Response to Reviewers' Comments

TECHNICAL REVIEWERS' RATING SUMMARY

R013-B

Energy Beet Research, Phase II

Green Vision
Principal Investigator: Lloyd Anderson
Request for $500,000; Total Project Costs $1,000,000

Rating Category	Weighting Factor	Technical Reviewer 3A Rating	3B Rating	3C Rating	Average Weighted Score
1. Objectives	9	4	5	3	36.00
2. Achievability	9	4	4	2	30.00
3. Methodology	7	4	4	3	25.67
4. Contribution	7	3	4	2	21.00
5. Awareness	5	4	4	1	15.00
6. Background	5	4	4	4	20.00
7. Project Management	2	3	4	4	7.33
8. Equipment Purchase	2	2	4	1	4.67
9. Facilities	2	3	5	5	8.67
10. Budget	2	4	3	3	6.67
Average Weighted Score		185	209	131	**175.00**
Maximum Weighted Score					**250.00**

OVERALL RECOMMENDATION

FUND		x	
FUNDING MAY BE CONSIDERED	x		x
DO NOT FUND			

R013-B
Energy Beet Research, Phase II
Submitted by Green Vision
Principal Investigators: Lloyd Anderson
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 3A (Rating: 4)
Several of the NDIC/RE goals are addressed, particularly: "encourage and promote the use of new technologies and ideas.."; "promote public awareness ..", as are several of the "grant priority objectives: "identify and develop renewable energy technologies presently not used in North Dakota," "develop baseline information that will lead to other projects …"

Reviewer 3B (Rating:5)
Sugar beet is one of the most important biomass in the State of North Dakota. Unlike other technologies on cellulosic biomass ethanol production, sugar ethanol production is a well-established and has been commercialized in the some countries. The phase II proposal aims at scale up, finalization of cost effective and energy efficient plant design, and beets and juice storage for year-round uses which support the mission of the Renewable Energy Council that to promote the growth of North Dakota's renewable energy industry through research, development, marketing, and education. The success of the phase II will provide technical information for construction of the commercial facilities. The proposed research and commercialization plan meet the goals and purposes of North Dakota industrial commission on renewable energy program in terms of biofuel production, creating new jobs, growing renewable energy industry and promoting public awareness (education program). The objectives of this phase II proposed-project are clear and consistency with North Dakota Industrial Commission/Renewable Energy Council goals.

Reviewer 3C (Rating:3)
This project proposes to address many issues associated with starting a sugar beet energy industry in North Dakota. The goals are mostly clear associated with yield trial, front end processing technology development and the education efforts. However, the goals for the insurance work are not clear. Project management is an integral part of any projects, it need not to a project goal. The proposers are encouraged to review the literature and they can benefit from doing so, since essentially all the sugar beet processing technologies can be used here. No need to reinvent the wheel.

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Insurance

The goal of the insurance work is to assist USDA in offering a new energy beet crop insurance policy through the Risk Management Agency. The policy would cover production risks only, as grower price risk would be mitigated with a supply contract. Sub-goals of this project are to risk

rate the crop and establish loss ratios based on historical production levels in regional North Dakota yield trials. A second sub-goal is to evaluate market demand for an energy beet crop insurance policy based on producer willingness-to-pay surveys. A final sub-goal is to partner with an existing crop insurance agency in North Dakota to delineate administrative and program delivery costs. The procedure to accomplish these goals is outlined in Appendix III.

Sugar Beet Processing Technologies

One of the aims of this project is to bypass most of the expensive and energy-intensive storage and processing steps used to produce extremely pure, crystal sucrose. The beet sugar industry goes through considerable effort to prevent sucrose from "inverting" to glucose + fructose; however, this inversion is the first step needed to produce ethanol. Consequently, extensive purification is not needed if the beet sugar used for ethanol. Another aim of the project is to extend beet production to areas of North Dakota in which stones will likely become embedded in beets, thereby posing a significant concern for conventional slicing and countercurrent diffusion processes. This is the rationale for Objective 1. The overall goal is to minimize processing steps which add cost. Biofuel production does not require food grade quality sugars. Thus, simpler machines such as hammer mills are used to reduce overall cost.

