INDUSTRIAL COMMISSION OF NORTH DAKOTA
RENEWABLE ENERGY PROGRAM

Governor
Doug Burgum
Attorney General
Drew H. Wrigley
Agriculture Commissioner
Doug Goehring

Renewable Energy Council Meeting: Grant Round 54

September 16, 2024, 9:00 am (CT)
Department of Commerce, WSI Boardroom, 1600 E. Century Ave., Suite 1, Bismarck

Join the meeting now
+1 701-328-0950,,669754585#

(approximately 9:00 am)

I. Call to Order

II. Administrative Business
   1. **Consideration of April 15, 2024 Meeting Minutes**

   2. Renewable Energy Program Project Management and Financial Report – *Reice Haase*

(approximately 9:30 am)

III. **Consideration of Grant Round 54 Requests** – *Rich Garman*

1. R-054-A – **Valorization of DDGS;** Submitted by North Dakota State University; Total Project Costs: $491,922; Amount Requested: $245,961
   a. Technical Reviewer Results
   b. Technical Advisor Recommendations
   c. Applicant Presentation

2. R-054-B – **ACS NewCarbon RNG Project**; Submitted by NewCarbon Feedstocks, LLC; Total Project Costs: $930,000; Amount Requested: $455,000
   a. Technical Reviewer Results
   b. Technical Advisor Recommendations
   c. Applicant Presentation

3. R-054-C – **VBD NewCarbon RNG Project**; Submitted by NewCarbon Feedstocks, LLC; Total Project Costs: $930,000; Amount Requested: $455,000
   a. Technical Reviewer Results
   b. Technical Advisor Recommendations
   c. Applicant Presentation

4. R-054-D – **Accelerating the Waste-to-Fuels Commercialization for the Sandwich Gasifier**; Submitted by Singularity Energy Technologies; Total Project Costs: $978,950; Amount Requested: $486,950
   a. Technical Reviewer Results
   b. Technical Advisor Recommendations
   c. Applicant Presentation

(approximately 10:45 am)

IV. Completion of ballots and **Renewable Energy Council vote on Funding Award Recommendations**

V. Presentation of “Unlocking Lithium Extraction in Produced Water” project by Wellspring Hydro

VI. Legislative discussion – *Reice Haase*

VII. Tentative Dates and Venue for next Renewable Energy Council Meeting:
May 2025

VIII. Other Business

IX. Adjournment

Minutes of the

RENEWABLE ENERGY COUNCIL (REC)

Monday, April 15, 2024

10:00 am (CT)

TEAMS Meeting Via Conference/Video Call

ONSITE Location: Workforce Safety & Insurance Board Room,

1600 E. Century Ave., Ste. 1, Bismarck, ND 58503

Members Present	**Staff Present**	
Rodney Holth	Reice Haase, NDIC	
Gerald Bachmeier	Erin Stieg, NDIC	
Terry Goerger, TEAMS	Brenna Jessen, NDIC	
Tony Grindberg, TEAMS	Joleen Leier, Commerce Dept.	
Rich Garman in place of Josh Teigen		
	Guests Present	
Jay Schulte	Jodi Bullinger, TEAMS	Russell Buchholz, TEAMS
Katherine Anagnost, EERC	Keiko Miller, TEAMS	Charles Crocker, TEAMS
Daisy Selvarat, EERC	Brad Stevens, TEAMS	Patrick Huvard, TEAMS
Tyler Hamman, EERC	Megan Hoye, TEAMS	Joey Harris, Tribune
Brian Kalk, EERC	Tom Oakland, TEAMS	Beth Croteau-Kallestad
Scott Iverson, MWEC	Heather Betts, TEAMS	Kyla Maki, TEAMS
Adam Miller**, TEAMS**	Cindy Savage, TEAMS	Adam Attenburg, TEAMS

WELCOME & OPENING COMMENTS

Rich Garman called the Renewable Energy Council (REC) meeting to order at 10:00 am. Garman explained he will be sitting in for Josh Teigen as Josh is recusing himself for the time-being for personal reasons. Garman welcomed the members and guests in the meeting room and on the TEAM video/audio platform.

Garman informed the board that Al Christianson (current board member) passed away this past week. He has been a valuable asset to energy and the Coal Creek Station. We had a moment of silence for Al and acknowledge he was one of the best leaders in the state.

ADMINISTRATIVE BUSINESS

Approval of Minutes

The minutes from the November 6, 2023, meeting was presented to the board. **It was moved by Gerald Bachmeier and seconded by Rod Holth to approve the November 6, 2023 meeting minutes as presented. The motion carried unanimously.**

Renewable Energy Program Project Management and Financial Report

Reice Haase provided overview. In the Industrial Commission-Managed Funds, you currently have 17 active projects and $8.8M in Renewable Energy Funds. The REC currently has $2.7M in the fund available to commit to new projects. $6.1M is committed to outstanding grants of $5.7 M and just over $300,000 for administrative costs and CO2 education. The $3M funding source comes from oil production taxes.

