

EERC RESPONSES TO REVIEWER COMMENTS

R011-D

Biomass Gasification in Entrained-Flow Systems
Submitted by Energy & Environmental Research Center
Principal Investigator: Jason Laumb
Request for \$325,000; Total Project Costs \$693,100

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

Reviewer 4A (Rating: 4)

The proposal involves biomass gasification and its objectives are consistent with the North Dakota Industrial Commission/Renewable Energy Council goals.

The proposal title implies a much bigger scope of work than that set by the objectives. As stated in the proposal, the objectives are (1) to characterize the raw syngas composition, and (2) define the requirements for appropriate syngas cleanup systems. In other words, the project covers research activities on only the post-gasification, downstream syngas characterization and upgrading, not mentioning the research on gasification/entrained-flow gasification (EFG) itself. In fact, syngas analysis is only of the 4 tasks. The other two tasks include system modification for use of biomass, and gasification of coal – biomass blends. To this reviewer, these two tasks are not insignificant in the overall project and will take bigger effects to accomplish, providing the complexity of operating ability with coal-biomass blends in EFG, effects of operating parameters on syngas yields/quality, emissions, and required modification of the existing EFG. This reviewer is confused and wonders if such research activities are on-going or planned separately for these two tasks. Otherwise, this proposal needs to include these aspects as major objectives for meaningful syngas characterization, which would lead to an enormous project, of course.

Task 2 proposes conducting more than just characterizing syngas composition. It is said also including analysis on solids, e.g., ash and slag, and liquids.

EERC Response

The majority of dollars budgeted for this program will be used to conduct gasification tests of biomass in the EFG and to perform the necessary analytical tests on the products of gasification. A rigorous test plan will be developed as part of the program. An example test plan can be found in Table 1 in the proposal. The program will focus not only on the products of gasification but also on operating parameters.

Reviewer 4B (Rating: 3)

The objective is to “completely characterize” the raw syngas from co-gasifying biomass and coal in an entrained flow gasifier. It is not clear whether this is for the purpose of synfuels production, as described in one of the three references included in this proposal, or for power production,

which I would expect was the main interest of their industry partner, GE. This is important to know when assessing the success of their efforts.

EERC Response

Both power and liquid fuels will be considered. Both are of interest to the EERC and GE.

Reviewer 4C (Rating:4)

Biomass gasification can help meet renewable fuel mandates. Gasification parameters/conditions and gas cleanup technologies are critical characteristics that need to be studied in order to produce a fuel that is economically viable.

2. 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.

Reviewer4A (Rating:5)

The two objectives set by the proposal, i.e., (1) to characterize the raw syngas composition and (2) define the requirements for appropriate syngas cleanup systems, are certainly achievable. It is the undefined tasks 1 and 2 that lead some uncertainty.

EERC Response

Task 1 is not well defined as feed system modifications have not been designed at the time of the proposal. Task 2 will be further defined as the project progresses. The initial test plan in Table 1 will be executed first. After evaluation of the first gasification tests, new parameters will be defined for subsequent tests. In addition, GE is conducting experiments at its facilities that will help to define the test parameters. The results of these tests were not available at the time of the proposal.

Reviewer 4B (Rating:3)

The investigators propose to use what appears to be a fully operational high pressure, slagging gasifier (although they do not present any previous results or reference any of their own publications on the subject to verify this claim). The investigators have avoided any explicit quantification of goals. For example, they do not indicate what kind of CO:H₂ ratio they hope to achieve. This makes their goals seem achievable. However, they do not appear to have adequate instrumentation to measure sulfur and nitrogen emissions to the desired accuracy and precision (Draeger tubes are usually considered suitable for field estimates but are rarely suitable to conduct \$500,000 research program). Thus, I cannot rank this higher than 3.