One goal is to document energy consumption at each step of beet processing as well as the anticipated reduction resulting from our approach. Energy consumption varies from plant-to-plant and over the course of the campaign, and is not readily available information. When compared to the numerous machines involved in the food grade crystal sugar process industry (e.g. 49 in the Putsch, Germany, Scheme of beet sugar production), our novel process uses only three machines such as hammer mill, modified ribbon mixer, and frame press – as our requirements for biofuel production are not as stringent.

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 3A (Rating: 4)
The specific objectives are nicely laid out and described, and relatively independent of each other, suggesting a high likeliness of being achieved. Research plan is commensurate with the proposed budget and time frame.

Reviewer 3B (Rating: 4)
Overall, the objectives proposed in the proposal are achievable. The multi-disciplinary team including scientists from University and engineers and scientists from industry has a capability and experiences on the proposed research.

Reviewer 3C (Rating: 2)
The lack of details for each of the objective made evaluation nearly impossible. The lack of progress report from the previous funding did not increase reviewer's confidence.

Response to Reviewers' Comments

Objective Details

Objective 1: Perform engineering design and evaluation of pre-processing whole energy beets for ethanol fermentation, applying alternative front end technologies that reduce machine and energy use as well as processing cost. Appendix I presents the proposed alternative technology that involves three machines with expected reductions in energy and cost compared to conventional food grade sugar processing methods.

Objective 5: Evaluate the impact of anaerobic storage on the quality of whole beets to be used for ethanol production. Appendix II details the amounts of beets to be stored and the various tests to be employed. We had not actually intended to include juice storage in this proposal, because it is being covered very well under the first project. However, it might be helpful to extend those results to the type of juice which will be prepared under Objective 1, which will likely be more dilute than juice from the countercurrent diffusers. It might also be helpful to include a pilot-scale demonstration of raw thick juice storage.

Progress Reports from Previous Funding

The following research reports from previous REC and APUC funding are attached.

i. Current juice study update from NDSU
ii. Stillage burn test report
iii. 2010 field trial results from NDSU
iv. A published economic feasibility study report from NDSU

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 3A (Rating: 4)
The methodology described is appropriate. As a minor comment, I believe the proposal would be improved if the fermentative conversion of the extracted juice were assessed directly during the front end engineering studies. The sucrose concentration, to be measured, is not necessarily proportional to ethanol yield via fermentation.

Reviewer 3B (Rating: 4)
In general, the proposed methodologies are justified. However, the following two technical issues are not clearly discussed.

For objective 1 (Appendix I), the design for front end processing is suitable for sugar extraction through diffusion process. The water spray will dilute sugar content in the juice. Therefore, evaporation step may be needed to concentrate the juice.

For objective 5 (Appendix II), the research approach did not mention how to store the beets juice. It is challenge to stabilize juice at room temperature without any treatment.

Reviewer 3C (Rating: 3)
Some methods are well stated, while sections lack details.

Response to Reviewers' Comments

Fermentation

We agree that a "fermentability" test is needed to ensure that new storage and front end processing do not result in changes that reduce ethanol yield. This will be evaluated under the current project as mentioned under Appendix II.

Dilution of Sugar Content in the Juice due to Water Spray

The optimal mix of hammer milled beets and water for juice extraction will be determined during testing. Water at the appropriate temperature will facilitate sugar extraction in the subsequent pressing operation so that the maximum amount of sugar can be economically recovered with minimum residual sugars remaining in the pressed pulp. The amount of water, its temperature, juice concentration, and residual sugar levels will be determined by the experiment and optimized for techno-economic feasibility.

Storage of Beet Juice

We agree that thin raw juice will spoil very rapidly. This is being addressed under the current project. Concentration of the juice and pH adjustment ensures long juice storage life.

