, Stairways & Platforms Arrgmt Drawings		X	
Pipe Racks, Supports& Bridges Arrangement Drawing		X	X
ARCHITECTURAL			
Architectural Symbols, Std Details, Numbering, General Notes		X	
Site Plan		X	
Architectural Layouts & Elevations		X	
Control Room Layout		X	
Construction Area Drawing		X	
Construction Permit Plan	X		
Construction Schedule		X	X
COMMISSIONING			
Commissioning Staffing Plan		X	X
Commissioning Schedule		X	X
Heavy Haul Study	X	Input	

APPENDIX B

EPRI STATEMENT OF WORK FOR A POST COMBUSTION CO_2 CAPTURE INTEGRATION PRE-FEED FOR GREAT RIVER ENERGY'S COAL CREEK STATION

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

STATEMENT OF WORK
SUPPLEMENTAL PROJECT AGREEMENT

A Post Combustion CO_2 Capture Integration Pre-FEED for Great River Energy's Coal Creek Station

1. Introduction & Background

This project will examine the retrofit of a CO_2 post-combustion capture (PCC) plant to Great River Energy's Coal Creek Station pulverized coal (PC) power plant. The Pre-FEED will highlight the technical and economic issues associated with installing an amine CO_2 PCC facility.

With many GWe of installed coal-fired plants in the US alone, plants currently in operation could be required to capture significant amounts of their CO_2. However, the retrofit of PCC to an existing plant presents significant challenges such as:

- Limited space for new plant equipment
- Limitations of the existing steam turbine
- Cooling water limitations
- Replacement power considerations
- Complicated pipe routings

Efficiency and economic penalties need to be accurately quantified when evaluating the suitability of current plants for CO_2 capture retrofit.

This proposed project will apply knowledge from previous and ongoing EPRI projects to begin detailing the retrofit of a specific technology supplier's commercially available amine PCC system to GRE's existing asset. It will continue on from a published 2012 PCC retrofit study initially undertaken by EPRI, however this particular 'Pre-FEED' will aim for a greater level of design detail and cost accuracy than its predecessor.

GRE wish to approach this overall carbon capture retrofit as two very separate, but related, projects. Namely:

- The PCC system project (Technology Provider scope)
- The PCC system integration project (EPRI team scope).

This aligns with GRE's overall vision for how this overall effort will be executed moving forward from this pre-FEED.

GRE's plan is for the final carbon capture system is that it ultimately be owned and operated by a third party. GRE may participate in this third party. Third party ownership is necessary since the project financials will be highly dependent upon the Section 45Q tax credits. These credits will be allocated by the IRS to the carbon capture system owner. Since GRE is a not-for-profit cooperative, with little use for tax credits, third party ownership is necessary. Therefore, the vision of the PCC system is not similar to a FGD system (a bolt-on emissions control system that is part of the plant). Instead the PCC system is a separate business entity that is an "off-taker" of steam, power, other utilities, and CO_2 from Coal Creek Station.

Going forward, GRE perceive that they will bear the costs of integrating the PCC system into the plant. The PCC system owner will bear the costs of final design and construction of the PCC system. GRE expects to use the results of the pre-FEED to engage potential third-party investor/owners.

With this mind GRE believe there needs to be a very clear separation between the PCC system costs and the Coal Creek Station integration costs (both capital and O&M). They are asking a Technology Supplier to conduct the pre-FEED for the PCC system, and the EPRI Team to conduct the pre-FEED for the plant integration (as described in this document).

The level of detail targeted within this Pre-FEED is between a level 3 and a level 4 cost estimate. The main purpose of the deliverable is to illustrate to a future 3rd party investors that GRE have a thorough understanding of the tasks, costs and design modifications required for the Coal Creek CO_2 capture retrofit. Essentially showing that they have diligently done their homework before engaging in their full FEED study.

2. Objectives

EPRI have conducted several technical and economic assessments of PCC retrofits to reduce CO_2 emissions from PC power plants. The work has highlighted the thermal and economic performance of PCC plant designs, improved heat integration of the PC with the PCC plants, and solvents with lower heats of regeneration.

Information previously supplied on the Coal Creek base plant without capture will be updated by the GRE (the site owners). Detailed Design information on a state-of-the-art commercial PCC system will be provided by a specific technology provider selected by GRE to facilitate optimum integration and performance from the installed capture system. All final report content will be reviewed by the site owners for approval prior to publication.

3. Scope of Work/Task Descriptions

The scope of this contract includes the following tasks:

Task 1: Project Management and Review

This task shall include all work elements required to contract, maintain, manage and report on activities in accordance with the project schedule. It shall also include the necessary activities to ensure coordination and planning of the project with GRE and other project participants such as the PCC technology supplier and GE, (the original steam turbine equipment manufacturer).

<u>Task 2:</u> Base Power Plant Data Review, Pre-FEED Basis and Kick-Off Meeting

Part A: Data Review
Bechtel/Nexant will review their existing data from the previous 2011 study and compile and issue to EPRI a list of updated information required from GRE to undertake the new retrofit Pre-FEED. Information required will include:

- Energy and material balances for the existing 2019 unit condition
- Current plot diagrams showing space available
- Existing equipment specification sheets (including any recent ST upgrades and performance of lignite drying equipment)
- Site data and conditions
- Available utilities
- Operating data
- Current environmental requirements
- Current power system evacuation system limitations

Part B: GRE provide required information update to EPRI/Bechtel/Nexant.
GRE will work closely with the EPRI team to clarify all aspects of the existing Coal Creek station design and performance. This will require engagement with the existing Steam turbine manufacturer to help understand steam extraction options and implications. The most practical level of CO_2 capture efficiency based on site-specific constraints will be considered, as well as the potential to make use of the very cold winter temperatures in North Dakota to improve the level of annual average CO_2 capture.

Upon receiving the required documents and information from the GRE, a Pre-FEED basis will be drafted with missing data and inconsistencies identified. Any limitations on other utilities that are needed by the PCC system, both utility supply and waste or utility discharge, (e.g. cooling water or raw river water, and wastewater) will also be considered at this point. This task will also feature communication/conference calls/WebEx with the Technology Supplier to discuss their initial PCC design and startup/shutdown/bypass operating philosophy.

Part C: Kick off Meeting at Site
The appropriate team members and EPRI will visit the selected plant for a Kick-Off (KO) meeting with the GRE to review the drafted Pre-FEED basis, to resolve any missing or inconsistent data, to clarify PCC startup/shutdown/bypass operating philosophies, to discuss proposed tie-in arrangements, and to agree on other critical design/operating/ maintenance criteria. A final Pre-FEED basis will be issued for GRE approval following the KO meeting.

A Preliminary Configuration Options Screening will also take place during the KO meeting. This would be a joint GRE, EPRI Team and PCC Technology Supplier brainstorming session, essentially to look ahead at Task 4 based on the experience and judgement of the collective team, coupled with the results of GRE's recently completed Concept Design activities.

***Task 3:* Develop Base Power Plant Model & Compare to Current Performance**
Bechtel will update their previous 2012 Gate Cycle model for the existing plant, and compare the model performance (output, heat rate) against documented performance provided by GRE. The model will incorporate the equipment design data received in Task 1, Bechtel will determine the maximum steam and power extraction limits for the existing power plant based on recommendations from the steam turbine OEM.

***Task 4:* System Analysis of Integration and Retrofit Options**
Using the Base Power Plant data from Task 2 and extraction limits from Task 3, Nexant/Bechtel will work with the previously selected PCC technology supplier to determine the optimum integration of the PCC plant (CO_2 removal and compression facilities) flow scheme with the existing Coal Creek plant.

Several options for supplying steam and electric power to the PCC island will be considered, such as:

- Adding a package boiler to provide the PCC system with the required steam, including an option for steam turbine driven CO_2 compressors
- Extracting steam from the existing Coal Creek steam turbine and using a back-pressure steam turbine to minimize the performance impact
- Modifying the existing steam turbine to allow for specific stream extraction for the technology suppliers system.
- The use of a gas turbine and HRSG to raise steam and supply make-up power
- Others?

In addition, any potential benefits of integrating the PCC plant waste heat into the existing Coal Creek steam cycle will also be investigated.

Furthermore, the ability of the PCC plant to accommodate fast shutdowns of steam from the coal creek plant will be examined in order to maximize revenue from electricity sales.

The results from tasks 4 analysis will be reviewed with the plant owners and recommendations on the optimal source of the auxiliary steam and PC / PCC integration will be made to GRE.

***Task 5:* Finalize PCC System Design**
This task involves defining power plant interfaces with the technology suppliers PCC design. Although the technology supplier selected by GRE will be responsible for the PCC process design Pre-FEED, to optimize the retrofit between Coal Creek unit and the new capture process, the EPRI retrofit team will require to clearly understand PCC plant integration potential and utility requirements, (e.g. flue gas conditioning, water cooling requirements, waste streams produced). This task will involve conference calls and meetings to interact with the technology supplier and best match the existing power plant needs with PCC system.

Task 6: Complete Final Retrofit Design and Performance Assessment

Bechtel will define the retrofit modifications, additional facilities and balance of plant equipment required to integrate the PCC into the power plant. Specific areas to be addressed will include:

- Coal Creek FGD (upgrade if necessary)
- DCC for PCC system (if necessary)
- Tie into existing Flue
- Ducting run to PCC
- return from PCC to existing stack
- Plume Buoyancy
- Fan / blower requirements
- Steam supply system, pipe work, valving. Turndown.
- PCC Cooling tower design supply
- Overall water balance
- Single line diagrams

Working with the Technology Supplier, develop the Pre-FEED layout of PCC plant and power plant interfaces with PC plant, including additional facilities for utility supplies.

The project team will evaluate and develop the scope of work for the final integration of the steam supply and other systems with the PCC facility with particular reference to coordination with outage schedules of the coal fired units.

Using Gate Cycle model established in Task 3 and PCC design requirements provided from the technology supplier, Nexant/Bechtel will develop the overall power plant and utility system H&M balances to assess overall power plant performance (output, heat rate) following final PCC addition.

Task 7: Estimate the capital and operating costs of the advanced amine post combustion retrofit design:

Bechtel will estimate capital costs for all power plant modifications. The level of detail required within this Pre-FEED is to be enough to generate a +/- 20% accuracy on costs.

The operating cost of the PCC plant and any additional power plant operating costs will be derived. Nexant will develop the incremental overall operating cost based on PCC plant consumptions and on incremental power plant consumptions supplied by GRE.

Task 8: Reporting

The final report will include the following key items:

- Description of the existing plant and the retrofit changes required to integrate CO_2 removal and compression.
- Process descriptions for power plant systems impacted by the PCC system, complete with process flow diagrams, including boiler island, steam/water

circuit, environmental controls, balance of plant, and PCC utilities provided by the power plant. Assessment of the most practical CO_2 capture efficiency based on site-specific constraints.

- A plot plan to establish the space required for the PCC plant and how interfaces are made between the power plant, PCC, and CO_2 compression plants.
- A description and justification of how the CO_2 removal facility will be integrated with the existing plant.
- Heat and mass balances for the power plant.
- Equipment lists with sizing of major items for the power plant and PCC utilities provided by the power plant.
- The amount and value of the electricity not sold due to the PCC addition

4. Deliverables

Reporting requirements are as follows:

- The work completed in Tasks 1 through 8 will be reported as an EPRI Technical Report. Draft versions will be reviewed by the host site participant. The final reports will be due 30 days after completion of the review.
- Key contents of the report are as described under Task 8 above.

The report will contain all 'Integration Pre- FEED' column items as provided by GRE in the Appendix section featured at the end of this document.

5. Schedule

The project is expected to be completed over a 9-month period.

The overall timetable will be influenced by the availability of data and timely input from the GRE. The retrofit team expects to be able to complete the defined scope in a period of 9 months, with the delivery of a draft technical report for GRE to review and comment. EPRI will include comments from GRE in subsequent delivery of the final Report.

The time quoted assumes that GRE will provide the information required for this assignment and the comments on our draft inputs on a timely basis, so that the 9-month period can be achieved.

Estimated completion dates and key milestones are outlined below.
Schedule to be finalized at the Kick off meeting in January.

Task Description	Completion Date
Project approval and contracts in place	End Dec 2019
Task 2: Review Plant Data • Part A: List of information needed by EPRI Team • Part B: GRE provide needed information • Part C: Site visit KO meeting & final Pre-FEED basis	 Mid Jan 2020 Early Feb 2020 End Feb 2020
Task 3: Develop Base Power Plant Model & Performance	Mid Mar 2020
Task 4: System Analysis of Integration and Retrofit Options • Configuration Options Screening	Mid Apr 2020
Task 5: Finalize PCC System Design • Define power plant interfaces	Mid Jun 2020
Task 6: Retrofit Design and Performance Assessment	Early Aug 2020
Task 7: Capital and operating costs of the retrofit design	Early Sep 2020
Task 8: Report	End Sept 2020

6. Estimated Price

The estimated price for undertaking the tasks above for the Coal Creek station PCC integration Pre-FEED is estimated at **$725k.**

EPRI will act as the project lead and prime contractor - subcontracting to Nexant and Bechtel. An identical arrangement and project structure to the previous successful GRE study undertaken in 2011 by EPRI. The resumes of key personnel from EPRI, Nexant and Bechtel will be provided to GRE.

