TECHNICAL REVIEWERS' RATING SUMMARY

R024-A

Sugar Beet Tailings to Advanced Ethanol

REVISED

BioMass Solution, LLC

Principal Investigator: Jacek Chmielewski

Request for $500,000; Total Project Costs $1,000,000

Rating Category	Weighting Factor	Technical Reviewer 1A	2A	3A	Average Weighted Score
		Rating			
1. Objectives	9	5	4	4	39.00
2. Achievability	9	4	2	3	27.00
3. Methodology	7	4	4	3	25.67
4. Contribution	7	4	3	3	23.33
5. Awareness	5	3	2	2	11.67
6. Background	5	4	3	3	16.67
7. Project Management	2	5	2	3	6.67
8. Equipment Purchase	2	5	5	5	10.00
9. Facilities	2	4	3	3	6.67
10. Budget	2	4	2	3	6.00
Average Weighted Score		208	152	158	**172.67**
Maximum Weighted Score					**250.00**

OVERALL RECOMMENDATION

FUND	x		
FUNDING MAY BE CONSIDERED		x	x
DO NOT FUND			

R024-A (Revised)
Sugar Beet Tailings to Advanced Ethanol
Submitted by BioMass Solution, LLC
Principal Investigator: Jacek Chmielewski
Request for $500,000; Total Project Costs $1,000,000

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 1A (Rating: 5)
The objectives are to perform a front-end engineering and design, and other preliminary assessments, to move forward with a biorefinery in Grand Forks that will convert sugar beet tailings, a waste product from sugar beet processing that currently is landfilled, into bioethanol at an 8 M gal/year capacity. The applicants have convincingly demonstrated the biorefinery will impact the Grand Forks economy via job creation. The estimates for jobs are in line with other biorefineries (e.g., the DuPont-Danisco site in Vonore, TN).

Reviewer 2A (Rating: 4)
The stated goal is very clear, but whether the plan is feasible, and therefore how likely it is those goals are to be achieved, is the larger and ultimately more important question.

Reviewer 3A (Rating: 3)
The overall goal of this project is relevant to the NDIC mission. However there are many gaps in the project in key areas, and the authors appear to believe that they simply need to pull various technologies off the shelf, cobble them together, and they will have a working, automated system. This is very naïve from several viewpoints: 1) the feedstocks they are using are not uniform and the composition will change during the course of the year during storage, 2) the feedstocks are unlikely to be available all year round, based on the sugarbeet processing season, 3) performance of at least the fermentation stage will be different than that found in corn ethanol production, and downstream processes will also be different (coproduct feed recovery and drying). This proposal is for a 5 month engineering design. What is really needed is some actual process data and validation at some scale to show that this technology can work.

Another objective of the process is production of "*high quality animal feed as a byproduct.*" However the potential composition and market value of this product are never discussed. Have any feeding trials with this material been performed? Is there any basis for assuming this material will be acceptable to feeders?

The price of the feedstock beet tailings or unmarketed beets are also not described. This is a key "selling point" for the process but it is glossed over.

The idea of small scale, distributed ethanol production has been around since the late 1970s, but has never materialized due to economies of scale issues. This project proposes an 8 million gallon/yr facility that would be at a severe economic disadvantage to the industry standard of 50-100 mgy facilities. The saving grace would be procuring feedstock (beet tailings, waste beets) at

low or even negative costs, but the feedstock costs are never discussed in the proposal. Another disadvantage of these feedstocks is their lack of availability from May through September, and the fact that their composition will be quite variable. A facility that operates only 9 months out of the year is doomed.

Reviewer 3A Revision (Rating: 4)
No revised comments for this section. See Section C – Overall Comments and Recommendations.

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 1A (Rating: 4)
The applicants have provided a rational plan to perform a front-end engineering and design (FEED), a preliminary plant design, and obtaining the necessary permits, in order to start up the new plant in July, 2016.

Reviewer 2A (Rating: 2)
It's impossible to say how achievable these objectives are because there are several unknowns that would need to be addressed. First and foremost, how realistic is utilization of SBT in the production of ethanol? Corn stover is obviously used, and thus there is somewhat of a corollary one can point to, but the devil always lies in the details. One is specifically required in the pre-processing phase that is innovative, and what has been proven elsewhere? What specific equipment can be ported for this particular process vs. what will have to be engineered? Has SBT been used elsewhere commercially to produce ethanol? Almost as importantly, what's the cost benefit analysis and is the process even economic?

I recognize that many of these questions likely cannot be answered without some of the preliminary engineering design work that is contemplated as part of this grant. But that leads to my main takeaway: not all of the envisioned design work needs to be completed in order for the overall feasibility of the proposed plant to be better understood. The FEL 1 work would provide significant answers to many basic questions: energy balance, preliminary capex requirements, initial capex assumptions, etc.

