LRC-V-24

minnesota power / 30 west superior street / duluth, minnesota 55802 / telephone 218-722-2641

March 30, 1990

Mr. Tim Kingstad
State Land Commissioner
State Capitol
Bismarck, North Dakota
58505

Dear Mr. Kingstad:

RE: Lignite Research Council Grant Application

Minnesota Power and BNI Coal, Ltd. are pleased to submit the attached application for an LRC grant. Please find attached five copies of the LRC grant application. If there are any questions or comments, feel free to contact me at tel: 218-722-2641.

Sincerely,

George R. Nehls Jr.

George R. Nehls Jr.

GRN:wjl

Attachment

CC: J. G. Miller
Coal Beneficiation

Hot Water Drying of North Dakota Lignite

Grant Application to the
North Dakota Lignite Research Council

for the amount of $15,000

submitted by,

BNI Coal, Ltd.
&
Minnesota Power

date of submission,
April 1, 1990

Principle Investigator,
George R. Nehls Jr.
tel: 218-722-2641

Project Summary

BNI Coal, Ltd. and Minnesota Power are developing the thermochemical process known as "hot-water-drying" to up-grade, or beneficiate, North Dakota lignite. The expected result of this project is the creation of a new industry which will market beneficiated North Dakota lignite for use in utility boilers both within and outside of North Dakota. Application for DOE Clean Coal Technology co-funding was made under the project title: *ELFUEL Demonstration of Low-Rank Coals.* The DOE did not select the project during Round III, however, the DOE recommended resubmitting for Round IV after certain deficiencies had been corrected. If these deficiencies can be corrected to BNI Coal Ltd., and Minnesota Power's satisfaction, the project will be resubmitted to CCT Round IV.

In preparation for resubmitting, BNI Coal, Ltd. and Minnesota Power are undertaking activities which will address the deficiencies of the earlier CCT application. Most of these activities are occurring in conjunction with the LRC grant funding cycle from October 1989 - March 1990. Additional works which should now be investigated are the continuing waste water treatment research and an initial, or preliminary, investigation of the potential applicability of Coal Water Fuel to the CCT Program. A total grant of **$15,000** is being requested. The estimated gross cost of the activities is **$40,000**.

The waste water treatment research can begin in July 1990, following completion of the waste water treatment work associated with LRC funding cycle October 1989 - March 1990. The Coal Water Fuel study can begin immediately.

Minnesota Power will provide the matching funds for this LRC funding cycle. The subcontractor will be the North Dakota Energy & Environmental Research Center.

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Objectives

The objectives of BNI Coal, Ltd. and Minnesota Power's lignite beneficiation project can be summarized as follows:

- The ultimate objective of the project is to economically up-grade, or beneficiate, North Dakota lignite to an export quality boiler fuel. An additional application may be found in blending the beneficiated lignite with raw lignite for use in sodium-limited boilers. This will require the construction and operation of at least one commercial-scale lignite processing plant following successful development of the beneficiation process under consideration.

- The intermediate objective of the project is the design, construction, and successful operation of a demonstration-scale lignite beneficiation plant. Co-funding was applied for through the DOE's Clean Coal Technology Program (Phase III). Although the project was not selected in Round III, the DOE encouraged its resubmittal following correction of several deficiencies. The purpose of the demonstration plant would be to provide a means to complete process development at a scale large enough to permit full-scale uses of the beneficiated lignite, to include boiler testing. The beneficiated lignite would be tested in applications by interested parties up to and including large utility boilers.

- The present objective at this time is to execute project research tasks which will provide continuing refinements of the market awareness, and possible new products, and the continued refinement of the waste water treatment system.

