TECHNICAL REVIEWERS' RATING SUMMARY

R023-A

Application of Agricultural Byproducts for Energy Systems

Woodshed Renewables
Principal Investigator: David Fiebelkorn
Request for $237,093; Total Project Costs $638,232

Rating Category	Weighting Factor	Technical Reviewer 2A Rating	2B Rating	2C Rating	Average Weighted Score
1. Objectives	9	4	4	3	33.00
2. Achievability	9	4	4	3	33.00
3. Methodology	7	4	4	3	25.67
4. Contribution	7	3	3	4	23.33
5. Awareness	5	4	3	3	16.67
6. Background	5	4	4	3	18.33
7. Project Management	2	4	3	2	6.00
8. Equipment Purchase	2	4	5	3	8.00
9. Facilities	2	3	4	4	7.33
10. Budget	2	4	5	3	8.00
Average Weighted Score		191	190	157	**179.33**
Maximum Weighted Score					**250.00**

OVERALL RECOMMENDATION

FUND	x	x	
FUNDING MAY BE CONSIDERED			x
DO NOT FUND			

R023-A
Application of Agricultural Byproducts for Energy Systems
Submitted by Woodshed Renewables
Principal Investigators: David Fiebelkorn
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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: 4)
Proposed project will provide preliminary feasibility data (lab-scale thermochemical analysis of agricultural waste biomass-derived briquettes, economic analysis), to pave the way to large-scale production of briquettes for heating, to replace non-renewables as heating fuels, for use in the agricultural industrial sector, and others. Applicants have convincingly identified a potentially large regional market for the briquettes. Project could bring new jobs to ND. Therefore, the long-term goals of this project align strongly with those of the NDIC/REC.

Reviewer 2B (Rating: 4)
Same as first submission - The project very clearly hits on three major objectives – promotion of ND's renewable energy resources, job creation and additional benefits to farmers.

Reviewer 2C (Rating: 3)
The goals, as best I can determine, are consistent with the NDIC goals. It is difficult to determine the exact objectives of the project. Five objectives are listed on page 4 while on page 7 six objectives are listed.

PIs Comment - The authors clearly understand and agree with reviewers concern. The difference in the number of objectives was due to distinction between objectives and scope of the work as specified in the NDIC form.

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)
Proposed Objs 1-5 are very likely to be achieved.

Reviewer 2B (Rating: 4)
There is a big improvement over the initial submission with regards to identifying who actually cares about ag biomass pellets, largely in the form of Appendix C. Fantastic work on doing the necessary market research up-front and identifying what looks to be a very credible customer segment that will purchase the pellets.

That said, you're still only half way there. WHY would the poultry industry want to purchase pellets derived from ag biomass? What are their current methods for heating, and what does it cost them? In order for this to make any sense, it'll have to be at least cost competitive or cheaper than alternatives. If not, then why would a poultry farmer want to heat with ag-derived pellets?

The data collection and economic analyses are crucial, and need to be done up-front, but I don't understand why they they're slated for 2 full years. I would think that a grad student or post doc could do a cost analysis in a few weeks / months – it wouldn't be perfect but it could be ballpark and should be a necessary gating item for the entire project. If, and only if, the cost analysis confirms that pellets produced from ag biomass can be produced for less than or equal to competing processes should any substantial commercial manufacturing attempts be made.

Reviewer 2C (Rating: 3)
The project is feasible in terms of objectives, time frame and budget.

2B/7B: A preliminary economic analysis will be conducted immediately after receiving the notice to proceed to gauge the commercial viability of the proposed enterprise. The analysis will estimate the production cost of ag-based pellets and compare this value with prevailing regional wood pellet prices. Given uncertainty in delivered feedstock prices and variation in wood pellet prices a sensitivity analysis will be completed to determine break-even prices and the likelihood of the enterprise achieving a minimum acceptable rate of return.

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: 4)
Standardized tests will be used for thermophysicochemical analysis of briquette feedstocks and products. Economics and feedstock supply schedule-related methodology appears to be sufficient. Woodshed Renewables possesses the expertise to perform scale- up.