Despite my desire to have answers to these questions, I do believe that this project has merit, and therefore my overall recommendation (and apologies for burying it here) is to fund this project, but in a staged matter. Funding provided for FEL-1 work, and if, and only if, the very preliminary energy balance, economic, feasibility, etc. questions are answered would I want to proceed with further funding. There are several clear steps in the overall project development process to pull up and ask, "does this even make sense?", and the completion of FEL-1 work is the first and most important.

Reviewer 3A (Rating: 1)
The timeline of this project in relation to the overall construction objectives are not anywhere close to feasible. For one, they indicate the project should be completed by "*the end of May*

2015" and indicate a 5 month duration. That means the project needed to start January 1, 2015. It is already the middle of January, and the NIDC program policies indicate that it can be up to 60 days following submission that the projects are awarded, and up to another 60 days before contractual agreements are signed. This puts the actual start date into March or April of 2015. They later indicate that the May 2015 end date is critical so they can begin construction of the commercial facility at that date, so it would be operational in the fall of 2016 for the sugar beet harvest. This timing is impossible to make work.

For a "paper only" engineering study, 5 months might be sufficient. However what is really needed is some hard performance data by operating the FEED system with the proposed feedstocks. If this information was available, it wasn't included in the proposal. If it is not available, this should be the first order of business. How can engineering projections be made without performance information???

Reviewer 3A Revision (Rating: 3)
No revised comments for this section. See Section C – Overall Comments and Recommendations.

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 1A (Rating: 4)
The methodology for the FEED is appropriate. BMS has aligned partners to assist with plant design, downstream separations, and downstream environmental assessment and compliance.

Reviewer 2A (Rating: 4)
The quality of the work is strong, it just takes the full funding for granted and needs to recognize that in an innovative ethanol production process (that's an assumption, if SBT has been used previously to produce ethanol you need to flag that!) its imprudent to begin the next phase of design work before the prior step has been completed. That could certainly delay the start of the project, but better to have a feasible project that still gets off the ground then a infeasible project that spent more money coming to that realization than it otherwise would have.

Reviewer 3A (Rating: 2)
The project proposes to use an upstream feedstock processing method that "*has similarities to existing processes deployed all over Europe*" in order to convert the feedstocks (sugar beet tailings and unmarketable sugar beets) into a form that can be processed by "*industry standard ethanol production technologies*." Unfortunately the PI fails to provide any insight into this method used in Europe and how it will be modified for their purposes. The feedstocks they will use are wastes or lower value beets, which will have a highly variable composition throughout the year (and will not be available during the summer months after the beet campaign has ended). These feedstocks will be contaminated with a wide range of organisms that will ferment the sugars into lactic and acetic acid, thus reducing the ethanol yield potential. More problematic is that even if the bacteria are removed in the front end of the process, the organic acids will pass through into the fermentation process and inhibit yeast metabolism, resulting in "stuck"

fermentations. There is no mention of this issue or how they might propose to address this problem.

The Front End Engineering and Design (FEED) stages are claimed to provide "*additional level of detail, testing, and validation of the overall plant design*." However the proposal only focuses on the design aspects, without adequately addressing testing and validation. Within the 5 month project duration it is impossible to conduct the needed testing and validation of the FEED aspects. As noted above, there are many elements of the FEED process that need to be optimized and validated, with the resulting slurry tested in the fermentation process. Thus there are major gaps in the needed workplan, and if these were included the project would require at least 1 year. Additional questions I have are listed below:

- What are the storage conditions for the SBT and unmarketable beets?
- What is the fate of the wash water used to clean the SBTs and beets?
- What is the polymer enhanced stratification process and what are its benefits?
- What is the anticipated sugar and ethanol titer of the process streams?
- If solids are removed prior to distillation, how will ethanol be recovered from these solids?
- Why are the animal feeds to be pelleted? Corn DDGS isn't pelleted.
- What is the advantage of the UV light photoelectrocatalytic water treatment process over biomethanators that are commonly used in ethanol plants.

Reviewer 3A Revision (Rating: 3)
No revised comments for this section. See Section C – Overall Comments and Recommendations.

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 1A (Rating: 4)
The assessments to be completed with NDIC/REC funds are anticipated by the applicants to lead to a demonstration scale bioethanol biorefinery in Grand Forks, ND, that will utilize a waste product from sugar beet processing and produce ~20 permanent jobs (~$65,000/year salary) after its anticipated start date in the summer of 2016.

