TECHNICAL REVIEWERS' RATING SUMMARY

R013-C

Improving the Profitability of North Dakota Ethanol Plants with Algae

Energy & Environmental Research Center
Principal Investigator: Peter Letvin
Request for $200,000; Total Project Costs $426,550

Rating Category	Weighting Factor	Technical Reviewer 2A Rating	Technical Reviewer 2B Rating	Technical Reviewer 2C Rating	Average Weighted Score
1. Objectives	9	3	4	4	33.00
2. Achievability	9	2	3	4	27.00
3. Methodology	7	1	3	3	16.33
4. Contribution	7	2	4	4	23.33
5. Awareness	5	1	2	4	11.67
6. Background	5	3	4	5	20.00
7. Project Management	2	3	4	4	7.33
8. Equipment Purchase	2	3	5	5	8.67
9. Facilities	2	3	4	4	7.33
10. Budget	2	2	4	4	6.67
Average Weighted Score		108	176	200	**161.33**
Maximum Weighted Score					**250.00**

OVERALL RECOMMENDATION

FUND			x
FUNDING MAY BE CONSIDERED		x	
DO NOT FUND	x		

R013-C
Improving the Profitability of North Dakota Ethanol Plants with Algae
Submitted by Energy & Environmental Research Center
Principal Investigators: Peter Letvin
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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 2A (Rating: 3)
The objectives are presented clearly.

Reviewer 2B (Rating: 4)
The overall objectives and their justifications are clear.

It would have benefited the proposal if some additional information on the slip streams were provided, such as quantities, concentrations of sugars, suspended solids etc. The authors have provided citations to the literature (which is OK), however it would have benefited the proposal if they would have also briefly summarized (or at least provided the volumes and concentrations of sugars in each slip stream of interest) key results from the citations into this proposal document.

Production of 19,000 lbs of algae per day, in my opinion, is not a trivial matter – that is about 3,000 dry tons per year and would require a typical system of 100-acres of ponds, possibly costing $2-3 million annually to operate. All that said, it is still unclear in my mind how much sugar and effluent volumes are available to sustain this heterotrophic growth.

Reviewer 2C (Rating:4)
The main goal is clear …to produce “high-omega-3 livestock feed additives”. This is a very high level goal that could still use some additional supporting detail to clarify what is proposed. The addition of Appendix A was helpful in determining the value of the respirometric analyses.

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 2A (Rating: 2)
I do not believe that the objectives are likely achievable by the approach and schedule presented. The proposal presents no in-house results or literature references that provide any level of confidence that algal species valued at or above $1 per pound can be produced economically in a heterotrophic reactor using waste streams from an ethanol plant as substrate.

Based on a typical stillage composition of 30 g/L total organic carbon, and 50 mg/L total Kjeldahl nitrogen, one would not expect algae concentrations at harvest of more than 60 g/L (0.6%), and this would require substantial nutrient supplementation, especially nitrogen. This compares very unfavorably with successful commercial processes which yield 25% algae concentrations at harvest.

Further, the proposal cites market prices of $1 and $9 per pound for kelp meal and *Spirulina*, respectively, in support of its claims. These prices are the result of current dynamics of supply and demand. For example, the U.S. market demand for *Spirulina*, less than 500,000 pounds, is met in a 7 month growing season by Earthrise Farms in southern California on 60% of the available land within their fence lines. Mass production, as proposed, would collapse the price without a concurrent increase in demand. And nutriceuticals like *Spirulina* must be grown under FDA GMP (good manufacturing practices), which add extensive costs with respect to plant design, construction, operation, and quality control.

I believe that, for a small fraction of the time and money invested in preparing this proposal, a simple series of bench scales tests could have been performed to support the proposal. That this did not happen, or was not reported, brings into further question the technical and economic feasibility of the proposed approach.

Reviewer 2B (Rating: 3)
The objectives and overall idea is very good. The research team is also outstanding. Good background justification and methods are presented for the omega-3 and respirometry parts in the Appendix; not much on the algae growth itself. The authors have not specified the types of organisms to be screened, whether the algal cultures will be grown autotrophically before the heterotropic stage, what the inoculum size will be, duration of hetrotrophic runs, etc.

It is specified that 8 cultures will be initially screened – however no information on these are provided. In my experience, strong proposals either have data or results from the literature that are provided as justification, or the authors have their own preliminary data that supports the achievability of results. The authors have not done either of these relevant to the algal culture tests. The respirometric methods have been cited off the text book which describes the methods of obtaining kinetic parameters very well – I have seen this widely used in bacterial tests but never in algae systems. It would be an assumption on my part at this point that the rates of uptake of oxygen will be comparable and the method would be appropriate. It would have strengthened the proposal significantly, if the authors would have taken a set of preliminary data and demonstrated briefly the measurements and methods of determining kinetics – details of the methods could very well be cited to a larger publication (like Chapter 5).

Reviewer 2C (Rating: 4)
The approach is still not described in detail with regards to culturing conditions, but the explanation of how the lab scale respirometry data will be related to scale up algal omega 3 production is a significant addition. This is an interesting concept, and while the details are still a bit scarce, the high quality people and the improved description make the technical approach likely to be achievable.