Reviewer 2B (Rating: 4)
There is a marked improvement in the marketing strategy, but again, it's only halfway there. You've identified A customer segment, but is there pull there? Are they currently utilizing wood pellets, and this would be a drop in solution, or would they require to completely overhaul their heating systems and purchase new furnaces. If so, what do those cost? What are percentage savings that customers could expect with ag pellets over their incumbent processes? What would a payback be for them to install the new system? Is that attractive to them?

You've made good in-roads in this front, but all of the questions above should be able to be answered prior to significant expenditures.

Reviewer 2C (Rating: 3)
No comments provided.

3B: This is a market segment, however, the market segment (as shown in the market study is large enough to support a regional pellet plant up to 40,000 tons of capacity.

The ability to burn renewable fuels would require a complete new heating system which is not necessarily a huge roadblock to the growth of this market segment. The industry continually faces the conflict of no appliances because there is no fuel and no fuel because of lack of appliances. The poultry industry would welcome an alternative heating system to the current open flame propane burner. There are a number of reasons for the lack of optimal performance of this open flame system. Listed below is a quick list of disadvantages of the open flame propane heating system:

1. the open flame propane system produces almost one gallon of water which is dumped into the air of the poultry house for each gallon of propane burned. This produces an atmosphere that requires the air in the grower house to be continually dumped to the outside and bringing in ambient cold air. Basically it heats up the ambient air, and dumps it outside to heat a new batch of air. This is extremely expensive and inefficient.

2. The presence of the water also shortens the life of the litter. The water condenses and falls mixing with the litter which creates a high concentration of ammonia. This causes bird health issues and raises the costs of the litter replacement.

3. The sale of the bird feet is a huge export market. Feet quality for food consumption in the export market requires that the feet not be "burned". Studies have proven that the per cent of healthy feet rises with the decrease of water in the house.

4. Pellets provide an alternative, back up heat fuel with a much more stable price point than propane. This provides the grower with cost options, increasing the payback. The cost of an appliance or system changeover will vary with each house, due to the age and construction to the building. A furnace and new system should provide on average 3.0 to 5.1 years based on the current market cost of propane and the added benefits of the new method of heating.

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 long-term goals of the proposed project address several objectives of the NDIC/REC. Briquettes from low-value agricultural product streams will reduce waste, thereby providing a value-added product for an identified market (e.g., regional poultry farms). Successful incorporation of agricultural residue feedstock into briquette manufacture will expand production of briquettes by Woodshed, and increase sustainable agriculture by expansion of briquettes as a fuel source in agricultural operations (e.g., poultry), thereby replacing fossil fuel-derived heating. Yet, the scientific contribution of the proposal is modest, since the manufacturing of briquettes is well established. There is some challenge in using agricultural residue-based feedstocks for the preparation of the briquettes, as described in the proposal.

Reviewer 2B (Rating: 3)
Same comment as before - If you can find a more ideal combination of existing agricultural biomass for pellet production that's obviously a valuable contribution, but again assuming that it can be done at cost and of course if it is technically feasible. I'm much more familiar with woody biomass pellets and aren't as familiar with pelletization capabilities for agriculture waste, so my question is: are there similar agricultural biomass-based pellet products that you can point to? Has what you're intending to do been done before? If not, why not?

Reviewer 2C (Rating: 4)
Nearly all of the goals for NDIC are in line with the technical contributions of this project. Specifically, maintaining or creating jobs, promoting economic development of a renewable energy source…

To our best knowledge there are several companies who are looking into this model. Specifically two Missouri companies are looking to pelletize crop residues and energy crops, following very different business models. MFA Oil Biomass is first developing a new energy crop and Enginuity worldwide started with an engineered pellet from agricultural biomass (Ref. Biomass Dec, 2013). Enviro Energy LLC of Unadilla, NY uses mixed grass and weeds and Show Me Energy, Kingsville, MO uses biomass crops for pellet production.

