

TECHNICAL REVIEWERS' COMMENTS

LRC-LXVIII(68) –B: “Oxy-Combustion Boiler Development for Tangential Firing of North Dakota Lignite”

Submitted by: Alstom Power, Inc.;

Request for: \$490,000; Total Project Costs: \$8,716,523;

Principal Investigator/Project Manager: Armand A. Levasseur; Project Duration: 10 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 09-10 (Rating: 4)

Oxy-combustion is a technology being developed to allow the continued use of coal and lignite to generate electricity in power plants equipped with cost-effective CO₂ capture equipment. The key to the oxy-combustion approach is the use of oxygen diluted with recycled CO₂ as the oxidant for combustion. By avoiding the use of air as the oxidant, the cost of CO₂ capture is markedly reduced. However, there is the additional cost of separating oxygen from air in an air separation unit. Oxy-combustion technology development is proceeding at several locations around the world. The scale of this work is still quite small (<50 M th) relative to commercial scale boilers. In the opinion of many, this technology is one of the leaders for use in utility scale commercial boilers in a future where CO₂ emissions will be constrained.

Obtaining the test data outlined in this program will allow for consideration of North Dakota lignite as a qualified fuel for oxy-combustion tangentially fired boilers in the future.

Reviewer 09-11 (Rating: 4)

The project objectives are to compare heat transfer, major gas species emissions, mercury emissions, ash deposition, and ash erosion when firing partially dried lignite in air and oxy-combustion for partially dried lignite. The main objective for BSF 3 (lignite test) is on mercury speciation and ash properties. These objectives are consistent with the NDIC/LRC goals.

Reviewer 09-12 (Rating: 3)

The testing of lignite in oxy-fuel application does meet the NDIC/LRC goals. Although 50% of the overall project has been completed for subbituminous coal, there is not a discussion as to the findings and their impact on the lignite testing proposed. BTW the only lignite being tested is the partially dried lignite. What is the technology impact on raw ROM lignite. It would seem that the economics (impact on the COE and parasitic power, etc) would be essential to meeting the NDIC/LRC goals. This activity is not proposed, leaving the bottom line of the technology in question. Perhaps it is assumed as part of the project.

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 09-10 (Rating: 4)

The proposed two-month lignite fired test program which is to be preceded by four months of testing of Subbituminous, Low Sulfur Bituminous, and High Sulfur Illinois Bituminous coals in Alstom's 15 MWth Boiler Simulation Facility (BSF) in both air-fired and Oxy-combustion configurations should be adequate to meet the test program objectives.

Reviewer 09-11 (Rating: 5)

The project is co-funded by the U.S. DOE and consortium of utilities. The budget is adequate and can be completed within the time available.

Reviewer 09-12 (Rating: 3)

There is no test matrix for the testing (parameters, test duration, etc.). There is also a discrepancy between the discussion on pg 26 relating to the interest in gaseous emissions testing by EERC for Campaign 2, and the list of "key issues" on pg 12, Key Objectives of mercury speciation and ash properties on pg 22 and Standards of Success on pg 27. The forms of Hg in lignite should follow the oxidation trend that already observed for subbituminous coal in their project (Campaign 1). Is the project going to conduct Hg control or capture testing?

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 09-10 (Rating: 4)

The program is very well organized with a very clear focus on obtaining the data required to support future commercial scale design activities.

Reviewer 09-11 (Rating: 4)

The combustion and air pollution control devices are very good. The measurements to be made also appear to be appropriate based on the proposal. Mercury measurement using the CMMs to determine potential for accumulation is good. The methodology to determine level of aerosols in flue gas was not clear. Aerosol formation during lignite combustion can have impacts on downstream gas cleanup systems. Simply determining ash loading may not be sufficient. Size distribution of the ash may be important.

Reviewer 09-12 (Rating: 4)

If the purpose of Campaign 3 is to document the performance of partially dried lignite in an oxy-fired system, then the methodology is above average. It is not clear how the testing addresses the bottom line (economics) and mercury capture technology performance. Can the Hg speciation and ash properties testing can be achieved from smaller-scale testing?

