TECHNICAL REVIEWERS' COMMENTS

LRC-LXXV(75)-D

"Feasibility Assessment of the NET Power Electric-Generation Technology when fueled with North Dakota lignite"

Submitted by: ALLETE, Inc.;
Request for: $150,000; Total Project Costs: $1,000,000;
Principal Investigator: William Sawyer

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 13-7 (Rating: 4)

Overall objectives are well defined for the project, however they could be more specific on how objectives would be met.

Reviewer 13-8 (Rating: 4)

The objective of this proposal is to complete a feasibility study of the NET Power system fueled by ND lignite. The proposal is consistent with NDIC/LRC goals and objectives to promote the use of lignite preserve jobs and create new jobs and ensure economic stability.

Reviewer 13-9 (Rating: 4)

The objective is to determine the feasibility of an innovative clean coal power generation cycle that is applied to lignite is clear and consistent with NDIC and LRC goals.

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 13-7 (Rating: 3)

Medium potential to achieve the stated goals based on what was presented. No real solid presentation on the technical approach. What software platform will be used (ASPEN, ThermoFlow and etc)? What unit operators will be modeled (some of these are mentioned in the proposal but there functionally is not described)? How detailed are the fundamentals for each unit operator? Without functions for unit operators that are well define in terms of the fundamentals of temperature, pressure, mass and volume flow rates, combustion chemistry, and heat transfer there will be little chance of achieving the objectives.

Reviewer 13-8 (Rating: 4)

The objectives of the proposal are most likely achievable. Similar studies are in progress, other studies have been completed, and studies are available on the Internet. Based on past and existing work, the proposed activities are most likely achievable.

Reviewer 13-9 (Rating: 4)

Budget is appropriate for the work conducted.

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 13-7 (Rating: 2)

The methodology is weak. System studies like these are very much dependent on what is in the "black box". If there are no first principle functions in the box then there is no chance of conducting a sensitivity study as a function of common parameters.

Cost studies can often be problematic when absolute values are discussed. One way to deal with this is to try and compare cost for different cases and hope that the errors in absolute numbers can be subtracted off and just difference examined. For instance what is the impact on cost for varying gasifier pressure or turbine firing temperature ? The best result might be to conclude and order of magnitude understanding of how changing certain parameters effect cost (a sensitivity analysis).

Reviewer 13-8 (Rating: 4)

The methodology displayed in the proposal is above average. The proposal contains sufficient management tools and qualified program management personnel to demonstrate above average capabilities.

Reviewer 13-9 (Rating: 3)

The methodology in general is appropriate. However the use of information derived from bituminous coal regarding feasibility of a lignite-fired technology is likely to have limited value. The properties of lignite are significantly different than bituminous coals and work needs to be conducted that are specific to lignite.

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 13-7 (Rating: 4)

Assuming objectives are met as stated the contribution of this work would be valuable to the funding agency and to the general community that is following the development of power systems based on directly heated (coal or natural gas) supercritical CO2 power cycles.

Reviewer 13-8 (Rating: 5)

The scientific and technical information derived from the proposed work could be extremely significant. Information on the combustion, separation, electrical generation and sequestration association with CO_2 is extremely critical for the lignite industry.

Reviewer 13-9 (Rating: 3)

The potential for a significant contribution is great. The proposal did not provide a clear description of how the influence of lignite's unique properties will be considered regarding the unique design and operation.

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 13-7 (Rating: 4)

The principals and partners involved in this project (EPRI;s David Thimsen and NET Power's David Freed) are very good and collectively have an extensive understanding of IGCC and the NET Power system. Supporting partners CB&I and Progressive Energy (Particularly CB&I) should bring good cost insight to this project.

Reviewer 13-8 (Rating: 4)

The PI's awareness of current activities is evident in the reference to existing industry programs. The PIs provide limited footnote reference to published literature or current activities. However, sufficient information is available in attached publications and easily available on the Internet to demonstrate the PIs awareness.

Reviewer 13-9 (Rating: 2)

Research on the use of lignite in gasification systems has been conducted for decades and is in the open literature. The effects of lignite properties on the performance of gasification, gas cooling, and gas cleanup systems has been a key component of the research activities supported by the NDIC over the past several years. In addition, there are numerous publications and reports in the open literature. The value of the EPRI lignite study is unknown since it is not in the public domain.

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 13-7 (Rating: 4)

Note: Reviewer 13-7 provided no comments.

Reviewer 13-8 (Rating: 5)

The background of the investigators is exceptional as related to the proposed work. The expertise available in the lignite, electrical generation and construction/engineering industry and EPRI makes this proposal exceptional.

Reviewer 13-9 (Rating: 4)

The backgrounds of the investigators are better than average.