Great River Energy Self Directed Funds (SDF) may be applied to this EPRI supplemental project.

7. Previous Project Experience

Appendix B below includes details of EPRI's CCS expertise, as well as a summary table of Bechtel's Full FEED and pre-FEED Carbon Capture project experience, including 11 specific studies with the EPRI and Nexant collaboration team.

Appendix C below includes resumes of the lead EPRI, Bechtel and Nexant personnel that will be involved in the project.

Appendix A:
GRE Deliverable Requirements

8/19/2019

Great River Energy
Carbon Capture at Coal Creek Station
Document Deliverables

Deliverable	GRE	PCC Pre-FEED	Integration Pre-FEED
PROJECT ENGINEERING / MANAGEMENT			
Project Economics	X		
Risk Management Plan	X		
Communications Plan	X		
Design Basis Document	Input	X	X
Project Schedule	X	X	X
Capital Cost Estimate		X	X
O&M Cost Estimate		X	X
Cost Forecasts		Monthly	Monthly
HAZOP/PHA/Operations Safety Review (Hazards Identification)		X	
PROCESS			
Process Symbols, Std Details, Numbering, General Notes		X	X
Studies or Evaluations (Configuration Options Screening)		X	X
Feedstock Specifications (Flue Gas Analysis)	X		
Chemicals Specifications		X	
Water Quality Specifications (River Water, Demin Water)	X	X	
Wastewater Quality Specifications		X	
Product Specifications (CO2)		X	
Process Description		X	X
Process Control Description		X	X
Process Flow Diagrams		X	X
Material Balance Diagram		X	X
Heat Balance Diagram		X	X
Utility Summary		X	?
Stream Property Tables		X	X
Safety/Shutdown System Design		X	X
Hazardous Area Classification Drawing		X	
Material Safety Data Sheets (MSDS)		X	
METALLURGICAL			
Piping & Vessel Materials Specifications		X	X
ENVIRONMENTAL			
Regulatory Review & Report	X		
Env Permit & License Plans	X		
Water Permit Review	X	Input	
Air Permit Review	X	Input	
Waste Permit Review	X	Input	
Use Permit Review	X		
MECHANICAL			
Piping & Instrumentation Diagram (P&ID)		X	X
Line List / Line Designation Tables		X	X
Tie-in Lists		X	X
Equipment List		X	X
Specialty Items Index		X	X

8/19/2019 1, 2 Document Deliverables -CCS2 PreFEED.xlsx

8/19/2019

Great River Energy
Carbon Capture at Coal Creek Station
Document Deliverables

Deliverable	GRE	PCC Pre-FEED	Integration Pre-FEED
General Arrangement Drawings		X	X
Preliminary Piping Routing Plans, Underground (Nominal Diameter >3")		X	X
Preliminary Piping Routing Plans, Above Ground (Nominal Diameter > 3")		X	X
ELECTRICAL			
Electrical Symbols, Std Details, Numbering, General Notes		X	X
Transformer Sizing		X	X
Single Line Diagrams		X	X
Electrical Equipment Location Plans		X	X
Preliminary Electrical Bus Duct Routing Plan		X	X
Raceway Layout Drawings - Above Ground		X	X
Duct Bank Layout Drawings - Below Ground		X	X
Substation & HV Distribution Drawings			X
INSTRUMENTATION & CONTROLS			
Controls Architecture (Block Diagram)		X	
FIRE PROTECTION			
Fire Protection Requirements Document		X	
Fire Protection System Description		X	
Fire Detection System Description		X	
GEOTECHNICAL			
Soil Sampling Specification	X		
Soil Sampling Report	X		
CIVIL/STRUCTURAL			
Clearing and Grubbing Drawing			
Grading & Drainage Plans		X	
Road and Paving Plans		X	
Curbing and Containment Drawings			
Ladders, Stairways & Platforms Arrgmt Drawings		X	
Pipe Racks, Supports& Bridges Arrangement Drawing		X	X
ARCHITECTURAL			
Architectural Symbols, Std Details, Numbering, General Notes		X	
Site Plan		X	
Architectural Layouts & Elevations		X	
Control Room Layout		X	
Construction Area Drawing		X	
Construction Permit Plan	X		
Construction Schedule		X	X
COMMISSIONING			
Commissioning Staffing Plan		X	X
Commissioning Schedule		X	X
Heavy Haul Study	X	Input	

Appendix B:
Project Team Experience from Relevant CCS FEED and Pre-FEED Projects

EPRI background and general CCS Technical Experience

The Electric Power Research Institute (EPRI), is headquartered in Palo Alto, California, with major locations in; Charlotte, North Carolina; and Knoxville, Tennessee. EPRI was established in 1973 as an independent, nonprofit center for public interest energy and environmental research. EPRI conducts research and development on technology, operations, and the environment for the global electric power sector. EPRI currently represents approximately 90% of the electricity generated in the United States and extends to participation in more than 35 countries. With an annual budget exceeding $400 million and a staff of more than 1000 people, EPRI is the largest non-profit research organization in the U.S. focused on power generation. The worldwide membership that supports our work comprises more than 1,000 organizations. While most members are electric utilities, others are businesses, government agencies, regulators and public or private entities engaged in some aspect of the generation, delivery, or use of electricity. Such an extensive network with structured advisory meetings and forums, enables EPRI to successfully realize its mission, of advancing safe, reliable, affordable and environmentally responsible electricity for society.

EPRI's research on CO_2 mitigation options provide vital insights into the expected cost, availability, performance, and potential risks of a range of fossil power plant CO_2 capture processes as well as long-term carbon storage and commercial utilization options. Technical and economic assessments of specific technologies, in addition to focused investment to develop and demonstrate the most promising, promotes the creation of commercially mature carbon capture and sequestration methods. This work is essential for directing research, development, and demonstration to yield the greatest return, develop coherent climate-change strategies, and encourage flexible, cost-effective, and environmentally sound public policy.

EPRI has been engaged in evaluations of pre-, post-, and oxy-combustion capture and from fossil power plants, for decades via its CO_2 Capture and Storage (CCS) research program and its Fossil Fleet for Tomorrow Program. As part of that effort, more than 140 different post-combustion technologies have been reviewed and numerous novel cycles evaluated. In addition, EPRI has conducted a series of extensive studies that examined the technical and economic feasibility of installing amine-based post-combustion systems on both existing coal and natural gas power plants. Experience and knowledge derived from such studies will ensure that the EPRI tasks within this proposal are executed efficiently.

Summary Table of Bechtel Carbon Capture FEED and Pre-FEED Projects:

Customer	Program, Location	Completion	Plant Rating, CO2 Capture, Efficiency	Pre-FEED Study	FEED Study
EPRI/Nexant	East Bend Station Unit 2 Initial Engineering Design of Post-Combustion CO2 Capture Using Membrance-Based Technology, Boone County, KY, USA	Ongoing	640MW	X	
CO2CRC	Retrofit of an Australian Brown Coal Power Station with Post-Combustion Capture, Conceptual Study, Loy Yang, Australia	2010	864MW 166-311 kg/MWh 76-84%	X	
World Bank/SENER	MX TF Carbon Capture, Utilization, and Storage Development in Mexico, Pre-Feasibility Study, Poza Rica, Mexico	2010	24MW 85-95%	X	
EPRI/Nexant	Assessment of Post-Combustion CO2 Capture for Pulverized Coal Power Plant Application, (Plant Barry Generation Station), Bucks, AL, USA	2015	777MW 6000tpd 45%	X	
EPRI/Nexant	Chilled Ammonia Process Design Applied to an 1100 oF Ultra-Supercritical Pulverized Coal Power Plant, Mountaineer Plant, WVA, USA	2013	633MW 15,294tpd 90%	X	
EPRI/Nexant	Assessment of Post-Combustion CO2 Capture for Pulverized Coal Power Plant Application, (Coal Creek Generation Station), Underwood, ND, USA	2011	621MW 27,462tpd 90%	X	
EPRI/Nexant	Assessment of Post-Combustion CO2 Capture for Circulating Fluidized Bed Coke-Fired Power Plant Application, (Bay Shore Generation Station), Oregon, OH, USA	2011	144MW 4200tpd 90%	X	
EPRI/Nexant	Assessment of Post-Combustion CO2 Capture for Pulverized Coal Power Plant Application, (Lingan Generation Station), Lingan, Nova Scotia, Canada	2011	665MW 14,300tpd 90%	X	
EPRI/Nexant	Assessment of Post-Combustion CO2 Capture for Pulverized Coal Power Plant Application, (Intermountain Generation Station), Delta, UT, USA	2011	2x547MW 37,562tpd 90%	X	
EPRI/Nexant	1300 °F Series Ultra Supercritical Plant Steam Turbine and Boiler Equipment Market Assessment, Market Application	2010	Materials Exploration	X	
EPRI/Nexant	Assessment of Post-Combustion CO2 Capture for Pulverized Coal Power Plant Application, (Powerton Station), EPRI/Nexant, Pekin, IL, USA	2010	772MW 36,453tpd 90%	X	
Shell	Peterhead Post-Combustion Capture FEED Study Review and Critique, Peterhead, Scotland, UK	2015	385MW net 1MtCO2/yr 90%		X
EPRI/Nexant	Post Combustion CO2 Capture for Supercritical Pulverized Coal Power Plant Applications, Task 3, EPRI/Nexant, Market Application	2009	615MW 15,200tpd	X	
Gassnova	CO2 Capture Facility Front-End Engineering and Design (FEED) Study Report, Karsto, Norway	2009	3400tpd 68.3%		X
Statoil/Hydro ASA	Front End Engineering Design (FEED) Study Report for the European CO2 Test Centre Mongstad - Amine Process, Mongstad, Norway	2008	100,000tpy 85%		X
EPRI/Nexant	Post-Combustion CO2 Capture for Supercritical Pulverized Coal Power Plant Applications,Tasks 1 & 2, Market Application	2007	750MWe net 14,47 tonnes/hr	X	
Norwegian Govt	Conceptual Design Study CO2 Capture Plant, Norwegian Water Resources and Energy Directorate, Karsto, Norway.	2006	420MW 3600tpd 85%	X	

Appendix C:
Key Project Personnel

Dr. Desmond Dillon | Senior Technical Leader
Electric Power Research Institute | Advanced Generation
Phone: (650) 855-2036 | E-mail: ddillon@epri.com

EDUCATION AND TRAINING
Ph.D., Mechanical Engineering, University of Strathclyde, 2002
B.Eng., Product Design Engineering, The University of Glasgow & Glasgow School of Art, 1994

RESEARCH AND PROFESSIONAL EXPERIENCE:
Electric Power Research Institute
Project Manager | Senior Project Manager | Senior Technical Leader | 2006 - Present

- Provide technical expertise in the field of clean coal combustion and CO_2 capture technologies applicable to large scale power generation plant such as pre, post and oxyfuel combustion capture processes.
- Provide project management within the EPRI's Fossil Fleet programs and related projects within the Advanced Combustion area of the Generation Sector, ensuring that projects meet technical and financial goals and high-quality R&D results are delivered on schedule and to budget.
- Work with member organizations to identify current and emerging technical issues related to advanced combustion power plant concepts, regularly conceiving and proposing innovative solutions and methods to address the many technical problems in development.
- Managing complex technical projects involving numerous collaborative partner companies.
- Work closely with EPRI member organizations alongside many prestigious European and worldwide manufacturers and research institutions in order to identify current and emerging technical issues related to the evaluation of CO_2 capture process concepts.
- Responsible for developing the key processes identified above through pilot and demonstration plant stages such that they rapidly evolve into the next generation of clean fossil fired utilities.
- Communicate strategies and results, written and verbal with program membership and potential EPRI members via published peer reviewed papers, international workshops and presentations at global forums and conferences

Mitsui Babcock Energy Ltd
Senior Project Engineer | 2000 – 2005

- Focused on development and evaluation of CO_2 abatement and capture technologies for the next generation of power plant.
- Main technical responsibilities centered on thermal and process design investigations of utility boilers, HRSG's and process plants as well as concept / feasibility studies of next generation technology.
- Mitsui Babcock's Principle Investigator and Work Package leader for European Union collaborative funded research, development and demonstration projects ENCAP and CASTOR. Thus, responsible for a number of work packages to the approximate value of 2 million euros and coordinating numerous partnered companies based both in the UK and mainland Europe.
- In addition, undertook commercial process design work for the UK nuclear sector.

