TECHNICAL REVIEWERS' COMMENTS

LRC-LXXVI(76)-C:
"ION Advanced Solvent CO_2 Capture Project"
Submitted by: ION Engineering;
Request for: $1,000,000; Total Project Costs: $20,194,045;
Principal Investigator: Alfred (Buz) Brown, Ph.D.

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 13-16 (Rating: 4)

(NOTE: Reviewer 13-16 provided no comments.)

Reviewer 13-17 (Rating: 4)

Although testing will not be on a ND lignite specifically, CO2 Capture may be crucial to ND plant viability.

Reviewer 13-18 (Rating: 2)

According to the ABSTRACT " The primary objective of this project is to test ION's lead CO_2 capture solvent under more realistic somewhat larger slipstream conditions (~ 0.7 MWe) during continuous long-term operation, and to demonstrate significant progress is being made to meet or exceed DOE's goal for second generation solvents of 90% CO_2 capture rate with 95% purity at a cost of $40/tonne CO_2 captured by 2025. As part of this goal, the project seeks to gather data at pilot slipstream scale of 0.5-1.0 MWe that is considered essential and necessary for scale-up and testing at 10-50 MWe, the next logical scale of testing as stated by DOE."

Smaller-scale test programs previously completed at EERC that utilized flue gas generated by combustion of low-sulfur Powder River Basin (PRB) coal have shown promising results in tests evaluating a first generation ION imidazole-amine solvent. Based on test results, calculations showed a potential to achieve a CO2 capture cost of $27/tonne, which is less than the DOE goal of a CO2 capture cost of less than $40/tonne.

Negotiations are under way with the Nebraska Public Power District to site a 0.5-1.0 MWe slip-stream pilot plant processing a flue-gas slipstream from the 1365 MW Gerald Gentleman Station power plant to collect the desired performance data. That plant is fueled with low-sulfur Powder River Basin Coal.

According to the proposal, the benefit to the North Dakota Industrial Commission (NDIC)/Lignite Research Council (LRC) for its proposed contribution of $1 million is:

> "Sponsorship by ND in this scale-up technology demonstration project will show continued support to advance CO2 capture technologies that will lead to cost-effective solutions and options that can be implemented in the future as CO2 regulations are implemented. Involvement in the project will provide ND utilities and coal companies with immediate and emerging information on a second generation CO2 technology that has promise to greatly reduce energy requirements and significantly lower capital and operating cost. While the technology and data that will be generated as part of the proposed project are believed to be directly applicable and transferrable to ND lignite plants and coals, sponsorship by ND will ensure that participants are fully aware of technology advancements and will further allow them input into the project to ensure that lignite-specific criteria is discussed and considered as the pilot-scale system is designed, constructed, and operated.
>
> The sponsorship of demonstration projects such as this provides the state with immediate access to information needed to make strategic decisions to prepare for the implementation of future regulations. Most of the data that will be generated is universal to coal use, independent of coal type, and directly applicable to the energy production of North Dakota."

It is not necessarily true as the proposal contends that "While the technology and data that will be generated as part of the proposed project are believed to be directly applicable and transferrable to ND lignite plants and coals". It is not clear to this reviewer that participation in this project, as currently defined will provide the NDIC/LRC and its participants with significant value beyond that which would be obtained from reading the DOE project reports.

Enhanced value to the NDIC/LRC would be provided by including lignite focused tests and analysis that would provide a mechanism to relate the performance of this solvent and pilot plant unit to make predictions about the performance that would be achieved when the system was used with a North Dakota lignite derived boiler flue gas. For example, the impurities present in the flue gas are different when firing the boiler with PRB coal or lignite. A project report addressing these differences would allow NDIC/LRC members to assess the potential value of these project results to their long-term decision making. Bench scale tests at EERC on North Dakota lignite in the same bench scale unit that was used unit for the preliminary PRB fueled tests would provide a data base for those comparisons.

Adding a standard analysis of a 550 MW power plant fueled with North Dakota Lignite that utilized the advanced ION solvent for CO2 capture would be a significant benefit to the NDIC/LRC and its participants

Utilizing NDIC/LRC funds, at least in part for such additional test and analysis Tasks would provide greater value to the NDIC/LRC for its proposed contribution.

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 13-16 (Rating: 4)

(NOTE: Reviewer 13-16 provided no comments.)

Reviewer 13-17 (Rating: 4)

The description shows the execution of the project is very well thought out. Its time frame is not overly aggressive.

Reviewer 13-18 (Rating: 4)

Assuming that the project undergoes some limited restructuring to include for lignite focused tasks, the project budget still appears appropriate.

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 13-16 (Rating: 4)

(NOTE: Reviewer 13-16 provided no comments.)