Agricultural Pellets Market – regionalization of production and usage are keys to creating a successful product and sale of the blended pellet. The process is not new. The attempts to produce a 100% ag pellet have not been as successful as projected. Our research to date suggests that a renewable blended pellet is a more optimal and flexible pellet production. The ag residue is an annual renewable raw material and it stretches the available wood supply by whatever "recipe" proves to be the highest economical return on investment.

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: 4)
The preparation of briquettes is well understood. There are a few reports on the use of agricultural residues (e.g., switchgrass and corn stover) as feedstock for briquettes, as described in the proposal. The authors have correctly identified the challenges of using woody biomass / agricultural residue feedstock blends rather than 100% woody biomass feedstock for preparation of briquettes.

Reviewer 2B (Rating: 3)
Similar comment as before - you cite some good research and broadly provide a picture for the market, but it's largely done at a 30k foot view. My main question here is the same as above: has someone else previously developed an optimized compositional blend of crop biomass, waste wood and agricultural byproducts? What academic and other research has been done in this space? If it is novel, why wouldn't you seek a patent?

If the answer to some of the questions here is that it's simply not economic to produce pellets from ag biomass, then you need to know that up-front.

Reviewer 2C (Rating: 3)
The project team is diverse enough to have an understanding of the technical (engineering), business (economics) and the marketing sides of the project.

As discussed in previous section there is a significant effort by private and public sector in the Midwest states to exploit agricultural biomass for densified energy products. Several state and federal agencies are working on this concept (West Kentucky Agricultural Biomass Pellet Report, 2012). Agricultural Utilization Research Institute (AURI) has published - A Feasibility Study Guide for an Agricultural Biomass Pellet Company (2007)

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)
The team at NDSU and Woodshed Renewables possesses the expertise needed for this project, in terms of economic analysis, feedstock characterization and compositional optimization, scale-up, and marketing/

Reviewer 2B (Rating: 4)
Much better explanation of Woodshed's existing operations, as well as the more detailed description of the distributor in Appendix C. The academic PIs also appear to be very well positioned. The team is a good combination of research and operations that should hopefully be able to commercialize the product.

Reviewer 2C (Rating: 3)
The three person team leading the project should complement each other nicely to provide a solid background for the proposed work.

The relationship between Heartland Energy Systems, Woodshed Renewables and Mr. Fiebelkorn may need to be clarified. Page 21 indicated Mr. Fiebelkorn is an owner of Heartland, yet his CV does not indicate any relationship to Heartland. Since, Heartland and Woodshed Renewables appear to be related entities it should be clarified how they are related.

When Woodshed Renewables, LLC was founded, all the costs relating to taking a product to market were explored prior to startup. Heartland Energy Systems was already in existence and we had about 18 months of market research and pre-marketing behind us. That allowed Woodshed to go to market quickly without starting from scratch and at a lower cost as HES markets for Woodshed strictly on a commission basis. This is a much lower risk for Woodshed. So HES has the exclusive marketing rights for Woodshed Renewables, LLC.

David Fiebelkorn is a founder and 33% owner of HES. I do have experience in the pellet market both on the fuel production and sale of pellets as well as appliances.

I am also the Chairman, CEO and President of Woodshed Renewables, LLC which creates a unique synergy of control and allows both entities to very mobile, agile and flexible in marketing Woodshed Renewables, LLC.

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: 4)
Management plan, consisting of monthly research group meetings and semiannual project reviews, will be effective, facilitated further by the geographical proximity of the project's work sites.

Reviewer 2B (Rating: 3)
My biggest recommendation – there should be a go / no-go decision after the data collection and economic analyses components have initial results. Figure out what your feedstock/input costs would be by talking to potential suppliers and understand what prices your customers would be willing to pay. How much margin is there in-between, and what sort of (very rough estimate)

production costs would you have? If it isn't penciling out, then you either need to find a customer who would be willing to pay more, understand how you can charge a premium, what state support / subsidy you can get, or decide not to proceed. There are seemingly plenty of technical / engineering challenges that will need to be overcome, but there's no point in trying to cross that road if the pellets aren't cost effective (maybe they aren't at first, but factor in economies of scale and learning curves).