National Engineering Laboratory (NEL)
PhD Researcher | 1997 – 2000

- Industrial sponsored research which involved studying combustion and NO_x predictions of anthracite fired burners using the FLUENT CFD code and validating results with test data from the Mitsui Babcock NO_x Reduction Test Facility.
- The academic content of the research was assessed by the University of Strathclyde with the final external examination of the thesis undertaken by the University of Leeds.

Rolls Royce Aero Engines
Development Engineer | 1996 - 1997

- Responsibilities centered on ensuring the V2500 engine's HP compressor met stringent criteria
  specified by both airworthiness authorities and customers.
- Supervised and implemented evaluations and test programs to identify deficiencies in component performance and design.
- Performed and managed technical investigations alongside complete engine testing and project management of test engine builds.

PUBLICATIONS:

1. An Engineering and Economic Assessment of Post-Combustion CO2 Capture for 1100°F Ultra D J Dillon 'Novel Advanced Ultra Supercritical (A-USC) Design Evaluations'. EPRI Report 3002006389, Palo Alto, CA: Dec 2016.
2. D J Dillon 'Flexible Operation of Current and Next Generation Fossil Pants with and Without CO_2 Capture' EPRI Report 3002003741 Dec 2014
3. D J Dillon, Post Combustion Capture on Natural Gas Combined Cycle Plants: A Technical and Economical Evaluation of Retrofit, New Build and the Application of Exhaust Gas Recycle IEA GHGT11 Proceedings July 2013.
4. D J Dillon, 'A summary of EPRI's Engineering and Economic Studies of Post Combustion Capture Retrofit Applied at Various North American Host Sites, IEA GHGT11 proceedings, July 2013.
5. Contributor '21st Century Coal: Advanced Technology and Global Energy Solution' International
   Energy Agency Coal Industry Advisory Board publication, September 2013
6. D J Dillon, 'Chilled Ammonia Process development: An Economic Assessment', Proceedings of the 12th Annual conference on Carbon Capture Utilization and Storage, May 14th, 2013.
7. D J Dillon, 'Experience of Supercritical Technology in the U.S' Designing a Cleaner Future for Coal Conference, Vietnam 15-19 Oct 2007. Conference was sponsored by US Aid and Asia Development Bank.
8. D J Dillon, R S Panesar, R A Wall, R J Allam, V White, J Gibbins and M J Haines *'Oxy-Combustion Processes for CO_2 Capture from Advanced Supercritical PF and NGCC Power Plant' G*HGT-7 Paper, Vancouver Canada Sept 2004.
9. D J Dillon. *'A study of Combustion Modelling and NO_x Prediction for Anthracite Flames'.* University of Strathclyde PhD Thesis, October 2002. Industrial sponsors: National Engineering Laboratory, East Kilbride and Mitsui Babcock, Glasgow.

Robert Chu / Process Engineering Manager
Nexant

EDUCATION
B.S., Chemical Engineering, University of California, Berkeley

SUMMARY OF QUALIFICATIONS AN EXPERIENCE
Mr. Chu was Nexant's Principal Investigator on the recent EPRI funded studies, looking into design requirements and the techno-economics of retrofitting existing coal-fired power plants for post combustion carbon capture. Prior joining Nexant, Mr. Chu was the Process Engineering Manager at Bechtel Corporation's San Francisco Offices. He has over thirty years of experience in process design and techno-economic analysis of gasification to fuels and chemicals production, gas processing, and petroleum refining. Mr. Chu has conducted many feasibility studies and detailed process designs related
to gasification systems. He served as the Chief Process Engineer for a $12 million DOE funded engineering study on gasification co-Production of power and Fischer-Tropsch fuels. Mr. Chu was on the Bechtel engineering team that performed the Cherokee Clean Fuels Project Feasibility Study of coal-to-SNG (synthetic natural gas) based on Lurgi gasification, CO shift, selective Rectisol H_2S and CO_2 removal, and methanation technologies. He was also on the design team that performed a detailed feasibility design for a gasification-based trigeneration of fuels, power and chemicals (including mixed alcohols) production project in China.

RELEVANT WORK HISTORY
Principal, Nexant Inc. [2000 – Present]
Mr. Chu is responsible for implementation of projects involving coal gasification, CO_2 capture, refinery
and chemical processing technologies. Currently, Mr. Chu is the technical lead/advisor of several key projects within Nexant's Energy Technology Group. Example projects include:

- Preliminary techno-economic analysis in support of the Ohio State University to develop a chemical looping based biomass gasification to methanol process.
- Conceptual engineering and feasibility assessment of a solar assisted post-combustion CO2 capture design for PC power plants, in support of Electric Power Research Institute.
- Engineering techno-economic analysis supports to the Arizona State University to develop a zeolite membrane WGS reactor based technology for IGCC CO2 removal.
- US DOE-commissioned techno-economic analysis of Aerojet Rocketdyne's (AR) advanced compact gasification system coupled with warm syngas cleanup offered by Research Triangle Institute (RTI) for IGCC and coal-to-methanol applications
- On behalf of DOE, led the techno-economic evaluation of Gas Technology Institute's (GTI) molten bed gasification for power production and coal-to-Fischer-Tropsch liquids applications
- Techno-economic evaluation comparing AR's dry solids pump (DSP) feed system to conventional lockhopper-based feed system when integrated in a Shell's gasifier-based IGCC power plant
- Led a DOE-commissioned techno-economic evaluation of GTI's oxygen-fired molten bed boiler for power production with CO_2 compression and purification for saline aquifer storage
- Saudi Aramco funded feasibility study of a combined hydrogen and electricity production facility with CO_2 capture based on petroleum feedstocks,

Process Engineering Manager/Nexant

- Working with EPRI (Electric Power Research Institute) to develop post-combustion CO_2 capture technologies and to assess the design requirements and techno-economics of retrofitting existing PC power plants for CO_2 capture,
- Techno-economic analysis, on behalf of EPRI, of chilled ammonia-based post combustion CO_2 capture of a 750 MWe ultrasupercritical pulverized coal power plant
- Conceptual design and feasibility evaluation of a 400 MW coal-based solid oxide fuel cell (SOFC) power plant
- Conceptual design of a 10,000 BPSD Korean and a 20,000 BPSD US coal gasification and Fischer-Tropsch liquid co-production plant,
- Engineering feasibility study of a 5,000 BPSD gasification based power and Fischer-Tropsch fuels co-production plant
- Technology support to develop a proprietary warm gas desulfurization process with integration
  into the GE/Bechtel reference IGCC (integrated gasification combined cycle) power plant,
- IGCC/Hydrogen co-production design utilizing ceramic membrane hydrogen separation technology vs. conventional PSA technology
- Plant design optimization to reduce the costs and energy consumption associated with using amine to separate and capture CO_2 in flue gases from natural gas combined cycle power and supercritical coal fired power plants.

Process Manager, Bechtel Technology and Consulting Group, San Francisco.[1995 – 1999]
Mr. Chu's responsibilities included process design and development of Bechtel's Molten Carbonate Fuel-
Cell Technology, feasibility study for di-methylether (DME) production from syngas, and feasibility study for iso-butanol manufacture from syngas.

Manager of Process Engineering, Bechtel Corporation, San Francisco. [1994 – 1995]

LIST OF RECENT PUBLICATIONS

1. "Chilled Ammonia Process (CAP) Development: An Economic Assessment" Desmond Dillon, Dick Rhudy, George Offen and Andy Maxson (EPRI), Robert Chu and Haoren Lu (Nexant), David Muraskin, Fred Kozak and Aytac Sezgi (Alstom Power), Carbon Capture Utilization and Storage Conference, May 13-16, 2013 Pittsburgh, PA

2. "Redesign, Optimization, and Economic Evaluation of a Natural Gas Combined Cycle with the Best Integrated Technology CO_2 Capture" Cristina Botero, Matthias Finkenrath, Michael Barlett, (GE Global Research) Robert Chu, and Gerald N. Choi (Nexant) Daniel Chinn (Chevron), 9th International Conference on Greenhouse Gas Control Technologies, November 11-20, 2008 Washington DC

3. "Cost Efficient Amine Plant Design for Post Combustion CO_2 Capture From Power Plant Flue Gas" Gerald N. Choi, Robert Chu and Bruce Degen (Nexant) Harvey Wen and Peter Richen (Bechtel) and Daniel Chinn (ChevronTexaco), 7th International Conference on Greenhouse Gas Control Technologies, September 5-9, 2004 Vancouver, Canada 2004.

William R. Elliott / Operations Manager
Bechtel Power

EDUCATION
Masters of Engineering, University of Minnesota
BS, Civil Engineering, Iowa State University

TECHNICAL QUALIFICATIONS AND SUMMARY OF EXPERIENCE
Registered Professional Civil Engineer, California, Minnesota, and New York
Diplomat of the American Academy of Environmental Scientists and Engineers
Fellow, Institute of Civil Engineers

Bill Elliot has been associated with a variety of domestic and international projects, largely with Bechtel, over his exceptional career of over 30 years. He has managed the design and construction of fossil-fired power plants, waste-to-energy projects, and civil projects. Along with technical and managerial expertise, he possesses substantial financial acumen, having developed investment models, led the execution of a $2 billion capital improvements program for United Utilities in the UK, and participated in the successful marketing and sale of Bechtel power generation assets. Currently, he is operations manager, overseeing Bechtel fossil projects worldwide.

RELEVANT WORK HISTORY
Operations Manager 2012–Present:
Currently, Mr. Elliott oversees the management and execution and customer interfaces of Bechtel fossil power projects worldwide, with a focus on business development and the early stages of new project execution. He provided oversight on several carbon capture study efforts for EPRI which were conducted in conjunction with Nexant, including analysis of utility tests and review of the utilities' approaches to carbon capture-ready design alternatives.

Study Manager–Alternative Energy Sources 2011:
Mr. Elliott was assigned to the Jubail Industrial City project in Saudi Arabia, the largest civil engineering project in the world. In the Jubail industrial park, 16 primary industries operate around the clock,
creating more than 30 different products. His duties were related to developing a new investment model for renewable energy for the Royal Commission of Jubail that encompassed waste-to-energy, carbon credits, and integration with and development of Ras Al Khair (formerly Ras Az Zawr) Minerals Industrial City in Saudi Arabia.

Deputy Program Manager 2009–2011:
For the Tube Lines rail project for the upgrade and maintenance of the infrastructure for London Underground's Jubilee, Northern, and Piccadilly lines, Mr. Elliott was responsible for train controls upgrades, subcontract system improvement, software program scheduling and control, and the tunnel installation safety program.

Manager of Projects
2006–2009: Mr. Elliott was the project manager on the KFx coal refinery project in Wyoming. This project uses a product known as K-Fuel to subject low-rank coals to high pressures and temperatures in a steam heated vessel to increase the heating value and lower the mercury content. Included were investigations of upgrading Indonesian coal for supply to Asian electric power utilities.

Project Director 2005–2006:
As project director, Mr. Elliott worked on front-end engineering design (FEED) studies on CO_2

capture for both the Mongstad and Kårstø projects in Norway. He also oversaw the preliminary design of a carbon capture facility for a 500 MW CCGT at Karstø. The Kårstø facility is designed to capture 85 percent of the CO_2 emissions (over 1 million tonnes per year) of an adjacent 420 MW gas-fired power plant in southwest Norway. Once completed, Kårstø will be the largest CO_2 separation facility ever constructed that treats gas turbine exhaust gas. The Mongstad Test Centre is designed to remove CO_2 from the flue gas of a combined heat and power plant and a residual catalytic cracker. Mr. Elliott was also the project manager on the 700 MW El Tebbin oil-/gas-fired steam power plant project on the Nile River in Cairo, Egypt.

Vice President & Managing Director – Bechtel Enterprises 1998–2005:
Mr. Elliot managed Bechtel's ownership interests in electric and water utilities and facilities. He served on the Board of Directors for Bechtel in several joint ventures that owned and operated those entities. He also served as President of Guayaquil Ecuador water utility prior to the sale of Bechtel's ownership interest in the utility.

Manager of USGen Assets–Electrical Generation 1997–1998:
Mr. Elliott oversaw Bechtel's investments in all power projects. He was also a member of the BEn team that successfully marketed and sold the BEn power generation assets previously owned jointly with USGen.

Director of Projects 1995–1997:
Mr. Elliott was responsible for the water projects executed by the Warrington, England, office of United Utilities and for coordination with regional market sectors. His responsibilities included executing a $2 billion capital improvements program.

