TECHNICAL REVIEWERS' RATING SUMMARY

R025-B

Biomass to Refinery Feedstock-Grade Liquids

EERC
Principal Investigator: Bruce Folkedahl
Request for $304,543; Total Project Costs $609,086

Rating Category	Weighting Factor	Technical Reviewer 1B Rating	2B Rating	3B Rating	Average Weighted Score
1. Objectives	9	4	4	4	36.00
2. Achievability	9	4	3	3	30.00
3. Methodology	7	4	3	4	25.67
4. Contribution	7	3	4	5	28.00
5. Awareness	5	3	2	2	11.67
6. Background	5	4	3	5	20.00
7. Project Management	2	4	2	5	7.33
8. Equipment Purchase	2	5	3	5	8.67
9. Facilities	2	5	4	5	9.33
10. Budget	2	4	4	4	8.00
Average Weighted Score		192	163	199	**184.67**
Maximum Weighted Score					**250.00**

OVERALL RECOMMENDATION

FUND	x		x
FUNDING MAY BE CONSIDERED		x	
DO NOT FUND			

R025-B
Biomass to Refinery Feedstock-Grade Liquids
Submitted by EERC
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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 1B (Rating: 4)
The research plan will leverage technologies developed by the applicants to prepare plans for a demonstration-scale biorefinery to convert manure and agricultural wastes into C14-C22 carbons for biofuels and biolubricants, which falls within NDIC/REC goals

Reviewer 2B (Rating: 4)
This is a project to test/develop a pilot-scale facility, which has been under development for some time, using agro-wastes (especially manure) as the potential feedstock to generate syngas and then convert syngas to liquid hydrocarbons.

The proposal aligns very clearly with the mission set by the North Dakota Industrial Commission/ Renewable Energy Council.

Reviewer 3B (Rating: 4)
The overall goal of this proposal is to develop a deployable system to gasify biomass and convert the syngas to liquid intermediates that can be transported to large, existing biorefineries for upgrading into high value products. This approach will help overcome the significant logistical challenge that biomass-to-energy processes face, and will use relatively well known processes of gasification and Fischer-Tropsch conversion. If successful this technology could be implemented across the state and potentially use an equally broad range of feedstocks. One of the main advantages of thermochemical processes is that in general they are much more feedstock agnostic than biochemical conversion approaches.

Another major advantage of this biomass to hydrocarbon approach is that it will generate intermediates that can readily be upgraded in existing petrochemical refineries and into products that will subsequently enter the marketplace as petroleum equivalent products. This avoids the blend wall" problem that is faced by current biomass to ethanol processes.

My only concern with the tasks is Task 1: Characterize manure and other selected biomass feedstocks. This information should already be available in the literature and should have been provided as an appendix in this application. Obtaining this information as part of the project uses valuable time and resources that could be used more productively in the other tasks.

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.

Reviewer 1B (Rating: 4)
Tasks 1-5 are very specific goals that are likely to be achieved, but are dependent on a successful catalyst screen (Task 2) and the ability of the applicants' fixed bed catalysis unit to convert feedstock (that can vary in composition from season to season?) into biogas.

Reviewer 2B (Rating: 3)
The project has an industrial partner and the testing will be within 12 months. Since this project is based on an existing facility and the goal of this project is to test and generate needed data for further development, it is this reviewer's believe that the project is likely achievable. The concern mainly comes from some technical issues that are not fully addressed in the proposal. These include evaluation of the energy cost in drying the manure feedstock for gasification, temperature distribution of the gasifier as affected by the moisture content in manure, purification/conditioning of the producer gas (i.e., the impure mixture of CO, H_2, CO_2, CH_4, other light HC, N-containing volatiles, O_2, N_2, etc., from gasifier) to syngas (i.e., CO + H_2 in certain molar ratios readily for F-T synthesis), and so on. Thorough investigation into these issues needs considerable time. Matching financial support from the industry partner shows the confidence of the project. Budget looks good for the activities proposed. However, considerations for investigating some technical aspects that are necessary but not included in the proposal may involve additional cost.

