

TECHNICAL REVIEWERS' RATING SUMMARY

R009-C

Promoting Standardization of Combustion Characteristics for Biofuels

Energy & Environmental Research Center
 Principal Investigator: Carolyn Nyberg
 Request for \$50,000; Total Project Costs \$110,000

| <u>Rating Category</u> | <u>Weighting Factor</u> | <u>Technical Reviewer</u> | | | <u>Average Weighted Score</u> |
|-------------------------------|-------------------------|---------------------------|-----------|-----------|-------------------------------|
| | | <u>2A</u> | <u>2B</u> | <u>2C</u> | |
| 1. Objectives | 9 | 2 | 4 | 3 | 27.00 |
| 2. Achievability | 9 | 4 | 4 | 4 | 36.00 |
| 3. Methodology | 7 | 2 | 4 | 1 | 16.33 |
| 4. Contribution | 7 | 3 | 4 | 2 | 21.00 |
| 5. Awareness | 5 | 2 | 5 | 1 | 13.33 |
| 6. Background | 5 | 4 | 4 | 3 | 18.33 |
| 7. Project Management | 2 | 3 | 4 | 5 | 8.00 |
| 8. Equipment Purchase | 2 | 5 | 5 | 5 | 10.00 |
| 9. Facilities | 2 | 5 | 5 | 5 | 10.00 |
| 10. Budget | 2 | 5 | 4 | 3 | 8.00 |
| Average Weighted Score | | 155 | 209 | 140 | 168.00 |
| Maximum Weighted Score | | | | | 250.00 |

OVERALL RECOMMENDATION

| | |
|---------------------------|---|
| FUND | x |
| FUNDING MAY BE CONSIDERED | x |
| DO NOT FUND | x |

R009-C
Promoting Standardization of Combustion Characteristics for Biofuels
Submitted by Energy & Environmental Research Center
Principal Investigator: Carolyn Nyberg
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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: 2)

The overall outcomes of this project would be consistent with the goals of the NDIC/REC in terms of providing information that could increase use of biomass as a fuel for combustion in electrical power plants. Such development would enhance economic development, increase use of renewable resources, and diversity markets for renewable resources. On page 6 there are 4 listed objectives, and the 4th one seems to be backwards. Instead of evaluating biomass candidates to develop standard reference methods, it seems as if they would select the standard reference methods and then apply them to the suitable biomass candidates. This objective also seems redundant with objective 2.

Response: The authors appreciate the reviewer's comments and would like to better define the 4th objective listed on page 6: [Evaluation of suitable biomass candidates for the development of standard reference materials]. Standard reference *materials* are different than standard reference *methods*. Reference materials are well characterized materials (e.g. coal, fly ash, fuel oil, etc.) that come with certificates of analysis that list known reference values for a variety of key parameters. They are commonly used in analytical laboratories for such things as calibrating equipment, performance checks, and method validation and should be of the same matrix or sample type as that of the analyzed samples. It is the authors' experience that several standard reference materials for coal and other fossil fuels are readily available from many vendors, however biomass standard reference materials are extremely rare. It is the authors' intent with this project to begin the development of biomass reference materials so that analytical laboratories will have the opportunity to utilize these materials in the near future to enhance their analytical capabilities regarding biomass characterization.

Reviewer 2B (Rating: 4)

The objectives of the research and rationale for the project are clearly stated and I find to be in line with the North Dakota Industrial Commission/Renewable Energy Council goals. This project will generate new knowledge to maintain and expand renewable energy business opportunities and maximize the market potential for renewable energy resources.

Response: The authors appreciate the reviewer's comments.

Reviewer 2C (Rating:3)

The goal of the proposed project are Clear and consistent with the NDIC. Standardizing biomass will enhance its usage and commercial tradability.

Response: The authors appreciate the reviewer's comment.

- 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: 4)

If the applicants make better use of existing resources to identify existing standard methods, then the project should be achievable. In Figure 1 I question why 5 months are needed to select biomass sources to evaluate. This should take about 10 minutes of discussion. The budget seems reasonable.

