

**TECHNICAL REVIEWERS' COMMENTS**  
**LRC-LXVI (66)–A**

**“Viability of North Dakota Lignite as a Feedstock for a Commercial Charfuel Coal Refining Facility in North Dakota”**

Submitted by: Carbon Fuels, LLC

Request for: \$1,493,171; Total Project Costs: \$2,986,343

Principal Investigator: Lee G. Meyer; Project Duration: 9 Months.

1. **OBJECTIVES**

The objectives or goals of the proposed project with respect to clarity and consistency with Industrial Commission/Lignite Research Council goals are: 1 - very unclear; 2 - unclear; 3 - clear; 4 - very clear; or 5 - exceptionally clear.

**Reviewer 09-1 (Rating: 2)**

As amended by the letter dated April 10, 2009, the objective in Phase I is to determine commercial design criteria for the 500/2500 tpd commercial demonstration project. The letter states the objective is “not to optimize the operating conditions for this particular lignite feedstock.” It is unclear if the amended objective is consistent with NDIC/LRC goals. In addition, the revised objective is not consistent with the four Phase I modules.

**Reviewer 09-2 (Rating: 4)**

The proposer is proposing to test ND lignite as a feedstock to evaluate the feasibility of producing liquid fuels, petrochemicals or other high BTU fuels using an existing proprietary 18 tpd “**Charfuel Coal Refining Process**” demonstration facility. If successful, a large-scale ND plant could consume 2,500,000 tons/yr of lignite and would produce numerous ND jobs, a growing economy and taxes.

**Reviewer 09-3 (Rating: 4)**

The objectives of the proposed project, should it be successful and transition to the commercial scale, meet several NDIC/LRC statutory goals, which includes: promoting the use of lignite and lignite-derived products; creating jobs in the production of lignite (through increased mining); creating jobs in the utilization of by-products (e.g., through refinery operations); and providing economic stability to the lignite industry.

2. **ACHIEVABILITY**

With the approach suggested and time and budget available, the objectives are: 1 - not achievable; 2 - possibly achievable; 3 - likely achievable; 4 - most likely achievable; or 5 - certainly achievable.

**Reviewer 09-1 (Rating: 2)**

It is possible the revised objective is achievable. However, it is unclear what coal feed and product slate will serve as the basis of the Commercial Demonstration Plant. It is unlikely that Module 2 Task 6, 7 and 8 can be accomplished in the timeframe available.

**Reviewer 09-2 (Rating: 3)**

The proposers first step would be to evaluate ND lignite for use as a feed stock for an existing proprietary 18tpd “**Charfuel Coal Refining Process**” located in Golden, Colorado.

The initial phase would evaluate the suitability of moisture reduction, reactivity, product flow(s) and thermodynamic characteristics.

Additional “hot run” tests will be conducted in an “oil recycle” mode to produce one or more of the following: liquid fuels, petrochemicals, fertilizer or boiler fuel. These tests will consume roughly 20 tons of lignite. A concern is the validity of using what appears to be a minimal lignite quantities that contain high moisture content and light volatiles and two relatively short term tests to justify a scale-up 500/2500 commercial facility.

**Reviewer 09-3 (Rating: 2)**

It is not clear that the objectives can be met, whether the objectives are to determine commercial design criteria for a demonstration plant or to optimize the operating conditions for lignite feedstock. Two 6-7 hour tests, in which operating conditions are varied, is extremely short to base design criteria on.

3. **METHODOLOGY**

The quality of the methodology displayed in the proposal is: 1 - well below average; 2 - below average; 3 - average; 4 - above average; or 5 - well above average.

**Reviewer 09-1 (Rating: 3)**

The proposed project and “Process Concept” are very ambitious. The methodology contains details in areas and lacks details in other areas.

**Reviewer 09-2 (Rating: 4)**

The proposed effort consists of four modules covering nine months. Module 1 activities include prepare procedures, project design reference, test plan, mechanical design, and preparing protocols, safety...etc. Module 2 includes commissioning and/operate the pilot facility and at least two sets of test runs. Module 3 includes analyses of process stream samples. Module 4 includes data analyses, and a performance economic study. The actual test runs will take place at the Hazen Research Facility in Colorado.

**Reviewer 09-3 (Rating: 2)**

The proposal is poorly written and very confusing. Discussion of 500/2500 tpd and 5000 tpd plants were not defined. One had to check web sites and read through additional materials (emails, reports and letters) to understand what was being proposed. Many funding agencies would only base their review on the primary proposal and not volumes of additional data/ web sites. The proposal contains many redundant comments instead of providing details. Although material and energy balances may be considered confidential, if the system is patented there should be more information on material and energy balances. For example, does the system produce 10% char and the balance fuels and chemicals or is 90% char produced with the balance fuels and chemicals?