Reviewer 13-17 (Rating: 4)

Great detail on the methodology.

Reviewer 13-18 (Rating: 4)

The project is well organized and logically developed. The gated structure with subsequent budget phases dependent on the success of work previously accomplished provides an important control mechanism to avoid unnecessary expenditures

The 1400 hour duration test as the final demonstration test of the optimum solvent/operation condition selection should provide an adequate of the long term stability of the solvent and equipment.

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 13-16 (Rating: 3)

(NOTE: Reviewer 13-16 provided no comments.)

Reviewer 13-17 (Rating: 3)

Looks good as of now. Hopefully some even less expensive technologies will come up over the next 10 years.

Reviewer 13-18 (Rating: 2)

The project has to be restructured somewhat as discussed in 1 above to specifically address the predicted performance of this technology, both solvent and equipment, when removing CO2 from flue gas resulting from combustion of North Dakota lignite.

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 13-16 (Rating: 4)

(NOTE: Reviewer 13-16 provided no comments.)

Reviewer 13-17 (Rating: 4)

The request touches a wide range of CO2 studies that some are even going full scale.

Reviewer 13-18 (Rating: 4)

The comparisons in the proposal that compare the potential performance of this solvent system chemistry with other currently available solvents in terms of heat required for regeneration and CO2 loading point out the potential value of the imidazole solvents that are proposed.

There is no discussion of the costs of these solvents specifically compared to alternate solvents. If these are expensive but with very good long term stability, this may not be an issue. The calculated cost per ton of CO2 captured is below the DOE goals noted in 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 13-16 (Rating: 4)

(NOTE: Reviewer 13-16 provided no comments.)

Reviewer 13-17 (Rating: 4)

The team described and potential hires will help the PI accomplish the goals.

Reviewer 13-18 (Rating: 4)

The leaders and staff of the various teams that have been put together for this project are all well qualified.

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 13-16 (Rating: 4)

(NOTE: Reviewer 13-16 provided no comments.)

Reviewer 13-17 (Rating: 3)

The plan is great, but hard to determine as detailed as it is until progress is made.

Reviewer 13-18 (Rating: 4)

A very detailed schedule with an appropriate budget breakdown by major Task is included in the proposal.
The project management approach and communication paths are well described.

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 13-16 (Rating: 3)

(NOTE: Reviewer 13-16 provided no comments.)

Reviewer 13-17 (Rating: 4)

The equipment will be needed. I am not fluent enough to judge sole sourcing sulzer.

Reviewer 13-18 (Rating: 3)

The major equipment purchase is the pilot plant at ~$6 million. There is no backup presented in the proposal for that estimate. Sulzer, the proposed vendor for that pilot plant. has a long history of supplying distillation equipment.

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 13-16 (Rating: 3)

(NOTE: Reviewer 13-16 provided no comments.)

Reviewer 13-17 (Rating: 3)

I would give a higher number if test was in ND.

Reviewer 13-18 (Rating: 3)

The major equipment to be purchased will be supplied as a package unit. A shakedown period to debug and learn to operate the unit has been included in the budget. This is appropriate.

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 13-16 (Rating: 4)

From perspective of $1M of funding for a $15M project is great leverage. The question is whether the LRC wants to take into account the DOE cofounding funding.

Reviewer 13-17 (Rating: 5)

Only covering 5% of total project cost and slip streams can provide significant information.

Reviewer 13-18 (Rating: 3)

This reviewer's issue with the value are related to the absence of any Tasks in the work Scope that are specific to power plant operation with North Dakota lignite. The NDIC/LRC has been asked to contribute $1 million to a $20 million project budget. It's only 5%, but the value is questionable since this project is specifically focused on operation with PRB coal. The value to the NDIC/LRC could be markedly enhanced if there was some deliverable that would allow the LRC and its participants to have some estimates of this system performance on North Dakota lignite

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 13-16 (Rating: FUNDING MAY BE CONSIDERED)

Good proposal w/broad applicability to existing pulverized coal fleet.

Reviewer 13-17 (Rating: FUND)

I recommend to fund. I believe this is an easy decision because of the push to find CO2 capture and the potential application in ND in the future.

[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 13-18 (Rating: FUNDING MAY BE CONSIDERED)

The flaws that this reviewer sees in this project are related to the observation that no Tasks that provide any new analysis, data, or CO2 capture cost estimates that are related to performance on North Dakota lignite. By utilizing a fraction of the $1 million that the NDIC/LRC has been asked to contribute, these issues could be addressed appropriately.

I would not recommend funding this project at the requested level unless the scope was modified to add some deliverables that would provide cost and performance estimates of how this solvent system and associated equipment would perform with North Dakota lignite.