TECHNICAL REVIEWERS' RATING SUMMARY

R027-C

ROWS-Replacing Oil with Straw

New Energy Spirit Biomass Refinery, LLC

Principal Investigator: Stephan Rogers

Request for $500,000; Total Project Costs $1,035,000

Rating Category	Weighting Factor	Technical Reviewer 1C Rating	2C Rating	3C Rating	Average Weighted Score
1. Objectives	9	5	4	4	39.00
2. Achievability	9	5	3	3	33.00
3. Methodology	7	4	3	4	25.67
4. Contribution	7	5	5	3	30.33
5. Awareness	5	5	3	4	20.00
6. Background	5	5	3	4	20.00
7. Project Management	2	5	4	5	9.33
8. Equipment Purchase	2	5	5	4	9.33
9. Facilities	2	5	4	4	8.67
10. Budget	2	5	4	2	7.33
Average Weighted Score		243	183	182	**202.67**
Maximum Weighted Score					**250.00**

OVERALL RECOMMENDATION

FUND	x	x	x
FUNDING MAY BE CONSIDERED			
DO NOT FUND			

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Submitted by New Energy Spirit Biomass Refinery, LLC
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While the applicant is grateful for the Reviewers' recommendation to fund the project, it seems wise to address the Reviewers' specific concerns in an effort to boost the ratings in each category and thereby assure the Commission of the project's worthiness and its compatibility with Commission goals within its Renewable Energy Program.

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 1C (Rating: 5)
The objectives of this proposal are clearly articulated.

Reviewer 2C (Rating: 4)
This is a project the North Dakota Industrial Commission/Renewable Energy Council wants to support because it is clearly in line with its goals and missions. Utilizing locally available feedstocks, producing bioenergy of different forms, and creating jobs for agriculture and other sectors, and protecting environment by utilizing low carbon print biofuels are all offered by this project. It would be even better if the proposal shows data of environmental and economic impacts to support directly the project goals.

Reviewer 3C (Rating: 4)
I think the objectives to the ROWS project align very closely with Commissions goals and are very synergistic in vision. The end goal of the ROWS project would be a very big win for the state of North Dakota and the growth of the Renewable Energy space in this state. I think the overall approach and logic are very good and give this project a good chance for success.

Response: The overall ROWS project is based on the well-established fact that renewable fuels deliver significant environmental benefits, particularly cleaner air and the reduction of greenhouse gas emissions. The ROWS project is expected to meet or exceed all previous renewable fuel projects in delivering such benefits, based on its exceptionally low carbon-intensity (CI) scores. In addition, all projects undertaken by New Energy Investors, LLC must meet criteria for three-dimensional investing: that is, they must deliver financial, societal, and environmental rewards. Beyond the environmental payback over 20+ years, the ROWS project is expected to reward investors with 20+ percent ROI; North Dakota investors will be encouraged to participate as fully as they are able and interested. The societal rewards are multiple: construction and plant operating jobs; biomass research acceleration for the state university, extra rural income from biomass sale, gathering, and delivery; expansion of an existing energy park; and enhancement of the state's reputation for energy innovation.

Phase 2 of the project (the scope of the grant application) is expected to have near-zero environmental impact, mainly from travel to the project site. Overall project construction and operation is expected to meet all environmental impact concerns through the permitting processes. For example, vapor emissions are fed to a vent scrubber to recover organic compounds and control Volatile Organic Compounds (VOC). If required, the vapors from the scrubber can be treated in a Regenerative Thermal Oxidizer (RTO).

On an annual basis, the cellulosic ethanol from the plant will replace approximately 10,000 gallons of gasoline, the lignin will replace 80,000 tons of coal, and the biogas will replace 400,000 mmBtu of natural gas. Accounting for the plant's own energy consumption, the products from the plant will provide approximately 100,000 tons of CO2 abatement annually.

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 1C (Rating: 5)
Proposed NDIC funds would be used to help Phase II of a well thought out plan to prepare a commercial scale lignocellulosic ethanol biorefinery. The proposed objectives for Phase II are achievable.

Reviewer 2C (Rating: 3)
This reviewer is a little uncomfortable with the timelines and budgets as against the objectives set in this proposal. Unless there are actions have been taken at the moment of this proposal is being reviewed, 4-6 months of time seem very tight, especially to the fact that more than 10 parties are involved. The objectives may be achievable, i.e., results/ outcomes are obtained, however, the completeness and the quality of such work are uncertain. This reviewer can't find the answers from the proposal as it was composed, but as a process engineer with some industrial experience, it is reasonable to question the timeline as against the objectives set.

Reviewer 3C (Rating: 3)
Overall, I think most of the objectives can be met in the time and within the budgetitary scope laid out. There are a few items I believe are either under estimated for time or should have alternative budget approaches considered. These will be discussed later on.