We've had 75 projects since conception and have received all the funding for the biennium ($2.7M).

Haase provided an update on the following projects:

- Gateway to Science Ethanol Exhibit

- Midwest Ag Energy CO2 Storage Assessment
- BWR Renewable Hydrogen Microgrid (project is complete and closed out March 2024)

Consideration of Project Decommitment:
R-050-064 – **Novel Process for Biocoal Production with CO2 Mineralization**; Submitted by Envergex, LLC in October 2022; Amount of Award to be Decommitted: $174,830.

Project was approved last year during Grant Round 50. Applicant wasn't able obtain their private match thus reached out to the board to return the funds. These funds would be added to the current $2.7M funds.

Gerald Bachmeier motioned to decommit the project and bring the funds back to the Council. Rod Holth seconded motion. Motion passed unanimously.

CONSIDERATION OF SPECIAL GRANT ROUND 53 REQUESTS

Rich Garman gave an overview of project R-053-A.

R-053-A – Twin Solar Complex
Submitted by Innovative Renewables, LLC
Total Project Costs: $756,370
Amount Requested: $378,185

Technical Reviewers' Results:
- Funding May Be Considered – 144/250
- Funding May Be Considered – 156/250
- Funding May Be Considered – 142/250
- Average Weighted Score – 147.33/250

Technical Advisor Recommendations:
Reviewers' recommendation is to consider funding.

Jay Schulte presented on the project.

Bachmeier confirmed the lot size is 25 x 150'. He also questioned zoning and waivers. Schulte explained that the City of Bismarck is willing to work with them for the project and set-backs of homes. Bachmeier questioned the design of home. Is a 25-foot lot. Schulte explained the building is 14 feet deep. The city wants 3 feet on back side of lot and would require fence, which is already there. The front of the lot is 6-8 feet. Again, the building is in the heart of town. Working with design company.

Bachmeier asked why this solar project is different. Schulte stated it's not very different, mainly showcasing it. This is a great way to expose this to the community.

Grindberg asked Mr. Schulte to confirm that this is an investment property project. Schulte stated Federal tax credits for solar, is that part of your modeling. Schulte stated they would be using the 30% federal tax credit for the solar install. This would be applied after the system is installed.

Also asked if we ever did a capital project. Reice stated he didn't recall a capital project, be we funded MHA Nation housing. That was more of a research project to model what it would look like and savings.

Bachmeier stated he feels like it's more of a marketing plan than on a new design or renewable since the technology is out there. Bachmeier sees it as a marketing plan to bring to the builders. Grindberg stated he concurred.

Rich gave an overview of Project R-053-B.

R-053-B – Regional Electric Vehicle Infrastructure Resiliency (REVIR) Plan
Submitted by Dr. Daisy Selvaraj, EERC-UND
Total Project Costs: $1,875,000
Amount Requested: $375,000

Technical Reviewers' Results

- Fund – 223/250
- Fund – 181/250
- Average Weighted Score 202/250

Technical Advisor Recommendations:
Reviewers' recommendation is to fund this project.

Dr. Daisy Selvaraj presented on the project.

Holth asked if they have the commitment from DOE, she stated yes.

Bachmeier asked if this was covering four states and why don't the other states contribute. Selvaraj stated they are exporting the power and can demand a premium on that.

How do you differentiate the power that goes on the grid that is going into each entity? NEVIP install along I94 & I29. Federal government is designating $5B for these; ND will be receiving $26M for 40 charging stations. Each station will have four charging ports; each having 150 kilowatts which will contribute to 6,000 megawatts. Brian Kalke, EERC, stated he had the same question six months ago. He stated they requested EERC ask other states to contribute in-kind money, however, want North Dakota to lead the study.

Grindberg asked, on 8/10/22 DOT submitted ND's plan for rollout of IHA funds for charging stations along the interstates. Does your plan factor in any gaps in the ND plan? EV installing but will look at the risks and challenges of the EV infrastructures across the four states because they are trying to come up with the interconnected EV infrastructure. EV plan will look into all the risks of each and every state. Then the EV plan will look into the unique risks of each and every state in the region and then the EV plan will integrate all these risks and implement these plans.

Russ Buchholz, NEVY Administrator for the DOT for the Program Daisy talked about which is $25.9M for the next five years of putting in the electric vehicle charging stations along the alternative fuel corridors which we designated as I-29 and I-94. He stated their intent is to go out with a notice of funding opportunity in mid June in rural. Looking at 18 charging stations within 50 miles of each other and no more than 1 mile off

the corridor. It will be charging stations at each site. It will be a privately owned operation due to legislation.