Manager, Hydro and Water Projects 1990–1995: Mr. Elliott was responsible for both domestic and international water-related projects. For Venezuela's Ministerio del Ambiente y de los Recursos Naturales Renovables, he directed the engineering of hydraulic structures, water supply, drainage, and solid waste projects in the Occidental Coastal Region of Venezuela, as well as the upgrade of the Trujillo water system. Domestically, he directed the construction of the Hingham water plant for American Water Works Company in Massachusetts and was responsible for improvements at Washington, DC's, Blue Plains treatment plant. Mr. Elliott oversaw development of an upgrade that involved installing eight 2.6-million-gallon anaerobic sludge digesters for methane generation and use in New York.

Manager of Business Development/Project Manager, Renewable Energy 1988–1990:
Mr. Elliott managed the business development activities of Bechtel's waste-to-energy projects as well as the Adana-Yumurtalik port project in southeastern Turkey.

Business Development Manager 1983–1987:
Mr. Elliott managed Bechtel Power Corporation's business development for the Middle East and North Africa. He directed the financial development of the 300 MW Shoubrah El-Kheima Unit 4 power plant project in Egypt, managed the Turkey Coastal coal project development efforts, and developed a power plant build-own-transfer acquisition model for the Turkish government. Mr. Elliott was responsible for sales for the Renewables and Waste-to-Energy business line and for marketing, planning, and administering development efforts.

Project Engineer/Project Manager 1980–1983:
Mr. Elliott was in charge of project engineering and directed Environmental Water Projects Department operations and business development on the US East Coast. He managed consulting engineering services for the Connecticut Resource Recovery Authority's (CRRA's) Mid-Connecticut

power project and the Housatonic Valley power project, as well as the Cuyahoga County and City of Cleveland's alternative energy program. Co-disposal of sewage sludge and municipal waste were investigated on several CRRA projects. He managed an analysis of the Hempstead energy recovery facility for the project financiers and an analysis of alternative water supply sources in the Boston area for the Metropolitan District Commission. Other assignments involved coordinating engineering for the Brunei Palace infrastructure design, managing a Dominican Republic water pipeline and treatment facility proposal, and developing a joint protocol with Philadelphia Suburban Corporation for offshore water projects.

APPENDIX C

EERC FLUE GAS CHARACTERIZATION AND SOLVENT TESTING

Energy & Environmental Research Center
15 North 23rd Street, Stop 9018 • Grand Forks, ND 58202-9018 • P. 701.777.5000 • F. 701.777.5181
www.undeerc.org

September 26, 2019

Mr. Vince Herda
Principal Engineer
Great River Energy
12300 Elm Creek Boulevard
Maple Grove, MN 55369

Dear Mr. Herda:

Subject: EERC Proposal No. 2020-0056 Entitled "Flue Gas Characterization and Testing"

Introduction

Great River Energy has requested a proposal from the Energy & Environmental Research Center (EERC) for flue gas characterization and CO_2 capture pilot testing at the Coal Creek Station.

Goals and Objectives

The goal of this proposal is to characterize flue gas at Coal Creek and evaluate a solvent-based CO_2 capture technology. Specific objectives of the proposed work will include the following:

1. Characterize flue gas at Coal Creek, concentrating on aerosol and SO_3 concentrations.

2. Conduct CO_2 capture testing at Coal Creek with the EERC's solvent testing system.

Work Scope and Budget

Task 1 – Flue Gas Characterization

It is assumed at this stage that all sampling will occur at the unit's stack. Four samplers will take part in the characterization effort. Sampling will include the use of a scanning mobility particle sizer (SMPS), a Dekati particle impactor sampler, and a Fourier transform infrared (FTIR) analyzer. With these methods, the characterization of aerosols and the presence of SO_3 and any other constituents observed will be reported. The sampling team will be available after

October 30, 2019, and can mobilize with 2 weeks' prior notice. A high-level schedule is given below:

- Day 1 – Sampling team arrives at Coal Creek Station and sets up equipment.
- Days 2–4 – Sampling occurs.
- Day 5 – Equipment is removed, and sampling team returns to the EERC.

Upon completion of testing, data analysis and reporting for the flue gas-sampling work can be completed in 3 weeks. The estimate to conduct this activity is $66,300.

Task 2 – CO_2 Solvent Pilot Testing

Sampling will involve bringing the EERC's portable CO_2 capture system on-site to Coal Creek Station to conduct a 3-month (12-week) program. The system utilizes approximately 100–120 scfm of flue gas from the facility. Testing will be conducted utilizing a liquid solvent selected by Great River Energy. The capture system will be manned 24 hours per day by EERC personnel. Periodic sampling of aerosols will be conducted on the outlet of the system to determine the increase or reduction caused by CO_2 capture as well as continuous monitoring for standard combustion gases (CO_2, CO, NO_x, O_2, and SO_2). The capture system will be available for use in the spring of 2020. A high-level schedule is given below:

- Installation of capture system – 2 months
- Shakedown testing – 1 week
- Testing – 3 months
- Demobilization – 1 month
- Reporting – 3 months after completion of testing

The estimate to conduct 3 months of capture testing is $1,406,000. Please note that this estimate does not include the following elements:

- Modifications needed to integrate the system into Coal Creek Station ductwork.
- Any modifications to the capture system that might be deemed necessary by the solvent vendor.
- Cost of the solvent.

Coal Creek Station will provide the following:

- An enclosure, with scaffolding, for the capture system – it is not weatherized.
- A source of cooling water: 25 gpm of cooling water is needed.
- Boiler-grade water for the steam system provided by the EERC.
- Solvent storage.

- Forklifts, telehandlers, and other equipment necessary to install the capture system.
- 200 amps, 480-volt power. Some will need to be stepped down to 208 volt and 120 volt.

The total estimated cost for this proposal is $1,472,325. Expenses will be invoiced monthly on a cost-reimbursable basis. A detailed budget is attached. The project period of performance is anticipated to be January 1, 2020 – December 31, 2020. The primary deliverable for the project will be the final report. The data collected will be presented in tables and graphs as considered appropriate, with a discussion of the test results.

If you have any questions regarding the proposed work scope or schedule, please contact me by phone at (701) 777-5114 or by e-mail at jlaumb@undeerc.org.

Sincerely,

Jason D. Laumb
Assistant Director for
Advanced Energy Systems

Approved by:

Charles D. Gorecki, CEO
Energy & Environmental Research Center

JDL/kal

Attachments

Project Associated Expense	GRE Share (Cash)
Labor	$ 777,856
Travel	$ 61,463
Supplies	$ 5,350
Communications	$ 30
Printing & Duplicating	$ 60
Rents & Leases - Boiler Rental	$ 27,000
Laboratory Fees & Services	
Natural Materials Analytical Research Lab	$ 3,838
Analytical Research Lab	$ 11,562
Particulate Analysis Lab	$ 5,481
Graphics Services	$ 338
Shop & Operations	$ 42,611
Engineering Services Fee	$ 15,700
Freight - System shipment via truck	$ 27,000
Total Direct Costs	$ 978,289
Facilities & Administration	$ 494,036
Total Cash Requested	**$ 1,472,325**

JASON D. LAUMB
Assistant Director for Advanced Energy Systems
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, ND 58202-9018 USA
701.777.5114 (phone), 701.777.5181 (fax), jlaumb@undeerc.org

Principal Areas of Expertise

Mr. Laumb's principal areas of interest and expertise include biomass and fossil fuel conversion for energy production, with an emphasis on pollution control and ash effects on system performance. He has experience with trace element emissions and control for fossil fuel combustion systems, with a particular emphasis on air pollution issues related to mercury and fine particulates. He also has experience in the design and fabrication of bench- and pilot-scale combustion and gasification equipment.

Qualifications

M.S., Chemical Engineering, University of North Dakota, 2000.
B.S., Chemistry, University of North Dakota, 1998.

Professional Experience

September 2019–Present: Assistant Director for Advanced Energy Systems, EERC, UND. Mr. Laumb assists the EERC executive team by providing leadership on projects related to advanced energy systems. Mr. Laumb leads a multidisciplinary team of scientists and engineers working on advanced energy technologies from pollution control to new energy platforms. Specific areas of interest include CO_2 capture, techno-economic modeling, environmental control systems, supercritical CO_2 power cycles, and advanced gasification technologies. Current research activities are focused on low-carbon-intensity power cycles for fossil fuel fired systems.

2008–August 2019: Principal Engineer, Advanced Energy Systems Group Lead, EERC, UND. Mr. Laumb led a multidisciplinary team of 30 scientists and engineers to develop and conduct projects and programs on power plant performance, environmental control systems, the fate of pollutants, computer modeling, and health issues for clients worldwide. Efforts focused on development of multiclient jointly sponsored centers or consortia funded by government and industry sources. Research activities included computer modeling of combustion/gasification and environmental control systems, performance of SCR technologies for NO_x control, mercury control technologies, hydrogen production from coal, CO_2 capture technologies, particulate matter analysis and source apportionment, the fate of mercury in the environment, toxicology of particulate matter, and in vivo studies of mercury–selenium interactions.

2001–2008: Research Manager, EERC, UND. Mr. Laumb led projects involving bench-scale combustion testing of various fuels and wastes as well as a laboratory that performs bench-scale combustion and gasification testing. He served as principal investigator and managed projects related to the inorganic composition of coal, coal ash formation, deposition of ash in

conventional and advanced power systems, and mechanisms of trace metal transformations during coal or waste conversion and wrote proposals and reports focused on energy and environmental research.

2000–2001: Research Engineer, EERC, UND. Mr. Laumb assisted in the design of pilot-scale combustion equipment and wrote computer programs to aid in the reduction of data, combustion calculations, and prediction of boiler performance. He was also involved in the analysis of combustion control technologies' ability to remove mercury and the suitability of biomass as boiler fuel.

1998–2000: SEM Applications Specialist, Microbeam Technologies, Inc., Grand Forks, North Dakota. Mr. Laumb gained experience in power system performance including conventional combustion and gasification systems; knowledge of environmental control systems and energy conversion technologies; interpreting data to predict ash behavior and fuel performance; assisting in proposal writing to clients and government agencies such as the National Science Foundation and the U.S. Department of Energy; preparing and analyzing coal, coal ash, corrosion products, and soil samples using SEM/EDS; and modifying and writing FORTRAN, C+, and Excel computer programs.

Professional Membership
American Chemical Society

Publications and Presentations
Has coauthored numerous professional publications.

JOHN P. KAY
Principal Engineer, Emissions and Carbon Capture Group Lead
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
701.777.4580 (phone), 701.777.5181 (fax), jkay@undeerc.org

Principal Areas of Expertise

Mr. Kay's principal areas of interest and expertise include applications of solvents for removing CO_2 from gas streams to advance technology and look toward transformational concepts and techno-economic assessments. He has 6 years of experience in field testing site management and sampling techniques for hazardous air pollutants and mercury control in combustion systems along with10 years of experience utilizing scanning electron microscopy (SEM), x-ray diffraction (XRD), and x-ray fluorescence (XRF) techniques to analyze coal, fly ash, biomass, ceramics, and high-temperature specialty alloys. He is also interested in computer modeling systems, and high-temperature testing systems.

Qualifications

B.S., Geological Engineering, University of North Dakota, 1994.
Associate Degree, Engineering Studies, Minot State University, 1989.

Professional Experience

2011–Present: Principal Engineer, Emissions and Carbon Capture Group Lead, EERC, UND. Mr. Kay's responsibilities include management of CO_2 separation research related to bench-, pilot-, and demonstration-scale equipment for the advancement of the technology. This also includes the development of cleanup systems to remove SO_x, NO_x, particulate, and trace elements to render flue gas clean enough for separation.

2005–2011: Research Manager, EERC, UND. Mr. Kay's responsibilities included the management and supervision of research involving the design and operation of bench-, pilot-, and demonstration-scale equipment for development of clean coal technologies. The work also involved the testing and development of fuel conversion (combustion and gasification) and gas cleanup systems for the removal of sulfur, nitrogen, particulate, and trace elements.

1994–2005: Research Specialist, EERC, UND. Mr. Kay's responsibilities included conducting SEM, XRD, and XRF analysis and maintenance; creating innovative techniques for the analysis and interpretation of coal, fly ash, biomass, ceramics, alloys, high-temperature specialty alloys, and biological tissue; managing the day-to-day operations of the Natural Materials Analytical Research Laboratory; supervising student workers; developing and performing infrared analysis methods in high-temperature environments; and performing field work related to mercury control in combustion systems.

1993–1994: Research Technician, Agvise Laboratories, Northwood, North Dakota. Mr. Kay's responsibilities included receiving and processing frozen soil samples for laboratory testing of chemical penetration, maintaining equipment and inventory, and training others in processing techniques utilizing proper laboratory procedures.

1991–1993: Teaching Assistant, Department of Geology and Geological Engineering, UND. Mr. Kay taught Introduction to Geology Recitation, Introduction to Geology Laboratory, and Structural Geology. Responsibilities included preparation and grading of assignments and administering and grading class examinations.