Response: Timetables and budgets for Phase 2 are expected to be very tight; the major players are experienced and skilled at working under those conditions without sacrificing quality of results. Key participants have deep experience working with one another and the technologies involved. Three examples: The process engineering firm, APS, has worked directly with certain New Energy and Leifmark partners since the 1990s, and played an instrumental role in the build-out of the grain-ethanol industry in the U.S. APS has also been deeply involved in the commercial scale-up of Inbicon technology for U.S. markets for the past 6 years. Christian Morgen, who will manage Phase 2 as well as the overall project, is a mechanical engineer who served for many years as Inbicon's international sales and marketing director. Executives of Great River Energy, owners of Midwest AgEnergy Group, have been working toward completion

of this particular project since 2009, when a group from the company attended the grand opening of the first Inbicon Biomass Refinery in Kalundborg, Denmark.

The strongest incentive for meeting the timetable and budget of Phase 2 is being able to move forward to Phase 3 of the biomass refinery in a timely manner. The strongest incentive for quality control is knowing there's one opportunity to do this right.

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 1C (Rating: 4)
It appears that the applicants have a good idea of their plans for this proposal, and have identified the subcontractors who will be completing the deliverables. However, the approaches to be used (e.g., the pre-FEED design and the mass and energy balances) are not given in detail in the proposal

Reviewer 2C (Rating: 3)
A section on methodology is not included in the main text of the proposal for the proposal work. Information covered in the document provided by the PIs as an appendix provides some ideas on how the project would be conducted, of which this reviewer is based on for review. It seems that the project team knows what they are doing and has the execution plan of the proposed work in mind, just not being documented.

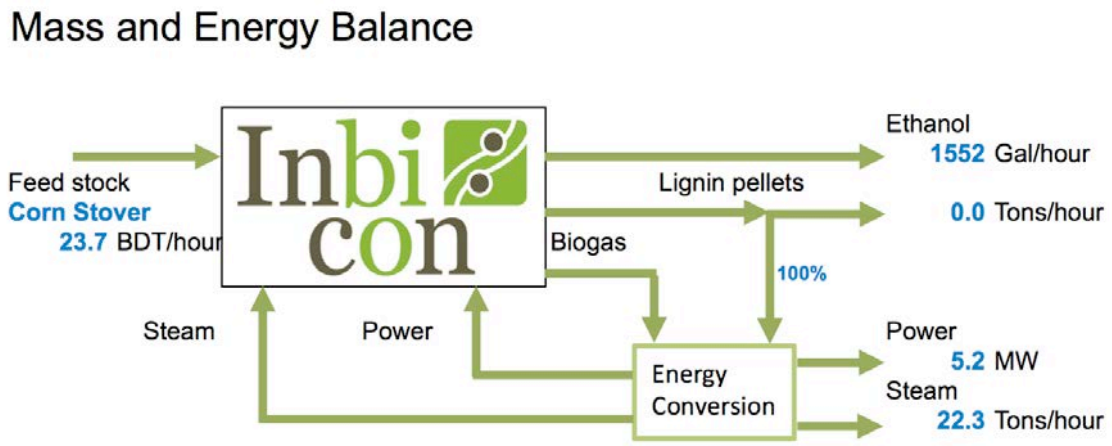
Reviewer 3C (Rating: 4)
The scope of work and the plan were very fluid and well though through. It was tied together well from top to bottom area of the plan and you can tell this is not the first time this group has pulled a development plan together. I think the team has under estimated the time and effort they need to spend on developing a feedstock supply plan and engagement with growers. With all of the efforts put in place to develop the technology and project, I think feedstocks are a bit under supported for the needs.

Response: The Pre-FEED design package will contain:
- *Conceptual design*
- *General process description*
- *Plant parameters*
- *Mass and energy balances*
- *Input/output figures*
- *Process Flow Diagrams (PFDs)*
- *Process model configuration data*
- *Environmental data/ Emission point list*
- *General layout, indicating area requirements (2D)*
- *General Construction Time Schedule*

Pre-FEED design package is build upon the generic data and process design already developed. The main product of the phase is to transform the generic technology data (existing FEL2 design

package) into a site-specific package based on the optimal plant configuration and local circumstances such as existing infrastructure, feed stock composition, and availability.

The generic biomass refinery configuration looks like this:



The calculations behind this configuration will be adjusted to conform to the North Dakota project specifications. This kind of calculation has been performed on three previous projects in order to develop specific pro formas. Present calculations show the biomass refinery will convert 23.7 bone dry tons per hour of corn stover to 1552 gallons per hour of denatured bioethanol, 10 dry tons per hour of solid fuel pellets with a heating value of 8600 Btu/lbs and 48 mmBtu per hour of biogas. The plant uses 5 MW of power and 30 tons (71 mmBtu) of steam per hour. The process uses water only in a start-up situation.

In response to the need for a more substantive feedstock supply plan, please see the attached "Spiritwood Short Biomass Memo" for a recent (May 2016) summary of the research conducted so far by Leifmark and others that is applicable to this project.

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 1C (Rating: 5)
The applicants have devised a detailed plan to construct and operate a lignocellulosic ethanol biorefinery in North Dakota that would benefit farmers, provide employment, and provide energy stability for the state. The partnering of their facility with an existing grain bioethanol facility and a power plant for readily available steam and electricity is a common sense approach that hopefully will be adopted by other start-ups in the bioenergy and bioproducts sector. The use of a low-water –based pretreatment technology has advantages in downstream separations and environmental sustainability.