Response: The timeline associated with the completion of activities one and two are only estimations at this point. The authors realize that the activity and task labeled "**Fuel Selection**" is somewhat misleading. This task will not only involve the identification and selection of suitable materials to characterize, but will also include the efforts associated with locating and obtaining sufficient quantities to be sent to the EERC. As stated in Task 2, the EERC will be relying on other North Dakota partners to help provide some of these materials and has allowed enough time in this task to coordinate schedules so that their activities are not significantly impacted.

Reviewer 2B (Rating: 4)

This project as written is ambitious in scope and expectation for achievements within the budget proposed. However, given the experience of the project leaders and budget detail, it can be assumed they have planned well and will be able to complete the project.

Response: The authors appreciate the reviewer's comments.

Reviewer 2C (Rating: 4)

The proposed goals are most likely achievable.

Response: The authors appreciate the reviewer's comment.

- 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: 2)

Task 1 issues: Evidently the EU already has standard methods and the equivalent of SRMs available for biomass feedstocks, and yet the applicants fail to provide any details about these resources. At a minimum they should have described what is available, and that a focus of task 1 would be to assess the suitability of these methods for application in the US. How long has the ASABE X564 working group been working on this same issue? This information should have been provided.

Response: The ASABE X564 working group has been working to compile the standards list since early in 2009. There has been some progress and a draft list was discussed at the last annual meeting in Pittsburgh, June 21st. It is unclear at this point when the list will be finalized. Although the efforts of this committee are in line with the objectives of this proposal, it is the intent of the authors of this proposal to utilize the resources of the EERC to help promote this information among the US biomass industry in a more timely manner.

Task 2 issues: The applicants fail to discuss how many samples of each type of biomass will be analyzed, where this biomass will be collected from, and if it will be collected from multiple years. It is well known that the composition of biomass varies depending on several factors, and if they propose to just analyze single samples, the data will just reflect snapshots. Instead the goal should be to establish the likely range of composition, as well as a nominal composition.

Response: The authors understand the relevance of determining the variability and compositional ranges among samples of the same biomass type, however these aspects are not the main focus of this project. Once *Task 1* is completed, appropriate methods will be applied to a select number of biomass types. The focus of the project is more on the evaluation and promotion of appropriate test methods and less on the evaluation of the biomass materials themselves. Nonetheless, a valuable outcome of evaluating the test methods will be a select group of well characterized biomass fuels, several of which will have originated in North Dakota.

Task 3 issues: While presenting the results of this work at conferences and workshops, and networking with industry is important, to get these standards “officially approved” will require interactions with appropriate “standards organizations.” Yet task 3 fails to describe what these “standards organizations” are, or if/how they will be approached with the data.

Response: As listed in Task 1, the standards organizations are ISO, ASTM, ASABE, and CEN. The project manager is a member of both ASTM and ASABE and is involved in committees within the organizations that meet to address the analytical needs and issues for biomass materials. The leaders of these organizations convey and communicate committee findings to other organizations such as ISO and CEN, and at the same time receive valuable information from other countries regarding biomass characterization. This information is then communicated with all committee members.

Task 5 issues: The applicants suggest that the information collected will be used to create new SRMs, however they do not describe if and how they will work with the National Institute of Standards and Technology to develop and approve these SRMs.

Response: The reviewer’s comment is valid. The authors were struggling with the 15 page limit and chose to minimize discussion of certain sections and apologize for not elaborating on this section. One of the authors has had discussions with NIST about packaging and distributing SRMs. There has been a verbal commitment by NIST to accept large quantities of well homogenized biomass materials that have had been previously characterized. They will further

evaluate the materials and repeat the analysis of key parameters to confirm concentrations and conduct statistical analysis in order to provide reference values. Depending on the outcome of the statistical analyses, the values will be given one of three classifications: certified, reference, or informational. At this point, the author is unable to provide a timeline for the commercial availability of these SRMs.

Reviewer 2B (Rating: 4)

The methodology as outlined is above average in relation to proposals evaluated by this reviewer on a regular basis. This proposal is well written, concise and very clear in intent and objectives.

Response: The reviewer's comments are much appreciated.

Reviewer 2C (Rating: 1)

The proposal does not mention many already existing testing methods. Please see section C for additional comments.