Grindberg thanked Dr. Selvaraj for her presentation. He also stated he would not endorse projects under his title with the company he works for to keep a separation of roles.

DISCUSSION/COMPLETION OF BALLOTS

Members online will need to email their ballots.

Ballots were distributed in the room and also emailed to members online. Reice reminded board members if they don't agree with the amount of the request members can make a recommendation.

R-053-A – Twin Solar Complex
Project Duration: 1.5 years
Requesting: $378,185
Total Project Costs: $756,370
Conflict of Interest: None
Fund: 1 w/conditions Do Not Fund: 4 Abstain: 0

R-053-B – Regional Electric Vehicle Infrastructure Resilience (REVIR) Plan
Project Duration: 24 months
Requesting: $375,000
Total Project Costs: $1,875,000
Conflict of Interest: None
Fund: 3 Do Not Fund: 2 Abstain: 0

Rich Garman entertained motion for project R-053-B to move forward to the Industrial Commission. Rod Holth moved to fund project R-053-B as requested. Gerald Bachmeier seconded the motion. Roll call vote all approved.

Reice will take the second proposal to the Industrial Commission will meet on April 20, 2024.

ADMINISTRATIVE BUSINESS

For the next round, the application deadline will be August 1, 2024. Proposed dates for the next REC Meeting is September 9th or 10th.

OTHER BUSINESS/ADJOURNMENT

After today's award REC has $2.4M remaining in this biennium.

Garman asked Haase to explain the process with the remaining funds and how it affects our legislation. Reice explained that when they testify to the legislature that will be with one more grant round to complete the biennium. The legislature will look at the funds allocated and what is remaining when determining if they will cut funding or grand new funds based on that. The biennium award is $3M, so if the legislature doesn't take any

actions, our assumption is that REC will be awarded another $3M for the next biennium.

Garman stated we should stress the applicants put more effort in the milestone and budget areas of the application.

Garman offered an opportunity for public input.

ADJOURNMENT

Rod Holth motioned to adjourn the meeting. Gerald Bachmeier seconded the motion. With no public comment, the meeting was adjourned at 11:11 am.

RENEWABLE ENERGY PROGRAM PROJECT MANAGEMENT REPORT

Reice Haase, Deputy Executive Director, NDIC

September 16, 2024

renewable ENERGY PROGRAM

NORTH Dakota

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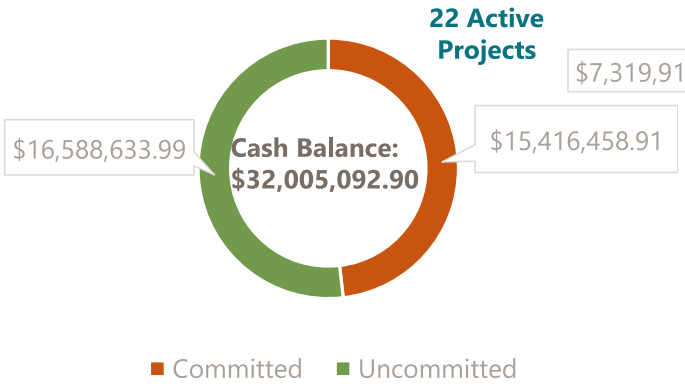
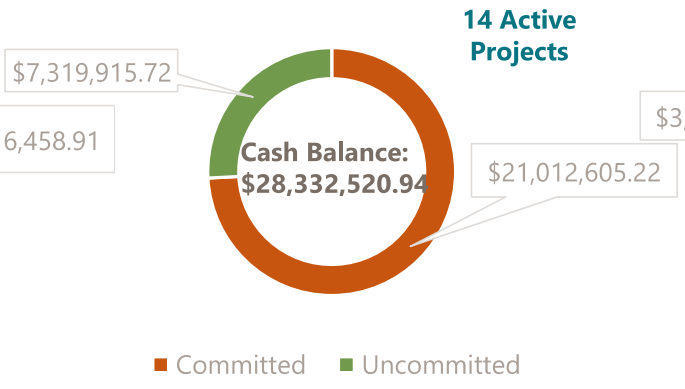
INDUSTRIAL COMMISSION-MANAGED FUNDS