Reviewer 3B (Rating: 3)
Task 2, Bench scale FT Testing will include catalyst performance tests. The EERC has 8 years of prior work in FT catalyst and operating conditions, and yet the description of this prior work and the basis for selecting catalysts was very weak. They indicate that an "ECC-specified catalyst" will be selected, however the criteria for this selection are not provided. Catalyst costs, performance, and lifespan are the key issues that have thus far restricted commercial deployment of thermochemical technologies. The "glossing over" of this issue in the proposal is troublesome. It would seem that the team would want to highlight and "sell" the performance of the catalyst based on the years of prior work.

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 1B (Rating: 4)
The methodology given for Tasks 1-5 is sound.

Reviewer 2B (Rating: 3)
This is not truly a scientific research proposal, rather a process development/ process testing project. The methodology is routine for the activities proposed. More details are needed for further review and comments. However, the previous experience of the project team and facilities available for the project seem adequate for successful implementation of the project activities.

Reviewer 3B (Rating: 4)
With the exceptions that Task 1 should have already been done, and more details should have been provided with respect to catalyst selection, the team has several years of experience in thermochemical and catalytic processes so should be well versed in appropriate methodologies.

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 1B (Rating: 3)
The applicants are basing their demonstration scale biorefinery on some promising technology, but have a long way to go to verify the overall system will integrate the various unit operations, that a demonstration scale operation will be economic viable, that a reliable feedstock supply system can be put in place, and that commitments from buyers (e.g., lubricant manufacturers) can be procured.

Reviewer 2B (Rating: 4)
Utilizing low cost (even cost-negative) agro-waste streams as feedstock for producing bio-based liquid fuels is meaningful environmentally. Techno-economic data are well needed to advance the BTL technology before decisions are made for commercial development. In this regard, the proposed work will very significantly contribute technical findings to addressing the goals set by the North Dakota Industrial Commission/ Renewable Energy Council.

Reviewer 3B (Rating: 5)
This project offers a technology to overcome several factors that currently limit the economic and technical feasibility of converting biomass into chemicals that can replace petroleum. The project builds upon several prior years of work at the EERC and makes use of well known technologies – gasification and FT conversion. If successful this project would help achieve NDIC goals. My main technical concerns relate to the prior data on catalyst development and the parameters/data used to select the catalyst to be used.

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 1B (Rating: 3)
The applicants have a strong reputation in the biofuels/ bioproducts area. However, there are other players in the manure-to-(drop-in) biofuels game. It is not clear how the applicants' technological approach fares in comparison to the competition based on the limited technological information given in this proposal.

Reviewer 2B (Rating: 2)
The proposal does not provide adequate information to show the PIs' awareness of current research activity and published literature on converting manure to syngas for F-T synthesis. The

PI may be well aware of the literature but the proposal just did not document it. The term of "syngas" used in this proposal (page 5 of the proposal in Objectives section), however, does give this reviewer an impression that the PI may need conducting an in-depth analysis into the technical challenges of syngas generation and conditioning for FT synthesis because it is one of the most challenging technical complications in realizing the BTL concept.

Reviewer 3B (Rating: 2)
The team has a strong history of work in this area, and likely has a strong publication record and understanding of the technical background. However only one publication was cited. As noted previously, the issues of catalyst design, performance, and cost was glossed over, in spite of the fact that this is the heart of the project.

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 1B (Rating: 4)
The applicants have a strong reputation in the biofuels/bioproducts area.

Reviewer 2B (Rating: 3)
No details are provided on the PIs' technical preparation. The existing facility that is to be used for this project shows that the project team has had the background and experience in operating the facility in the past and to conduct the proposed work.

Reviewer 3B (Rating: 5)
The team has been working on this for some time and has good expertise.

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 1B (Rating: 4)
The applicants have laid out an appropriate list of milestones in Table 1. EERC and the PI have expertise leading large projects. It is clear from reading the proposal that Epcot-Crenshaw and the EERC are working effectively together currently. But, a detailed communication plan has not been provided, other than to have meetings upon the achievement of milestones.