Response: The authors acknowledge that suitable methods are available for the feedstock assessment of biological conversion parameters such as lignin and carbohydrates listed in the table in section C, however these test methods don't apply to the goals and objectives of this project. The intent of this project is to assess the availability and suitability of methods used for combustion characteristics only, such as those listed in Table 1 of the proposal.

Table 1. Chemical and Fuel Quality Parameters to be Determined

| Parameter | Technique |
|--|---|
| Proximate (moisture, ash, volatile matter, fixed carbon) | Automated TGA ¹ |
| Carbon, Hydrogen, Nitrogen | High temperature combustion followed by IR ² detection for carbon and hydrogen, and TC ³ detection for nitrogen |
| Sulfur | High temperature combustion followed by IR detection |
| Halogens (bromine, chlorine, and fluorine) | Pyrohydrolysis followed by ion chromatography |
| Heating value | Isoperibol calorimeter |
| Ash chemistry (major and minor oxides) | X-ray fluorescence spectrometry |
| Trace elements (arsenic, lead, mercury, selenium, etc.) | Digestion followed by ICP-AES and/or GFAAS |
| Ash fusibility | Observation of melting behavior in a controlled furnace |
| Bulk Density | Mass/volume using a standardized measuring container |
| Thermodynamic Modeling | FactSage |

¹ Thermogravimetric analysis

² Infrared

³ Thermal conductivity

Specific methods were not listed for these parameters because one of objectives of this project is to ascertain the most appropriate method(s) for each of the parameters listed in Table 1. Based on the authors experience, literature information, and discussion with other laboratories, it is apparent that many *fossil* fuel based methods are being applied to biomass fuels, which are not always applicable. Many assume that these methods apply to all fuels and even if they don't think they apply, there is confusion as to which methods to use for biomass analysis of parameters such as ash content, heating value, ash chemistry, etc.

- 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: 3)

The overall goal of increasing use of biomass to generate electricity via combustion is worthy and matches the Council goals. However a significant amount of the information the applicants describe is already available. For example, one of the anticipated results is “appropriate, reliable, and reproducible standard test methods for the detailed chemical characterization of biofuels.” The American Organization for Analytical Chemistry (AOAC) is the repository for standard chemical analysis methods, and yet they aren't mentioned in the proposal. Again, this looks like another case of reinventing the wheel. Perhaps the chief value of this proposal will be as a catalyst to bring all this information together more quickly than it otherwise would.

Response: Please see the response to Reviewer 2C under section 3.

Reviewer 2B (Rating: 4)

The work proposed in this project is necessary to enhance the movement of biomass to biofuels. Directly this work will promote the efficient and environmentally sound development and use of North Dakota's (and other state) renewable energy resources, which will attract industry and create jobs. This work will most certainly encourage and promote the use of new technologies to have a positive impact on the bioenergy industry in the state and nation.

Response: The reviewer's comments are much appreciated.

Reviewer 2C (Rating: 2)

The incremental benefits from this proposed work appear to be minor.

- 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: 2)

The applicants fail to note that significant data on the chemical composition of biomass is already in existence. While slagging behavior, and the concentration of some minor components might not be available, there is abundant information already available. The applicants fail to describe past/current efforts of national and international bodies to develop appropriate test methods, and to take advantage of this existing information. Much of this proposal reads as if this is the first effort in history to evaluate biomass composition.

Response: The authors acknowledge that there is abundant information available about the chemical composition of various biomass materials, however as stated in other responses, the test methods used to analyze these materials and obtain this information in the past may or may not have been the most appropriate.

Reviewer 2B (Rating: 5)

The PI and all those involved with the project including partners have demonstrated knowledge of their project and related areas of research and the PIs have reached to very key partners to accomplish their objectives.

Response: The authors appreciate the reviewer's comment.

Reviewer 2C (Rating: 1)

Based on the review of existing testing method, the PI's awareness of the current research activities appears to be very limited.

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: 4)

Appears sufficient

Response: The authors appreciate the reviewer's comment.

Reviewer 2B (Rating: 4)

Those involved with the project have the background and professional credentials to execute the project.

Response: The authors appreciate the reviewer's comment.

Reviewer 2C (Rating: 3)

Background of the investigator is adequate for the proposed work.