Reviewer 2C (Rating: 5)

This reviewer is confident that the conduction of this proposed work and accomplishment of the overall biomass refinery project will contribute greatly to the goals by the North Dakota Industrial Commission /Renewable Energy Council. Completion and operation of such a project of biomass to bioenergy will not only promote environmentally sound development and use of North Dakota's renewable energy resources, but also create jobs and economic opportunity for farmers and other related sectors while providing positive environmental impact in North Dakota.

Reviewer 3C (Rating: 3)
This project would expand the technical contribution to a space that no one yet has in North Dakota. I think the unique nature in which the proposal is tying together the integration of an existing ethanol plant, a power plant and an agriculture community is a pretty strong technical maneuver.

No further response.

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 1C (Rating: 5)
Applicants appear to be very knowledgeable in the area of lignocellulosics biofuels and related business start-up.

Reviewer 2C (Rating: 3)
There is no literature review or other sort of documentation to show the investigators' awareness of the current development and research activities. However, developing technologies for bioenergy production and environmental protection is the nation's strategy and the investigators' knowledge in research and development in the area may have been evidenced in the previous phase of the overall project.

Reviewer 3C (Rating: 4)
The proposal clearly laid out multiple different pathways of either reviewing past technical documents reviewed or re-evaluating the space for additional literature that is available.

Response: The key participants have performed much of the original or substantiating research in this field; most of this has been regarded as confidential and kept secret, or shared narrowly, except for broad descriptions of process and results made available within the industry. Little, and in many cases none, has been published by the participants in peer-reviewed scientific or technical journals. The intent has always been to develop practical commercial applications in a highly competitive environment. While these were once based on early findings of various researchers, including universities in Denmark, today most published research confirms what is already known to key participants. Competitors in particular severely restrict what is made public about their operations and research results.

In the early 1990s, for example, one of the companies that later formed DONG Energy conducted biomass research to devise a treatment of the biomass that would reduce or eliminate boiler scaling when the biomass was burned to generate renewable electricity in Danish power plants. That primary research led to exploration into turning wheat straw into cellulosic ethanol. Inbicon was then set up as an R&D arm of DONG Energy with the intent of developing a commercially viable technology.

Another example: from about 2010 through 2014, DONG Energy conducted enzyme research at its Kalundborg facility in collaboration with three leading developers and manufacturers of enzymes and yeasts. The operation was so secretive that only the plant manager knew which particular enzyme was being used for biomass conversion on a particular day. The results were carefully measured and recorded and shared with the particular manufacturer; only the plant manager knew the comparative scores. None of this research, to the best of New Energy's knowledge, has ever been published and remains classified. However, all three of these manufacturers have been authorized by DONG Energy to supply enzymes for commercial biomass refining using the Inbicon process.

That said, many government agencies provide highly useful research that supplements the participants' existing knowledge. For example, Department of Energy's Billion Ton Biomass Study, which aggregates other research from Oakridge National Laboratory and various universities, is helpful in planning. The EIA is essential for up-to-date energy information and trends. The Argonne National Laboratory offers a new Energy Zones Mapping Tool that may prove a useful predictive aid for future project site selections. For biomass mapping and crop data and forecasting, the DOE, EIA, and USDA sites offer useful information.

Other sources of research include findings shared at industry trade shows and workshops, and through private collaboration with such agronomic and equipment specialists as Monsanto, John Deere, New Holland, and others. In reality, the best possible research project will be the commercial operation of the New Energy Spirit Biomass Refinery.

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 1C (Rating: 5)
The applicants and subcontractors possess the relevant expertise.

Reviewer 2C (Rating: 3)
There is no documentation on the investigators' experiences and background, rather than names are mentioned. It is this reviewer's discretion that this is a project that has been beyond its fundamental research stage and into engineering development and financial planning; the expertise of the project team, plus the contracted services to be pursued by the project, is then adequate to perform the activities proposed in this proposal.

Reviewer 3C (Rating: 4)

While reviewing the documents, I got a strong sense that this group has executed this type of process and document before. I felt comfortable that they had scoped the project well and that they have produced a sound work plan to execute. It felt like the investigators were well versed in many areas and where not, had supported themselves with area experts.

Response: In addition to the backgrounds already cited in the application, below are additional biographic details of key participants relevant to the proposed work, both Phase 2 and the overall refinery project.

Phase 2, Project Start, and the overall biomass refinery project will be managed by Christian Morgen, COO and Board Member of New Energy Investors, joined Leifmark after leaving DONG Energy, where he served as Inbicon's General Manager, International Sales and Marketing, for a decade. During his time at Inbicon, Christian was instrumental in advancing the Inbicon tech¬nology from an early idea phase to the commercial-scale process it is today. Christian guided the negotiations with Inbicon's first client, Mitsui Engineering and Shipbuilding (MES), which is licensed to pursue commercial production of the Inbicon technology in Southeast Asia. He holds a degree in mechanical engineering and a master's in business, both from the Technical Institute of Denmark.