1990–1992: Research Assistant, Natural Materials Analytical Laboratory, EERC, UND. Mr. Kay's responsibilities included operating an x-ray diffractometer and interpreting and manipulating XRD data, performing software manipulation for analysis of XRD data, performing maintenance and repair of the XRD machine and sample carbon coating machine, preparing samples for XRD and SEM analysis, and performing point count analysis on the SEM.

Professional Memberships
ASM International
American Ceramic Society
Microscopy Society of America

Publications and Presentations
Has authored or coauthored numerous publications.

APPENDIX D

EERC 3D SEISMIC STUDY

EERC
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018 • Grand Forks, ND 58202-9018 • P. 701.777.5000 • F. 701.777.5181
www.undeerc.org

September 27, 2019

Mr. Adam Dunlop
Director – Regulatory & Technical Services
Midwest AgEnergy Group, LLC
2841 3rd Street Southwest
Underwood, ND 58576

Dear Mr. Dunlop:

Subject: EERC Proposal No. 2020-0057 Entitled "Geologic CO_2 Storage Site Characterization of the Midwest AgEnergy Blue Flint Ethanol Plant"

The University of North Dakota Energy & Environmental Research Center (EERC) is pleased to submit this proposal to Midwest AgEnergy in support of your proposal to the Lignite Research Council's Lignite Research, Development and Marketing Program. The EERC will support site characterization efforts and stratigraphic test well planning to advance geologic CO_2 storage as a means of managing CO_2 associated with ethanol production at Midwest AgEnergy's Blue Flint Ethanol Plant.

The EERC is committed to providing technical expertise to Midwest AgEnergy for proposed activities involving 3-D seismic data interpretation, modeling, and simulation to inform stratigraphic test well placement. The EERC will also help develop a drilling and completion plan for a stratigraphic test well. A detailed description of the EERC's proposed scope of work can be found in Appendix A.

This work will be accomplished through 9 months. The total estimated cost for this proposed scope of work is $429,885. This work will be completed on a fixed-price basis.

We look forward to the opportunity to collaborate with Midwest AgEnergy on this exciting project. If you have any questions, please contact me by phone at (701) 777-5073 or by e-mail at bbotnen@undeerc.org.

Sincerely,

Barry W. Botnen
Hydrogeologist

Approved by:

Charles D. Gorecki, CEO
Energy & Environmental Research Center

BWB/kal

Attachment

APPENDIX A

INTRODUCTION

The purpose of this scope of work is to support Midwest Ag Energy's efforts related to acquiring a 3-D seismic survey at the Blue Flint Ethanol plant near Underwood, North Dakota, to inform stratigraphic test well placement in addition to developing a drilling and completions plan for the test well. A description of the services the Energy & Environmental Research Center (EERC) will provide to support these efforts is as follows.

3-D Survey Planning and Logistics

The EERC will provide assistance and technical guidance with 3-D survey planning and permitting.

Field Observation

EERC personnel will be on-site for data acquisition operations to observe acquisition procedures. Field observations are necessary to understand data quality related to noise and other field conditions that may influence the type of algorithms needed to process the data.
Note: this task does not include survey management such as the supervision of contractors, cost control, or ensuring contractor compliance with state requirements and site-specific safety regulations. This task also does not include EERC personnel being on-site for surveying and drilling operations.

Data Processing Management

The EERC will provide the third-party data-processing company contracted by Midwest AgEnergy with additional information about potential data quality issues that may require specialized algorithms not included in its standard workflow. The EERC will participate in regular update meetings with the processing company, review intermittent processing results and help advise parameter selection.

Seismic Data Interpretation and Modeling

The EERC will use industry standard data interpretation software packages to interpret the thickness, structure, and heterogeneity of the target reservoir and its seal as well as identify potential hazards. Interpretation results will be used to update the static geologic model, which will be used to run dynamic reservoir simulations. Interpretation and simulation results will be used to inform recommendations for well placement.

Well Drilling and Completions Plan

The EERC will develop a well drilling and completion plan for a stratigraphic test well to support the stratigraphic test well permit process. The completion plan will be constructed to provide a provisional pathway to transition the well from a stratigraphic test well to a Class VI injection well in the future. As part of this task, a meeting will be held with the North Dakota Industrial Commission to discuss Class VI injection well completion standards as they relate to transitioning the well from a stratigraphic test well to a Class VI injection well. It should be noted that this task does not include compiling a bid packet and requesting formal bids.

TIME LINE

The proposed work is estimated to take a maximum of 9 months to perform. This period of performance is contingent on receiving processed data from the seismic data-processing company by Month 5.

DELIVERABLE

A report will be generated discussing the interpretation results and recommendations for well placement. The outcomes of this effort can be used by Midwest AgEnergy and its partners to reduce uncertainties in the geologic model and simulations, inform well placement, and support Class VI permit applications. The format of the project's deliverable will be determined through discussion with Midwest AgEnergy.

COST

The fixed-price cost for the proposed effort is $429,885 (Table 1). The budget includes approximately 3200 EERC personnel hours. Once the Lignite Research, Development and Marketing Program provides notice of award, the EERC will enter into contract negotiations with Midwest AgEnergy. An invoice for 50% of the cost will be submitted to Midwest AgEnergy upon execution of a mutually negotiated agreement. The balance will be invoiced upon submittal of the project deliverables. This quote is valid until December 31, 2019.

Table 1. Project Cost

Project Associated Expense	Midwest AgEnergy
Labor	$275,027
Travel	$3,795
Communications	$50
Printing & Duplicating	$75
Laboratory Fees & Services	
Graphics Services	$6,691
Total Direct Costs	$285,638
Facilities & Administration	$144,247
Total Cash Requested	$429,885

EXPLORATION GEOPHYSICS, INC.

310 W. WALL, SUITE 700
MIDLAND, TEXAS 79701-5123
MAILING ADDRESS:
P.O. BOX 10038
MIDLAND, TEXAS 79702-7038

September 26, 2019

Mr. Adam Dunlop
Blue Flint Ethanol

McLean County, ND 3D Seismic Survey
7 square miles (estimate)

Proposed Acquisition Parameters:
Source Line Interval: 1,760'
Source Interval: 220'
Receiver Line Interval: 880'
Receiver Interval: 220"
Recording Patch: Static Patch (orthogonal)
Source: Dynamite
Hole Depth: 120'(or greater)
Dynamite: 11 lbs.
Record Length: 4 sec.
Geophone: 6 / station
Sample Rage: 2 ms.

Estimated Cost:
Permits and Permitting Charges: Unknown.

Survey and Recording:	$25,000/square mile
Drilling & Dynamite:	$50,000/square mile
Water Well Testing:	$ 1,000/square mile
Particle Motion Monitor:	$ 1,000/square mile
Quality Control/Super.:	$ 3,000/square mile

TELEPHONE: (432) 685-1094 ✦ www.egi-seismic.com

APPENDIX E - RESUMES

GREAT RIVER ENERGY

John Bauer

Dave Farnsworth

Vince Herda

EAGLE CREEK CONSULTING

Charles Bullinger

EERC

Jason Laumb

John Kay

EPRI

Desmond Dillon

BECHTEL

William Elliot

NEXANT

Robert Chu

John Bauer

jbauer@grenergy.com, office (701) 442-7000, Cell (701) 897-1853

Summary

As Director of North Dakota Generation for Great River Energy I have oversight of Great River Energy's North Dakota fossil facilities. With over 38 years of experience in the industry, I possess a wealth of power and process knowledge and strive to enhance culture, teamwork and leadership to maintain a highly engaged work force.

The honor to serve as a member of the Bismarck State College foundation board and as chair of Electric Power Research Institute's operations management technology program provides an opportunity to offer input that creates a well-trained workforce ensuring we improve operations and achieve safe, reliable, cost-effective and environmentally responsible power generation.

This first-hand knowledge and experience allow me to effectively contribute to the overall success of GRE's North Dakota operation regardless of the situation.

EXPERIENCE:

Director, North Dakota Generation
March 2017 – current
Lead, plan and direct the operation and maintenance of North Dakota generating facilities in accordance with Great River Energy's (GRE) values, mission, and strategic imperatives, to achieve safe, reliable, efficient and environmentally sound production of electricity.

Manager, North Dakota Operations Services
April 2015 – March 2017
Provide management oversight for plant operations, fuel operations and utility groups at Great River Energy's Coal Creek, Stanton and Spiritwood facilities. Provide overall site management for Spiritwood Station. Current Alternate Designated Responsible person for North Dakota environmental compliance.

Leader, Plant Operations (day coordination) Great River Energy, Coal Creek Station
Oct 2005 – April 2015
Act as the Operating Authority and provide daily coordination for Coal Creek Station Plant Operations, Facilitate hiring and training for new hires (Operators / Operator Technicians), Mentor the 60 member Operations Team, coordinate new projects affecting the station, system start-up commissioning, work around guidance and emergent response to limit generation loss, Incident Commander for HazMat, fire and unit incidents, Provide leadership to the Operator Technician, Building Maintenance Utility and Temp Labor groups.

Leader, Plant Operations (shift coordination) Great River Energy, Coal Creek Station
Sept 2001 – Sept 2005
Act as the Operating Authority of Coal Creek Station, coordinate shift operation of a 12-member self-directed work team at Coal Creek Station, provide maintenance guidance on short outage and emergent situations to limit generation losses.

Control Room Operator Great River Energy, Coal Creek Station
July 1994 – Aug 2001

John Bauer

jbauer@grenergy.com, office (701) 442-7000, Cell (701) 897-1853

Operate Coal Creek Station from the central control room, coordinate maintenance efforts to support maintenance teams with clearances and equipment outage scheduling. Train other levels of plant operations to ensure qualified members for advancing positions.

Additional operations positions, Great River Energy, Coal Creek Station
Mar 1981 – June 1994
Monitor equipment, provide clearances, perform minor maintenance and provide troubleshooting support for Assistant Control Operator, Auxiliary Operator and Equipment Operator plant systems at Coal Creek Station. Provide job leader support for unit outages.

EDUCATION:

Great River Energy Leadership Training, Great River Energy
Foundational Leadership and Leadership in Action
MARC – Managers Guide to Employee Relations Leadership Training

Bismarck State College, Bismarck ND
Power Plant Technology

LEADERSHIP IN OTHER ORGANIZATIONS:

Bismarck State College Foundation board member

Program Chair for Electric Power Research Institute Operations Management and Technology Program

President, Ridgefield Condominium Association, Bismarck

SKILLS AND ABILITIES

Leadership Operations
Project Coordination
Mentoring
Safety
Expertise
Project Commissioning
Teamwork

Dave Farnsworth

dfarnsworth@grenergy.com

Office (701) 442-7002, Cell (701) 219-9744

EXPERIENCE:

Manager, North Dakota Power Generation and Engineering, Great River Energy
February 1996 – present
Manage the power generation, engineering, laboratory services groups for the North Dakota generation facilities. Included in these efforts is the management of the capital budgets, construction, and outages for North Dakota generation. Currently directly oversee the efforts of four Leaders and three principal or senior engineers, with a total organizational oversight of about 40 engineers and technical staff. During major outages, I manage the efforts of 600 - 900 individuals. During my tenure, I have overseen all the major and minor scheduled outages, two major turbine upgrades, three major controls upgrades, rebuild of large sections of the boilers, and major construction and startup of systems, such as the DryFining™ System. Station output has increased by over 110 MW and is reliability greatly improved. Currently serving as National Co-chair for a Program on Integrated Portfolio Planning and Market Analysis for the Electric Power Research Institute.

Outage Manager, San Onofre Nuclear Power Station, Southern California Edison
February 1985 - February 1996
Following 1.5 years involved in Operations in the startup of San Onofre Nuclear Units 2 & 3 (two 1150 MW commercial nuclear units), I became the Outage Planning Supervisor for a few years, before progressing to Outage Manager for San Onofre Units 2 & 3. Major accomplishments during my tenure were a 40 percent reduction in outage lengths and greatly improved capacity factors for the units. I also participated in benchmarking efforts for Southern California Edison and as an industry representative for the Institute for Nuclear Power Operations in implementing best practices and technology used throughout the nuclear power industry.

Control Room Supervisor, Satsop Nuclear Power Station, Washington Public Power Supply System
October 1981 - February 1985
Directed the efforts of 45 individuals in developing master equipment lists, creation of system operating procedures, piping and instrumentation drawings, and operator qualifications guides for Satsop Unit #3, a 1300 MW commercial nuclear power plant under construction in western Washington State. In my last two years, I worked on loan to assist in the startup of San Onofre Nuclear Generating Station in southern California (see above).

