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 13-19 (Rating: 3)**

*(NOTE: Reviewer 13-19 provided no comments.)*

**Reviewer 13-20 (Rating: 4)**

The $500,000 in funds requested from NDIC/LRC, together with $125,000 additional from Alstom, are to support an additional Task in an existing 36 month $10 million research project funded primarily by DOE with significant cost sharing from Alstom to further develop a new boiler technology referred to as the “Limestone-based chemical looping combustion process (LCL-C™)”. That new Task will include testing both run-of-mine and partially dried (25-30% moisture) North Dakota lignite in bench scale units and a 3 MW Prototype unit.

The goal of this development is to be able to develop a boiler system that can capture 90% of the carbon in the fuel as CO2 at a cost that raises the cost of electricity by less than 20% above that if there was no CO2 capture compared to conventional pulverized coal-fired or circulating fluidized bed units. This is much less expensive than the current DOE goal of an increase of less than 35% in the cost of electricity for that level of carbon capture. The current conceptual plan has a target for operation of a 100-150 MW commercial prototype unit in the 2020-2025 time frame.

Recent experimental results in the 3 MW prototype unit on another coal have demonstrated that the process is technically feasible and analyses of that data has indicated that they can achieve 90% CO2 capture at a projected electricity price that is about 25% above the no capture option, reasonably close to their commercial goal.

The proposal states that “This proposed work would address potential operational issues or benefits unique to North Dakota lignite (e.g., high-sodium, high-moisture contents), optimize the chemical looping process design and operating conditions, and provide information needed to evaluate and demonstrate the use of North Dakota lignite for chemical looping combustion at a larger scale. By testing dried North Dakota lignite from Great River Energy, the work would also evaluate the benefit of pre-drying North Dakota lignite.”

Success in this overall development could lead to the availability of a lower cost boiler option for lignite fueled power plants that were required to capture 90% of the CO2 that was generated.

**Reviewer 13-21 (Rating: 3)**

The project fits within goals of the NDIC and LRC. Objectives are presented, but they are very broad and additional detail regarding how the objectives will be met are vague throughout the proposal.
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 13-19 (Rating: 3)**

*(NOTE: Reviewer 13-19 provided no comments.)*

**Reviewer 13-20 (Rating: 4)**

Bench-scale tests will be conducted to evaluate the effect of the North Dakota lignite fuel properties (high sodium and high moisture) on the LCL-CTM design and performance. The experimental test program is to culminate with a one week around the clock test of the two feed stocks, the run-of-mine lignite and the partially dried lignite. A topical report that covers the North Dakota lignite test program will be prepared.

The budget allocated for this effort appears reasonable.

**Reviewer 13-21 (Rating: 4)**

The objectives are most likely achievable given the three year project timeframe. The move of the test unit could cause some project delays, but a sufficient amount of time appears to have been allocated for the move.

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 13-19 (Rating: 4)**

There will be a significant scale up challenge in “balancing” the thermal host. Stable pressure management and control will be significant challenge using the two reactor approach.

**Reviewer 13-20 (Rating: 4)**

The description of the objectives of these tests with regard to the special features of North Dakota lignite, namely relatively high moisture and high sodium, indicate an understanding of how these characteristics impact boiler design choices.

**Reviewer 13-21 (Rating: 2)**

Overall, the test plan is fairly vague. Additional detail is needed regarding a detailed test matrix, with sampling points are frequencies. Sampling protocols related to which methods are to be used must also be stated. Details related to what analytical techniques are going to be used for analysis are also insufficient.

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 13-19 (Rating: 2)

(NOTE: Reviewer 13-19 provided no comments.)

Reviewer 13-20 (Rating: 4)

The future availability of a lower cost boiler technology, compared to currently available options and advanced options (such as oxycombustion) would present an excellent option for power producers burning North Dakota lignite.

Reviewer 13-21 (Rating: 4)

Chemical looping, if proven at the full-scale, has the ability to be a cost effective technology option for CO2 capture in the future. This project will provide valuable data on the benefits and potential challenges associated with utilizing lignite fuel in the process.

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 13-19 (Rating: 4)

(NOTE: Reviewer 13-19 provided no comments.)

Reviewer 13-20 (Rating: 4)

Expertise in the design of fluidized and circulating fluidized bed boilers is required for the successful design of the oxidation and reduction reactors used in the chemical looping technology.

Reviewer 13-21 (Rating: 1)

A list of references was included at the end of the report, but the text does not have any specific references annotated in the main body of the proposal. The references must be linked to statements, thoughts, and/or concepts within the proposal and not just a random list included at the end of the proposal.

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 13-19 (Rating: 4)

(NOTE: Reviewer 13-19 provided no comments.)