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 13-7 (Rating: 5)

Note: Reviewer 13-7 provided no comments.

Reviewer 13-8 (Rating: 4)

The project management plan is very good. The proposal includes more than adequate detail and individuals with very good program management skills. This combination makes a very good program management plan.

Reviewer 13-9 (Rating: 4)

Involvement of ALLETE and Dakota Gasification in the details of the study are essential in ensuring this project is a success. It is essential that their direct experience with lignite properties and behavior be transferred in such a way that the other project participants – EPRI, CB&I, NET Power – are able incorporate the information specifically on lignite to the feasibility study.

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 13-7 (Rating: 5)

Note: Reviewer 13-7 provided no comments.

Reviewer 13-8 (Rating: 5)

"No capital equipment will be purchased as a part of this Project." - *(Proposal, page 15)*

Reviewer 13-9 (Rating: 5)

Note: Reviewer 13-9 provided no comments.

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 13-7 (Rating: 5)

Partners and participants should have all of the required tools, at a sophisticated level, to complete this project.

Reviewer 13-8 (Rating: 5)

The facilities available for this project are exceptional.

Reviewer 13-9 (Rating: 5)

Note: Reviewer 13-9 provided no comments.

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 13-7 (Rating: 5)

Budget is reasonable and well cost shared. If all of the stated standards for success (page 7 especially number 3) are met the project will be of a very good value. I would take two at this price if all stated objectives can be met.

Reviewer 13-8 (Rating: 5)

The proposal includes matching funds from a variety of sources. The proposal contains a high percentage of funding from non-Lignite Research Fund sources. The ND lignite industry is providing $1 for each Lignite Research Fund 1$. Other sources of matching funds make this a project of very high value.

Reviewer 13-9 (Rating: 5)

See below.

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 13-7 (Rating: FUND)

Funding is recommended.

Overall this would be a technically valuable piece of work with a budget that can be fully justified. However my experience with system models for this technology is that they need to be rigorous with significant technical detail.

Some general concerns include:

Heat exchangers and recuporators: What are the approach temperatures, what are the pinch point temperatures. Are there any cross over temperatures? What are the designs?

[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.

IGCC integration with the supercritical CO2 Power cycle: Benefits have been claimed with this integration but a full technical disclosure / explanation has not been completely forthcoming.

Gas stream cleanup will be a concern for this application along with the buildup of contaminants.

How will the oxy-fuel (oxygen and Syngas) combustion be modeled, this is very high pressure, combustion could be an issue

The general turbo machinery configuration needs to be established along with the overall efficiency of the turbo machinery.

How will trace amounts of O2 in the working fluid be dealt with or is it not a concern?

Reviewer 13-8 (Rating: FUND)

The strengths of this proposal include:

1. high percentage of funding from other sources,
2. program participation from a variety of qualified sources,
3. the potential significance of the work to ND and the industry,
4. the overall quality of the proposal, and
5. the outstanding capability of the participating PIs.

The weaknesses of this proposal include:

1. the limited published and available technical and economic detail provided in the proposal,
2. an explanation why the use of lignite could be technically desirable or economically advantageous,
3. uncertainty with regard to the marketability of sequestrated CO_2 in ND, and
4. any reference to the potential of a future demonstration project.

The limited basic technical information is a significant weakness in this proposal. For those not familiar, US Patent 2011/0179799 A1 provides an excellent source of technical information for the NET Power System. Likewise, National Energy Technology Laboratory (2010) "Cost and Performance Baseline for Fossil Energy Plants Volume 1: Bituminous Coal and Natural Gas to Electricity", presents technical and economic information on comparative technical and fuel source options addressing the issue of CO_2 emissions and sequestration. The publication provided with the proposal is an excellent starting point which is further enhanced by reviewing these two sources of information available on the Internet. The area of CO_2 emissions, capture and sequestration are extremely important to lignite and all fossil fuel based electrical generation. Therefore, this type of work is very significant for ND, the lignite industry and fossil fuel electrical generation. The CO_2 combustion/sequestration approach to electrical generation may be a potential means to achieve an economic advantage. Therefore this work is recommended for funding.

Reviewer 13-9 (Rating: FUNDING MAY BE CONSIDERED)

The determination of the feasibility of a lignite fired NET Power Electric-Generation Technology to produce electric power and carbon dioxide is consistent with the goals of the NDIC LRC goals. The project has the potential to provide information that can be used to identify the optimum next generation lignite power system. The major flaw of the proposal was the lack of discussion and reference to literature that would demonstrate an understanding of the influence of lignite properties on the design/operability of a gasifier, gas cooling, and gas cleanup system. Based on the lack of this information a consider for funding may be considered recommendation is made.