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 09-10 (Rating: 3)

The data collected will be applicable to the future design of commercial scale Alstom oxy-combustion tangentially-fired, lignite fueled boilers sometime in the future. The results of this program are necessary to meet that objective. It is possible that this specific work will define the need for additional experimental efforts required to deal with any problems that are encountered.

Reviewer 09-11 (Rating: 3)

The scientific/technical contributions of this project have the potential to be great. Major challenges for lignite include moisture and sodium content. The moisture content is being addressed by testing a partially dried lignite. Comparison of the results of testing to run-of-mine is unclear. The fate and behavior of high sodium containing lignite will not be adequately addressed. Falkirk lignite typically does not contain levels of sodium that are very challenging. Lignites from other mines can contain levels of sodium oxide in the ash that are above 6 %. Determining the mercury speciation is very important and will be a contribution.

Reviewer 09-12 (Rating: 4)

The proposed large scale testing of partially dried lignite (albeit only one type of lignite fuel) present very significant scientific and technical contributions. The proposal states that Alstom can go from this testing to designing a commercial system. As such, one would assume that the costs and impacts on COE would result from this work. If that is the case, this work would represent a major step forward in addressing this CO2 capture technology.

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 09-10 (Rating: 4)

The proposal cites up-to-date experience with worldwide oxy-combustion development activities and facilities.

Reviewer 09-11 (Rating: 4)

The principal investigator is very knowledgeable regarding the oxy-firing of fuels. The PI did not demonstrate in the proposal an adequate knowledge of lignite properties and potential challenges in the proposal. However, it is likely that the PI is aware of the issues because of involvement in past programs. The participation of GRE and EERC in the project is very good and will likely make sure the unique properties of lignite are considered in the testing.

Reviewer 09-12 (Rating: 4)

The proposer is aware of the state of the oxy-fuel technology and with GRE they are aware of the costs and state of the art of GRE's drying 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 09-10 (Rating: 4)

The team proposed for the project is well qualified as a result of their long term experience with the design of T-fired boilers and the development and utilization of BSF generated data that will support their future design activities.

Reviewer 09-11 (Rating: 4)

The backgrounds of the PIs in the program are very good. They have significant experience in combustion and air pollution control systems.

Reviewer 09-12 (Rating: 5)

The principal investigator and the team are very qualified as demonstrated with their resumes and the company's involvement in oxy-fuel development.

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 09-10 (Rating: 3)

The milestone chart and schedule are well defined. There is no budget by task presented for this large project, which would have been helpful in comparing the cost of the incremental add-on effort with the remainder of the project. The paragraphs dealing with communication mention periodic meetings with the sponsors and distribution of periodic reports. The only reference to reports to be delivered to NDIC is the statement that "In addition, progress reports will be provided as required by NDIC". More attention should have been paid to normal NDIC requirements in preparing estimates of the incremental cost of the lignite-based experiments.

Reviewer 09-11 (Rating: 5)

The project management plan is well defined.

Reviewer 09-12 (Rating: 4)

The project management plan is dictated by the DOE requirements and is very good. The schedule for the work is 3 months and as such saves money by adding onto an existing program. The budget is defined and the communication to NDIC is also well defined.

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 09-10 (Rating: 5)

It has been assumed by this reviewer that no equipment will be purchased for this incremental add-on effort. NDIC may want to confirm this assumption

Reviewer 09-11 (Rating: 5)

The breakdown between equipment/supplies appears to be all materials and supplies for a total of \$236,400. No equipment is to be purchased.

Reviewer 09-12 (Rating: 5)

The budget shows no equipment to be purchased as part of the proposed NDIC funding.

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 09-10 (Rating: 5)

The BSF is a very powerful tool that has been used in the past by Alstom to scale up elements of their T-fired boiler technologies

Reviewer 09-11 (Rating: 5)

The facilities and equipment at PPL are excellent.

