

TECHNICAL REVIEWERS' COMMENTS
LRC-LXV-(65)-A

“CO₂ Capture Demonstration Project”

Submitted by: Basin Electric Power Cooperative.

Request for: \$2,700,000; Total Project Costs: \$5,400,000.

Project Manager: James J. Sheldon; Project Duration: 6 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 08-13 (Rating: 4)

The objective of the “Grant Application for a CO₂ Capture Demonstration Project” is to complete a Front End Engineering Design (FEED) study for a Powerspan ECO-SO₂ and ECO₂ demonstration project on AVS Unit 1. The goal is to provide a liquid stream bearing (NH₄)₂SO₄ for making fertilizer. A goal of the Powerspan ECO₂ technology is to remove 90% of the CO₂ from the flue gas stream and recover 3,000 tons per day of pipeline quality CO₂. The FEED study goal is to provide engineering detail, schedule and a ±15% cost estimate for a 120 MW demonstration plant.

The objectives are very clear and consistent with the NDIC/LRC goals: 1) Promote economic, efficient, and clean uses of lignite, 2) Preserve and create jobs, 3) Ensure economic stability, growth and opportunity, 4) Maintain a stable and competitive tax base, and 5) Conduct development in an environmentally sound manner. The proposal is consistent with the definition of a Clean Coal Demonstration Project.

Reviewer 08-14 (Rating: 4)

Carbon management, i.e., capture and sequestration, from lignite-fired power plants is a critical issue with regulations limiting CO₂ emissions likely to be implemented in the future. Lignite’s role as a major fuel source in the power generation industry, and hence as an integral part of North Dakota’s economy, will hinge upon CO₂ capture and sequestration technologies. Therefore, the overall goal of the proposed research most definitely is consistent with the NDIC/LRC goals.

Reviewer 08-15 (Rating: 3)

The objective of this project is to complete a FEED (Front End Engineering Design) Study that will allow Basin Electric (the owners of both the Antelope Valley Station and the Great Plains Synfuels plant) to generate a cost estimate with a ±15% accuracy for the design of a 120 MW (equivalent) slip-stream CO₂ capture plant. The plant will be designed to capture 90% of the CO₂ in that flue gas stream. The pre-treatment section of that plant will also capture SO₂ from the flue gas and send an ammonium sulfate-rich liquid stream to the section of the Great Plains Synfuels plant that recovers ammonium sulfate crystals. The technologies being demonstrated are owned by Powerspan Corporation. The CO₂ capture technology is known as ECO₂. The SO₂ capture process is known as ECO-SO₂. Both processes utilize an aqueous ammonia solution for separate capture of SO₂ and CO₂.

Several other commercial-scale ECO₂ projects are proceeding toward construction for treating flue gases resulting from power generation utilizing other coals.

This project would be the first to demonstrate the capture of a significant amount of CO₂ from a power plant burning North Dakota lignite. The technology could be used to retrofit existing lignite-burning power plants as well as for new power plants burning North Dakota lignite. As such the project would be consistent with the NDIC goal of contributing to the development and demonstration of technology that will maintain and increase the use of North Dakota lignite.

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 08-13 (Rating: 4)

Given the approach, time and budget outlined in the proposal the objectives are most likely achievable. Given the background, support, engineering expertise and operations of BEPC, DGC, Powerspan ECO and others, the objectives are most likely achievable.

Reviewer 08-14(Rating: 4)

The specific objective of the proposed project, delivery of a FEED study, is most likely achievable with such a large budget (\$5.4 million) although diligent project coordination and management will be critical to meet the 6-month schedule.

Reviewer 08-15 (Rating: 4)

The total budget for this project is \$5.4 million with \$5.0 estimated for the FEED study and \$0.4 million for administrative and internal costs. The scheduled duration of the FEED study is six months. That study will begin after one month of satisfactory operation of a pilot plant unit at the Burger Station of First Energy.

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 08-13 (Rating: 4)

The quality of the methodology is above average. The proposal combines existing and new demonstration scale operational data and knowledge yielding an above average methodology.

Reviewer 08-14 (Rating: 4)

The various components that need to be addressed in the FEED study appear to be well thought out. The project team has done a good job identifying the critical areas that need to be studied.

Reviewer 08-15 (Rating: 4)

The description of the work to be done under the FEED appears to address all the key technical issues associated with integration of the ECO-SO₂ and ECO₂ technologies with the existing power and synfuels plants.

