

LRD-III-16

CARBONTEC CORPORATION

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March 31, 1989

Mr. John W. Dwyer, Chairman
Lignite Research Council
1016 E. Owens Avenue, PO Box 2277
Bismarck, ND 58502

Dear John:

Enclosed is our application entitled, "Utilization of the Carbondry Coal Drying Process for the Production of Enriched High BTU, 2 x 0 Inch Shippable Coal from North Dakota Lignite". This is in response to the invitation received from your office for Round 3 of this research program.

Carbontec Corporation is the submitting organization, and hereby commits the organization to the execution and completion of the project, providing approval is obtained by the Industrial Commission, State of North Dakota, pursuant to recommendations submitted by the North Dakota Lignite Research Council.

The objective of this program is to enhance the utilization of North Dakota lignite through the application of our unique patented drying process, "The Carbondry Coal Drying Process." The total amount of the project is \$80,000 and the total amount of our request is \$40,000.

North Dakota has lost a large market with the sugar beet plants in the Red River Valley. These plants had previously been served by coal from the Beulah District. These plants are currently burning southeastern Montana coal under a long-term contract. The estimated loss for a 20 year period in the sugar beet plant market alone is in excess of \$200,000,000. There is a potential loss of additional lignite coal markets to mines in Montana and Wyoming according to King's Western Coal publication. Dried 10,000 to 10,500 BTU lignite could, on the other hand, gain markets as a cost-effective, high BTU fuel could reach markets in Minnesota and other states.

We are currently completing a \$50,000 test program, shared 50:50 between the Industrial Commission and Carbontec Corporation.

Mr. John Dwyer
March 31, 1989
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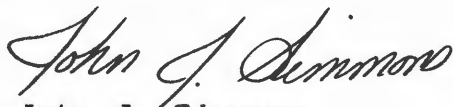
This program has produced initial results which indicate that a shippable, 2 x 0 inch, dried lignite coal, containing from 10,200-10,600 BTU/lb. and 10-12% moisture, can be obtained from Gascoyne coal. Sodium reductions of more than 25% have also been obtained.

The program outlined in the proposal submitted herewith would not only expand the Gascoyne research program, but also include coal from the Beulah District, which was dropped when the amount of effort of the original proposal was reduced. The program proposed herewith would further suggest a major ongoing pilot/demonstration plant program with Knife River Coal Company on Gascoyne coal. It will also enable us to further investigate the reduction of sodium in lignite coal. Test results, a part of which are included in draft form in this proposal, show sodium reductions ranging from -15 to 40%.

We appreciate the North Dakota Lignite Research Council and the North Dakota Industrial Commission's interest in our project, and trust that you will see fit to approve the project as submitted.

Yours very truly,

CARBONTEC CORPORATION



John J. Simmons
President

cc: Karlene Fine, Industrial Commission
Governor George Sinner
Attorney General Nicholas Spaeth
Tim Kingstad, State Land Department

Utilization of The
Carbondry Coal Drying Process
For the Production of Enriched High BTU
2 x 0 inch Shippable Coal From North Dakota Lignite

by

John J. Simmons
Carbontec Corporation
Bismarck, North Dakota

April 1, 1989

Amount of Project - \$80,000
Amount of Request - \$40,000

SUMMARY

A. PROJECT OBJECTIVE

Carbontec Corporation shall investigate the potential to produce 2 x 0 inch, high BTU, shippable coal from mine-run North Dakota lignite coal, using a unique chemical drying process, called the Carbondry Process. This effort will be directed towards obtaining a dried lignite coal, containing more than 10,000 BTU/lb., from mine-run 6,000-6,500 BTU/lb. raw lignite coal. This dried coal could be shipped in open top railroad cars to utilities and industrial users without the severe penalties incurred when shipping high moisture coal. The availability of high BTU coal prepared from low cost North Dakota lignite could provide a competitive fuel, thereby increasing employment opportunities, and providing a broader North Dakota state tax base.