You reference a 5% margin as a conservative number – that's very thin and not very attractive.

Reviewer 2C (Rating: 2)
The project would be strengthened by more clearly laying out when specific aspects of the project will be completed and how the results of each aspect will be presented to other investigators, the public or NDIC. The one sentence on page 12 following "Information Dissemination" is an extremely weak plan for sharing project results.

(See 2 A) A preliminary economic analysis will be conducted immediately after receiving the notice to proceed to gauge the commercial viability of the proposed enterprise. The analysis will estimate the production cost of ag-based pellets and compare this value with prevailing regional wood pellet prices. Given uncertainty in delivered feedstock prices and variation in wood pellet prices a sensitivity analysis will be completed to determine break-even prices and the likelihood of the enterprise achieving a minimum acceptable rate of return.

The industrial collaborator is investing significantly in this project, the intellectual property generated in this project will be shared with North Dakota Industrial Commission and they will have the right to put the information in the public domain. The NDSU researchers will be allowed to disclose the findings of this research either through technical bulletins or extension activities.

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: 4)
A lab-scale pelletizer is requested, serving as an integral part of the research plan.

Reviewer 2B (Rating: 5)
Substantially mitigated due to Woodshed's commitment to purchase the necessary equipment and do pilot testing in their current facility.

Reviewer 2C (Rating: 3)
All equipment purchases seem appropriate.

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)
Facilities at NDSU are adequate. The proposal does not provide a lot of information on the facilities at Woodshed Renewables; however, it appears that Woodshed possesses sufficient facilities for small-scale production, and has made plans for scale-up (e.g., planned purchase of a commercial scale pellet mill, with the purchase used as matching funds by Woodshed).

Reviewer 2B (Rating: 4)
It's difficult to say without more fully understanding Woodshed's existing operations, but it sounds like much of the required infrastructure is already in-place, which substantially mitigates the capital intensity of building an entirely new plant.

Reviewer 2C (Rating: 4)
All required non-lab equipment seems to already be in place.

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: 4)
The majority of the budget requested of NDIC, for salary of a postdoc and student to conduct the economic and materials-related research, respectively, is justified. Other expenditures are well justified. Therefore, the investment by NDIC of the proposed project would provide several identified direct/short-term and indirect/long-term returns on the investment. The only value-related issue to this reviewer is the charging of ~1/3 of the proposed budget for Indirect Costs by a state-funded university (NDSU), to a state- funded research grant-related agency (NDIC).

Reviewer 2B (Rating: 5)
Updated budget items are more in-line with expectations

Reviewer 2C (Rating: 3)
The project has sufficient matching funds and if the results of the project prove to be favorable economically, the results may be repeatable for other wood pellet manufacturers near agricultural waste streams.

[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 2A ***(Fund)***
Proposal strengths: The conversion of North Dakotan and regional low-value agricultural residues and waste products into briquettes for heating, thereby replacing fossil fuel-derived heating fuels, is an objective worthy of pursuit, to enhance environmental sustainability in ND agriculture, and may ultimately provide future employment. The proposed objectives, to identify and quantify ND ag waste feedstock supplies, perform an economic and market analysis, and adapt processing methods currently employed for woody biomass to ag waste feedstocks are reasonable goals that are commensurate with the proposed two-year project and the funding level. The project team members possess the expertise to complete the proposed research.
Weaknesses: Concerns are mostly minor. Transportation costs for moving feedstocks to the Woodshed Renewables facility in Finley, ND, will be a key economic factor, exacerbated by the

low density of biomass feedstocks. Therefore, it will be important that the applicants identify feedstock sources that are nearby to Finley. The other possible concern in whether the feedstock and processing optimization being proposed is sufficient to deal with feedstock variability. Moreover, the availability of woody biomass and agricultural residues will certainly vary seasonally. (Do the applicants have facilities and plans for adequate storage of the feedstocks?) The scientific merit is modest, since briquette manufacturing is well established, and some literature is available on the processing of corn stover and other agricultural residues. However, there will be some challenges in optimization, to formulate conditions for woody biomass/agricultural residue blends (and to address feedstock variability).
Summary: The proposal, to develop technology for preparing briquettes for heating fuel from agricultural wastes, is a pursuit worthy of investment by the NDIC, and should be carefully considered for funding. The research team possesses the expertise to complete the proposed research.