Utilization of lignite is currently limited due to its high moisture content. It also has other undesirable qualities, such as high sodium content, and tendencies to decrepitate, dustiness, and spontaneously ignite following exposure after mining. The hot-water-drying-based process under development appears to simultaneously reduce all of the above undesirable features. The end product is expected to be a high grade boiler fuel, and perhaps other fuel products, with stabilized physical characteristics. In order for the process to succeed at the commercial level, continued process refinement must be undertaken. The assistance of LRC funding will help provide the basis for expanded lignite marketability, to include the establishment of a new lignite export industry.

Details of the program activities are given in the section entitled: **Methods**.

Background

Minnesota Power has been investigating coal beneficiation processes for a number of years. The most recent efforts have been directed at up-grading raw lignite into a product suitable for utilization in utility sized boilers that were originally designed for burning a higher rank coal. Minnesota Power has been investigating the process known as "hot-water-drying" of low rank coals since early 1986. BNI Coal, Ltd. has provided valuable information regarding lignite characteristics and resource availability. Bechtel National, Inc. an Architect & Engineering firm, has considerable experience in coal beneficiating processes. Bechtel National Inc., assisted in the design and preparation of the CCT III application. Bechtel National Inc., is also prepared to assist in the Round IV application, if needed.

Hot-water-drying is a thermochemical means of improving, or beneficiating, low-rank coals such as lignite. The process has the potential to economically transform raw lignite into an exportable fuel product. The product may be marketable as a replacement fuel for utility boilers currently firing higher sulfur content coals. It may also find use in other areas, such as a diesel fuel replacement for large, fixed engines.

The primary benefit derived from hot-water-drying a low-rank coal is improved heating value, which results from reducing the moisture and oxygen contents of the coal. For example, raw lignite characteristically has a heating value of 7000 Btu/lb, a moisture content of 35%, and an oxygen content of 12%. After hot-water-drying, the product lignite may be expected to have a heating value of 10,500 Btu/lb, a moisture content of 12%, and an oxygen content of 7% (assuming it is prepared in a large-lump format). The improvement in heating value results because water and oxygen content both contribute nothing to the heating value of the lignite: hence they are termed weighty impurities. Reducing the weighty impurities increases the heating value of the fuel, which improves the economics of transportation. In addition, reducing the moisture content of the fuel also helps improve combustion efficiency. During combustion, water present in the fuel must be evaporated, which requires a significant amount of energy. The energy required for evaporation then is no longer available for use in performing work, and is usually lost as steam with the rest of the combustion gases.

Another significant benefit derived from hot-water-drying lignite is that the process has the potential to significantly reduce the lignite's sodium content. Sodium can have seriously detrimental effects on the ability to cleanly burn lignite in a combustion process. Many operators of lignite-fueled boilers have become familiar with boiler fouling and forced outages due to high sodium content in the lignite. The fouling effect on boilers designed for higher rank coals can be even more serious. Hot-water-drying is almost unique among commercially attractive coal processes in its ability

to reduce sodium content by as much as 85%, although 50% should be considered more the norm.

Other benefits resulting from the hot-water-drying process are improved fuel stability, resulting in reduced spontaneous combustion tendencies, and reduced tendency of the lignite to break down into dusty fine particles.

The hot-water-drying process makes use of a fundamental process which runs counter to intuition. A low rank coal, such as lignite, is immersed in water, pressurized, and heated for a short period of time. The temperatures used are usually in the range from 260° C to 320° C. The pressure must be maintained high enough to prohibit the water surrounding the coal from boiling: hence the term hot-water drying. Under these process conditions water is forced out of the coal particle, rather than into the coal particle. Keeping all water in the liquid phase during the process has another desirable side effect: since evaporating water (energy requirement about 1000 Btu/lb) is avoided, the process is inherently energy efficient. The fact that evaporation is avoided is particularly important when higher moisture content coals are the feedstock. For example, reducing the moisture content of a ton of lignite from 35% to 10% requires the removal of over 550 lbs. of water. The energy required to evaporate this is substantial. As a result, hot-water-drying requires generally one-third to one-fourth of the energy of a conventional coal-drying process. In addition, liquid water is produced as a process byproduct, which may have value in arid regions.