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 2A (Rating: 1)
The methodology as presented in this proposal is well below average for the amount of funding requested. It would support, in my opinion, at best a preliminary experimental effort of well less than $100,000 in total. There is little, if any, discussion of the nutritional requirements for cost effective heterotrophic growth of high-value algal strains, and how those compare with the proposed substrate. This reflects an inattention to detail that is unacceptable for a proposed program of this size.

Reviewer 2B (Rating: 3)
My comment here is similar to that presented in question 2 above. The team is excellent and EERC is certainly a well-recognized leader. In my opinion, though, the proposal as written lacks a strong literature review and key details in the algae cultivation aspects.

Reviewer 2C (Rating: 3)
Still, very little technical information was provided on the methodology that was proposed. The text was provided was vague as to how (e.g., what methods?) would actually be used. The addition of Appendix A improved some of this, but many details still are left out.

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 2A (Rating: 2)
Based on the low likelihood of success for the proposed effort, as discussed above, it would be difficult to value the contribution to NDIC goals as anything more than small.

Reviewer 2B (Rating: 4)
If successful, this can have very useful impacts both on science and economic development as pointed out by the authors.

The authors have also made a good case for the ND ethanol industry needing these advancements (e.g. SD pipeline) and that the industry has the infrastructure to market these products readily (via. Existing product marketing pathways).

The potential of algal protein and omega-3 fatty acids for animal feed is well described and is an economically attractive option.

Reviewer 2C (Rating: 4)
It appears that scientific and/or technical contribution of the proposed work would be advanced beyond what is known already, particularly with regards to carbon-bearing wastes from ethanol production.

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 2A (Rating: 1)
The key question, whether or not high-value algae can be grown heterotrophically in a cost effective manner, using ethanol plant waste streams, is given no support in the references cited. The references which are cited first digest the waste streams and then grow the algae on the digester effluent, which may make more sense than the proposed approach. There is no discussion in the proposal of this route for growing algae, and this is a glaring omission.

Reviewer 2B (Rating: 2)
Based on what was written in the proposal, the authors did an excellent job making the case for growing algae with high omega-3 fatty acids and feeding to animals. This was supported by several citations. However, in my opinion, the proposal was not strong in describing the state of the art in heterotropic or mixotrophic growth of algae – such information as expected productivities, methods of cultivation, substrate concentrations, etc could have helped the proposal further. The authors have cited a thesis and several manuscripts describing similar work – it would have been a much stronger proposal if key results from those work would have been presented here with citations for more detailed information.

Reviewer 2C (Rating: 4)
The addition of the algae references is a significant improvement here. Some additional improvements could still have been made in this area, particularly with regards to questions 3 and 4 above.

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 2A (Rating: 3)
The background of the investigators ostensibly is suitable for the proposed work, but the weakness of the proposal calls this into question.

Reviewer 2B (Rating: 4)
All partners in this team are well qualified and bring something unique to the team. The significant prior experience of Mr. Letvin in commercial algal production is a key strength. Both Drs. Cowan and Raymond are very well qualified and key to the team. Other industrial partners are also excellent fits. Overall, very good team.

Reviewer 2C (Rating: 5)
The investigators appear to be very experienced in this area, and have made a significant improvement to the overall proposal quality.

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 2A (Rating: 3)
The project management plan is adequate, although I would expect that tasks 1 and 2 should continue for the full year of the program, and beyond.

Reviewer 2B (Rating: 4)

Reviewer 2C (Rating: 4)
The management plan is appropriate for a research project of this size.

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 2A (Rating: 3)
There is no equipment proposed for purchase by the NDIC share.

Reviewer 2B (Rating: 5)
With Dr. Cowan's expertise in using respirometric systems, this effort will contribute significantly in reporting growth kinetics of heterotrophic algae in the literature.

Reviewer 2C (Rating: 5)
The equipment would be purchased on the matching funds.

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 2A (Rating: 3)
The facilities and equipment on hand and proposed are deemed adequate.

Reviewer 2B (Rating: 4)

Reviewer 2C (Rating: 4)
The facilities appear to be more than sufficient to perform the proposed experiments and analyses.

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 2A (Rating: 2)
Based on the previous comments, I assess the value of the proposed work to be low. The key question of whether high-value strains of algae can be grown cost effectively should be answered first, and this could be done for less than ¼ the total cost of the proposed program.

Reviewer 2B (Rating: 4)

Reviewer 2C (Rating: 4)
The revised proposal has improved the level of information on previous algal research in this area and provided more details on the respirometry and analytical measurements. This is complimented by apparent quality of the team assembled for this proposal.

[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 2A **(Do Not Fund)***

Reviewer 2B ***(Funding May Be Considered)***
Overall, this is a very good team pursing a worthy idea. The proposal could have been much stronger if some preliminary data was presented (or citations to work along the same lines by others) and if greater detail was presented in the methodology for algae production and processing.

Reviewer 2C ***(Fund)***
Overall, I like very much the topic and the team, and the revised proposal addressed the major weaknesses detailed in the original review - a relevant literature review focused on the main issue of heterotrophic production of omega-3 and more details regarding the methods. Within the constraints of the review questions, these additions have significantly improved my rating of the proposal. I would suggest that this proposal be funded.