Also from New Energy Investors:

Robert J. Johnsen, Chief Executive Officer and Board Member, has nearly two decades of experience founding, funding, leading, and commercializing renewable energy companies and two decades as Chief Executive Officer. He's combined executive management and investment banking skills in transforming alternative fuel companies Primus Green Energy, Promethegen, Mascoma, Verenium (formerly BC International) from technology developers into commercial entities. All of the biofuel companies entered into strategic relationships with major global corporations and had suc¬cessful exits through sales to three of their partners (BP, Total, and Lallemand). Prior to that, he held executive posts with major investment banks where he completed over $3 billion of financings pri¬marily in asset and project finance, last as Managing Director at Dain Rauscher Wessels (now RBC Capital Markets) and previously at Lehman Brothers, Bank of America, and the merchant banking arms of Chase Manhattan and Credit Agricole.

Stephan Rogers, Chairman of the Board, has 35 years of experience in large-scale project man¬agement and finance. He was Chief Operating Officer and CEO of cellulosic ethanol technology company Qteros, which raised over $55 million financing from Soros Fund Management, Battery Ventures, VeraSun and others. He has been the President and CEO of Rogers Management for 20 years, providing project development financing. Prior to founding his own firm, Stephan was a senior manager for multiple successful startup companies. Steve is currently CEO of NextChar llc, a bio¬mass-to-energy and soil amendment company headquartered in Massachusetts.

Thomas Corle, Chief Marketing Officer and Board Member, founded Leifmark in 2012. For 7 years, Tom was instrumental in building Inbicon from a relatively unknown Danish bio¬mass refinery technology into a leader in renewable fuel and energy sector. Tom also helped found the

Advanced Ethanol Council (now ABBC), a lobbying group focused on advancing the devel¬opment of the next generation of ethanol. For 11 years, Tom shaped the strategy that turned Delta-T, a leading technology in the build-out of the first-generation ethanol industry, into a highly valued brand. At the sale of the company R. L. Bibb Swain, the company founder, cited Tom's "considerable contributions" to growing Delta-T's business from annual revenues of $5 million to $500 million.

Judith Giordan, PhD, Chief Technology Officer and Board Member, has over a 30 years of ex¬perience in the chemicals and consumer products industries. Judith has a strong record of success with market aligned, biobased and natural intensive products and processes. She brings Fortune 500 business leadership experience, having served in executive management positions such as CTO and VP R&D at PepsiCola, International Flavors and Fragrances, Henkel Corporation, and Qteros. Judith's leadership has produced new products generating estimated annual revenues of over $30 billion.

New Energy advisor:

Bob Scaglione, Project Engineer, is the Founder, President, and Chief Executive Officer of Ad¬vanced Process Solutions, Inc., Richmond, VA. Prior to starting APS, he was the Regional Engineer¬ing Manager for a Mid-Atlantic engineering consulting firm. Bob has over 24 years working in the fields of industrial engineering and construction management. His expertise includes project develop¬ment and mechanical design. For over a decade, he's worked with several Leifmark partners, first in grain-ethanol plant design and later in commercial design for Inbicon.

Also from Leifmark:

Jesper Bang Andersen, Partner, Finance and Alliances, joined Leifmark in 2013 to develop financial solutions around renewable energy projects and to establish partnerships with key industry players for the North American market. Jesper is an 18-year veteran of Denmark's DONG Energy. In 2010, he began focusing full-time on Inbicon marketing and sales, co-developing and later helping implement the partner strategy while building a supply chain for the Inbicon Biomass Refinery technology. His interpersonal skills in contract negotiations, combined with his highly technical contract knowledge and expertise, translate into partner and client satisfaction and the acceleration of agreements that allow commercial projects to move forward. He has earned a master of science in economics and a master's degree in mediation and conflict resolution.

Paul Kamp, the Leifmark Partner responsible for Business Development, has an extensive background in bio-based fuels, chemicals, renewable resources, legislative affairs, and new technology implementation. Based in Chicago, he heads the commercialization efforts for Inbicon Biomass Refinery technology. Paul has traveled extensively across the U.S. and Canada, collaborating with biofuel industry owners, operators, ag groups, investors, engineering firms, contractors, and regulatory agencies. Much of his work is with the existing grain ethanol industry, developing sustainable, co-location platforms for cellulosic and grain ethanol production. He once led a global group of industry leaders in fuel, forest, waste, and chemicals

in bio-based supply chain strategy. As North American business development director for Delta-T Corporation during its heyday, he played key roles in first generation ethanol projects totaling over $1 billion.

Roger Moore, Partner, is responsible for all Leifmark marketing communications. He wrote Inbicon marketing communications from 2008 to 2014 and helped position the brand as an global leader in The New Ethanol industry. Prior to Inbicon, his creative ideas and copy helped turn Delta-T into a highly valuable brand. His business writing has included articles in Ethanol Producer and Biorefining magazines.

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 1C (Rating: 5)
The applicants have organized a management board to help keep track of deliverables and activities performed by the subcontract recipients. It appears that the applicants and subcontractors already have strong relationships, which will enable communication.