Pilot plant testing has been completed and results indicate that the fuel product appears to be satisfactory for use in many industrial boilers. Several key questions remain, however. The marketability of the product, and details of the process design need additional refinement. Performing these studies at this time are timely regarding the overall schedule of the project.

Much of the fundamental development of hot-water-drying processes has taken place at the North Dakota Energy & Mineral Research Center in Grand Forks, ND.

Goals

- The general goal of the proposed work is to continue to improve the chances of success of the project as it proceeds toward the demonstration of the technology.

- The specific goals of the proposed work are to:

  1) Continue to develop the waste water treatment methods to be used in the demonstration and commercial scale projects. Satisfactory progress will have been made when a working model of the waste water treatment process is developed, along with suggested areas for further improvement and development.

  2) Perform an initial scoping study, or preliminary investigation, into the potential of Coal Water Fuel (CWF) as a Clean Coal Technology Project (CCT). Satisfactory progress will have been made with the publication of a report which explores the stringent requirements of the CCT Program in relation to the future program of CWF.

Methods

A detailed description of the two primary tasks is given below.

Waste water Treatment Program

The hot-water-drying process under development produces large amounts of water containing organic and inorganic detritus. A commercial scale facility could be expected to produce about a million gallons of water per day. The source of this water is the raw lignite, from which it is extracted. Although this water in the raw state cannot be returned to the environment, with appropriate treatment it can become a valuable by product.

BNI Coal Ltd., and Minnesota Power initiated wastewater treatment studies with North Dakota's Energy and Environmental Research Center (EERC) in February 1989 with a characterization of the waste water produced in autoclave experiments LRC funding cycle 4/89 - 9/89). The primary goal of the next program (LRC funding cycle 10/89 - 3/90) was to determine the most effective means of converting the process waste water into a useable by product. The EERC is currently performing activated sludge experiments on waste water produced in the pilot plant test experiments. This work has been undertaken by BNI Coal Ltd. at a cost of approximately $75,000 and is expected to be completed by July 1990. The purpose of the current test program is to determine the effectiveness of current state-of-the art technology in chemical and biological oxygen treatment of the process waste water.

The objective of the waste water treatment research in LRC funding cycle 4/90 - 9/90 will be to:

- Evaluate alternate methods to hit target Chemical Oxygen Demand (COD) goals, including activated carbon adsorption and ozonation

- Refine operation and activated sludge stability. This will be performed at the bench scale and will consist of operation at different mixed liquor pH, and also include polymer addition to aid flocculation and settling in the secondary clarifier.

The funding application for LRC cycle 10/89 - 3/90 identified membrane separation technology as the next step in the establishment of preferred waste water treatment process. Evaluation of this type of technology will be deferred until the activated sludge/COD work has been completed.

It is expected that this new round of study will begin upon completion of the current work. The current work is expected to be completed in July, 1990. It is not expected that a final solution to the waste water treatment process

will be completed during the next six-months; instead, the waste water treatment process development will likely continue up to and through the demonstration project.

Coal Water Fuel Evaluation (CWF)

The marketing study just initiated will concentrate on conventional, industrial/utility use of an upgraded lump fuel product. One of the minor deficiencies of the Round III filing, according to the DOE, was the dependence on rail transportation to bring the product to market.