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 08-13 (Rating: 5)

The scientific and technical contribution of the proposed work to address NDIC/LRC goals will be extremely significant. Regulatory actions, based on perceived adverse impacts from anthropogenic CO₂ emissions, represent a major challenge to existing and future uses of North Dakota lignite. Work in the area of CO₂ capture, control and sequestration is extremely important for the long term health and existence of the lignite industry.

Reviewer 08-14 (Rating: 5)

The information obtained from a large carbon management demonstration is critical in ensuring lignite's continued role as a leading fuel source in North Dakota. As a first step, the FEED study must be performed in order for the interested parties to make decisions. Therefore, the contribution from the proposed work is extremely significant to the economic livelihood of North Dakota.

Reviewer 08-15 (Rating: 2)

The work described for the feed is very specific to the Antelope Valley Station and the Great Plains Synfuels plant and relates to integrating the ECO-SO₂ and ECO₂ technologies with operations in those two plants. Its goal is to complete a ±15% cost estimate. Previously a three-month duration Feasibility Study was completed that produced a ±30% cost estimate of \$200-300 million for this project. The purpose of this project is to produce a more accurate cost estimate on which the Basin Electric Board of Directors can make a more informed decision about whether to proceed with approval for construction of the new facilities at their plant.

Since the scope of the work is so specific, the scientific/technical contribution of the project is likely to be small.

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 08-13 (Rating: 3)

Referenced literature is very limited in this proposal. Referenced literature is supported by footnotes and a bibliography, neither of these is found in this document. However, the discussion of scientific, technical and engineering aspects of the work are sufficient to justify an adequate level of awareness. Why not cite the literature?

Reviewer 08-14 (Rating: 3)

There is some indication of the principal investigator's awareness of current research activity as it pertains to Powerspan's process development and testing and PCOR's objectives. This is adequate because the intent is to use a specific process in the future demonstration.

Reviewer 08-15 (Rating: 2)

There is no discussion in the proposal about the technical issues associated with SO₂ and CO₂ capture from flue gas derived from combustion of North Dakota lignite, the relative capital cost, the technical advantages/disadvantages, the CO₂ capture cost of these technologies compared to other technical approaches for CO₂ capture such as the use of amine scrubbers.

Therefore the technical contribution of this work to the general subject of capturing CO₂ in flue gas generated by combustion of North Dakota lignite is likely to be small.

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 08-13 (Rating: 5)

The background of the investigators and the expertise available in the principal organizations is exceptional as related to the proposed work. This area is an outstanding feature of the proposal.

Reviewer 08-14 (Rating: 4)

The lead investigator, James Sheldon, is relatively inexperienced, especially for a project of this size and importance. I have concerns about him managing a project of this size to be able to stay on the schedule that is proposed. However, the supporting team looks strong as it is very experienced and these individuals will need to make sure that the lead investigator receives the support he needs to successfully complete the project.

Reviewer 08-15 (Rating: 4)

The personnel proposed for this project by Powerspan and Burns and McDonnell are very familiar with the proposed technologies and estimating the costs of power plants modifications respectively.

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 08-13 (Rating: 3)

The project management plan may be adequate. The AVS Milestone Schedule (Appendix C, page 69) provides an overview through 2013. However, the use of Gantt, communication, organization and milestone charts for the FEED project were not found. A Statement of Work (SOW) and appropriate management charts for the FEED Phase (Appendix C) would be helpful. When are the deliverables due? Are the deliverables of the FEED study described in pages 12-31 confidential?

Reviewer 08-14 (Rating: 1)

In my opinion, this is a major weakness of the proposal. There is a schedule proposed but no details regarding milestones, a financial plan, a plan for communications among investigators and subcontractors. This is definitely a shortcoming for such a major project (\$5.4 million).

Reviewer 08-15 (Rating: 3)

The proposal does not contain a milestone chart, detailed schedule, financial plan, or communication plan for the six-month FEED study. It is reasonable to assume that such plans exist in view of the experience of the companies involved.

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 08-13 (Rating: 1)

The level of detail in the proposed budget is insufficient to determine what equipment purchases are proposed. In fact, the level of detail is insufficient to justify any cost item.

Reviewer 08-14 (Rating: 5)

No equipment to be purchased. This is a paper study.

Reviewer 08-15 (Rating: 5)

No equipment is to be purchased.

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 08-13 (Rating: 5)

The facilities and equipment available are exceptionally good.

Reviewer 08-14 (Rating: 4)

No equipment is needed in the project. Facilities are primarily personnel for the study.

Reviewer 08-15 (Rating: 3)

This is a paper study. No equipment is to be used in this project.

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 08-13 (Rating: 4)

The budget is a high value for the proposed work. The budget is of high value because of the proximity, information, operation and expertise of the BEPC, AVS, and DGC. The operation of the Burger Plant in Ohio is very significant to the 'high value' and the Burger plant operation should be monitored.