Reviewer 2C (Rating: 4)
This reviewer would consider the project management is very good. This proposal convers one stage of the overall project of biomass to bioenergy (multiple forms) refinery. This is a complicated process, involving quite a few partners and other parties. The project management is then very important. It seems that there are on-going activities led by a leadership. The proposed project in this proposal will be managed by a full-time person who has had experiences in similar projects previously, especially in scale-up of pilot scale and demonstration projects. This reviewer would like to see more details in coordinating project activities between the multiple parties involved, but the milestones and monthly reports may reflect adequately the project management plan.

Reviewer 3C (Rating: 5)
As similar to the comments for #6, this plan was well written, thought trough and executable. I like how they clearly identified milestones, mapped those out, have target timeline and share a plan for communication.

Response: Christian Morgen, the ROWS overall project manager, and Phase 2 manager, was a key player during the formative years of Inbicon technology advancement, deeply involved in the scale-up of two Inbicon pilot plants, the Inbicon demonstration plant at Kalundborg, and the commercial design being used today.

For coordination of project partners during Phase 2, a lead company will be appointed for each of the 11 work items defined, and the overall coordination between the work items will be handled by the project manager, Christian Morgen. Since both Danish (Inbicon, Processbio) and U.S. companies are participating, and in order to ensure best possible coordination, the project

will use Basecamp – a recognized project management tool specifically suited for management of projects with participants in many different locations. During the project, a number of coordination meetings (4-5) will be held, and all parties will meet in a physical location (Spiritwood or Denmark). This will support the team efficacy and provide committing milestones for all project members.

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

Reviewer 2C (Rating: 5)
Budget is lack of specific justifications but is assumed mainly for personnel and contract service costs. No equipment or any hardware is requested for the scope of work covered by this proposal.

Reviewer 3C (Rating: 4)
This group has budgeted very little for this and where they have it is necessary.

No further response.

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 1C (Rating: 5)
The team has the necessary facilities to complete the proposed work

Reviewer 2C (Rating: 4)
The nature of the proposed project is more on engineering planning and process design. Equipment available (or to be purchased) for the proposed research does not seem critical in conducting the activities proposed here. In reviewer's opinion, the facilities needed for conducting the project are assumably adequate.

Reviewer 3C (Rating: 4)
Very little was used for facilities. I think the team realized they did not need much and therefore did not look to spend more than needed for the facilities to execute this.

Response: The entire Phase 2 preparation is expected to be extremely lean and efficient. Overhead is exceptionally low for the major participants; the owners' engineer will have the most significant operating expenses. Costs are kept low in part due to extensive work by all major participants already completed prior to the application (see item #10).

10. The proposed budget "value"[1] relative to the outlined work and the financial commitment from other sources[2] is of: 1 – very low value; 2 – low value; 3 – average value; 4 – high value; or 5 – very high value. (See below)

Reviewer 1C (Rating: 5)
The proposal is of high value: furthering the establishment of a lignocellulosic biorefinery to convert underutilized agricultural co-products, corn stover and straw, into bioethanol, thereby benefitting farmers, future employees, and the energy security of North Dakota. Funds will be used mostly to prepare the pre-front-end engineering design and conduct mass and energy balances for the proposed facilities. Budget appears to be reasonable.

Reviewer 2C (Rating: 4)
This reviewer considers the return from the proposed budget is in high value. The proposed activities/ expected outcomes form this project, such as conceptual design with process control scheme, mass and energy balances, environmental analysis and construction planning, are well needed for the overall project to move to next stage. Funds from this grant program will be well spent.

Reviewer 3C (Rating: 2)
This was the lowest area I score the project. Two things stuck out to me. First, I think there are areas that are under budgeted for at this juncture. I think the biomass procurement plan will come up short on content and budget. As well, how well is the conversion technology really being flushed out? Second, I somewhat struggle with the proposed budget of the commission 100% covering the costs of certain engineering areas. I am a believer that the engineering cost for a project like this should be covered at some type of cost share. The project would have to do them either way, so they should not be able to push those off 100% to another group. I think they could spend those moneys in other areas to help support the project and would like to see the parent company spend more to help cover the engineering costs.

Response: To date, the most significant and highest value research done anywhere on cellulosic ethanol and lignin biofuel production has taken place at the Inbicon Biomass Refinery in Kalundborg, Denmark. It represents 15 years of process development, over 17,000 hours of operation, extensive biomass and enzyme testing, mechanized biomass handling, the latest advances in C5 and C6 conversion, and commercial sale for four years of the plant's cellulosic ethanol, lignin, and biogas.

To reach this point of commercial development, where industrial utilization is now possible, DONG Energy has spent over $200 million.

As a foundation for this NDIC application, the applicant and project group has already performed a feasibility study and developed a generic FEL2 design package. One of the main objectives within this project is to develop a site specific design package. More than a million dollars has already been spent by various parties to reach the current level of engineering for the North American market.

In addition, New Energy Investors intends to raise matching funds to bring the total investments in Phase 2 of the New Energy Spirit project to $1,035,000.