Shift Supervisor, Naval Reactors Facility, Westinghouse Electric Corporation,
June 1978 - October 1981
Responsible for the operations, maintenance, training, and administration of forty civilian and U.S. Navy staff and another forty U.S. Navy officer and enlisted trainees on the operations of U.S. Navy reactor plants. Trained and qualified over 350 U.S Navy personnel for the nuclear fleet. Served as Engineering Officer of the Watch for over two years. Served as Shutdown Coordinator during major maintenance overhaul and refueling.

Dave Farnsworth

dfarnsworth@grenergy.com
Office (701) 442-7002, Cell (701) 219-9744

EDUCATION:

LeaderSource Great River Energy Executive Training, Minneapolis MN
Foundational Leadership and Leadership in Action
MARC – Managers Guide to Employee Relations Leadership Training

Eastern Washington University, Cheney WA
Heat Transfer College Course

Westinghouse, Idaho Falls ID
Graduate of Westinghouse Nuclear Power School

Southern Illinois University, Edwardsville IL
Master of Business Administration

North Dakota State, Fargo ND
Civil Engineering (ASCE)

Bismarck State College, Bismarck ND
Engineering

LEADERSHIP IN OTHER ORGANIZATIONS:

Governor's Workforce Development Council (three 3-year terms)

Alumnus of the Year, Bismarck State College

Industry representative for the Institute for Nuclear Power Operations

National Co-chair-Integrated Portfolio Planning and Market Analysis Program for the Electric Power Research Institute

SKILLS AND ABILITIES

Organizational skills
Building relationships/partnerships
Environmental management
Computer usage
Presentation skills
Strategic planning
Media/public relations
Engineering economics analysis
Cost-benefit analysis
Budgeting/budget management
Financial analysis
Risk management
Construction management
Planning

Vince Herda

Principal Engineer, vherda@grenergy.com, office (763) 445-5810, Cell (612) 850-6310

Summary

- Proven Project Manager.
- Successful in planning, developing, and implementing new technology systems.
- Proven track record in leading cross functional teams to on time, under budget success.
- GRE representative to electric utility and civic organizations.
- In-depth knowledge of the electric utility industry, MISO power market, and electric cooperatives.

EXPERIENCE:

Principal Engineer, Great River Energy
November 2016 – current
Provide leadership of complex projects with critical financial and/or technical significance to GRE and/or other utilities in the region. Make technical decisions on behalf of GRE in regional or national forums. A GRE expert in technical disciplines on issues with broad regional and/or national impact.

Senior Project Manager, Great River Energy
August 2006 – November 2016
Project manager for generation division capital projects. Responsibilities include design development, budgeting, cost, schedule and quality control, coordination of procurement, construction management, and start-up testing. Example projects include:

- Elk River Peaking Station. New plant construction. Two hundred MW combustion turbine peaking station. Completed $106 million project $16 million under budget. All performance objectives were met or exceeded.
- Spiritwood Station water treatment plant projects. These projects were critical in enabling plant commercial operation. Projects completed $2.7M under budget, on time, and met all technical requirements.
- Elk River Resource Processing Plant optical classifier project. Completed on time, under budget, met requirements.
- Stanton Station turbine uprate. Evaluate steam turbine improvements and impacts to coal fired boiler and all balance of plant systems.

Project coordinator and technical lead for project development studies. Work scope includes concept designs, capital cost estimates, schedule development, permit plans and financial analysis.

Engineering Manager, Despatch Industries, LLC
2003-2006
Manager, responsible for the design of the company's process heating projects. Responsible for an engineering team of 20 engineers, designers, and administrative personnel. Successfully executed a 100% increase in sales, through efficiency increases, hiring, and managed outsourcing. Decreased annual warranty costs by over $800,000. Directed a new product development effort which resulted in $3.4 million in new business.

Engineering Manager, Deltak, LLC
2000-2003
Manager responsible for the design of the company's gas turbine heat recovery (HRSG) projects. Increased company design capacity by over 100%, enabling revenue growth

Vince Herda

Principal Engineer, vherda@grenergy.com, office (763) 445-5810, Cell (612) 850-6310

from $150 million to $500 million. Effectively managed a department of 90 engineers and designers with an annual budget of $7 million. Strengthened department technical expertise by implementing a department-wide training program.

Project Engineer, Nova District Energy Services, Inc.
1996 – 2000
Responsible for the design development and cost estimating of district energy projects involving cogeneration of electric power, ice-based thermal energy storage, and central heating and cooling systems.

Project Engineer, Pacific Engineering Co.
1994 - 1996
Responsible for project engineering, mechanical design, construction coordination, and commissioning of a $10MM polypropylene compounding expansion project at Lyondell Polymers Bayport, TX facility.

Project Engineer, Bechtel Corporation
1990 - 1994
Responsible for multi-discipline coordination and design of petroleum refining and power projects.

Project Officer, Long Beach Naval Shipyard
1986 - 1990
U.S. Naval Officer. Responsible for planning and implementation of modernization to ship systems.

Engineering Officer, USS Harry W. Hill (DD-986)
1980 - 1984
U.S. Naval Officer. Supervised 30 engineering technicians as Main Propulsion Assistant and Damage Control Assistant. Responsible for O&M of ship propulsion systems.

EDUCATION:

Naval Postgraduate School, Monterey, CA
Master of Science, Mechanical Engineering,

United States Naval Academy, Annapolis, MD
Bachelor of Science, Mechanical Engineering

LEADERSHIP IN OTHER ORGANIZATIONS:

Steering committee member for the Electric Power Research Institute Program 66 Fossil Fleet for tomorrow, Reciprocating Internal Combustion Engines Interest Group

Active member of the Electric Power Research Institute Program 94 Energy Storage

SKILLS AND ABILITIES:

- Project management
- Construction management
- Teambuilding
- Project budgeting and scheduling
- Cost-benefit analysis
- Project commissioning

Bullinger, Charles W.

Eagle Creek Consulting LLC
charliewbullinger@gmail.com
3313 80th St. S.E., Bismarck ND 58504
701-219-9745

Summary

Held several positions at Coal Creek Station, a 1200 MW lignite fired electric generating plant. Retired from Great River Energy in 2018 and founded Eagle Creek Consulting LLC in June the same year. Consulting focuses in the evaluation of all things coal, plant efficiency, emissions reduction, project proposal, and grid resilience/grid stability related issues. Current clients include Great River Energy, the Lignite Energy Council, EERC and Peter Reineck Consulting. Member of the National Coal Council since 2015.

Experience

Great River Energy | Coal Creek Station, Underwood ND

Engineer 1977 – 2018

- Led engineering group for 15 years, beginning in 1977.
- Was responsible for environmental upgrades to Precipitators, FGD Scrubbers, Turbine Generators, and Low NOx installations.
- Organized and led a team of professionals that developed DryFining™, a technology that uses waste heat and segregation to improve the quality of low rank coals.
- Led team responsible for nine coal beneficiation patents.
- Assisted GRE Business Development in the commercialization and licensing of DryFining™ coal beneficiation technology which led him to Australia, China, India, Indonesia, and Eastern Europe; countries with challenged coal.
- Was advisor to EPRI Programs P75 Integrated Environmental Control and P165 Carbon Capture and Sequestration, and was utility chair for EPRI's Fossil Fleet Program, P66, for over 10 years.

JASON D. LAUMB
Assistant Director for Advanced Energy Systems
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, ND 58202-9018 USA
701.777.5114 (phone), 701.777.5181 (fax), jlaumb@undeerc.org

Principal Areas of Expertise

Mr. Laumb's principal areas of interest and expertise include biomass and fossil fuel conversion for energy production, with an emphasis on pollution control and ash effects on system performance. He has experience with trace element emissions and control for fossil fuel combustion systems, with a particular emphasis on air pollution issues related to mercury and fine particulates. He also has experience in the design and fabrication of bench- and pilot-scale combustion and gasification equipment.

Qualifications

M.S., Chemical Engineering, University of North Dakota, 2000.
B.S., Chemistry, University of North Dakota, 1998.

Professional Experience

September 2019–Present: Assistant Director for Advanced Energy Systems, EERC, UND. Mr. Laumb assists the EERC executive team by providing leadership on projects related to advanced energy systems. Mr. Laumb leads a multidisciplinary team of scientists and engineers working on advanced energy technologies from pollution control to new energy platforms. Specific areas of interest include CO_2 capture, techno-economic modeling, environmental control systems, supercritical CO_2 power cycles, and advanced gasification technologies. Current research activities are focused on low-carbon-intensity power cycles for fossil fuel fired systems.

2008–August 2019: Principal Engineer, Advanced Energy Systems Group Lead, EERC, UND. Mr. Laumb led a multidisciplinary team of 30 scientists and engineers to develop and conduct projects and programs on power plant performance, environmental control systems, the fate of pollutants, computer modeling, and health issues for clients worldwide. Efforts focused on development of multiclient jointly sponsored centers or consortia funded by government and industry sources. Research activities included computer modeling of combustion/gasification and environmental control systems, performance of SCR technologies for NO_x control, mercury control technologies, hydrogen production from coal, CO_2 capture technologies, particulate matter analysis and source apportionment, the fate of mercury in the environment, toxicology of particulate matter, and in vivo studies of mercury–selenium interactions.

2001–2008: Research Manager, EERC, UND. Mr. Laumb led projects involving bench-scale combustion testing of various fuels and wastes as well as a laboratory that performs bench-scale combustion and gasification testing. He served as principal investigator and managed projects related to the inorganic composition of coal, coal ash formation, deposition of ash in

conventional and advanced power systems, and mechanisms of trace metal transformations during coal or waste conversion and wrote proposals and reports focused on energy and environmental research.

2000–2001: Research Engineer, EERC, UND. Mr. Laumb assisted in the design of pilot-scale combustion equipment and wrote computer programs to aid in the reduction of data, combustion calculations, and prediction of boiler performance. He was also involved in the analysis of combustion control technologies' ability to remove mercury and the suitability of biomass as boiler fuel.

1998–2000: SEM Applications Specialist, Microbeam Technologies, Inc., Grand Forks, North Dakota. Mr. Laumb gained experience in power system performance including conventional combustion and gasification systems; knowledge of environmental control systems and energy conversion technologies; interpreting data to predict ash behavior and fuel performance; assisting in proposal writing to clients and government agencies such as the National Science Foundation and the U.S. Department of Energy; preparing and analyzing coal, coal ash, corrosion products, and soil samples using SEM/EDS; and modifying and writing FORTRAN, C+, and Excel computer programs.

Professional Membership
American Chemical Society

Publications and Presentations
Has coauthored numerous professional publications.

JOHN P. KAY
Principal Engineer, Emissions and Carbon Capture Group Lead
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
701.777.4580 (phone), 701.777.5181 (fax), jkay@undeerc.org

Principal Areas of Expertise

Mr. Kay's principal areas of interest and expertise include applications of solvents for removing CO_2 from gas streams to advance technology and look toward transformational concepts and techno-economic assessments. He has 6 years of experience in field testing site management and sampling techniques for hazardous air pollutants and mercury control in combustion systems along with10 years of experience utilizing scanning electron microscopy (SEM), x-ray diffraction (XRD), and x-ray fluorescence (XRF) techniques to analyze coal, fly ash, biomass, ceramics, and high-temperature specialty alloys. He is also interested in computer modeling systems, and high-temperature testing systems.

Qualifications

B.S., Geological Engineering, University of North Dakota, 1994.
Associate Degree, Engineering Studies, Minot State University, 1989.

Professional Experience

2011–Present: Principal Engineer, Emissions and Carbon Capture Group Lead, EERC, UND. Mr. Kay's responsibilities include management of CO_2 separation research related to bench-, pilot-, and demonstration-scale equipment for the advancement of the technology. This also includes the development of cleanup systems to remove SO_x, NO_x, particulate, and trace elements to render flue gas clean enough for separation.

2005–2011: Research Manager, EERC, UND. Mr. Kay's responsibilities included the management and supervision of research involving the design and operation of bench-, pilot-, and demonstration-scale equipment for development of clean coal technologies. The work also involved the testing and development of fuel conversion (combustion and gasification) and gas cleanup systems for the removal of sulfur, nitrogen, particulate, and trace elements.

1994–2005: Research Specialist, EERC, UND. Mr. Kay's responsibilities included conducting SEM, XRD, and XRF analysis and maintenance; creating innovative techniques for the analysis and interpretation of coal, fly ash, biomass, ceramics, alloys, high-temperature specialty alloys, and biological tissue; managing the day-to-day operations of the Natural Materials Analytical Research Laboratory; supervising student workers; developing and performing infrared analysis methods in high-temperature environments; and performing field work related to mercury control in combustion systems.

1993–1994: Research Technician, Agvise Laboratories, Northwood, North Dakota. Mr. Kay's responsibilities included receiving and processing frozen soil samples for laboratory testing of chemical penetration, maintaining equipment and inventory, and training others in processing techniques utilizing proper laboratory procedures.