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 3A (Rating:3)
The investigation of juice storage is very important, to allow for utilization for biofuel production during the winter months, when cultivation is not possible. The proposal states the front end engineering approach ".. poses several technical challenges and research questions that require a scientific investigation." Yet, these "challenges" are not apparent. The research plan reads as a simple optimization of common processing equipment: mill; hot water sprayer; filter press. Energy efficiency and low cost for the "front end processing" are listed as objectives, but are not assessed.

Reviewer 3B (Rating: 4)
The proposal aims at development of an energy beet biofuel industry in North Dakota which support the mission of the Renewable Energy Council that to promote the growth of North Dakota's renewable energy industry through research, development, marketing, and education. The proposed research and commercialization plan meet the goals and purposes of North Dakota industrial commission on renewable energy program in terms of biofuel production, creating new jobs, growing renewable energy industry and promoting public awareness (education program).

The objectives of this proposed project are clear and consistency with North Dakota Industrial Commission/Renewable Energy Council goals.

Reviewer 3C (Rating: 2)
The reviewer doesn't think that the project is revolutionary for the bioenergy industry. Some of the work is needed, however, the impact is low.

Response to Reviewers' Comments

Juice Storage

Please see the revised objective statement under the "Response to Reviewers' Comments" in Summary #2 for juice storage.

Challenges to Front End Engineering Approach

The strength of the proposed front end processing system is its simplicity. It employs three common machines for milling, spraying, and juice pressing as opposed to more than 45 pieces of equipment typically used for food grade sugar production. The challenge is to use these machines economically while producing juice with the least amount of residual sugar remaining in the pulp. As the proposed front end processing is novel, the proof of concept is necessary to demonstrate that the system works.

Technical challenges that require investigation can be assigned to each of the three machines in our simplified process flow (Appendix I). Researchable questions include:

1) Hammer mill: What size particle (screen size) best ensures no-clog operation of the hammer mill when using fresh whole beets (high moisture)? Does particle size have a significant effect on the juice recovery and residual sugar on pulp?

2) Modified mixer: What combinations of water quantity and temperature optimize sugar levels in the juice? While low moisture is good for efficient mixing and makes the material flowable, and high moisture acting as a carrier of juice – What should be the optimum quantity of water to strike a balance yet having a positive effect on the whole process flow?

3) Filter press: What moisture and temperature levels of the input material optimize sugar recovery in juice and leaves minimum residual sugar on pulp? Is the pulp sugar level sufficient after a single press or are multiple presses with hot water mixing required?

Project Innovations

The project is innovative in a number of respects. We are developing entirely new types of beets for ethanol production which will be produced in parts of North Dakota that are not currently producing sugar beets. We propose a major change in the storage of those beets and in juice

extraction front end technology utilizing three pieces of major equipment, so as to produce ethanol in a much more affordable and less energy-intensive manner. If this succeeds, energy beet ethanol will achieve designation as an "advanced biofuel."

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 3A (Rating: 4)
The research team, based on a literature review, appears to be leaders in the use of sugar beets as a source of bioethanol in the US, in North Dakota in particular.

Reviewer 3B (Rating: 4)
I believe the principal investigators have strong industrial experiences on biofuel, and gained experience from phase I project.

The scientist and engineer from NDSU are well qualified for the project.

Reviewer 3C (Rating: 1)
While the PIs seem to have good credentials in conducting the work proposed. Lack of literature review is a concern.

Response to Reviewers' Comments

Literature Review

Juan Manuel Vargas-Ramirez, a graduate student working under Dr. Dennis Wiesenborn, prepared a literature review for his MS thesis research proposal which is attached.

Other related literature is also attached.

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 3A (Rating: 4)
Profs. Wiesenborn and Cannayen are well qualified to complete the beet juice storage and front end engineering studies, respectively. Dr. Gustafson is an appropriate lead to achieve the federal crop insurance status. The personnel at the Green Vision Group and NDSU possess the expertise to complete the field trials.

Reviewer 3B (Rating: 4)
The proposed research brings together a multi-disciplinary team including scientists from University and engineers and scientists from industry through partnership. The team has a capability and experiences on the proposed research. NDSU has strong research program on sugar beet research. Dr. Wiesenborn and Dr. Gustfson are good scientist and engineer in the field.