Considerable research has been previously carried out to develop a shippable, dried North Dakota lignite coal, with little success to date. Major problems difficult to overcome have been prevention of spontaneous combustion and reabsorption of moisture. The Carbondry Process shows considerable promise in overcoming these problems. Preliminary tests on North Dakota lignite by Carbontec produced a high 10,000+ BTU dried product. The project objective will be to study process variables, provide additional data, and define optimal conditions to facilitate a full scale continuous pilot plant test program.

On March 1, 1988, Carbontec Corporation submitted a research proposal to utilize the patented Carbondry Coal Drying Process to produce a high BTU, low moisture, shippable coal from several North Dakota lignite mines.

The cost of its project was \$100,000 and the amount requested from the North Dakota Industrial Commission was \$50,000. The Industrial Commission authorized a grant of \$25,000.00 and the program was reduced by 50%.

Recent newsreleases (Kings Western Coal, Issue 674, September 20, 1988) announced that Otter Tail Power Company, which operates power plants at Big Stone Lake, South Dakota and Fergus Falls, Minnesota, is purchasing Wyoming and Montana coal for test burns at their plants. Knife River Coal Mining Company currently supplies coal to Ottertail from two North

Dakota lignite mines; the Beulah Mine ships to the Fergus Falls plant and lignite coal from the Gascoyne Mine is shipped to the Big Stone Lake Plant. The Big Stone shipments amount to approximately 2,000,000 TPY, or about 95% of the total Gascoyne Mine production.

Beulah and Gascoyne lignite contain 6,800 and 6,000 BTU/lb., and 35 to 40% moisture, respectively, while Wyoming and Montana coal contain from 8,500-8,900 BTU and 25 to 29% moisture. Earlier, North Dakota lignite coal lost its major sugar beet plant market in the Red River Valley to coal from southeast Montana. This market, formerly served by Knife River Coal Mining Company, is now served by Nerco's Spring Creek, Montana mine. Shipments from the Spring Creek mine contain approximately 9,200 BTU, and 24% moisture, vs. former shipments from Beulah which contained 6,800 BTU and 35% moisture. This represents the loss of \$200 million over the next 20 years.

It is estimated that lignite coal would have to be dried at a competitive cost to produce a product containing more than 10,000 BTU and less than 12% moisture to again be acceptable in the marketplace.

A test program is currently being conducted by Carbontec Corporation, funded through the North Dakota Lignite Research Council by the North Dakota Industrial Commission. Bulk samples have been obtained from the Gascoyne mine and tested under an initial time/temperature screening program. Dried lignite containing from 9,600 to 10,600 BTU/lb. was produced. These results indicate that a shippable, 2 x 0 inch dried lignite containing from 10,200 to 10,600 BTU/lb. and 10-12% moisture might be obtained from Gascoyne lignite coal. The test program scheduled for Beulah coal was eliminated from the current test program, since the funding request of \$50,000 was cut in half to \$25,000.00.

This proposal, if accepted and fully funded, would reinstate the Beulah test program and further expand the Gascoyne test program. Since the Gascoyne Mine is in danger of closure, with a major loss of jobs as well as state and county revenue, it is important to place further emphasis on the Gascoyne portion of this development program. Carbontec has the technology, facilities and trained personnel. The Company respectfully requests the participation at the 50% funding level from the Industrial Commission.

B. EXPECTED RESULTS:

The program is expected to produce lignite coal with BTU content in excess of 10,000 BTU's and a moisture content of less than 15% at a competitive cost. In addition, a reduction of 10% or more in sodium content of the dried, high BTU lignite is expected.

C. TIME PERIOD:

The program will be integrated into the current program and start within 30 days, with concurrent testing of both Gascoyne and Beulah lignite coal. The program will be completed within 9 months.

D. TOTAL PROJECT COST: \$80,000 Amount of Request: \$40,000

E. MAJOR PARTICIPANTS:

1. John J. Simmons
2. Donald Samples
3. Steve Simmons
4. Rich Bernhardt

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Table 3. Ash Sodium Reduction Tests Conducted on North Dakota Lignite.