Response: The authors appreciate the reviewer's comment.

- 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 most significant gap I see in this project the minimal description on page 6 of how the project will seek to gather relevant information from European Groups who have been working on this issue for decades. I would have like to have seen some direct interactions with CEN or ISO groups to speed up development of this standardized testing protocol.

Response: Please see the responses under section 3.

Reviewer 2B (Rating: 4)

The project management plan is very good and the context and content of the proposal make it clear there is excellent communication between and among groups.

Response: The authors appreciate the reviewer's comment.

Reviewer 2C (Rating: 5)

The project management plan is exceptionally good.

Response: The authors appreciate the reviewer's comment.

- 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: 5)

NA

Reviewer 2B (Rating: 5)

Reviewer 2C (Rating: 5)

- 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: 5)

Analytical facilities are fine.

Response: The authors appreciate the reviewer's comment.

Reviewer 2B (Rating: 5)

Excellent facilities and will use other labs for split samples to assure the work is credible and repeatable.

Response: The authors appreciate the reviewer's comment.

Reviewer 2C (Rating: 5)

The research group have needed equipment in place.

Response: The authors appreciate the reviewer's comment.

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: 5)

Budget appears appropriate and matching funding is sufficient.

Response: The authors appreciate the reviewer's comment.

Reviewer 2B (Rating: 4)

This research will add significantly to the knowledge base needed to grow the bioenergy industry in North Dakota and surrounding states that have large amounts of biomass. This research will address several of the environmental issues thought to be “solved” with biomass and those that to be created again valuable data. This project has as required achieved a match of 50% cost share.

Response: The authors appreciate the reviewer's comments.

Reviewer 2C (Rating: 3)

Budget value from this work will be average.

Response: The authors appreciate the reviewer's comment.

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 (Funding May Be Considered)

My main concerns are the limited discussion (and potential understanding) of all of the methodology and compositional data that is already available. In the first paragraph of the abstract the applicants point out the extensive experience of European countries in “utilizing biomass as a fuel for energy production for decades and have established suitable methods for biomass chemical characterization.” They indicate that the European Committee for Standardization (CEN) and the International Organization for Standardization (ISO) have or are already establishing appropriate test methods. This begs the question as to why this project is then needed.

In Task 1 the applicants describe two EERC researchers are members of an ASABE group that is already gathering and reviewing information from the groups above, as well as ASTM International, and that their output will be the very “list and/or book of reliable chemical and fuel quality testing methods” proposed herein. It is not explained how the funding proposed in this project will support or speed up the work of the ASABE committee. It simply looks like a redundant activity.

Reviewer 2B (Fund)

Reviewer 2C (Do Not Fund)

There are a number of standard protocols for biomass characterization, for example,

| Analysis | Standard protocol |
|-----------------------|------------------------------|
| Acetic acid | LAP-017 |
| Acid-soluble lignin | LAP-004 |
| Acid-insoluble lignin | ASTM E-1721-95 |
| Arabinan | ASTM E-1821-96, or E-1758-95 |
| Ash | ASTM D-1102 |
| Cellulose | ASTM E-1821 or E-1758-95 |
| Extractives | ASTM E-1690-95 |

| | |
|---|---------------------------------------|
| Galactan | ASTM E-1821-96, or E-1758-95 |
| Glucan | ASTM E-1821-96, or E-1758-95 |
| Hemicelluloses | ASTM E-1821-96 or E-1758-95 |
| Mannan | ASTM E-1821-96, or E-1758-95 |
| Starch | LAP-016 |
| Total lignin | ASTM E-1721-95 and T-250 (or LAP-004) |
| Uronic acids | Scott 1979 |
| Xylan | ASTM E-1821-96, or E-1758-95 |
| C | ASTM E-777 |
| H | ASTM E-777 |
| N | ASTM E-778 |
| O | By difference |
| S | ASTM E-775 |
| Volatile matter | ASTM D E-872 |
| High heating value (HHV) moisture free | ASTM E-711 |
| Lower heating value (LHV) moisture free | ASTM D-2015 |

It would have been beneficial if the PI would explain the additional value from the proposed work. However, slagging behavior would be of additional value from this project.