Reviewer 2A (Rating: 3)
More attention should be paid to the pre-processing approach that is contemplated. It is only mentioned in passing and for its innovation – is that innovation already well understood, or is it expected to be further fleshed out as part of the FEED work? Regardless, many biomass to ethanol plays have been caught up in the pre-processing phase, so a valid breakthrough in this area could have relevance to additional SBT plants and other biomass to fuel opportunities globally.

Reviewer 3A (Rating: 2)
The project is largely focused on design of the FEED process, and provides little if any information on how the process works, let alone any performance data. The PI indicates the "*SBT handling and pre-processing is a new process that is being introduced in ND*." Without adequate background on the process it is impossible to judge if it can be a workable system. The PI appears to believe that this is a turn-key solution to processing the SBT and unmarketable/waste beets, but this does not convince me, due to the issues mentioned in #3 above. This process needs to be tested and performance validated before it can be assumed to be workable.

The PI correctly indicates that fermentation and the following downstream processes are well known. However those technologies are based on a completely different feedstock (corn) and a beer that is readily flowable and contains 15% ethanol. The fermented slurry from beet processing will contain far lower ethanol levels and have a much higher viscosity. Therefore energy and capital costs per gallon of ethanol will be substantially higher.

Reviewer 3A Revision (Rating: 3)
No revised comments for this section. See Section C – Overall Comments and Recommendations.

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 1A (Rating: 3)
There is not very much specifically in the proposal to allow for a thorough assessment of the awareness of current literature and research. The authors identify their novel scientific contribution as the "pre-processing" technology that is applied to the sugar beet tailings feedstock prior to using conventional fermentation and downstream purification technologies. A small glimpse of the technological aspects of the pre-processing is given in Appendix III. No literature references are cited.

Reviewer 2A (Rating: 2)
There's really no mention of this. There must be at least cursory academic research somewhere as to the viability of SBT as an ethanol feedstock. Or, if it has been done commercially previously, more would needs to be presented regarding the pros and cons of the approach. What limitations have there been previously to the approach?

Right now the request is: we need the funds to complete the engineering, permitting and legal work. From there it's just a matter of building the actual facility. But what work has been done previously that you can point to that indicates the overall viability of the process? Someone must have looked at this previously…

Reviewer 3A (Rating: 1)
There is no literature citation section and as per my comments above, it appears that this team has little if any background on processing beets or beet tailings. I even question their understanding of the corn ethanol industry based on some of the assumptions they make concerning fermentation and downstream processing.

Reviewer 3A Revision (Rating: 2)
No revised comments for this section. See Section C – Overall Comments and Recommendations.

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 1A (Rating: 4)
The investigators from BMS have many years of experience in the relevant areas of expertise. The use of a third party to review the FEED documents, BGI, is a meritorious approach. Yet, in perusing the website for BMS and on-line information for the company, I found little specific information of BMS's capability to handle a rather large, 8 M gal/year biorefinery.

Reviewer 2A (Rating: 3)
Good capabilities around plant construction, financing and operation, but it's unclear how strong the capabilities are to engineer new pre-processing approaches. Is that to be handled entirely by BGI? What are their capabilities and experiences with various biomass to ethanol approaches?

Reviewer 3A (Rating: 1)
The project participant section just lists the roles of each of the participants, but does not describe any level of prior expertise in the ethanol industry. Thus it is not possible to judge whether the team has the needed background and expertise. This engineering design project looks to be a "paper only" study working from assumptions that have not been proven (at least they have not provided such data.)

Reviewer 3A Revision (Rating: 3)
No revised comments for this section. See Section C – Overall Comments and Recommendations.

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 1A (Rating: 5)
The use of third parties to review the project's deliverables is a great idea.

Reviewer 2A (Rating: 2)
The project management plan needs to include breaks amongst the various FEL steps to determine whether or not further work is necessary. Funding should also coincide with this

approach: $x allocated to FEL-1, and if successful, $y to FEL-2, etc. Why fund permitting and legal costs up-front if the overall economics don't work out?

Reviewer 3A (Rating: 3)
Nothing out of the ordinary.

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 1A (Rating: 5)
No equipment is to be purchased

Reviewer 2A (Rating: 5)
No equipment purchases are contemplated here, but there needs to be at least a cursory discussion regarding initial cost estimations for the actual plant. Is this plant $20m or $200m to construct?

Reviewer 3A (Rating: 5)
No equipment requested.

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 1A (Rating: 4)
It is assumed that the FEED assessment will be done at BMS headquarters, and that they have the necessary infrastructure to complete the work. The permits and surveys will occur on the proposed site in Grand Forks.

Reviewer 2A (Rating: 3)
No equipment necessary.