OBJECTIVES

Carbontec Corporation shall investigate the production of high BTU 2 x 0 inch shippable coal from crushed mine-run North Dakota raw lignite coal, using a unique chemical drying process, called the Carbondry process. The effort is directed towards defining optimal conditions for obtaining a dried lignite coal, containing more than 10,000 BTU/lb., utilizing mine-run 6,000-6,500 BTU/lb. raw lignite coal. The objective is to obtain a high BTU, low moisture, relatively coarse coal which can be shipped in open top rail cars to utilities and industrial users without the severe penalties incurred by shipping high moisture coal. The availability of high BTU coal prepared from low cost North Dakota lignite could provide a competitive fuel with increased employment opportunities, larger coal company shipments and profits, and a broader North Dakota state tax base. Although considerable research and development has been carried out in the past to develop a shippable, dried North Dakota lignite coal, little success, to date, has been obtained. This is evident by the fact that there are no commercial lignite coal drying plants in operation. Two major problems in drying lignite have been very difficult to overcome; namely spontaneous combustion and

reabsorption of moisture. An inherent feature of the Carbondry Process shows considerable promise in overcoming both of these problems. Coal from several North Dakota lignite mines will be tested in this process, which is described in U.S. Patent No. 4,750,533, dated November 10, 1987, and U.S. Patent No. 4,800,015, dated January 24, 1989, "Utilization of Low Ranked Coal and Peat", granted to John J. Simmons. Improvements in the procedures and process discovered by John J. Simmons and Carbontec Corporation since the above patent filing dates will also be investigated.

The objective of this program will be to outline the basic operating parameters to produce dried lignite coal with a minimum energy content of 10,000 BTU/lb. The Carbondry Process involves a liquid to solid heat transfer system, and drying effectiveness and time required for moisture removal is based on a particle size and the time/temperature relationship between solid lignite coal and hot liquid chemicals. The coarser 2 x 1 inch coal fraction requires more drying time than the 1 x 3/8 inch fraction. Drying time can generally be decreased by increasing the temperature of the drying medium; the optimum temperature varying to some degree with the type of coal. This program will define the optimum drying parameters for individual coal types and sizes, based on this drying time/temperature relationship. This data is necessary to provide engineering data

to further evaluate the commercial economics of the process and provide information for future pilot plant tests. Previous test work by the company indicates that in addition to obtaining a dried high BTU product, some reduction in the sodium content of the ash in the final dried product might be accomplished. Since sodium is a particular detrimental element present in all North Dakota lignite, the removal of even a small portion of sodium would be beneficial. This research program will test the potential to reduce sodium in both high and medium sodium bearing North Dakota lignite coals.

BACKGROUND

Vast quantities of low and medium sulfur, low rank lignite coal are located in North Dakota. These large reserves are located near the surface and can be strip mined at a cost of between \$.45-\$.75/MM BTU, which is an extremely low and favorable cost for the production of fossil fuel.

These, low mining costs could provide large tonnages of a very competitive coal fuel to the multi-million ton utility and industrial market if a satisfactory high BTU fuel can be obtained. This fuel would be substantially lower in sulfur content than the medium and high sulfur midwestern coals currently being burned.

The activities of Carbontec's personnel to develop a viable process to dry lignite coal to produce shippable products goes back about 12 years. This earlier work was not successful, and paralleled similar coal drying test work by several other firms and governmental agencies, including Commonwealth Edison, American Machine & Foundry, Allis Chalmers, The US Bureau of Mines, Texas A & M, and the University of North Dakota. The combined lack of success is evident by the fact that there are no commercial drying plants in North Dakota any only one in the other western states, even though more than 240 million tons of high moisture, low sulfur coal are currently being mined and shipped from the states of North Dakota, Wyoming, Montana, Colorado, New Mexico, and Texas. Only a small portion of the total tonnage of the lignite coal produced in North Dakota is shipped to out-of-state utilities (Ottertail, Fergus Falls, Minnesota, and Big Stone Lake, South Dakota), with the majority being consumed at mine mouth power plants. The high moisture and low BTU content of lignite precludes shipment to distant markets. There is a real possibility that the two remaining out of state markets will be lost, unless a commercially feasible method of upgrading North Dakota lignite is found. The sugar beet plants located in North Dakota and Minnesota, from Drayton to Moorhead to Wahpeton, previously were substantial users of North Dakota lignite coal. Much of this market (a \$200,000,000+ market over

twenty years!!) is now being served by coal producers from Montana and Wyoming, who can offer a higher BTU, low moisture coal, assaying from 8,300-9,400 BTU and from 24-28% moisture. A dried North Dakota lignite coal containing 10,000+ BTU and less than 15% moisture could be in a position to recapture this market, as well as to serve additional markets further to the east in Minnesota, Michigan, and Wisconsin.