[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 1C ***(Fund)***

This is a strong proposal. Funds are requested to enable "Phase II" of the establishment of a biorefinery to convert underutilized (and unwanted) low-cost agricultural co-products into bioethanol. The overall plan to prepare, construct, and operate the biorefinery is also strong. The applicants are going forward in the right direction to secure resources: feedstock procurement, core conversion technologies, facility logistics, venture capital, etc. Phase II involves several of these logistics: preparing a front-end design and mass and energy balance for the design, civil engineering designs of the facility, and others. I find that the applicants have arranged all of their ducks in a row (resources, partners; both upstream and downstream), and their proposed research and development plan would be "ready deployable" upon receiving funding. I am an advocate of the general approach to be used to prepare the bioethanol: the use of robust pre-treatment based on low water usage (hydrothermal), enzymatic saccharification using enzymes and whole cells from industrial leaders (with built-in flexibility to change enzyme / fermentation products), and the production of lignin as a co-product in a form that us useful for a specific application (that perhaps can be utilized for new value-added lignin applications that may be developed in the future.) As mentioned above, the coupling of a lignocellulosic biorefinery with a grain ethanol biorefinery and a power plant makes a lot of sense.

I will add a couple of minor items of caution. First, there is a lot of uncertainty regarding bioethanol as a robust biofuel, due to the competition by abundant and low-cost fossil fuels (at least for a few years, but not for the long term), and the uncertainty of government subsidies for

biofuels in the near and distant future. Related, national and international interest may migrate to other biofuels, such as biobutanol, thereby requiring continual re-visitation. Second, although I was happy to see mention of the potential benefit to the UND and NDSU on p8, I am concerned that such collaboration would be difficult to develop due to the conflict between needing to protect intellectual property at the biorefinery versus the inherent need to openly present and publish new findings in academia. Yet, such a collaboration could be very valuable, in establishing a bioenergy/biomass community in the regions and state (that may foster further entrepreneurship), training skilled employees for the biorefinery, and leading to basic scientific discoveries that may be beneficial to all parties. I encourage that applicants to consider adding an academic representative to their management board, or some other meaningful means of involvement.

Reviewer 2C ***(Fund)***
This proposal impresses this reviewer as a project on full speed. The project team seems to has a vigorous plan and dedicated determination for accomplishing the project, which they believe will be a successful one, from the views of both environmental and economic impact and benefits. Technically, it is assumed sound for that the technology to be implemented is from a proprietary source which is said being fully tested. However, due to the lack of technical description in the proposal, this reviewer cannot make meaningful comments. This is a proposal more of an engineering development project prior to commercialization.

Reviewer 3C ***(Fund)***
Overall, I thought this was a very sound project the aligned very well with the objectives and goals of the Industrial Commission. The timelines and milestones are well laid out and achievable. The project scope is unique and positioned to give the project a very good chance at success. The team leading this seems seasoned and well prepared to execute. My only drawback was the level of financial support mapped out for engineering work to be covered by the commission and not shared by the parent company. Outside of this, I think the Industrial Commission should consider funding this effort.

1C. Although much effort has gone into, and will continue to go into, mitigating overall project and operational risks, it is admittedly impossible to mitigate political risk or predict political support. Partly for this reason, the design of the biomass refinery is such that the sugars produced are of sufficient purity that they can be sold to produce other higher-value bio products instead of being converted into ethanol.

Expanded dialogue and collaboration with the University of North Dakota and North Dakota State University is highly desirable. DONG Energy does this routinely with Danish universities. For example, the University of Copenhagen has test plots of the latest Danish crops to be evaluated for potential biomass. Adding an academic partner to the New Energy Spirit management boards sounds like a reasonable and wise action worth exploring with the universities. Most recently, representatives from NDSU are visiting Denmark on June 22-23, continuing the dialogue. There is much more to know about enzymes, yeast, bio materials, and biochemicals; a state-of-the-art biomass refinery could provide an unprecedented research opportunity for the universities that would also pay off for New Energy Investors.

2C. For a technical description of the New Energy Spirit Biomass Refinery, please see below:

A technical description of the biomass refinery + biomass handling….

This section describes all the key elements of the Biomass Refinery – input, technology, output and consumables needed to operate the plant. The core of the biomass refinery is the Inbicon technology consisting of hydrothermal pre-treatment (steam cooking) of the biomass and the subsequent enzymatic treatment, fermentation, distillation, dehydration, liquid/solid separation and anaerobic digestion. A description of the front end of the biomass refinery – the biomass handling – is included. This section of the Biomass Refinery is critical due to the importance of getting a uniform quality of feed material to optimize the process.

Technology – A biomass refinery consists of the following process unit systems:
1000: Biomass handling
2000: Hydrothermal Pre-treatment
3000: Enzymatic Hydrolysis & Liquefaction
4000: Fermentation
5000: Distillation and Dehydration
5900: Ethanol Storage
6000: Solid Biofuel (Lignin) Separation
7000: Solid Biofuel (Lignin) Drying and Pelletizing
7900: Solid Biofuel (Lignin) Storage
8000: Vinasse Evaporation
8900: Vinasse Storage
9000: Utilities and Auxiliaries
9600: Wastewater Treatment and Biogas Production
On-Site CHP Operations (optional)

