

TECHNICAL REVIEWERS' COMMENTS

LRC-LXXVII(77)-A:

“Combustion Enhancement of Solid Fuels Using ClearSign’s Technologies”

Submitted by: ClearSign Combustion Corporation

Request for: \$50,000; Total Project Costs: \$400,000;

Principal Investigator: Joe Colannino, Chief Technology Officer

1. OBJECTIVES

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

Reviewer 14-01 (Rating: 4)

I believe this project supports the achievement of many of the Commission’s goals. I would have liked to have seen more emphasis on measuring efficiency improvements and thus CO2 emission reductions. Also, it is not immediately clear what the NOx reductions will likely be.

Reviewer 14-02 (Rating: 5)

I agree that the project is consistent with LRC goals as it promotes efficiency and clean use of lignite.

Reviewer 14-03 (Rating: 4)

No comment.

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 14-01 (Rating: 4)

The tests considered are likely to determine whether the technology has the potential to reduce emissions significantly or not. The test equipment, time and budget seem reasonable. However, a more detailed budget and more information on the kinds of tests and variables which will be changed during those tests would have been helpful.

Reviewer 14-02 (Rating: 4)

Effective furnace preparation (Task 2) will be key to accomplishing the Phase 1 objectives.

Reviewer 14-03 (Rating: 4)

No comment.

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 14-01 (Rating: 4)

The phased approach to testing the technology is a good idea. It is not clear yet what the milestones will be for determining whether to proceed with the next phase. Setting target ahead of time may be useful. At some point minimum reduction thresholds will be required to determine whether to proceed with further work. I would have also liked to have seen some rudimentary economic benefits of the achieved results estimated at the end of this phase of work.

Reviewer 14-02 (Rating: 4)

The phased project approach is good.

Reviewer 14-03 (Rating: 4)

No comment.

4. CONTRIBUTION

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

Reviewer 14-01 (Rating: 5)

The economic benefit of this technology could be quite large on a number of fronts. It appears there may be benefits on CO₂, CO and NO_x emission reduction. There may also be benefits associated with ash handling and capture. Finally, it may make coal plants more efficient reducing coal consumption.

Reviewer 14-02 (Rating: 5)

Much of the value of this proposal is found in the potential development of a suitable NO_x reduction technology that accounts for the sodium in lignite. Potential reductions in CO, PM and in boiler fouling are all meaningful to operators of generating units.

Reviewer 14-03 (Rating: 5)

No comment.

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 14-01 (Rating: 3)

The proponent provided some information showing the purported effect on flames. However, very little data was provided indicating impact on NO_x, CO or CO₂ emissions. Some information was provided on impact on ash.

Reviewer 14-02 (Rating: 5)

The White Paper included in the proposal demonstrates solid understanding of the status of research.

Reviewer 14-03 (Rating: 4)

No comment.

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 14-01 (Rating: 3)

The proponent appears to have the equipment which can operate at a wide range of conditions. It is not clear though that they know how their technology does what it does. Nor is it clear that they know how changing various variables is likely to impact the benefits expected.

Reviewer 14-02 (Rating: 5)

Mr. Colannino and Mr. Ruiz have impressive R&D credentials. Mr. Colannino has authored articles and reference books regarding combustion and modeling of combustion systems.

Reviewer 14-03 (Rating: 4)

No comment.

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 14-01 (Rating: 3)

The plan could benefit from some more detail on the testing regimes they plan to conduct. Little detail was provided on who will be conducting the tests and their expertise. They could also have provided a more detailed budget.

Reviewer 14-02 (Rating: 4)

The overall project management plan and schedule were very good. I would like to have seen more detail on the expected costs associated with the individual tasks in Phase 1.

Reviewer 14-03 (Rating: 4)

No Comment.

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 14-01 (Rating: 4)

They propose to purchase a feeding mechanism and heavy-duty high temperature camera. They also propose to design the grate required. They also propose to purchase an appropriate power supply. All of this equipment is required. However, we don't know how much they will cost.

Reviewer 14-02 (Rating: 5)

The objectives of the furnace preparation (Task 2 of Phase 1) are clearly defined, and equipment customized for the subject be obtained or built.

Reviewer 14-03 (Rating: 4)

No comment.

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 14-01 (Rating: 3)

It was not clear that they have the gas sampling technology required to monitor changes in O₂, CO, CO₂ and NO_x. It is not clear from the proposal how they plan to do this sampling and how samples will be taken and how often. The combustion facility and the equipment they need to purchase seem appropriate for the proposed tests.

Reviewer 14-02 (Rating: 4)

The solid fuels grated furnace at ClearSign, modified as required, appears to meet the needs for the Phase 1 testing.

Reviewer 14-03 (Rating: 4)

No comment.

10. BUDGET

The proposed budget "value"¹ relative to the outlined work and the financial commitment from other sources² is of: 1 - very low value; 2 - low value; 3 - average value; 4 - high value; or 5 very high value.

Reviewer 14-01 (Rating: 2)

Very little information was provided on the budget. It is not clear what the capital requirements and the operating requirements will be. The proponent does not have sufficient funds from other sources to complete the project yet.

Reviewer 14-02 (Rating: 4)

The proposer is requesting \$50,000 out of a total estimated project budget of \$400,000. Commitments have already been received for \$100,000 from SaskPower (\$25,000), Great River Energy (\$25,000) and NRECA (\$50,000). More than the minimum 50% of the Phase 1 total project budget comes from the financial commitment from other sources.

My opinion is that the ClearSign's total Phase 1 estimated cost is reasonable.

Reviewer 14-03 (Rating: 4)

No comment.

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.

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 14-01 (Rating: FUND)

This technology has the potential to provide a lot of benefit for little cost. It could help coal producers meet NOx emission reduction requirements inexpensively. I wonder though about the cost of the conductive solid or fluid they propose to inject into the fuel. I also wonder about the health effects of the electromagnetic fields they propose to create.

Given that this technology may help significantly advance many of the objectives and goals of the Commission, I recommend funding this project.

Reviewer 14-02 (Rating: FUND)

ClearSign's ECC technology offers possible improvements in several areas important to plant operators – most importantly better combustion management and reduction of criteria pollutants. I recommend that this be funded.

Reviewer 14-03 (Rating: FUND)

No comments.