Large and small utilities and industrial furnaces currently consume tens of millions of tons of low sulfur Western coal which they blend with high sulfur Midwestern coal. If a suitable high BTU, low cost, shippable fuel can be produced from North Dakota lignite at costs lower than is now available with the present technology, the benefits to the producers, users, and the State of North Dakota, could be substantial.

The unique Carbondry chemical drying process, developed by John J. Simmons and Carbontec Corporation, provides a fast, economical, and safe method of drying lignite coal. This hot chemical drying process is carried out in mild steel drying vessels, at moderate temperatures (300-325 Degrees Fahrenheit) and atmospheric pressure; therefore, the system does not require complicated, expensive, high temperature, high-pressure units, which usually result in substantially higher capital and operating costs. Preliminary results obtained by the Company indicate that North Dakota coal can provide a high energy,

useable fuel at reasonable capital and operating costs. The results obtained in the research and development program suggested under this proposal will add to the base information necessary to the successful operation of a larger scale drying program in a continuous pilot plant.

RESEARCH PROGRAM GOALS

The proposal will conduct research to study the process variables and provide additional data that will help to determine the potential of producing high energy, stable, coal fuel from North Dakota lignite.

Previous testing of lignite with the "Carbondry Coal Drying Process," has produced low moisture (3-15%), high energy, dried coal fuel products containing from 9,500-11,000 BTU/lb. from crushed, mine-run lignite coal. This program will add to the base of information now available, and zero in on such operating parameters as the time/temperature requirements for specific coal sizes; information that is essential for the next phase - the drying of large tonnages of lignite in a pilot plant. Previous test work has also indicated the potential to reduce the sodium content of lignite ash. This program will further study this

potential product improvement, since a lower sodium lignite would be more acceptable to the utilities and easier to market. Several electric utilities and industrial plants, including Northern States Power Company, Ottertail Power Company, and Blandin Paper Company have expressed an interest in testing this fuel once it becomes available.

THE CARBONDRY COAL DRYING PROCESS

Essentially, the process consists of crushing the lignite coal to a size of 2 x 0 inches, screening the crushed coal into three sizes, 2 x 1 inch, 1 x 3/8 inch, and 3/8 x 0 inch, and conveying each size to a separate, specifically designed, dryer units. A blend of oil-based chemicals, the liquid oil-chemical medium, is pumped to the drying units at a temperature that can be varied between 300-350 Degrees Fahrenheit. The moisture is released from the coal and discharged as steam. In a commercial unit, the coal will move continuously through the drying unit with the process time controlled to produce a dried product of uniformly low moisture content. The dried product is discharged to a shaking screen, which removes the surface chemical, and then proceeds to a secondary drying unit, where additional heat is added. The secondary drying unit removes a portion of the drying chemical, plus some additional moisture. The drying chemical released is recovered and recycled. The process is controlled to

retain a small amount of the drying chemical on, and within, the coal. This provides protection, both to the surface and within the coal, to prevent moisture reabsorption and spontaneous combustion. The dried coal product is a 2 x 0 inch product that could be shipped in open-top rail cars.

PREVIOUS WORK

Lignite coal samples have been submitted to Carbontec by mine operators, utility users, or in some instances, obtained by Carbontec's personnel. Lignite from mines in the Beulah, Center, and Gascoyne Districts has been tested and dried on a preliminary basis with encouraging results. A summary of the test results conducted on three of these coals are as follows:

Table 1.

North Dakota Lignite
Carbondry Test Results

<u>Mine</u>	<u>Raw Coal</u>		<u>Carbondry Coal</u>	
	<u>Moist</u>	<u>BTU/lb.</u>	<u>Moist</u>	<u>BTU/lb.</u>
Beulah District	34.00	7270	11.50	10490
Gascoyne District	42.00	6110	10.20	10060
Center District	35.50	6620	9.10	10155

Table 2.