4. **CONTRIBUTION**

The scientific and/or technical contribution of the proposed work to specifically address Industrial Commission/LRC goals will likely be: 1 - extremely small; 2 - small; 3 - significant; 4 - very significant; or 5 - extremely significant.

**Reviewer 09-1 (Rating: 2)**

The scientific and technical contribution of the proposed work to specifically address NDIC/LRC goals will likely be small. Nowacki (Chemical Technology Review No. 131, 1979) summaries flash hydrolysis conversion of North Dakota lignite (NDL). This early review and work by Brookhaven National Laboratories, Rocketdyne, Rockwell, IGT, Occidental, City Services and TVA have demonstrated the amenability of various coals, including some NDL, to pyrolysis, flash pyrolysis, and hydrodisproportionation. The scientific and technical contribution to specifically address NDIC/LRC goals, could best be met with; (1 long term continuous operation of greater than one month with 24-hour days, (2 complete feedstock and product characterization and yields, and (3 public disclosure of operation, feed, product and yield data.

**Reviewer 09-2 (Rating: 5)**

The “Charfuel Coal Refining Process” is a proprietary developed by Carbon Fuels LLC and Hazen Research over a period of 15 years. Most important data is classified proprietary, including technical information produced by engineering organizations and R&D groups. Additional information is available at: <http://www.icis.com/Articles/1991/06/24/14268/carbon-fuels-develops-new-coal-refining-process.html> The Hazen team has successfully produce fuels and liquid products with WY sub bituminous and CO bituminous coal. Although ND lignite has high moisture and light volatiles compared to higher rank coal, the proposers indicate that it is likely to be a suitable feedstock. Assuming the 18 tpd Charfuel tests are successful, Carbon Fuels LLC will proposed that a 500/2500 tpd Charfuel commercial demonstration facility be established in ND. The Charfuel® Coal Refining Process is touted as environmentally friendly, producing no emissions, including greenhouse gases like carbon dioxide, sulfur, nitrogen, mercury and CO2 can be captured and become valuable co-product commodities. It is proposed that the ND first-of-a-kind Charfuel facility be located adjacent to energy facilities such as the Mandan Tesoro refinery or a MDU power plant.

**Reviewer 09-3 (Rating: 2)**

The argument is not convincing that a couple of 6-7 hour tests are sufficient to scale the process up to a commercial facility.

5. **AWARENESS**

The principal investigator's awareness of current research activity and published literature as evidenced by literature referenced and its interpretation and by the reference to unpublished research related to the proposal is: 1 - very limited; 2 - limited; 3 - adequate; 4 - better than average; or 5 - exceptional.

**Reviewer 09-1 (Rating: 2)**

Evidence of the PI's awareness of current research by literature citation and reference is limited.

**Reviewer 09-2 (Rating: 4)**

Significant R&D and processes and process equipment have developed the Charfuel® Coal Refining Process. The coal refining producing liquids and char is touted as environmentally friendly, producing no emissions that include greenhouse gases sulfur, nitrogen, mercury and CO2 can be captured and become valuable co-products for the commodity markets. Some information has been was available on the internet since most information is proprietary. However, Hazen Research several major engineering companies have conducted several due diligence studies using companies that range from technical and economic assessments through process, design and operations should have been addressed by these studies. One concern may be release of refinery-type odors, which could be offensive to local communities.

**Reviewer 09-3 (Rating: 4)**

Although there is no reference to literature provided, it appears from the backgrounds of the PI and his colleagues that they are knowledgeable in the various aspects of the process.

6. **BACKGROUND**

The background of the investigator(s) as related to the proposed work is: 1 - very limited; 2 - limited; 3 - adequate; 4 - better than average; or 5 - exceptional.

**Reviewer 09-1 (Rating: 3)**

The backgrounds of the PIs as related to the proposed work is adequate.

**Reviewer 09-2 (Rating: 5)**

The core management and technical team have up to 30 years of experience in the energy area such as chemical, petroleum refining and environmental and coal. Education background includes PhD chemical engineers, and administrative and legal talent. The PI was a key team member that developed the original Charfuel technology and successful refined Wyoming subbituminous and Colorado coals.

**Reviewer 09-3 (Rating: 4)**

The backgrounds of the investigators are very good.

7. **PROJECT MANAGEMENT**

The project management plan, including a well-defined milestone chart, schedule, financial plan, and plan for communications among the investigators and subcontractors, if any is: 1 - very inadequate; 2 - inadequate; 3 - adequate; 4 very good; or 5 - exceptionally good.

**Reviewer 09-1 (Rating: 3)**

The management plan is adequately defined for this project. However, the amended objective causes confusion with regard to proposed work, time frame and budgets.