Area 1000 Onsite biomass handling technology
•This section describes the onsite handling system necessary to handle biomass delivered to site. The information has been provided to Leifmark by Danish vendor Processbio.
Bale unloading and storage
•When a truck enters the plant, the driver cues up, and waits for his time to enter the barn. The Intra Log System tells him which barn to go to. The driver cues up in front of the designated barn (controlled by traffic lights), and waits for his time to enter the de-net area; the driver demounts the load securing net and straps. When that task is completed, the driver moves the lorry directly to the un-loading position below the robotic crane. He stops the lorry at a certain position. With the automatic de-loading system running, the driver will be helped by traffic lights – same system as in standard commercial car wash systems. If the automatic de-loading system is not running, he stops at a fixed position painted on the floor. After positioning the lorry correctly, the driver leaves the de-loading area and enters a safety zone, where he confirms the data given at the entering to the plant and confirms that there is nobody in the de-loading area on a touch screen.
•When the crane picks up the bales from the truck, it measures the weight and the moisture content of the bales. Data is stored and used for payment of the supplier. If the bales do not comply with the quality specifications, they are put back on the truck and rejected.
25 MT/h automated bale handling system

•When the stover preparation system calls for bales, the crane receives information from the Intra Log System to pick up a complete layer of bales (12 pcs.) from the barn. The system decides which bales to pick up as a result of an inventory analysis. The decision parameters could be how long the bales have been stored, or a demand from the operators, that a certain area of the barn must be cleared for maintenance or cleaning.

Bale handling

•Square bales are supplied to one of the receiving conveyors by the robotic cranes. The bales are always supplied 12 at a time, standing in 6 pairs, orientated short edge leading.
•The bales are conveyed via an eight string chain conveyor to an transfer unit, leading the bales to the bale distribution unit – wide edge leading. After the bales have been transferred, the bales are buffered on the next conveyor.
•When the bales enter the bale distribution system in front of the stover pre-processing equipment, the bales are pushed as single bales, onto the eight receiving/buffering conveyors. The speed of the conveyors must be synchronized to fit the speed of the pushers by means of frequency controllers. The conveyors deliver the bales single to the ten biomass pre-processing lines. The conveyors can be equipped with weighing cells.

Mechanical treatment

•The stover preparation system consists of four to eight identical lines each with a capacity of 6-6.5 MT/hour and a milling fineness of approximately 100 mm. The total capacity is 25 to 50 MT/hour.
•The bales arrive from the transfer-vehicle at the receiving table, where they are conveyed towards the string remover and bale breaker further ahead. The first step is to cut the strings/twine under the bales. A curved knife is pulled linearly across in the slot between 2 conveyors and cuts all 6 strings/twine. The bale expands and creates a consistent line of "bale wads."
•The stover wad will be loosened up in the stover shredder. Foreign objects in the stover will drop into the shredder chute. They will either go with the stover, get broken up or continue over the "wall." All foreign objects will continue to a stone trap.
•Behind the shredder wall the stover hits an inclined belt conveyor and is conveyed to the top. A spinning chain rotor beats the stover again to get rid of possible lumps. Above the belt conveyor a drum levels out the stover and pushes excess product back. This system creates a mat of stover for metering purposes. The drum gives together with the belt speed the right flow of material for further processing. At the end of the conveyor the stover drops into a chute in a free fall. A counter air stream catches the light products (stover) and leaves the heavy items (foreign objects and grain) behind in a waste skip. The stover is shredded and metered and all foreign objects are removed and situated in the ducting to a hammer mill.

Area 2000 Biomass Pretreatment

•After storage, handling and mechanical treatment the biomass undergoes thermal pre-treatment. The main step of this process feeds the biomass into a thermal reactor. The thermal reactor is subsequently emptied using a reactor discharger and the biomass is then led to the washing and pressing step.
•In the pre-treatment phase the biomass is first wetted with process water and then thermally treated at an optimum temperature to open the lignin structure of the biomass. The thermal treatment enables the enzymes to gain access to cellulose and hemicellulose. During the thermal treatment, a portion of the hemicellulose is hydrolyzed into monomeric sugars.

•When discharged from the thermal reactor, the biomass is diluted using recycled filtrate (referred to as C5 liquid) and is fed into a flash vessel. The biomass slurry from the flash vessel is then pressed to recover C5 liquid for recycling.
•The Inbicon pretreatment is based on industrial principles that are commercially established in the pulp and paper industry, and comprises the following equipment; one screw plug feeder, one horizontal thermal reactor system, a flash vessel, a biomass slurry press, filtrate tanks and a filtrate filter.

Area 3000 Enzymatic Hydrolysis & Liquefaction
•The fibers from the pretreatment phase are sent through a hydrolysis phase where they are diluted with process water and treated with enzymes to convert the cellulose and hemicellulose into glucose and xylose (monomeric sugars).
•The excess liquid, which contains C5 sugars, is led to a later stage of the hydrolysis process allowing the enzymes to convert sugar oligomers to monomeric sugars.
•The technology supplier has three certified cellulase enzyme suppliers: DSM, DuPont (Genencor), and Novozymes. All three have done extensive testing and validation in conjunction with the technology supplier.