Sodium Reduction Tests - North Dakota Lignite Coal

Coal Source: Beulah
 Coal Type: Lignite
 Test Sample: 2 x 3/8, CD 5/0

<u>Product</u>	<u>Moist</u>	<u>BTU/lb</u>	<u>MM BTU/ Ton</u>	<u>% Ash</u>	<u>% Na₂O</u>	<u>lbs/MM Ash</u>	<u>BTU Na₂O</u>
Raw Coal	35.98	7424	14.8	4.50	13.6	6.1	0.83
Carbondry Coal	13.54	10370	20.7	6.16	11.8	6.0	0.70

Moisture Reduction: -72.2%
 BTU Increase: +39.7%
 Sodium Decrease: -15.7%

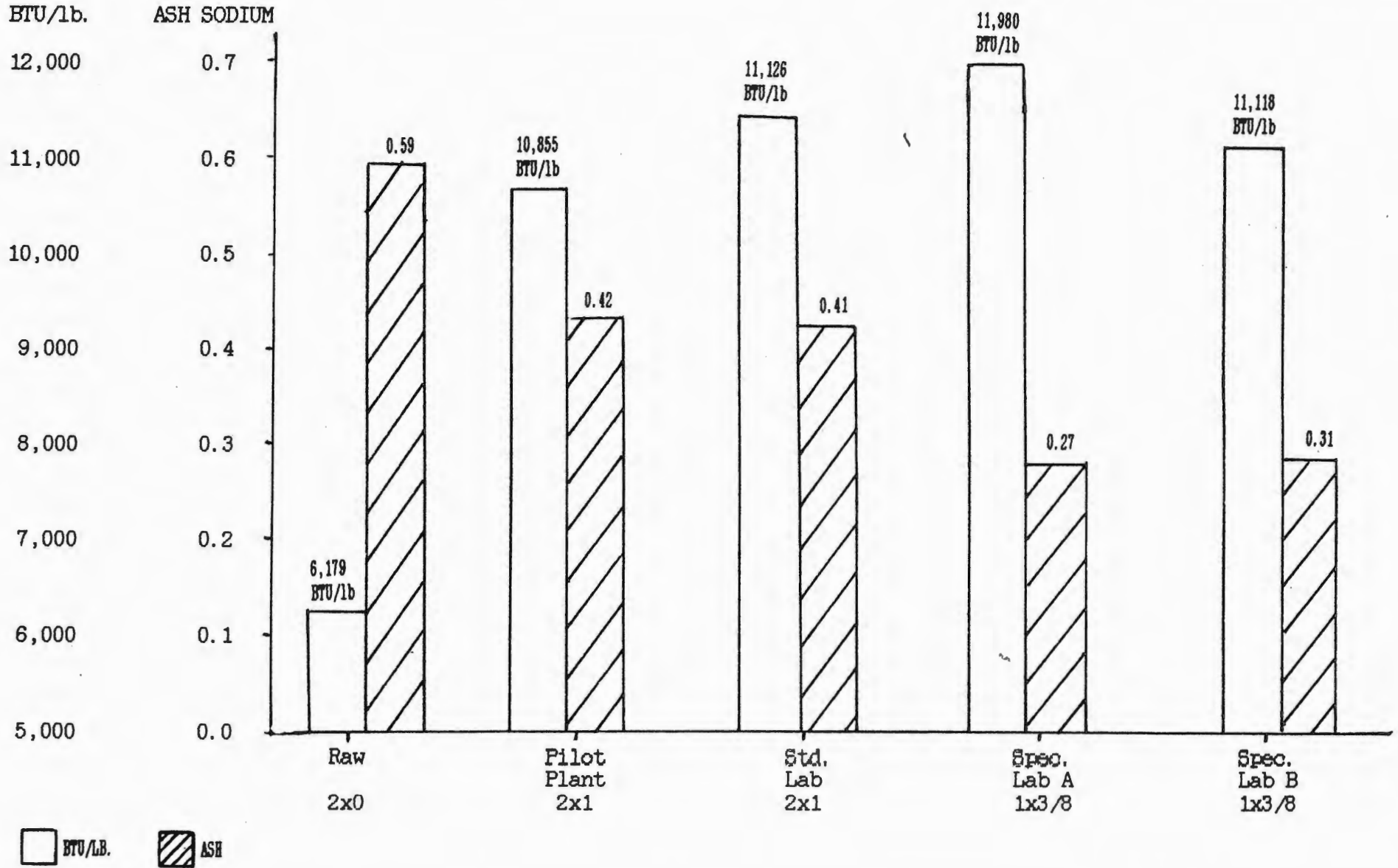
Additional tests conducted on Gascoyne lignite, as shown in the graph on the following page, further reduced sodium in ash by 29 to 54%.