**Reviewer 09-2 (Rating: 2)**

The project management plan contains a defined schedule, milestone chart, and a corresponding financial plan. An organization communications schematic should be prepared to define Team participant reporting relationships and functions, including the LRC contract manager.

**Reviewer 09-3 (Rating: 4)**

A very good schedule and plan have been provided; however, it is lacking in experimental work/ test runs that are crucial in determining design criteria.

8. **EQUIPMENT PURCHASE**

The proposed purchase of equipment is: 1 – extremely poorly justified; 2 – poorly justified; 3 – justified; 4 – well justified; or 5 – extremely well justified. (Circle 5 if no equipment is to be purchased.)

**Reviewer 09-1 (Rating: 3)**

It is necessary to purchase equipment, but it is uncertain if the purchases are adequately justified in the proposal. What if the amended objective results in omitting operation of the pilot plant with NDL?

**Reviewer 09-2 (Rating: 3)**

The lignite characteristics will require mechanical and operational changes to the 18 tpd Charfuel research facility.

**Reviewer 09-3 (Rating: 2)**

If there is an existing facility, it is not clear what the extensive configuration entails. To develop costs for the proposal, equipment and material lists would have had to be prepared. Where are they? They should be part of the proposal to justify the costs. The information provided in the addendum is too general for the amount of funding being requested.

9. **FACILITIES**

The facilities and equipment available and to be purchased for the proposed research are: 1 – very inadequate; 2 – inadequate; 3 – adequate; 4 – notably good; or 5 – exceptionally good.

**Reviewer 09-1 (Rating: 4)**

The facilities at Hazen are notably good.

**Reviewer 09-2 (Rating: 3)**

The Charfuel facility has been developed over the previous 15 years and has demonstrated its capability using WY and CO coals. Some process modifications will be required due to lignite properties. The research team's experience developing and operating the unit should provide an accurate account of the feasibility of using ND lignite.

**Reviewer 09-3 (Rating: 2)**

There is insufficient detail to properly assess.

10. **BUDGET**

The proposed budget "value"<sup>1</sup> relative to the outlined work and the financial commitment from other sources<sup>2</sup> is of: 1 - very low value; 2 - low value; 3 - average value; 4 - high value; or 5 very high value.

**Reviewer 09-1 (Rating: 2)**

The project is of low value. Contribution of an existing facility as in-kind matching is of low and questionable value.

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<sup>1</sup> "Value" – The value of the projected work and technical outcome for the budgeted amount of the project, based on your estimate of what the work might cost in research settings with which you are familiar.

<sup>2</sup> Financial commitment from other sources – A minimum of 50% of the total project must come from other than Industrial Commission sources to meet the program guidelines. Support greater than 50% from Industrial Commission sources should be evaluated as favorable to the application.

**Reviewer 09-2 (Rating: 5)**

Carbon Fuels, LLC and the 18 tpd Charfuels facility is an innovative approach to generate refinery chemical energy products using ND lignite. If the planned tests using the 18 tpd Charfuel facility are successful, Carbon Fuels would propose to develop a 500/2500 tpd facility. The Mandan Tesoro's refinery and Montana-Dakota Utilities support the project.

**Reviewer 09-3 (Rating: 2)**

It is this reviewer's assessment that the costs are too high for the short tests and limited amount of data that will be generated.

**OVERALL COMMENTS AND RECOMMENDATION:**

Please comment in a general way about the merits and flaws of the proposed project and make a recommendation whether or not to fund.

**Reviewer 09-1 (Rating: DO NOT FUND)**

Full disclosure of operating conditions and results are needed to permit adequate evaluation by the public and private partnership known as the North Dakota Lignite Program. The proposal lacks technical data and details concerning operation of the existing and previous Charfuel© process facilities. Full disclosure can not be anticipated from this proposal.

The proposal as originally submitted features two short runs with NDL. These short runs, if completed on schedule would not be sufficient to substantiate process operation or NDL amenability. Operations without internal recycle are not sufficient to demonstrate the process or establish process viability.

It is critical to generate product yields under continuous recycle operation so reliable information can serve as the basis for mass and energy balances. The process must be operated under continuous recycle operation to demonstrate product yields and recycle. Operations should be monitored, yields verified and all data publicly disclosed.

If the revised objectives do not include long term operation with NDL, then the project is not valuable to the Lignite Program. Another set of commercial operating design criteria is not of value unless it is based on reliable, thorough, complete and fully disclosed data generated from long term operation with NDL. Two limited 6 to 7 hour runs with NDL is not sufficient to provide reliable data and to verify operability.