Area 4000 Mixed Sugar Fermentation
•The fermenters are operated in a fed batch mode. The hydrolyzed fiber mash and C5 filtrate is cooled, and transferred to one of the four fermenters, where the fermentable C6 and C5 sugars are converted into alcohol by yeast or other ethanologens. The carbon dioxide gas and the volatile organic compounds (VOC) produced during fermentation are treated in a scrubber to recover ethanol and control the amount of VOCs vented to the atmosphere.
•When complete, the content of the fermenter is transferred to the Beer Well and the fermenter is cleaned. From the Beer Well, the fermented fiber mash is transferred to the distillation section.
•The yeast type is a modified saccharomyces cervisiae organism. There are more than 3 certified suppliers of yeast and ethanologens.
•The hydrolysis, saccharification and fermentation processes are based on the Separate Hydrolysis and Fermentation (SHF) principle.

Area 5000 Distillation and Dehydration
•The fermented fiber mash is pumped from the beer well to the distillation process, where it is preheated as is enters the top of the beer column, then distilled and rectified in a multi-column distillation system similar to the current ICM process unit. The final removal of water to produce fuel grade ethanol is achieved in a molecular sieve dehydration system or via a membrane system.
•The plant is designed to produce bioethanol to be used as an automotive fuel component. Un-denatured anhydrous (UDA) fuel ethanol will meet the specifications outlined per ASTM D4806.

Areas 6000 & 7000 Solid Biofuel Separation, Drying and Pelletizing
•Lignin separation and solid biofuel drying and pelletizing are accomplished using existing industrial solid/liquid separation equipment and methods. Water and solids (referred to as lignin whole stillage) from the bottom of the distillation system are separated in a filter press. The dewatered cake (about 50% moisture) from the press is dried to 10% or less moisture in a

rotary drum dryer and then pelletized. Vapor from the steam dryer is integrated with the evaporator in order to minimize the overall steam consumption of the process.
•The lignin from the demonstration plant in Kalundborg is used in power plants in Denmark to produce renewable electricity and reduce CO2 emissions.
•If lignin is to be combusted on-site in a CHP unit, it may be favorable to leave it in a powdered or higher moisture cake format. If the lignin pellets are stored or transported off site for sale, the dried and pelletized format will be produced.

Area 9600 Wastewater Treatment and Biogas Production
•The thin stillage from the pressing system is transferred to an anaerobic digestion (AD) system for the primary conversion of organic materials, to produce biogas and reduce the organic load. The AD system consists of a number of closed insulated tanks called digesters. The digesters contain microorganisms that convert organic materials to methane (CH4) and carbon dioxide (CO2), known as "biogas". The digestion process requires a specific environment in the tank to allow the microorganisms to work optimally, e.g. the correct temperature and pH must be maintained. The recovered water from the anaerobic digestion system is filtered to remove suspended solids.
•Anaerobic digestion is a continuous process, thus it is necessary to supply biomass and remove biogas and degraded matter. All digesters are fed sequentially in a way that is designed to suit the number of digesters. The waste water treatment/AD plant will be provided as an engineered process unit by a supplier certified by the technology supplier. During plant construction, it is expected that this process unit will be completed earlier than the rest of the plant to allow for operations startup lead-time.

Area 8000 Vinasse Evaporation
•In order to remove additional impurities, particularly dissolved solids, the liquid effluent is treated in an evaporator system consisting of multiple shell & tube heat exchangers commonly called "effects". As liquid flows through each of the effects, water is evaporated, thus concentrating the effluent to 50% solids. Concentrated effluent, known as Vinasse, is sent to storage. Recovered water is collected for reuse in the Hydrolysis area. Energy for the evaporation system is provided as flash vapor from the thermal pretreatment system, vapors from the Lignin Dryer, and steam.
•Chemical Storage
•Bulk chemicals used within the biomass refinery will be stored in a centrally located chemical storage area.

Emissions Control
•Vapor emissions are fed to a vent scrubber to recover organic compounds and control Volatile Organic Compounds (VOC). If required, the vapors from the scrubber can be treated in a Regenerative Thermal Oxidizer (RTO).

General Control Philosophy
•The Biomass Refinery is controlled by a process control system (PCS) supervised by operators to adjust the capacity of the individual units according to demands regarding capacity and quality of products and by-products. The PCS allows measuring, controlling and supervising of

the process. Further, the PCS will cover all requirements regarding operation, visualization, alarming, event logging, protocolling and permanent archiving.
•The plant is equipped with relevant safety devices and functional safety systems designed and installed in accordance with known codes and standards to ensure maximum safety for the operators.

CIP Requirements
•A Cleaning-In-Place (CIP) system is included to periodically clean and sanitize various process equipment and piping. The CIP solution is expected to be a dilute aqueous solution of sodium hydroxide. Concentrated sodium hydroxide solution and process water will be mixed in the CIP Supply tank to achieve the required concentration.
•Also, utilization of ag residues as biomass refinery feedstock introduces significant amounts of dirt and ash into the ethanol production process. Equipment with a risk of solid sedimentation and build up requires regular cleaning. A list of specific equipment and cleaning procedures will be provided in the Pre-FEED and FEED engineering packages.

3C. Please see response to #10.