PRELIMINARY ENGINEERING AND DESIGN WORK

An evaluation had been prepared on coal from another state to show that the Carbondry Process can produce dried coal on a continuous basis at reasonable costs. As a part of this study, former engineers of Davy McKee Company prepared general arrangement drawings and cost estimates for a 1 million TPY coal drying plant. A similar plant could be designed for North Dakota lignite, once more definitive data from both additional research

and pilot plant operation is available. Since the process operates at atmospheric pressure and moderate temperatures, expensive drying apparatus and costly materials are not required. With the exception of a specially designed Carbondry Coal Drying unit, a typical plant, as mentioned above, would use off-the-shelf items such as conveyors, screens, pumps, centrifuges, and coolers. Carbontec has performed its own energy balances, but as a matter of providing an outside source for confirmation, the M. A. Hanna Research Company was hired to prepare an energy balance of the Carbondry Coal Drying Process. Their report was satisfactory, and confirmed the high efficiency of this liquid solid heat transfer system. The Hanna reports concluded that only 1,760 BTU of energy per lb. water removed was required. Heat for a commercial plant would be supplied by burning screen fines, $-1/4 \times 0$ inch coal. Since the drying plant would be located at the mine, this coal represents a cheap source of drying fuel.

CARBONTEC CORPORATION
 KNIFE RIVER COAL MINING COMPANY
 GASCOYNE LIGNITE
 ASH SODIUM TESTS



METHODS - SCOPE OF WORK

- 1.1 Obtain large bulk samples of North Dakota lignite from three open pit mines located in the Beulah, Center, and Gascoyne mining districts. Crushing, screening, and sampling of the raw coal products, preparation of sized feed for the drying process.
- 1.2 Dry each size and each lignite mine type separately in a chemical at several controlled temperatures ranging from 250-350 Degrees Fahrenheit. Adjust the chemical medium according to Carbontec's proprietary data base to arrive at three separate drying mediums. Vary the residence time of each size product at each temperature to obtain the optimum time/temperature relationship. After a preliminary review and screening program, determine on the basis of product results, which test series should be subjected to the Stage II drying process. Conduct Stage II drying on a pre-selected group for each mine source. Analyze the products to determine the moisture and BTU content of the general test series, with ash, sodium, and sulfur assayed from certain selected group series. Based on information obtained, prepare selected dried coal samples for wet scrubbing tests to determine if additional sodium can be removed.

1.3 Preliminary engineering and economic analyses based on the results of 1 and 2.

1.4 Final report preparation.

TIMETABLE - PERFORMANCE SCHEDULE

Task 1.1 Completed 1 1/2 months after start of program.

Task 1.2 Completed 7 months after start of program.

Task 1.3 Completed 8 months after start of program.

Task 1.4 Completed 9 months after start of program.

DELIVERY OF PRODUCTS

Carbontec shall provide a final report containing data from the experiments performed according to the Task 1.2, along with preliminary engineering, economic analysis, and conclusions based on this data, according to Task 1.3.