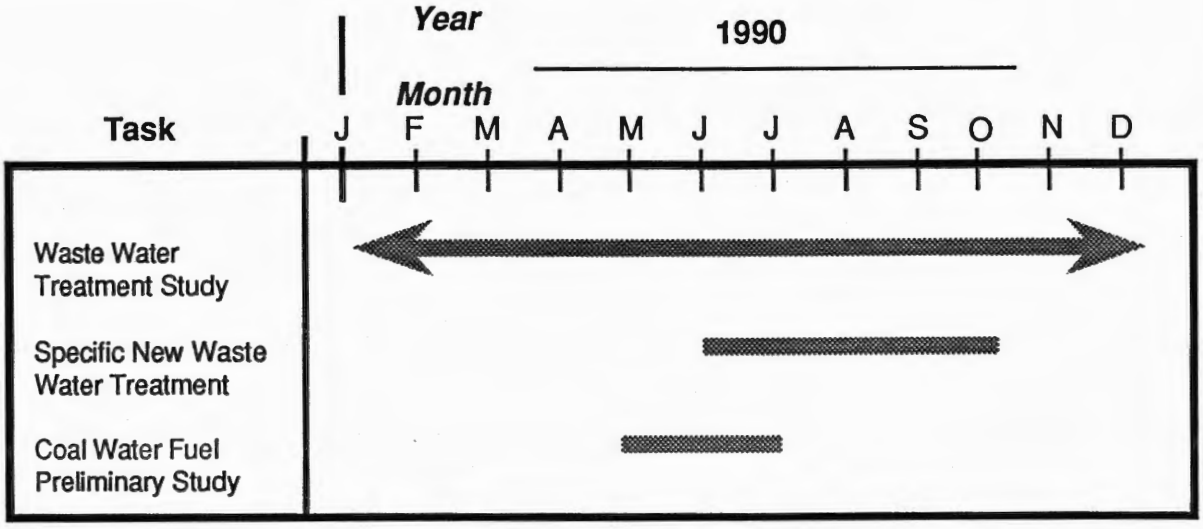
The specific objective of the study to be performed (by the North Dakota Energy & Environmental Research Center) is an initial screening, or scoping of the potential for CWF to be applied to the CCT program. It may be attractive, as a new fuel form, and potentially a transportation alternative, from the DOE's viewpoint.

The common ground between the two processes is that both the process under development by BNI Coal Ltd., and Minnesota Power, and the CWF process use hot-water-drying.

Timetable

A timetable of the major activities by task is presented below. Following the timetable, brief descriptions of the tasks with date and deliverable summaries are given.

Lignite Beneficiation Project Timetable



Description of Tasks

Waste Water Treatment Research Evaluate alternate methods to reach target Chemical Oxygen Demand in waste water. Refine operation and stability of activated sludge process. The work is expected to begin in July and continue for four months.

Coal Water Fuel Study An initial assessment of the potential of Coal Water Fuel applied to the DOE's Clean Coal Technology Program. Work can begin immediately after authorization, and is expected to take two months.

Personnel

Brief narrative summaries of the experience and qualifications of the principal investigator and other major participants in the project are provided as required. The major project participants for the pilot plant test program are Minnesota Power, North Dakota EERC, and Combustion Engineering.

Minnesota Power

George R. Nehls Jr. -- Principle Investigator
Research Engineer

Mr. Nehls is responsible for research activities in the area of fuels technology and minerals development. His primary duties include the investigation and evaluation of advanced coal technologies and advanced extractive metallurgical processes.

Mr. Nehls has an extensive background in industrial processes and thermochemical systems. He has participated in numerous studies determining the technical and economic feasibility of alternative energy supply systems, coal beneficiation, and advanced steelmaking.

North Dakota Energy and Environmental Research Center

Todd A. Potas
Research Supervisor
Low-Rank Coal Beneficiation

Mr. Potas has been the Research Supervisor of the Low-Rank coal Beneficiation Group since 1987. His primary duties currently involve supervising and performing research programs involving low-rank coal cleaning and drying technologies and coal/water fuel preparation. Mr. Potas has extensive experience with the EERC's continuous hot-water-drying pilot plant, and coal gasification analysis.

Mr. Potas' principle areas of expertise include thermal upgrading and drying of low-rank coals, physical and chemical cleaning of low-rank coals, and the preparation and rheology of coal/water fuel.