The matching funding commitment is of low or limited value. An adequate financial cash contribution to Hazen for plant operation is desirable. As structured, Hazen is a third party subcontractor to Carbon Fuels. It would be preferred to have Hazen as the prime contractor to NDIC/LRC with matching funding from industry to Hazen. This arrangement would assure independent technical objectivity and reporting.

Economic viability must depend on the non-char products. It will be difficult to establish economic viability under volatile and low petroleum markets. NDL has a steady and known market. The char market depends on mixing or replacing NDL. Char does not have an existing market or market value. The products may have limited markets and discounted values in North Dakota. It is unclear that the markets for the Charfuel© products has been adequately evaluated for the NDL case.

**Reviewer 09-2 (Rating: FUND)**

Carbon Fuels, LLC and Hazen Research have developed a Charfuel® Coal Refining Process to refine coal (lignite) producing liquid fuels, petrochemicals, combustible char and is touted as environmentally friendly, producing no air emissions such as sulfur and nitrogen oxides, mercury and CO<sub>2</sub> and become valuable co-products for ND and national commodity markets and a residual supplemental combustible char that could be used in power plants. The refining process does not require natural water sources.

If the 18 tpd Charfuel demonstration lignite test is successful, Carbon Fuels would propose scaling the technology to develop a 500/2500 tpd commercial facility; a successful facility could consume up to 5,000,000 tons/yr.

Letters of support for the Charfuel project were provided by Mandan's Tesoro Refinery and Montana-Dakota utilities.

A large scale Charfuel facility would expand the use of lignite, generate jobs, boost local economies, and general state and local taxes. Overall, one or several Charfuel Refinery facilities would benefit all economic sectors of ND.

The LRC R&D Director should be added to the Management Team and participate in review meetings.

**Reviewer 09-3 (Rating: DO NOT FUND)**

I recommend that the proposal not be funded. This was a difficult decision because of the support/ interest by MDU, Tesoro, and I believe, GRE with them drying coal for the project through in-kind support. However, this is not a convincing proposal as illustrated in my comments provided above as well as additional comments that follow. I feel that the request is for a large amount of funding with insufficient detail and potential results obtainable.

Other comments include:

Overall this was a poorly written proposal that was lacking in detail and was confusing. In looking at the resumes of the project team, it is surprising that this occurred.

If the facility exists, what does the configuration entail? What is meant that if the unit is configured for lignite no other coals can be tested then? Are the proposers insinuating that this facility is continuously operating? I find this difficult to believe.

Page 39 states that there are advancing discussions to commercialize this process. With all the years of work on this process, why isn't there a commercial process already in operation, especially if the economics are exceptionally profitable?

If the use of lignite will require extensive system rework (ultimately higher capital and operating costs?), will this lessen the chance that it will become commercial (as compared to using a bituminous coal feedstock)?

Why does Carbon Fuels have a high degree confidence that a demonstration in North Dakota will draw significant private industry capital when they have not been able to do so to-date?

The proposal makes reference to "prior engineering studies with lower rank coals" but yet none of this is presented and the proposal is written such that no information is known about using a low-rank coal like lignite.

Scaling the system from 18 to 5,000 tpd does not seem like a realistic jump. This type of increase is not common engineering practice.

Getting sufficient results from two 6-7 hour tests are questionable. Typically, longer term runs are performed to demonstrate a technology, assess equipment wear and operation, and identify operation issues, etc. If the major costs, per the proposal, are getting the system up and running for the tests, then why not perform longer tests? The major costs at that point are operator labor, utilities (?), and analytical charges. These should be small compared to the equipment, assembly, etc. costs.

Very little information on material and energy balances was provided. Although I understand that some of this may be proprietary, that is no excuse not to provide the funding agency with the information in order to make a decision, especially if the system is patented. I have seen proposals not funded by other agencies because the proposers were not willing to provide sufficient detail with the same excuse provided by Carbon Fuels. This proposal did not even give general values on char to liquid fuels/chemicals splits. This is not acceptable for a review process.

On page 24 of the proposal there is a reference to a comparison chart. This was missing from the proposal.

Where does the mercury go in this process? Does it go into the fertilizer? If so, is this a saleable product then?

Metallurgical coke has many specifications, other than pollutants, which would have to be assessed from the lignite char/coke. Since the proposal has little detail on products, this cannot be assessed but the NDIC/LRC needs to be aware of this. According to the American Institute of Iron and Steel, not only are there volatile matter, ash, and sulfur specifications, but there are also total alkali specifications ( $\leq 0.2\%$ ). Lignites have alkali concentrations. Also, coke reactivity and stability are important parameters. In summary, this is potentially a nice by-product from the process but there is insufficient data in the proposal to determine if the coke is of metallurgical quality.