PERSONNEL

1. John J. Simmons - Mr. Simmons (age 56), President of Carbontec Corporation, has more than 20 years of high level managerial experience, much of which has been in coal and energy related business. He has worked directly with Lurgi Gesellschaft, Frankfurt, Germany, in earlier low temperature lignite coal carbonization developments, and more recently, was responsible for the "Carbondry Process", a proprietary lignite and sub-bituminous coal drying process. Previously managerial responsibilities included direct supervision over some 300 engineers, superintendents, and other employees of major projects. His management, financial, and technical experience is of importance not only in the direct operation of the Carbondry process, but also in implementing new developments that could increase total overall value of future production.
2. Donald Samples - Mr. Samples (age 50) is a former Vice President of Operations Support and Engineering of Peabody Coal Mining Company, the largest coal mining company in the United States, with coal sales in excess of 80 million tons annually, and annual revenues of \$1.4 billion. Mr. Samples, a recognized leader in the coal industry, had been with the Peabody organization for more than 20 years. His executive

responsibilities included all aspects of developing new mines and plants for Peabody Coal Company. He routinely handled several projects, many with budgets of from \$82,000,000 to \$120,000,000 per year. His responsibilities also included financial evaluation of projects and acquisitions, contract negotiations and administration, as well as both short range and strategic planning of operations.

3. Steve Simmons - Mr. Simmons (age 27), attended Bismarck State College for one year. Mr. Simmons has worked on engineering field projects and in the process and analytic laboratories of both Minnesota Valley Testing Laboratory and Carbontec Corporation. Previous experience includes work as a field technician for Western Geophysical Company in Wyoming, Utah, and Mexico. Previous experience includes laboratory research and development on the initial development on the initial development and testing parameters of the Carbondry Coal Drying Process, the coal-water slurry process, and the Carbontec coal-oil slurry process. He has also served as project coordinator on the Carbontec/Boise Cascade wood chip drying project at Carbontec's Crosby, Minnesota laboratory.

QUALIFICATION OF APPLICANT

Carbontec Corporation, a North Dakota corporation headquartered at 400 N Broadway, Bismarck, has performed coal drying tests on North Dakota lignite coal and other high moisture sub-bituminous coal, for more than two years. Prior to work by Carbontec Corporation, similar coal drying research and development was carried on by personnel currently working for Carbontec Corporation.

Carbontec Corporation operates a coal drying laboratory located at 26th Street South and Airway Road, Bismarck, North Dakota, and is currently constructing a Carbondry coal drying pilot/demonstration plant at that location.

MATCHING FUNDS

Carbontec Corporation will furnish matching funds as heretofore described. Carbontec reserves the right to furnish the funds from its own account or from the account of other interested parties. In any event, Carbontec Corporation will be responsible for furnishing matching funds as described above.

FUNDING LEVEL NECESSARY FOR EFFECT.

In the event that less funding is available than requested, the above test program will be reduced in scope and the reduced data obtained will have a negative effect on the total anticipated results.

BUDGET

DIRECT MATERIAL

Laboratory Chemicals, Disposables and Supplies			\$ 3,250.00	\$ 3,250.00
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DIRECT LABOR

(Rates incl. payroll taxes
and ins.)

Senior Personnel

John Simmons	320			
Donald Samples	60			
Daniel Urich	180			

TOTAL	560	42.00	\$23,520.00	
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Senior Lab Technicians	1100	18.50	\$20,350.00	
Lab Technicians	450	12.50	5,625.00	
Equipment Operator (Sample Program)	80	14.50	1,160.00	
DIRECT LABOR SUB-TOTAL			\$50,655.00	

Fringe, overtime, vacation pay @ 15% direct labor			7,600.00	
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TOTAL LABOR			\$58,255.00	\$58,255.00
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OUTSIDE SERVICES

Laboratory testing, analytical			\$ 6,000.00	
Consultants, other outside services			\$ 2,000.00	

TOTAL OUTSIDE SERVICES			\$ 8,000.00	\$ 8,000.00
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EQUIPMENT

(Company owned, leased and rental)

Pickup trucks, 1 ton sample trucks, front-end loader			\$ 5,500.00	\$ 5,500.00
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TRAVEL

Transportation, air, automobile
Per Diem

\$ 3,500.00
3,500.00

TOTAL TRAVEL

\$ 7,000.00 \$ 7,000.00

SUB TOTAL

\$82,005.00

General Overhead, Laboratory Rental,
Office Rental, Laboratory Equipment
and Accounting @ 22%

\$17,995.00

TOTAL PROJECT COST

\$100,000.00

AMOUNT OF REQUEST

\$80,000 x 50%

40,000²
\$ 50,000.00