1991–1993: Teaching Assistant, Department of Geology and Geological Engineering, UND. Mr. Kay taught Introduction to Geology Recitation, Introduction to Geology Laboratory, and Structural Geology. Responsibilities included preparation and grading of assignments and administering and grading class examinations.

1990–1992: Research Assistant, Natural Materials Analytical Laboratory, EERC, UND. Mr. Kay's responsibilities included operating an x-ray diffractometer and interpreting and manipulating XRD data, performing software manipulation for analysis of XRD data, performing maintenance and repair of the XRD machine and sample carbon coating machine, preparing samples for XRD and SEM analysis, and performing point count analysis on the SEM.

Professional Memberships
ASM International
American Ceramic Society
Microscopy Society of America

Publications and Presentations
Has authored or coauthored numerous publications.

Dr. Desmond Dillon | Senior Technical Leader
Electric Power Research Institute | Advanced Generation
Phone: (650) 855-2036 | E-mail: ddillon@epri.com

EDUCATION AND TRAINING
Ph.D., Mechanical Engineering, University of Strathclyde, 2002
B.Eng., Product Design Engineering, The University of Glasgow & Glasgow School of Art, 1994

RESEARCH AND PROFESSIONAL EXPERIENCE:
Electric Power Research Institute
Project Manager | Senior Project Manager | Senior Technical Leader | 2006 - Present

- Provide technical expertise in the field of clean coal combustion and CO_2 capture technologies applicable to large scale power generation plant such as pre, post and oxyfuel combustion capture processes.
- Provide project management within the EPRI's Fossil Fleet programs and related projects within the Advanced Combustion area of the Generation Sector, ensuring that projects meet technical and financial goals and high-quality R&D results are delivered on schedule and to budget.
- Work with member organizations to identify current and emerging technical issues related to advanced combustion power plant concepts, regularly conceiving and proposing innovative solutions and methods to address the many technical problems in development.
- Managing complex technical projects involving numerous collaborative partner companies.
- Work closely with EPRI member organizations alongside many prestigious European and worldwide manufacturers and research institutions in order to identify current and emerging technical issues related to the evaluation of CO_2 capture process concepts.
- Responsible for developing the key processes identified above through pilot and demonstration plant stages such that they rapidly evolve into the next generation of clean fossil fired utilities.
- Communicate strategies and results, written and verbal with program membership and potential EPRI members via published peer reviewed papers, international workshops and presentations at global forums and conferences

Mitsui Babcock Energy Ltd
Senior Project Engineer | 2000 – 2005

- Focused on development and evaluation of CO_2 abatement and capture technologies for the next generation of power plant.
- Main technical responsibilities centered on thermal and process design investigations of utility boilers, HRSG's and process plants as well as concept / feasibility studies of next generation technology.
- Mitsui Babcock's Principle Investigator and Work Package leader for European Union collaborative funded research, development and demonstration projects ENCAP and CASTOR. Thus, responsible for a number of work packages to the approximate value of 2 million euros and coordinating numerous partnered companies based both in the UK and mainland Europe.
- In addition, undertook commercial process design work for the UK nuclear sector.

National Engineering Laboratory (NEL)
PhD Researcher | 1997 – 2000

- Industrial sponsored research which involved studying combustion and NO_x predictions of anthracite fired burners using the FLUENT CFD code and validating results with test data from the Mitsui Babcock NO_x Reduction Test Facility.
- The academic content of the research was assessed by the University of Strathclyde with the final external examination of the thesis undertaken by the University of Leeds.

Rolls Royce Aero Engines
Development Engineer | 1996 - 1997

- Responsibilities centered on ensuring the V2500 engine's HP compressor met stringent criteria
  specified by both airworthiness authorities and customers.
- Supervised and implemented evaluations and test programs to identify deficiencies in component performance and design.
- Performed and managed technical investigations alongside complete engine testing and project management of test engine builds.

PUBLICATIONS:

1. An Engineering and Economic Assessment of Post-Combustion CO2 Capture for 1100°F Ultra D J Dillon 'Novel Advanced Ultra Supercritical (A-USC) Design Evaluations'. EPRI Report 3002006389, Palo Alto, CA: Dec 2016.
2. D J Dillon 'Flexible Operation of Current and Next Generation Fossil Pants with and Without CO_2 Capture' EPRI Report 3002003741 Dec 2014
3. D J Dillon, Post Combustion Capture on Natural Gas Combined Cycle Plants: A Technical and Economical Evaluation of Retrofit, New Build and the Application of Exhaust Gas Recycle IEA GHGT11 Proceedings July 2013.
4. D J Dillon, 'A summary of EPRI's Engineering and Economic Studies of Post Combustion Capture Retrofit Applied at Various North American Host Sites, IEA GHGT11 proceedings, July 2013.
5. Contributor '21st Century Coal: Advanced Technology and Global Energy Solution' International
   Energy Agency Coal Industry Advisory Board publication, September 2013
6. D J Dillon, 'Chilled Ammonia Process development: An Economic Assessment', Proceedings of the 12th Annual conference on Carbon Capture Utilization and Storage, May 14th, 2013.
7. D J Dillon, 'Experience of Supercritical Technology in the U.S' Designing a Cleaner Future for Coal Conference, Vietnam 15-19 Oct 2007. Conference was sponsored by US Aid and Asia Development Bank.
8. D J Dillon, R S Panesar, R A Wall, R J Allam, V White, J Gibbins and M J Haines *'Oxy-Combustion Processes for CO_2 Capture from Advanced Supercritical PF and NGCC Power Plant'* GHGT-7 Paper, Vancouver Canada Sept 2004.
9. D J Dillon. *'A study of Combustion Modelling and NO_x Prediction for Anthracite Flames'*. University of Strathclyde PhD Thesis, October 2002. Industrial sponsors: National Engineering Laboratory, East Kilbride and Mitsui Babcock, Glasgow.

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

William R. Elliott / Operations Manager
Bechtel Power

EDUCATION
Masters of Engineering, University of Minnesota
BS, Civil Engineering, Iowa State University

TECHNICAL QUALIFICATIONS AND SUMMARY OF EXPERIENCE
Registered Professional Civil Engineer, California, Minnesota, and New York
Diplomat of the American Academy of Environmental Scientists and Engineers
Fellow, Institute of Civil Engineers

Bill Elliot has been associated with a variety of domestic and international projects, largely with Bechtel, over his exceptional career of over 30 years. He has managed the design and construction of fossil-fired power plants, waste-to-energy projects, and civil projects. Along with technical and managerial expertise, he possesses substantial financial acumen, having developed investment models, led the execution of a $2 billion capital improvements program for United Utilities in the UK, and participated in the successful marketing and sale of Bechtel power generation assets. Currently, he is operations manager, overseeing Bechtel fossil projects worldwide.

RELEVANT WORK HISTORY
Operations Manager 2012–Present:
Currently, Mr. Elliott oversees the management and execution and customer interfaces of Bechtel fossil power projects worldwide, with a focus on business development and the early stages of new project execution. He provided oversight on several carbon capture study efforts for EPRI which were conducted in conjunction with Nexant, including analysis of utility tests and review of the utilities' approaches to carbon capture-ready design alternatives.

Study Manager–Alternative Energy Sources 2011:
Mr. Elliott was assigned to the Jubail Industrial City project in Saudi Arabia, the largest civil engineering project in the world. In the Jubail industrial park, 16 primary industries operate around the clock,
creating more than 30 different products. His duties were related to developing a new investment model for renewable energy for the Royal Commission of Jubail that encompassed waste-to-energy, carbon credits, and integration with and development of Ras Al Khair (formerly Ras Az Zawr) Minerals Industrial City in Saudi Arabia.

Deputy Program Manager 2009–2011:
For the Tube Lines rail project for the upgrade and maintenance of the infrastructure for London Underground's Jubilee, Northern, and Piccadilly lines, Mr. Elliott was responsible for train controls upgrades, subcontract system improvement, software program scheduling and control, and the tunnel installation safety program.

Manager of Projects
2006–2009: Mr. Elliott was the project manager on the KFx coal refinery project in Wyoming. This project uses a product known as K-Fuel to subject low-rank coals to high pressures and temperatures in a steam heated vessel to increase the heating value and lower the mercury content. Included were investigations of upgrading Indonesian coal for supply to Asian electric power utilities.

Project Director 2005–2006:
As project director, Mr. Elliott worked on front-end engineering design (FEED) studies on CO_2

capture for both the Mongstad and Kårstø projects in Norway. He also oversaw the preliminary design of a carbon capture facility for a 500 MW CCGT at Karstø. The Kårstø facility is designed to capture 85 percent of the CO_2 emissions (over 1 million tonnes per year) of an adjacent 420 MW gas-fired power plant in southwest Norway. Once completed, Kårstø will be the largest CO_2 separation facility ever constructed that treats gas turbine exhaust gas. The Mongstad Test Centre is designed to remove CO_2 from the flue gas of a combined heat and power plant and a residual catalytic cracker. Mr. Elliott was also the project manager on the 700 MW El Tebbin oil-/gas-fired steam power plant project on the Nile River in Cairo, Egypt.

Vice President & Managing Director – Bechtel Enterprises 1998–2005:
Mr. Elliot managed Bechtel's ownership interests in electric and water utilities and facilities. He served on the Board of Directors for Bechtel in several joint ventures that owned and operated those entities. He also served as President of Guayaquil Ecuador water utility prior to the sale of Bechtel's ownership interest in the utility.

Manager of USGen Assets–Electrical Generation 1997–1998:
Mr. Elliott oversaw Bechtel's investments in all power projects. He was also a member of the BEn team that successfully marketed and sold the BEn power generation assets previously owned jointly with USGen.

Director of Projects 1995–1997:
Mr. Elliott was responsible for the water projects executed by the Warrington, England, office of United Utilities and for coordination with regional market sectors. His responsibilities included executing a $2 billion capital improvements program.

Manager, Hydro and Water Projects 1990–1995: Mr. Elliott was responsible for both domestic and international water-related projects. For Venezuela's Ministerio del Ambiente y de los Recursos Naturales Renovables, he directed the engineering of hydraulic structures, water supply, drainage, and solid waste projects in the Occidental Coastal Region of Venezuela, as well as the upgrade of the Trujillo water system. Domestically, he directed the construction of the Hingham water plant for American Water Works Company in Massachusetts and was responsible for improvements at Washington, DC's, Blue Plains treatment plant. Mr. Elliott oversaw development of an upgrade that involved installing eight 2.6-million-gallon anaerobic sludge digesters for methane generation and use in New York.

Manager of Business Development/Project Manager, Renewable Energy 1988–1990:
Mr. Elliott managed the business development activities of Bechtel's waste-to-energy projects as well as the Adana-Yumurtalik port project in southeastern Turkey.

Business Development Manager 1983–1987:
Mr. Elliott managed Bechtel Power Corporation's business development for the Middle East and North Africa. He directed the financial development of the 300 MW Shoubrah El-Kheima Unit 4 power plant project in Egypt, managed the Turkey Coastal coal project development efforts, and developed a power plant build-own-transfer acquisition model for the Turkish government. Mr. Elliott was responsible for sales for the Renewables and Waste-to-Energy business line and for marketing, planning, and administering development efforts.

Project Engineer/Project Manager 1980–1983:
Mr. Elliott was in charge of project engineering and directed Environmental Water Projects Department operations and business development on the US East Coast. He managed consulting engineering services for the Connecticut Resource Recovery Authority's (CRRA's) Mid-Connecticut

power project and the Housatonic Valley power project, as well as the Cuyahoga County and City of Cleveland's alternative energy program. Co-disposal of sewage sludge and municipal waste were investigated on several CRRA projects. He managed an analysis of the Hempstead energy recovery facility for the project financiers and an analysis of alternative water supply sources in the Boston area for the Metropolitan District Commission. Other assignments involved coordinating engineering for the Brunei Palace infrastructure design, managing a Dominican Republic water pipeline and treatment facility proposal, and developing a joint protocol with Philadelphia Suburban Corporation for offshore water projects.

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Robert Chu / Process Engineering Manager
Nexant

EDUCATION
B.S., Chemical Engineering, University of California, Berkeley

SUMMARY OF QUALIFICATIONS AN EXPERIENCE
Mr. Chu was Nexant's Principal Investigator on the recent EPRI funded studies, looking into design requirements and the techno-economics of retrofitting existing coal-fired power plants for post combustion carbon capture. Prior joining Nexant, Mr. Chu was the Process Engineering Manager at Bechtel Corporation's San Francisco Offices. He has over thirty years of experience in process design and techno-economic analysis of gasification to fuels and chemicals production, gas processing, and petroleum refining. Mr. Chu has conducted many feasibility studies and detailed process designs related
to gasification systems. He served as the Chief Process Engineer for a $12 million DOE funded engineering study on gasification co-Production of power and Fischer-Tropsch fuels. Mr. Chu was on the Bechtel engineering team that performed the Cherokee Clean Fuels Project Feasibility Study of coal-to-SNG (synthetic natural gas) based on Lurgi gasification, CO shift, selective Rectisol H_2S and CO_2 removal, and methanation technologies. He was also on the design team that performed a detailed feasibility design for a gasification-based trigeneration of fuels, power and chemicals (including mixed alcohols) production project in China.