Reviewer 09-12 (Rating: 5)

The testing facilities are exceptional and represent a large-scale demonstration (15MWe).

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 09-10 (Rating: 5)

According to the proposal the incremental add-effort is estimated to cost \$653,737 (not including \$50,000 of in-kind funding from GRE for dried lignite fuel). The total estimated project budget is \$8,716,523 (including the \$50,000 GRE contribution for dried lignite and the \$490,000 requested from NDIC). The amount requested from NDIC, which will be used support the testing of North Dakota lignite (and none of the other parts of the larger project) represents 5.6% of the total project budget,

However the requested NDIC contribution amounts to 75% of the cost of this incremental add-on with the other project participants picking up the remaining 25%.

This overall arrangement does represent a good value for NDIC.

IV-B-2-5

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 09-11 (Rating: 5)

The financial commitment from other source including DOE and Alstom are significant. The ability to have lignite tested as part of the program is good value and meets Industrial Commission guidelines.

Reviewer 09-12 (Rating: 4)

The value of the proposed work is a high value for the project overall. The value of the proposed Campaign 3 can be considered as average if the economics, mercury capture, and the ROM lignite testing and analysis are not provided as part of the testing.

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 09-10 (Rating: FUND)

This project should be funded.

This proposal requests funding for the testing on North Dakota lignite in an incremental two-month add-on effort to a twenty-four month project funded by DOE and other participants.

The base program will test Subbituminous, Low Sulfur Bituminous, and High Sulfur Illinois Bituminous coals in Alstom's 15 MWth Boiler Simulation Facility (BSF) in both air-fired and Oxy-combustion configurations, The test results will enable Alstom to develop a design basis for commercial scale 850 MW tangentially-fired (T-fired) boilers that utilize the Oxy-combustion approach.

The project is well organized and the results are intended to allow Alstom to provide commercial designs for North Dakota lignite T-fired boilers. In the absence of this add-on project, the cost of a stand-alone program to accomplish the same goal would be much higher.

Reviewer 09-11 (Rating: FUND)

This is a good project that will provide important information on the combustion characteristics and resulting emissions of a selected ND lignite during oxy-firing. The lignite proposed to be used in the study is a partially dried lignite from the Falkirk mine of ND. The testing will provide data that can be used in future designs of oxy-fired boiler and retrofits to existing boilers. The project addresses some of the key challenges for ND lignite that include the ash properties and mercury speciation. The project will not address the impacts of high sodium lignite on combustion and emission control systems. The use of partially dried lignite is a very good idea; however, discussion on how it will be compared to run-of-mine lignite was not adequately addressed. This project will provide some of the key data needed for the use of ND lignite in oxy-fired systems. I recommend that the project be funded.

Reviewer 09-12 (Rating: FUND)

The existing DOE funded proposal is a very good scientific and technical evaluation of a limited number of coal types in a large-scale demonstration (15 MWe) oxy-0fired facility. The technical issues that the project addresses are sound and the results will contribute to the technical viability of the technology for CO2 capture.

The proposed “add-on” project, funded essentially 90% (\$26K EERC DOE and \$50K GRE in-kind), is limited in that it addresses (1) only a subset of ND lignite fuels – partially dried lignite from GRE’s process,(2) only mercury speciation by EERC (\$100k effort), and ash properties testing under bench-scale testing. The speciation and ash properties under oxy-fired conditions seem to be more economically achieved in smaller-scale units. As such, the large costs of operating the 15MWe facility for these objectives can be questioned.

The overall project proposal speaks to the resulting information being sufficient to design and build a commercial unit, yet the economics and impact on COE are not specifically addressed in the proposal, either on an absolute basis or in a comparative basis between the fuel types. Some estimate of the cost impacts would certainly strengthen the proposed results and assist in meeting the goals of the NDIC/LRC.

Although it is recommended to fund the project, perhaps clarity on the above mentioned issues can be addressed and some sort of economics of the oxy-fired combustion of GRE’s partially dried lignite on COE be included.