Reviewer 3C (Rating: 4)
PIs, especially those from NDSU have great credentials and background to conduct the project.

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 3A (Rating: 3)
The milestone chart is reasonable. The communication plan appears to involve quarterly meetings, quarterly reports, and semiannual advisory board meetings, as per the milestone chart, which would also be reasonable. The exact role of Heartland Renewable Energy (HRE) and the division of labor between Green Vision Group (GVG) and HRE, and between the individuals listed on pp. 9-10, are not clear.

Reviewer 3B (Rating: 4)
Management plan is justified.

Reviewer 3C (Rating: 4)
This was described as an objective of the project. It is adequate.

Response to Reviewers' Comments

Historically, this project has been unique in that all parties (GVG, HRE, NDSU) have shared equally in managerial oversight of all research activities. Certainly this has been the case for past APUC and REC grant projects. Project meetings to formulate goals, assign tasks, and report accomplishments have been attended by all parties.

Going forward with this larger and more complex grant proposal, we foresee a need for specialization. Therefore we expect 75% of the project management time will come from the three GVG principals. The remaining 25% of time will be provided by HRE and focused on front end processing and juice storage. GVG time will be spread across all the objectives. NDSU Agribusiness will continue to informally assist with overall project management, reporting, and results dissemination to assure successful completion of the grant.

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 3A (Rating: 2)
$54,450 is specified as budgeted major equipment needed for the front end engineering study, with no other detail or information provided.

Reviewer 3B (Rating: 4)
They proposed $54,450 equipment fee but no details about what equipment they are going to buy.

Reviewer 3C (Rating: 1)
About $55K is requested and it is not clear what equipment will be purchased.

Response to Reviewers' Comments

Equipment Budget Details for Front End Engineering Study

Equipment list	Purpose	Cost
1. Hammer mill with screens	Whole beets are shredded/ground into particle sizes suitable for juice extraction (various suppliers)	$10,000
2. Ribbon mixer	Mixing of the shredded beets with additives such as cold or hot water. 1 cubic ft, stainless steel, 1 HP (Machinery and Equipment Company, San Francisco, CA)	$8,450
2a. Heater + spray fabrication	This is a custom modification to the ribbon mixer involving indigenous design and fabrication. Basic ribbon mixers may not have provision for water spraying. We modify the basic system to incorporate cold and hot water spraying arrangement (various local suppliers)	$6,000
3. Chamber filter (Putsch)	This is commercial brand chamber filter press from "Putsch Filtration System." Model: Type 470, Semi-automatic electro hydraulic operation, about 200 liters capacity with 30 filters (H. PUTSCH GmbH & Comp. US & Germany)	$30,000
Total		**$54,450**

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 3A (Rating: 3)
The facilities for the field studies and the beet juice storage investigation will probably be more than adequate, based on the reputation of the NDSU co-investigators. The facilities to be used for the front end engineering studies are not clear. Are they currently available? What equipment needs to be purchased?

Reviewer 3B (Rating: 5)
Yes,

Reviewer 3C (Rating: 5)

Facility from NDSU is adequate for this project.

Response to Reviewers' Comments

Facilities Needed for Front End Engineering Study

Available facilities include physical, mechanical, and thermal properties measurement capabilities of whole beets and pressed pulp – these experiments could be carried out in the "NDSU Biomass Testing Laboratory at NGPRL." Also available are metal and wood fabrication shops. The sugar content of beets, juice, and pulp will be determined using standard procedures (refractrometer and chemical method).

Major equipment to be purchased is outlined in Item 8. The other purchase related cost is the supplies.

It is expected that the entire system is co-located at an existing processing facility where the inflow of beets and other outflow streams generated are properly handled by the existing infrastructure.

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 3A (Rating: 4)
I rate this proposal as "high" for this criterion, due to proper justification of budgeted items as needed to complete the proposed research plan, and the reasonable expectation of enhanced knowledge and utilization of sugar beets as a North Dakotan bioenergy source

Reviewer 3B (Rating: 3)
The proposed budget looks fine but I do think the funds for planting and harvesting as well as project management may be over budgeted. More funds should go to research part.