Reviewer 13-20 (Rating: 4)

Alstom is one of the world’s leading vendors of solid-fuel boilers, particularly fluidized bed and circulating fluidized bed boilers. This background provides the expertise needed to succeed in developing and commercializing the LCL-C™technology.
Reviewer 13-21 (Rating: 5)

The investigators have a very long and vast background in combustion, CFB, and chemical looping research.

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 13-19 (Rating: 3)

*(NOTE: Reviewer 13-19 provided no comments.)*

Reviewer 13-20 (Rating: 4)

The part of this project related to this question, the North Dakota lignite Task, is not described in detail in the proposal. However, the layout of the existing project is excellent. The specific deliverable associated with this additional Task, namely a Topical Report summarizing the North Dakota lignite related work is specifically called out in the proposal.

Reviewer 13-21 (Rating: 3)

The project management plan is adequate for the proposed work. The proposed time frame for the lignite test is not listed in the project schedule.

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 13-19 (Rating: 3)

*(NOTE: Reviewer 13-19 provided no comments.)*

Reviewer 13-20 (Rating: 5)

No additional equipment is to be purchased with these funds.

Reviewer 13-21 (Rating: 4)

Equipment modifications seem justified and center on modifications necessary to feed ND lignite fuel as well as material costs associated with the additional testing with ND lignite fuel.

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 13-19 (Rating: 3)

*(NOTE: Reviewer 13-19 provided no comments.)*
Reviewer 13-20 (Rating: 5)

The bench scale and Prototype equipment already in place for this work is unique. Recent operating success in achieving autothermal operation of the 3 MW Prototype is an important experimental accomplishment. Heat losses at that scale make it very difficult to achieve.

Reviewer 13-21 (Rating: 4)

The bench- and pilot-scale systems are already built and only slight modifications are proposed under the current work. The test systems appear sufficient to carry out the proposed test campaign.

10. **BUDGET**

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

Reviewer 13-19 (Rating: 1)

Total funding for effort = $625,000/Funds requested $500,000 = 20% cost share.

Reviewer 13-20 (Rating: 5)

The proposal states “In this proposal, Alstom requests $500,000 from the North Dakota Industrial Commission for the added North Dakota lignite scope. The total cost estimate for the added scope is $625,000. Alstom is committed to provide 20% of the cost as cost-share. The budget estimate for the base DOE/NETL-sponsored Alstom program PLUS the North Dakota lignite coal test is $10,489,821. The DOE/NETL cost share is $7,891,857 with Alstom, State, and industry providing the balance cost share (NDIC cost share is 4.8%).”

This is an excellent value.

Reviewer 13-21 (Rating: 4)

The budget value for the proposed project is very high because it is an add-on for an already funded DOE project, which is supplying the majority of the funds for the overall project. It would have been beneficial to secure letters of interest from additional lignite utilities, but overall the leverage of NDIC LRC dollars is very high.

**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 13-19 (Rating: FUNDING MAY BE CONSIDERED - If cost share is adjusted upward to 50%, currently 20% cost share.)

It is not clear if proposed Ignite Testing will be used in future scale up tasks. Lignite testing is “tacked onto” large existing program for developing LCL-C\(^{TM}\) technology.

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1 “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.

2 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 13-20 (Rating: FUND)

This project should be funded.

Previous work on other coals and techno-economic analyses of those earlier results lead Alstom to the conclusion that that is an attractive option for the future coal-fired boiler market in cases where 90% CO2 capture is required.

As a follow-up or under another DOE program, a standard techno-economic case study should be done for a commercial LCL-C™ plant to determine how this technology would rate compared of other lignite –fueled boiler options with 90%CO2 capture. This would provide a mechanism for NDIC/LRC participants to evaluate how this option may fit into their future plans for new lignite-fired electricity production.

Reviewer 13-21 (Rating: FUNDING MAY BE CONSIDERED)

Funding may be considered.

In general, this has the potential to be a high value project for the LRC to evaluate the benefits and challenges of firing a ND lignite fuel in a bench- and pilot-scale chemical looping process. The data collected will be able to determine key technical hurdles that must be addressed in order for the technology to be implemented at larger scales. The updated economic data will also provide some key data regarding the cost-effectiveness of the technology.

Although the project has the potential to be of high vale, the proposal was lacking in several points. A detailed test matrix needs to be developed and presented before funding can be recommended. Sampling points, sampling frequency, and methods to be employed need to be clearly stated so that a successful test campaign can be conducted with a high probability of valid data. The data associated with the sampling is critical in evaluating the challenges and benefits with firing ND lignite and is also a key aspect to any test campaign. In addition, the analytical techniques to be employed need to be explicitly stated in order to ensure that the data is valid.

Until a clear test matrix is presented, I can only recommend that the project be considered for funding.