EERC Response

Limited work has been conducted with slagging entrained-flow systems that are biomass-fed. Many of the major gasifier vendors are just now beginning to research in this area. Very limited results are in the public domain. The EERC has vast experience in the gasification of biomass with atmospheric downdraft systems. The CO:H₂ target ratio is highly dependent on the desired end product. The project will consider both electrical power and liquid fuels. The proposers agree that Draeger tubes provide excellent estimates. Draeger tubes will be used

along with highly sensitive gas chromatographs. In some instances, the fast response time of a Draeger tube can be desirable in a research setting during upset conditions.

Reviewer 4C (Rating:4)

Preliminary studies will be conducted at GE-GR on a bench scale unit. This information will provide researchers insight on parameter modifications.

3. 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 4A (Rating:4)

The methods for conducting the tasks are moderately clear. Details of syngas components and trace elements are listed and corresponding analytical means are indicated.

Reviewer 4B (Rating:4)

The methodologies appear to be appropriate except possibly the use of Draeger tubes for trace gas analysis.

EERC Response

Draeger tubes will be used along with highly sensitive gas chromatographs. In some instances, the fast response time of a Draeger tube can be desirable in a research setting during upset conditions.

Reviewer 4C (Rating:4)

The methodology is applicable for the tasks proposed.

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

Reviewer 4A (Rating: 5)

This is a project on gasification with coal-biomass blends. If the gasification itself is also systematically investigated, it would directly and greatly contribute to the goals of the North Dakota Industrial Commission/Renewable Energy Council, i.e., encouraging the renewable energy generation and uses in North Dakota.

Reviewer 4B (Rating: 3)

The *topic* of biomass gasification has the potential to make contributions to the renewable energy aspirations of North Dakota, but the proposal itself does not well articulate what this might be. Will the research contribute toward commercialization of gasification for power or fuel synthesis? Producing raw syngas is hardly sufficient for moving this technology forward. I would have thought more valuable would have been construction of a gas cleaning system to use with the existing gasifier that meets the demands of syngas derived from either biomass or coal feedstocks. The literature is full of previous efforts to co-gasify coal and biomass, but the investigators have not explained what is unique about their proposed study.

EERC Response

Both power and liquid fuels markets will be considered. A warm-gas-cleaning system is already in place for the existing gasifier. Its applicability to biomass will be evaluated as part of the project. The use of an entrained-flow process makes this research unique. Much of the past work has been done with atmospheric downdraft systems. The pressurized entrained-flow system will lead to better carbon conversion and lower tar production.

Reviewer 4C (Rating: 5)

Biomass gasification provides an alternative renewable fuel source that can be economically feasible with the right feedstock, operating parameters and syngas cleanup systems. This can provide great economic impacts and growth in the renewable energy industry.

5. 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 4A (Rating: 3)

No thorough literature review is provided in the proposal on the research topic. Since the PIs are fairly experienced researchers in this area, their awareness of the current research activity and published literature are assumed adequate.

EERC Response

Limited publications on the gasification of biomass with entrained-flow systems are in the public domain.

Reviewer 4B (Rating: 2)

The investigators offer only three references to support their proposal. Nothing is said of the expected levels of contaminants or the challenges of co-gasifying two feedstocks with very different physical and chemical attributes.

Reviewer 4C (Rating: 4)

6. 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 4A (Rating: 4)

The PIs have been researching in the area for quite a few years and well qualified in conducting the proposed research.

Reviewer 4B (Rating: 5)

The team is well qualified to perform the proposed work.

Reviewer 4C (Rating: 4)

- 7. 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 4A (Rating: 4)

The proposal presents briefly a fairly good management plan. The PI will oversight the project and the tasks are led by the other two PIs. The timelines are reasonable. The proposal indicates that there are other technical personnel involved in this project, but no roles are assigned and no management plan is to be implemented.

Reviewer 4B (Rating: 5)

The North Dakota EERC has considerable experience in managing projects of this type, which is well reflected in their organization chart, scheduling, and budgeting.

Reviewer 4C (Rating: 4)

Management plan is very complete.