Reviewer 08-14 (Rating: 3)

Basin Electric is providing 50% cost share in the form of cash and in-kind support. This meets NDIC's requirement but I am surprised that a project of such importance to the lignite industry is not receiving support from other sources. I would think that mining companies and other lignite utilities would be interested in the outcome of a project such as this and would be providing support to the project as well, thereby reducing the overall burden on NDIC.

Reviewer 08-15 (Rating: 3)

The 50% cost sharing meets the minimum requirement. Since the project is so specific and involves support of a project that is a normal part of the steps normally taken by management to arrive at an investment decision, a higher fraction of cost sharing might be considered more appropriate.

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 08-13 (Rating: FUND)

The merits of this proposal are the technical area, participants, supporting activities and the proposed site. The perceived adverse impact from anthropogenic CO₂ emissions on global climate change is the largest threat to the lignite industry. The relatively high CO₂ to energy (Btu or MWH) ratio makes lignite particularly vulnerable to potential CO₂ regulations. The CO₂ capture and pipeline ready costs of \$45 to \$50 per ton in 2012 are significant. It is important to continue to follow and compare the lignite costs including CO₂ capture costs to alternative electrical generation options. In addition, this technical alternative must be protected from adverse and preserved by legislative initiatives.

The participants in this proposal provide a unique combination of expertise and interest capable of solving technical and scientific aspect of this project. Powerspan provides technology and information from previous research and operation. BEPC/AVS provides technical and operations capability of the lignite-electrical generation industry. DGC provides the knowledge of (NH₄)₂SO₄ fertilizer plant operations and CO₂ capture and pipeline operations.

The operation of the Burger Plant in Ohio is important. The FEED 120 MW proposed AVS site is a reasonable scale-up from the 50 MW Burger Plant. Supporting activities and operation at the Burger Plant should be monitored.

The proposed site at the AVS plant near Beulah gives the final project an outstanding synergistic advantage. The fertilizer and CO₂ pipeline operations of DGC in close proximity with the AVS power plant are an advantage for potential demonstration of the operation for the ECO-SO₂ fertilizer and ECO₂ technologies. If the technical and economic issues are successfully demonstrated at this site, then it could be possible to commercialize similar operations at other lignite facilities.

The major flaw of this proposal is inadequate project management details. A SOW coupling work tasks with milestone charts and budget detail would raise the proposal above the level of a certain "Bailout" document. Standards of success comparing lignite CO₂ sequestration costs to alternative fossil fuel and non-fossil fuel power generation costs, benefits and availabilities could be useful. Organization and communications charts are an omission that should be corrected. In addition, a plan for following the Burger Plant operation for the NDIC/LRC should be developed.

If this phase is successful and a decision to proceed is reached, will the participants request additional NDIC/LRC funds?

The CO₂ work is crucial for the industry and state. This work should be encouraged and funded.

Reviewer 08-14 (Rating: FUNDING MAY BE CONSIDERED)

I recommend that funding may be considered. A CO₂ capture project from a lignite-fired power plant with subsequent CO₂ sequestration is a necessary step towards evaluating and demonstrating technically- and economically-feasible carbon management technologies. These technologies are necessary to ensure that lignite-fired power plants will remain operational as carbon management legislation is implemented.

If technologies are not available, this will have a devastating effect on North Dakota's economy. My concerns regarding this proposal, as stated previously, are:

- An inexperienced principal investigator, which means that senior supporting personnel must be very involved;
- No project management plan for a project of this size; and
- The minimum amount provided as cost share (i.e., a larger burden on NDIC/LRC) when this project should be of interest to many other utilities and coal mining companies.

Reviewer 08-15 (Rating: FUNDING MAY BE CONSIDERED)

Funding for this project could be considered. The problem at this time is that there is nothing contained in the proposal that puts this technology in context with other technologies that can achieve the same objective of 90% CO₂ capture. As a reviewer, it is important to understand why Basin Electric selected this technology for a FEED study. For example:

- What are the specific issues associated with capturing CO₂ from flue gas resulting from combustion of North Dakota lignite?
- How do the ECO-SO₂ and ECO technologies deal with those issues? Are there advantages of these technologies in dealing with those issues relative to other approaches?
- How does the CO₂ capture cost of the ECO₂ technology compare with other technologies?
- How does the auxiliary power requirement of these technologies compare with other technologies?

The answers to those questions would allow a better assessment of whether a very significant NDIC contribution to a FEED study is commensurate with NDIC goals and objectives.