Reviewer 2B (Rating: 2)
The proposal claims that EERC has a long history of successfully managing projects with multiple partners, which this reviewer believes. However, it does not show in this proposal how this project is to be managed.

Reviewer 3B (Rating: 5)
The EERC has decades of experience in successfully managing large projects that involve multiple participants.

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 1B (Rating: 5)
No equipment will be purchased using NDIC/REC funds.

Reviewer 2B (Rating: 3)
A budget of $7,000 is requested for a piece of equipment, which is justified for the project.

Reviewer 3B (Rating: 5)
A booster compressor is proposed for $7,000. This will be provided as part of the cost share.

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 1B (Rating: 5)
The EERC has state-of-the-art lab and pilot-scale facilities.

Reviewer 2B (Rating: 4)
The facility as related to activities in this project is presented with some details. It appears notably adequate for performing the proposed testing in this project.

Reviewer 3B (Rating: 5)
The team has been working on this for some time and has needed facilities and equipment.

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 1B (Rating: 4)
NDIC/REC funds to the amount of $304K will be used to leverage good preliminary results and a strong team of applicants to move forward with developing a technological platform in development for a manure/ag waste-to- drop-in fuel or biolubricant feedstock technology. Tempering a higher score are the lack of a feedstock supply system, market analysis, and evidence of interest by users of the long-chain derivatives to be made.

Reviewer 2B (Rating: 4)
The industry partner is very confident and committed to the project. It has provided 50% matching to the requested fund.

Reviewer 3B (Rating: 4)
The applicants have met the minimum matching requirements from commercial partners

[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 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.*

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 1B ***(Fund)***
The proposal involves further development of sustainable technology (anaerobic digestion, producing biogas, and Fisher-Tropsch synthesis, converting biogas into long-chain alkyl derivatives) that utilize manure and agricultural wastes from North Dakotan farms. The proposed research, laid out in five achievable tasks, consists mainly of further developing a pilot-scale Advanced Fixed-Bed Gasifier (anaerobic digestion), optimizing catalysts developed by partner EEC for use in pilot-scale Fisher-Tropsch reactor, and developing a front-end design for a demonstration-scale facility. EEC (and ARG) are strongly supporting this proposal through a 1:1 cash match. The applicants possess the expertise and facilities needed to complete the project's deliverables, and leverage preliminary research. The weaknesses (risks in funding) of this proposal are the absence of economic viability data, a reliable feedstock supply, and a reliable buyer of the finished product. It could be argued that several of the weaknesses will be addressed in future R&D, through collaboration with SET (p. 13).

Reviewer 2B ***(Funding May Be Considered)***
The concept of BTL evolves from CTL (coal to liquid fuels) and CTL has been long researched and established as an economically viable technology to produce liquid transportation fuels. BTL has also been researched in the past 2 decades, however, its practical application has not been proven mainly because of its economical deficiencies caused by the less-energy content and the high moisture content in biomass feedstocks. If the ultimate goal of this project is to realize such a BTL operation in North Dakota, a feasibility study of evaluating the techno-economic aspects prior to or after this project is necessary.
A merit of this project is to use manure as the potential feedstock. Using manure as the potential feedstock, on the other hand, provides also a challenge in gasification to generate the producer gas. The energy needed is so enormous in bringing the high moisture in manure (85% or even higher depending the types of manure) down to a level of approx. 8-10% as required for gasifiers in normal operation that the overall process may not necessarily break even in terms of energy requirement. Therefore, careful consideration of this aspect should be practiced in decision making and in project execution.

Reviewer 3B ***(Fund)***
This is a strong proposal by a strong and experienced team. My main concern is with the lack of details on catalysts, and this has been the real challenge for thermochemical technologies. If the catalyst doesn't perform as needed the project will suffer. Additional information on their prior catalyst work and reasons for selecting a specific catalyst would have made the proposal much stronger.