Advanced Processing of North Dakota Lignite

Grant Application to the
North Dakota Lignite Research Council

for the amount of $25,000

submitted by,

BNI Coal, Ltd.
&
Minnesota Power

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Principle Investigator,
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Project Summary

BNI Coal, Ltd. and Minnesota Power have continued to develop an advanced North Dakota lignite upgrading process. The overall process continues to use the the thermochemical process known as "hot-water-drying". Additionally, a physical cleaning step has been included to lower the detritus content of the lignite product. The current efforts are intended to estimate the cost of the process at the commercial scale. If the process development work continues to be successful, it could culminate in new industry for the state of North Dakota.

The specific project work undertaken during this funding cycle is the engineering estimation of the process cost at two different commercial plant sizes. A total grant of **$25,000** is being requested. The estimated gross cost of the activities is **$55,000**.

BNI Coal, Ltd. and Minnesota Power will provide the matching funds for this LRC funding cycle. The subcontractor will be Bechtel National, Inc.

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 present objective at this time is to estimate the cost of the process at commercial scale.

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.

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.

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. In addition to simple hot-water-drying, North Dakota lignite has a fairly high percentage of physically removable detritus, such as quartz, clay, and pyrite. The advanced up-grading process under development combines both hot-water-drying, and physical cleaning to produce an export quality boiler fuel which can compete on the open market. Determining the expected process cost at the commercial scale is important to the overall economics and marketability of the process.

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 60% 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.

Hot-water-drying does not, however, effectively remove mineral matter from coal. North Dakota lignite has a relatively large amount of its sulfur content present as easily removable pyrite. Laboratory tests have shown that physically cleaning the lignite prior to hot-water-drying is an effective method for further upgrading the coal product. The expected results, in addition to reduced sulfur emissions, are somewhat further increased heating value, and reduced ash deposition problems within a boiler.

Two basic process designs at the commercial scale have been executed. One process design is based on a 4,000,000 tons per year capacity delivered to the Bismarck area for further transport via rail. The second process design is based on a 10,000,000 tons per year capacity delivered to the Duluth, Minnesota area by slurry line. The study being undertaken will develop process cost information of the two process versions. This information will be key to understanding the future viability of this type of technology.

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 overall project can be described as developing an economical process that can modify run-of-mine North Dakota lignite into an export quality, "compliance" level boiler fuel. "Compliance" level means having sulfur emissions of less than 1.2 lbs of sulfur dioxide per million Btus of coal fired.

- The specific goals of the proposed work are to:

  1) Estimate the total cost of a combined physical cleaning/hot-water-drying process at a capacity of 4,000,000 tons per year.

  2) Estimate the total cost of a combined physical cleaning/hot-water-drying process at a capacity of 10,000,000 tons per year.

Methods

The subcontractor (Bechtel National, Inc.) will provide an engineering cost estimate of constructing and operating the processes two annual capacities: 4,000,000 tons per year, and 10,000,000 tons per year of product. The engineering cost estimates will take the form of a final report whereby each individual process element will be described and its cost estimated.

The capital and operating cost requirements will be included in an overall model which is being developed to determine the marketability of up-graded lignite. In essence, if the product can be produced at a competitive cost, the future of the process will be enhanced commensurably. Conversely, should the process cost appear too high, either the project can be modified to reduce costs, or other opportunities sought.

Timetable

The project is expected to take six months from its starting date to completion of the final report.

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 commercial scale estimating program are Minnesota Power, BNI Coal, Ltd., and Bechtel National, Inc.

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.

Bechtel National, Inc.

Horst Huettenhain
Manager, Solid Fuels Management

Mr. Huettenhain has many years experience with coal upgrading technology. He has been manager of Bechtel's Solid Fuel Management Department, Research & Development Division for thirteen years.

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 **$25,000** from the Lignite Research Council to help defray the cost of their lignite beneficiation study during fourth quarter 1991 - first quarter 1992. The gross cost of all the tasks described in this application is estimated to be **$55,000.**

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 proposed commercial process study work will be subcontracted to Bechtel Nation, Inc. for an estimated $50,000.

In addition to the fixed price contract, Minnesota Power expects that in-house labor to administer, manage, and engineer the commercial process study will require one person-month of effort. This is equivalent to a cost of $5,000. These costs are summarized below.

Commercial Process Estimate	**Cost ($)**
BNI, MP labor	5,000
Subcontract A&E Project	50,000
Total Gross Cost	**$55,000**
Lignite Research Council Grant	**($25,000)**
BNI Coal, Ltd. & Minnesota Power Net Project Cost	**$30,000**

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