Reviewer 3C (Rating:3)
Due to the match obtained for this project, the project should yield average value.

[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.

Response to Reviewers' Comments

Regarding the Funds for Planting, Harvesting and Project Management

We consider planting and harvesting as part of our research. Planting and harvesting budgets are based on actual cost commitments for past plot /yield trials conducted. There is also analytical work on the harvested beets, publishing of trial results, weeding, chemical applications for various needs, plot management time, and substantial travel time, including moving equipment around the state for the planting and harvesting.

10a. <u>Financial commitment from other sources</u> – 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.

*<u>Reviewer 3A **(Funding May Be Considered)**</u>*
This proposal will further the development of sugar beets as a potential bioenergy source for North Dakota. The research plan is a nice blend of diverse activities focused upon this goal: increased field trials; enhanced bioprocessing and storage; enablement of federal crop insurance. The research plan is scientifically sound, with goals and subgoals expected to be achieved.

Sugar beets have many inherent factors which will deter its short-term economic viability, particularly its high cost relative to fossil fuels and the competitive use of beets as a source of sucrose. However, if biofuels from beets will succeed in any US state, it would be in North Dakota, due to its horticultural expertise with beets, its ideal climate, and abundant farmland. The use of irrigation to enable new farmland for beets would be a plus. The conversion of beets into biofuels is enabled by simple and inexpensive bioprocessing, due to the production of sugars in the form of a simple disaccharide, sucrose. I believe one of the most significant components of the research plan is the development of proper storage for beet juice, which would be needed for proper utilization as a bioenergy feedstock during the winter months, or to serve as a stockpile.

I encourage the applicants to consider more carefully in their Phase III, or other future, work the more cost-effective utilization of the pulp co-product. It is enriched in cellulose, pectin, proteins, etc., which may be converted into useful bioenergy feedstocks or products.

*<u>Reviewer 3B **(Fund)**</u>*
Sugar beet is one of the most important biomass in the State of North Dakota. Unlike other technologies on cellulosic biomass ethanol production, sugar ethanol production is a well-established and has been commercialized in the some countries. Sugar beet ethanol industry is suitable in North American too and will have large impact on the North Dakota's biofuel industry. The phase II proposal aims at scale up, finalization of cost effective and energy efficient plant design, and beets and juice storage for year-round uses which support the mission of the Renewable Energy Council that to promote the growth of North Dakota's renewable energy industry through research, development, marketing, and education. The success of the phase II will provide technical information for construction of the commercial facilities. The proposed research and commercialization plan meet the goals and purposes of North Dakota industrial commission on renewable energy program in terms of biofuel production, creating new

jobs, growing renewable energy industry and promoting public awareness (education program). The objectives of this proposed project are consistency with North Dakota Industrial Commission/Renewable Energy Council goals.

Research on storability of beet jounce for year-round use is extremely important for this special biomass.

The proposed research brings together a multi-disciplinary team including scientists from University and engineers and scientists from industry through partnership. The team has a capability and experiences on the proposed research. NDSU has strong research program on sugar beet research. Dr. Dennis Wiesenborn, Dr. Igathi Cannayen, and Dr. Cole Gustafson are good scientist and engineer in the field. The involvement of NDSU is critical to insure the project successful.

Weakness:

The detailed methodologies for objective 1 and 5 are needed.

From industry side, most of the investigators are at presidents or at top administrative level. Therefore, the research capability from industrial side is kind of weak.

More funding should be allocated on the research part.

Overall, my suggestion is that the proposal is fundable.

Reviewer 3C ***(Funding May Be Considered)***
The proposal addresses a very important area of the bioenergy industry. The major concern about this proposal is the lack of literature review. Considering the sugar beet processing industry is a mature industry, the processing technology and storage issues have been well addressed. Only literature review can identify the knowledge gap. Progress report from previous funding needs to be submitted before any new funding will be given. Committee might consider suggesting more involvement of NDSU, so that the literature will be done and more critical thinking can be used to design a more effective project.