- 8. 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 4A (Rating: 2)

The proposal provides a list of things to purchase for a “fabricated equipment”. Included in the list are tubing (\$10k), fittings (\$20k), insulation (\$15k), and vales & regulators. These may not be qualified as equipment but quite significant requests. There are no details in the proposal on the uses of the “fabricated equipment”. The necessity of such “fabricated equipment” is not justified.

EERC Response

The materials listed under fabricated equipment will be used for feeder modifications and construction of a quench probe that will be used to vary residence times in the gasifier.

Reviewer 4B (Rating: 5)

Reviewer 4C (Rating: 3)

Need more detail in proposal on what equipment/instrumentation is being purchased or fabricated.

- 9. 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 4A (Rating: 5)

The PIs’ institution has the needed facilities for the proposed work. The overall capability at EERC for conducting gasification research is adequate.

Reviewer 4B (Rating: 3)

The investigators recognize that trace contaminant measurement (sulfur and nitrogen) is important to their investigation. I would add accurate trace contaminant measurement. They very poorly indicate methodologies and instrumentation to be used for this purpose. The use of Draeger tubes is unlikely to provide the accuracy required.

EERC Response

Draeger tubes will be used along with highly sensitive gas chromatographs.

Reviewer 4C (Rating: 5)

The EERC facilities and equipment are capable to complete the proposed research.

10. The proposed budget “value”¹ relative to the outlined work and the financial commitment from other sources is of: 1 – very low value; 2 – low value; 3 – average value; 4 – high value; or 5 – very high value. (See below)

Reviewer 4A (Rating: 4)

The budget request is high for the proposed work. Unless it is the high funding level by the ND Industrial Commission/Renewable Energy Council program, the \$693k sounds a bit of high for achieving the two objectives in the 12-month project. It may well be the case if operating the gasifier is included, which is included in the tasks but not as objective(s).

Industry matches \$34k (~5%) to the project. The Biomass Utilization program funded by DOE matches \$334k (~48%) to the project.

EERC Response

The level of funding requested includes operation of the gasifier as it is necessary to achieve the stated objectives.

Reviewer 4B (Rating: 4)

The budget is not out of line with the cost of performing similar type of work at other institutions. However, I would have preferred that they invest some of the requested resources toward purchase of instrumentation to pursue more exacting trace gas analysis.

EERC Response

Necessary equipment for trace gas analysis is already present at the EERC. The specific details of this equipment were erroneously left out of the proposal.

Reviewer 4C (Rating: 3)

The budget is typical of what would be expected in a research center.

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.

10a. Financial commitment from other sources – A minimum of 50% of the total project must come from other sources to meet the program guidelines. Higher priority is to

be given if the application has private industry investment equal to or at least 50% or more of total cost.

The minimum 50% cash match is demonstrated.

Section C. Overall Comments and Recommendations:

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 4A (Fund)

This is a fairly well constructed proposal. The objectives are clear and achievable, although the actual proposed work does not match the objectives. Successful accomplishment of this project would benefit the biomass utilization programs in the state of North Dakota.

This reviewer recommends that the proposal be funded. Justification may be needed for the “fabricated equipment” before granting the \$90k request.

EERC Response

More details on the fabricated equipment can be provided if necessary.

Reviewer 4B (Funding May Be Considered)

The proposal has some merit for funding. Biomass gasification has interesting potential for production of both fuels and power, especially the latter. The investigators are qualified to work on the proposed activities and have excellent facilities at their disposal. However, I am not particularly enthusiastic in my support of the proposal because it falls well short of what the team is capable of accomplishing. The work plan is almost exploratory rather than tightly focused on testing specific scientific questions or solving a particular engineering problem. This is too bad and prevents me from giving a strong endorsement.

EERC Response

The project is addressing several engineering problems with the gasification of biomass in entrained-flow systems, those being biomass feeding, gas cleanup, and ash-related fouling.

Reviewer 4C (Fund)

Gasification can provide an alternative renewable fuel source that can be economically feasible with the right feedstock, operating parameters and syngas cleanup systems. This technology can also reduce CO₂ emissions. This project can provide great economic impacts and growth in the renewable energy industry for North Dakota. The project should be funded.