We agree that the cost of delivered feedstock is critical to viability of the platform and that feedstock characteristics will impact blending economics. The economic analysis will address each of these issues and incorporate the role of uncertainty in the analyses to address them.

Reviewer 2B ***(Fund)***
You've made a lot of good progress on looking at the market and thinking about who will want to buy your pellets, but you still have some more work to do.

You've identified the poultry industry, but **why** would these farmers want to purchase your pellets? There needs to be a compelling value proposition for them to switch away from their incumbent heating processes. It most likely would be price, so you need to know what the price of your pellets would be and how that compares to what they're doing now. I know that a lot of time and resources are devoted within the project plan to answering this question, but you should be able to get a ballpark figure sooner rather than later. If you run your analyses and find that feasible combinations of ag biomass and waste wood would cost more than incumbent heating technologies, even at scale, then you need to re-think how viable the product is.

I recommend funding the project, but the first steps should be answering this cost question. If it can be cost competitive, then proceeds to material testing / lab work / commercial runs, etc.

Reviewer 2C ***(Funding May Be Considered)***

- The proposal lists the expected benefits/results of the project on pages 5, 10, 11, 12 and 13. The proposal would be improved significantly if these were combined into a single section. This would also help provide clarity to the actual expected benefits/results. Currently the proposal wonders each time they are listed. Some expected results clearly detract from the proposal. For example "It will give North Dakota and Minnesota resident's protection against spike in heating costs." This assumes that 1) these households have a pellet stove 2) biomass pellets will be less volatile in price 3) biomass pellets will be a preferable alternative to tradition wood pellets. The sentence also has a grammatical error.
- Page 11 states "all actionable market research will be immediately" but the 1 sentence information dissemination plans doesn't give much confidence that this will be done.
- Page 11 also states "environment will benefit from locking the carbon in a sustainable product that will stay in place for a relatively long span of time." The pellet produced will be burned thus releasing the carbon not locking it place for "relatively long span of time".

- Page 31. It states that an undergraduate student will be employed for 250 hours per year at $10 per hour for two years. The math should be 250*10*2=$5,000 yet the proposal says $2,500.
- Page 32. I don't understand how this statement relates to the budget. "Adjustment assumed for year 2 of 772 hours."
- Page 32, last line. I don't understand how the year 2 salary ($23,809) was calculated.

This project has some considerable upside potential. The proposal is not particularly well developed, focused or written but the underlying project is stronger than the proposal.

Authors tried to list the benefits and results of the project on several pages as per guidelines and format of the NDIC application form. We agree it will be helpful if all the potential benefits of the project are listed on one page. As far as dissemination of results is concerned it will be done as per guidelines of NDIC, however university researchers will have freedom to share the results in the state, at the biomass expositions, extension meetings or through technical bulletins.
We agree on page 11 the statement about carbon locking should be rephrased. What we mean to say is the use of sustainable energy is going to stabilize the CO_2 generation. On page 31 there is a typo it should read as 125 hours per year, so the total budget is $2,500.

A primary driver in the cost of pellets as a fuel is the location of the production vs the source of raw material compared with the market demand. Controlling this segment of the pellet cost will provide the stabilization of the pellet price. Woodshed Renewables is currently in the market by using production from a sister plant in New Mexico. Woodshed has quoted numerous retailers as well as direct sales requests in the upper Midwest region from this location. Transportation costs have not allowed Woodshed to be competitive-we have to be local. Producing in North Dakota provides a potential to fill the void that exists in this region. The pellet market has doubled in a ten year period with the number of appliances sold each year. The export demand for US and Canadian produced pellets has also increased in that same time period. The pellet fuel institute tracks the annual price of pellets and over the ten year period described above, the volatility has been a modest 1-3%.

The appliances and demand are there and will continue to grow as the fear of propane availability becomes evident.