RELEVANT WORK HISTORY
Principal, Nexant Inc. [2000 – Present]
Mr. Chu is responsible for implementation of projects involving coal gasification, CO_2 capture, refinery
and chemical processing technologies. Currently, Mr. Chu is the technical lead/advisor of several key projects within Nexant's Energy Technology Group. Example projects include:

- Preliminary techno-economic analysis in support of the Ohio State University to develop a chemical looping based biomass gasification to methanol process.
- Conceptual engineering and feasibility assessment of a solar assisted post-combustion CO2 capture design for PC power plants, in support of Electric Power Research Institute.
- Engineering techno-economic analysis supports to the Arizona State University to develop a zeolite membrane WGS reactor based technology for IGCC CO2 removal.
- US DOE-commissioned techno-economic analysis of Aerojet Rocketdyne's (AR) advanced compact gasification system coupled with warm syngas cleanup offered by Research Triangle Institute (RTI) for IGCC and coal-to-methanol applications
- On behalf of DOE, led the techno-economic evaluation of Gas Technology Institute's (GTI) molten bed gasification for power production and coal-to-Fischer-Tropsch liquids applications
- Techno-economic evaluation comparing AR's dry solids pump (DSP) feed system to conventional lockhopper-based feed system when integrated in a Shell's gasifier-based IGCC power plant
- Led a DOE-commissioned techno-economic evaluation of GTI's oxygen-fired molten bed boiler for power production with CO_2 compression and purification for saline aquifer storage
- Saudi Aramco funded feasibility study of a combined hydrogen and electricity production facility with CO_2 capture based on petroleum feedstocks,

Process Engineering Manager/Nexant

- Working with EPRI (Electric Power Research Institute) to develop post-combustion CO_2 capture technologies and to assess the design requirements and techno-economics of retrofitting existing PC power plants for CO_2 capture,
- Techno-economic analysis, on behalf of EPRI, of chilled ammonia-based post combustion CO_2 capture of a 750 MWe ultrasupercritical pulverized coal power plant
- Conceptual design and feasibility evaluation of a 400 MW coal-based solid oxide fuel cell (SOFC) power plant
- Conceptual design of a 10,000 BPSD Korean and a 20,000 BPSD US coal gasification and Fischer-Tropsch liquid co-production plant,
- Engineering feasibility study of a 5,000 BPSD gasification based power and Fischer-Tropsch fuels co-production plant
- Technology support to develop a proprietary warm gas desulfurization process with integration
  into the GE/Bechtel reference IGCC (integrated gasification combined cycle) power plant,
- IGCC/Hydrogen co-production design utilizing ceramic membrane hydrogen separation technology vs. conventional PSA technology
- Plant design optimization to reduce the costs and energy consumption associated with using amine to separate and capture CO_2 in flue gases from natural gas combined cycle power and supercritical coal fired power plants.

Process Manager, Bechtel Technology and Consulting Group, San Francisco.[1995 – 1999]
Mr. Chu's responsibilities included process design and development of Bechtel's Molten Carbonate Fuel-
Cell Technology, feasibility study for di-methylether (DME) production from syngas, and feasibility study for iso-butanol manufacture from syngas.

Manager of Process Engineering, Bechtel Corporation, San Francisco. [1994 – 1995]

LIST OF RECENT PUBLICATIONS

1. "Chilled Ammonia Process (CAP) Development: An Economic Assessment" Desmond Dillon, Dick Rhudy, George Offen and Andy Maxson (EPRI), Robert Chu and Haoren Lu (Nexant), David Muraskin, Fred Kozak and Aytac Sezgi (Alstom Power), Carbon Capture Utilization and Storage Conference, May 13-16, 2013 Pittsburgh, PA

2. "Redesign, Optimization, and Economic Evaluation of a Natural Gas Combined Cycle with the Best Integrated Technology CO_2 Capture" Cristina Botero, Matthias Finkenrath, Michael Barlett, (GE Global Research) Robert Chu, and Gerald N. Choi (Nexant) Daniel Chinn (Chevron), 9th International Conference on Greenhouse Gas Control Technologies, November 11-20, 2008 Washington DC

3. "Cost Efficient Amine Plant Design for Post Combustion CO_2 Capture From Power Plant Flue Gas" Gerald N. Choi, Robert Chu and Bruce Degen (Nexant) Harvey Wen and Peter Richen (Bechtel) and Daniel Chinn (ChevronTexaco), 7th International Conference on Greenhouse Gas Control Technologies, September 5-9, 2004 Vancouver, Canada 2004.

APPENDIX F

LETTERS OF SUPPORT

Ms. Karlene Fine
Executive Director
North Dakota Industrial Commission
Attn. Lignite Research Development and Marketing Program
State Capitol
600 East Boulevard Ave. Dept 405
Bismarck North Dakota 58505-0840

Ms. Karlene Fine:

McLean County encourages your support of Great River Energy's Lignite Research Council grant application for a Pre-Feed (Pre-Front End Engineering and Design) study of a full-scale carbon dioxide capture system at North Dakota's largest power plant, Coal Creek Station.

North Dakota is a national leader in "all of the above" energy production, and this project is another step in the direction of North Dakota's leadership on the national scene. We need continued leadership in this area to allow responsible use of our vast coal resources.

Coal Creek Station has had a huge economic impact on McLean County by providing excellent employment opportunities for our citizens and tremendous support for our communities. Coal Creek Station has been a "good neighbor" and a great partner for McLean County.

Great River Energy has a track record of implementing innovative and successful changes at Coal Creek Station to reduce carbon emissions, including numerous efficiency improvements such as Dryfining, the lignite fuel enhancement system.

This project is one more step in the right direction to assure Coal Creek Station continues to provide clean, reliable, and affordable electricity for the future.

Steve J. Lee
Chairman, McLean County Commission

NRECA
America's Electric Cooperatives

September 20, 2019

Ms. Karlene Fine
Executive Director
North Dakota Industrial Commission
Attn: Lignite Research, Development and Marketing Program
State Capitol
600 East Boulevard Ave. Dept. 405
Bismarck, ND 58505-0840

Dear Ms. Karlene Fine:

NRECA is the national trade association representing more than 900 local electric cooperatives. From growing suburbs to remote farming communities, electric co-ops serve as engines of economic development for 42 million Americans across 56 percent of the nation's landscape. The Coal Creek Station is an essential and economic baseload facility that delivers reliable and affordable energy to the regions 28 member cooperatives in Minnesota who serve over 1.7 M consumers.

Great River Energy is evaluating a potential carbon capture project at the Coal Creek Station, an 1,154-megawatt plant near Underwood, N.D. Great River Energy has a history of embracing change at Coal Creek Station to reduce carbon intensities. That includes several efficiency improvements, including the addition of the DryFining™ lignite fuel enhancement system in 2009. We believe this potential project is another step forward in this process.

We support Great River Energy's Lignite Research Council grant application for a pre-FEED (Pre-Front End Engineering and Design) study for a full-scale carbon dioxide capture system at Coal Creek Station, North Dakota's largest power plant.

Evaluation and assessment of emission reduction technologies, especially developing long-term strategies to mitigate CO_2 emissions is an integral part of our technology support mission to our members. Coal-fired generation remains significant for the co-ops while they move to diversify their electric generation portfolio through natural gas and renewables.

NRECA's participation in the Initiative will help us understanding the potential and limitations of the CCUS technologies and disseminate the information to our members.

NRECA gives this project its highest support and looks forward to reviewing the results of this effort. If you have any questions, please feel free to contact me at 703.907.6846 or Daniel.walsh@nreca.coop.

Sincerely,

Daniel Walsh

Senior Power Supply and Generation Director
Business and Technology Strategies, NRECA

cc: Rachel Retterath - Manager, Business Development & Governmental Affairs
David E. Farnsworth -ND Manager of Power Generation and Engineering

NORTH AMERICAN COAL CORPORATION

September 27, 2019

Ms. Karlene Fine
Executive Director
North Dakota Industrial Commission
Attn: Lignite Research, Development and Marketing Program
State Capitol
600 East Boulevard Ave. Dept. 405
Bismarck, ND 58505-0840

Dear Ms. Fine:

The North American Coal Corporation (NACoal) is pleased to support and encourages your support of Great River Energy's Lignite Research Council grant application for a pre-FEED (Pre-Front End Engineering and Design) study for a full-scale carbon dioxide capture a system at Coal Creek Station, North Dakota's largest power plant.

Great River Energy has a track record of implementing innovative and successful changes at Coal Creek Station to reduce carbon dioxide emissions which include several efficiency changes including DryFining, the lignite fuel enhancement system. This project is one more step in the right direction to assure Coal Creek Station continues to provide reliable and affordable electricity for the future.

The North American Coal Corporation has benefited greatly from knowledge gained and collaborative opportunities available through research programs with multiple partners. We also have a vested interest in helping our partners enhance, preserve, and protect existing coal resources for decades to come; and we believe this will lead to more opportunities for those that share that same interest.

We look forward to seeing the results of this exciting opportunity and will continue working to benefit the many people who rely on the lignite industry.

Sincerely,

The North American Coal Corporation

David Straley
Director, Government and Public Affairs

NORTH DAKOTA SENATE

STATE CAPITOL
600 EAST BOULEVARD
BISMARCK, ND 58505-0360

Senator Rich Wardner
District 37
1042 12th Avenue West
Dickinson, ND 58601-3654
rwardner@nd.gov

Majority Leader

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

I strongly support Great River Energy's Lignite Research Council grant application for a pre-FEED (Pre-Front End Engineering and Design) study for a full-scale carbon dioxide capture a system at Coal Creek Station, North Dakota's largest power plant.

North Dakota is a national leader in "all-of-the-above" energy production. The energy industry is one of our state's largest sectors of the economy. As we plan and prepare to produce energy for our nation's future, we need to support projects like Coal Creek Station's carbon dioxide capture study. It's the right thing to do to make sure we are still producing power for a carbon-managed future.

Not only is Coal Creek Station an essential and economic baseload facility that has been delivering reliable and affordable energy to the region for over forty years, the plant, mine and adjacent ethanol plant provide over 800 direct jobs and thousands of indirect jobs that are the backbone to many communities throughout North Dakota. North Dakota has over 800 years of lignite coal reserves, we need to responsibly use this resource to producing reliable and affordable energy.

Great River Energy has a track record of implementing innovative and successful changes at Coal Creek Station to reduce carbon dioxide emissions which include several efficiency changes including DryFining, the lignite fuel enhancement system. This project is one more step in the right direction.

Please contact me with any questions,

Sincerely,

Rich Wardner

Rich Wardner
Senate Majority Leader

APPENDIX G

AFFIDAVIT OF NO TAX LIABILITY

STATE OF MINNESOTA)
) ss. **AFFIDAVIT REGARDING APPLICANT**
COUNTY OF HENNEPIN)

I, Steve Leyh, under oath or affirmation make the following statements:

1. Steve Leyh is the Controller of Great River Energy, a Minnesota cooperative corporation, the corporation named as applicant in the "Lignite Research Grant Application – Preliminary Front End Engineering and Design (pre-FEED) Study for a Full-scale Carbon Dioxide Capture System at Coal Creek Station."

2. Said applicant's principal place of business is at 12300 Elm Creek Blvd, Maple Grove, Minnesota.

3. Applicant has no outstanding tax liability owed to the state of North Dakota or any of its political subdivisions.

Affiant knows the matters herein stated are true and makes this affidavit for the purpose of meeting the application requirements set forth in North Dakota Administrative Code chapter 43-03-04, section 1.15.

Steve Leyh

Subscribed and sworn to before me

by Steve Leyh,

this 24th day of September, 2019.

Jackelyn K. VanNorman
Notary Public

JACKELYN K. VANNORMAN
Notary Public-Minnesota
My Commission Expires Jan 31, 2020

This instrument was drafted by:

GREAT RIVER ENERGY
12300 Elm Creek Blvd
Maple Grove, MN 55369-4718

APPENDIX H

REFERENCES

AACE International Recommended Practice 18-R-97, Cost Estimate Classification System – As Applied in Engineering, Procurement, and Construction for the Process Industries. March 6, 2019.

An Engineering and Economic Assessment of Post Combustion CO_2 Capture Applied to Great River Energy's Coal-Fired Coal Creek Station: Post-Combustion CO_2 Capture Retrofit Study-Report 4. EPRI, Palo Alto CA: 2012. 1019397.