Reviewer 3A (Rating: 3)
As a "paper study" the needed items are available. However what is really needed is a pilot scale facility to test and validate performance of the FEED system and how it will integrate into the ethanol production process. These are evidently not available.

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 1A (Rating: 4)
The $500K investment by NDIC/REC will provide the resources needed to perform the preliminary engineering design and (primarily via cost sharing) preparation for the proposed biorefinery site in Grand Forks. Moreover, the investment will help bring what appears to be a

great notion, converting a waste product from identified sugar beet processors into a value-added product, bioethanol, into an operational biorefinery within 18 months. The proposed budget appears to be intended to cover personnel time to complete the engineering design work.

Reviewer 2A (Rating: 2)
$500k, with the separate $500k of private matching funds (although there was reference to $250 of 'equity' to be contributed, presumably separate from the applicant – where is this money coming from? Is it already identified?), is a sizeable lump sum to be given to a project that ultimately may not be viable. Ultimate viability can likely be determined with a much higher degree of confidence by providing a much small sum of money to complete preliminary design work. The project may ultimately be successful, in which case, fantastic, but if SBT to ethanol isn't even viable, then it's a large sum to figure that out.

Reviewer 3A (Rating: 1)
Without solid performance data for the entire system, any design/engineering projections made will be based on assumptions. The value of the output will equal the value of the input.

Reviewer 3A Revision (Rating: 3)
No revised comments for this section. See Section C – Overall Comments and Recommendations.

[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 1A ***(Fund)***
The applicants appear diligent and committed to establishing a bioethanol biorefinery in Grand Forks that will utilize a sugar beet waste product and proprietary pre-processing technology that is specifically adapted to the sugar beet waste tailings. The biorefinery will minimize the environmental impact of a waste product, provide a commodity that currently possesses value (ethanol at 8 M gal/yr; with a recommended reassessment in a few years to see if another fermentative product, e.g., biobutanol, would make more sense at that time) and would create ~20 full time jobs. The feedstock supply and plant site have already been selected. The proposed funds would be used to prepare the engineering designs (NDIC funds) and the infrastructural preparation of the site (e.g., licenses and permits). The overall goal fits well within the NDIC program objectives.

Reviewer 2A ***(Funding May Be Considered)***
I am a big fan of distributed assets, and more generally waste to value of all types. The overall project sounds great, but it's difficult to say right now with much certainty how feasible the approach is. I would suggest funding, but only if 1) the team provides additional research pertaining to prior work done on SBT, and if none, an honest assessment of what's different and where challenges lie, and 2) a staged funding approach, where enough funds are given to cover the first FEL step, and then additional funds only if the results of that study are promising.

Reviewer 3A ***(Do Not Fund)***
Conversion of beet wastes or unmarketable beets into useful products has the potential to solve an environmental problem, while creating economic development. Key issues to be addressed include: 1) feedstock storage and availability to allow 12 month/yr operation, and 2) methods to overcome the low bulk density of beets in a liquid processing format, so that conventional fermentation and distillation technology can be used.

This proposal is aimed at conducting an engineering design for such an integrated system, based on a combination of a FEED technology adapted from Europe, combined with fermentation and downstream processing unit operations from corn ethanol.

Unfortunately the proposal fails to provide sufficient detail on the design and performance of the FEED system, so that it is not possible to judge whether this technology will work. The applicants also fail to mention the several technical challenges (chief among them feedstock spoilage and production of organic acids) that stand in the path of successfully deploying this technology. These oversights lead me to question the understanding of the applicants, and therefore the value of the results this project would generate. Thus I strongly recommend NOT FUNDING this project.

Reviewer 3A ***(Funding May Be Considered)***

Reviewer 3A response to supplemental information provided by applicants:
The applicants addressed many of my concerns, and that has resulted in my revision of the point totals above. There are still issues that either have not been addressed in the proposal, or that will require further experimental validation:

1. Beet waste will contain lactic and acetic acid as a result of bacterial contamination. The process addresses methods to remove the bacteria. However the organic acids will still be present and will inhibit yeast metabolism.
2. The claims that automation will save labor over corn ethanol plants is unlikely to be accurate. If such automation is available, corn ethanol plants (which are relatively simple and have 30+ years operational experience would have implemented these technologies. The beet process has enough differences from corn ethanol that more direct observation and labor will be needed, not less.
3. The UV light photoelectrocatalytic process has evidently been used on fracking water, which is primarily mineral in nature. The beet wastes are organic, and it is naïve to assume the process will work the same on this material. Testing is needed.
4. It is good that cattle feeding trials are underway, and the results are necessary to assign an accurate value to this byproduct.