Gale G. Mayer
Research Supervisor
Waste Water Treatment

Mr. Mayer has been the Research Supervisor of the Waste water Treatment program since 1982. He has an M.Sc in geology and a B.Sc. in biology and chemistry, both from the University of North Dakota. He has planned and directed numerous research and development projects to address the

characterization and treatment of effluents from coal beneficiation and conversion processes.

Mr. Mayer's principal areas of expertise are in the areas of physical, chemical, and biological treatment of process waters generated from the hot water-drying of coal and from various gasification processes. Pilot and bench-scale treatment processes studied have included both novel and conventional methods.

Qualifications

BNI Coal, Ltd. (BNI) was incorporated in the state of North Dakota in 1949. BNI is engaged in the business of surface mining and sale of North Dakota lignite coal. BNI operates the Center Mine, which delivered 3.7 million tons of lignite to its customers in 1987. Historically, BNI has been one of the lowest cost producers of lignite in the state of North Dakota. BNI is a wholly owned subsidiary of Minnesota Power.

Minnesota Power (MP) is an investor-owned electric utility operating generating facilities and providing electric service in northern Minnesota and northwestern Wisconsin. MP operates the coal-fired Clay Boswell Steam Electric Station in Cohasset, Minnesota. Clay Boswell SES is rated at over 1,000 MW of generating capacity. In addition, MP operates the Syl Laskin SES near Aurora, MN, and the Hibbard steam station in Duluth, MN.

Budget

BNI Coal, Ltd. and Minnesota Power are requesting a grant of **$15,000** from the Lignite Research Council to help defray the cost of their lignite beneficiation project during 1990. The gross cost of all the tasks described in this application is estimated to be **$40,000**. A substantial amount of work is currently being executed and is associated with the LRC funding cycle 10/89 - 3/90.

BNI Coal, Ltd. and Minnesota Power charge at a rate of $29 per person-hour ($5,000 per person-month), including overheads. Detailed information regarding subcontractors can be obtained from Minnesota Power and/or the specific sub-contractor.

The project budget is separated into two primary tasks: Waste water-Treatment Study, Coal Water Fuel. Descriptions of the costing of each are given below.

The Waste water-Treatment Study is expected to cost **$25,000** during the current study cycle. The specific sub-tasks included in this cycle include the proposed work with alternate COD processes, and refinement of the activated sludge research. Specifically excluded from this list is work undertaken and listed in the previous application to the Lignite Research Council. Work which fell in the excluded category was the present waste water treatment work at EERC (activated sludge and packed bed surface water removal: authorized July 6, 1989), and the expected future work involving treatment and re-use of the final brines and pure water.

- The proposed waste water treatment work will be subcontracted to the EERC for an estimated $20,000.

In addition to the fixed price contracts, Minnesota Power expect that in-house labor to administer, manage, and engineer the waste water treatment will require one person-month of effort. This is equivalent to a cost of $5,000. Contingency costs are included in the Future EERC Testing estimate. These costs are summarized below.

Waste water-Treatment	**Cost ($)**
BNI, MP labor	5,000
Subcontract EERC Testing	20,000
Total Gross Cost	**$25,000**

The Coal Water Fuel Study is estimated to cost **$15,000**. This is split between a retained consultant expenditure of $10,000, and an assumed $5,000 in-house expenditure at BNI Coal, Ltd. and Minnesota Power (one person-months of effort). Contingency is included in the consultant estimate. These costs are summarized below:

Coal Water Fuel	**Cost ($)**
BNI, MP labor	5,000
Consultant	10,000
Total Gross Cost	**$15,000**

A summary of the total anticipated program cost is given below:

Two Task Program	**Cost ($)**
Waste water Treatment Study	25,000
Coal Water Fuel	15,000
Total Project Gross Cost	**$40,000**
Lignite Research Council Grant	**($15,000)**
BNI Coal, Ltd. & Minnesota Power Net Project Cost	**$25,000**

This concludes BNI Coal, Ltd. and Minnesota Power's research grant application to North Dakota's Lignite Research Council.