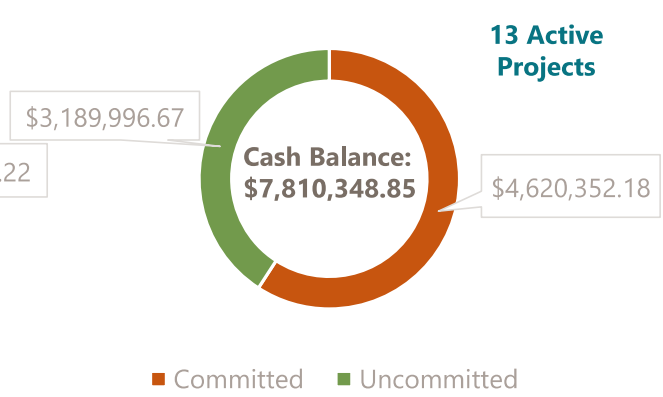
Lignite Research Fund



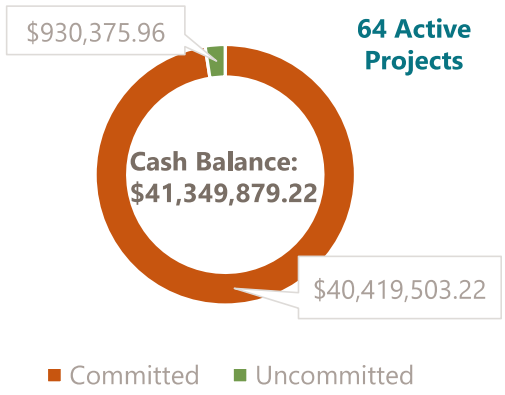
Oil and Gas Research Fund



Renewable Energy Fund

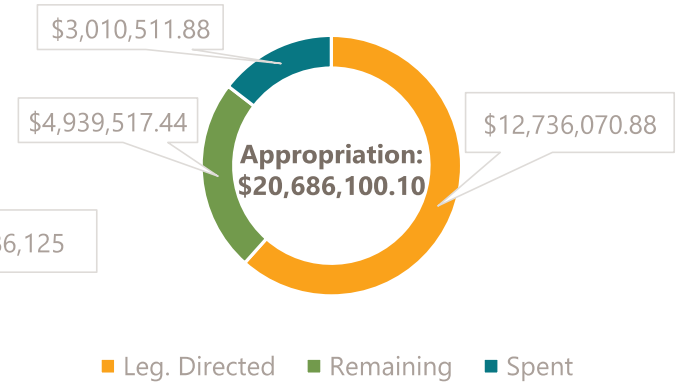


Outdoor Heritage Fund

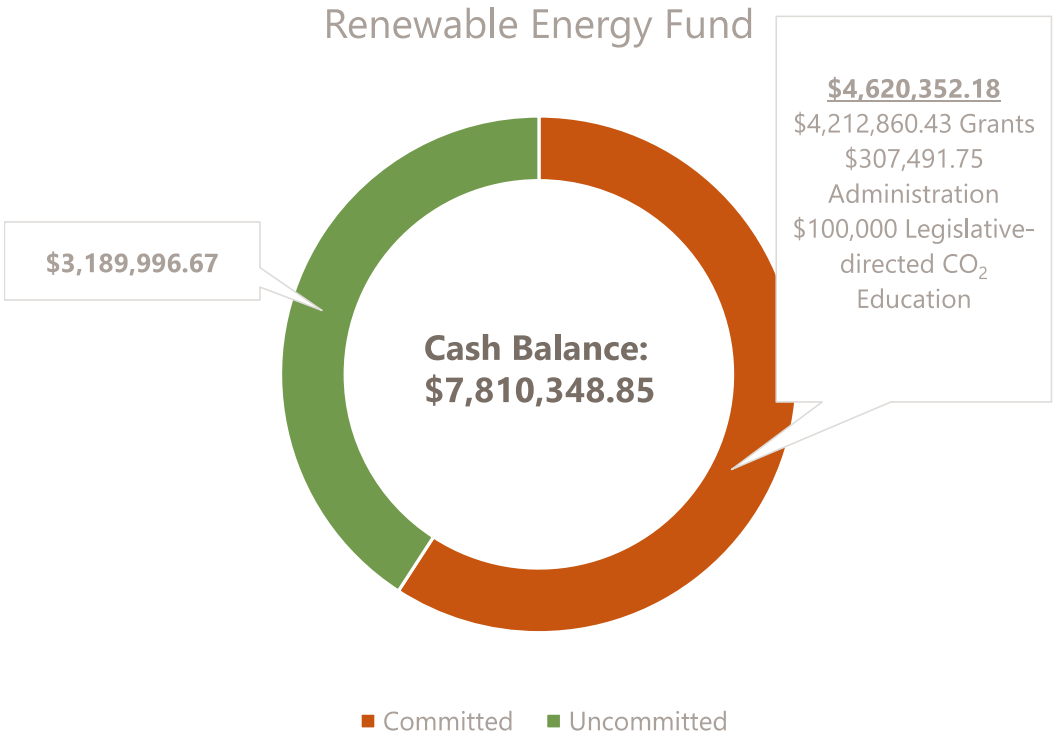


CSEA Fund*

SERC Fund



RENEWABLE ENERGY FUND BALANCE SEPTEMBER 16, 2024



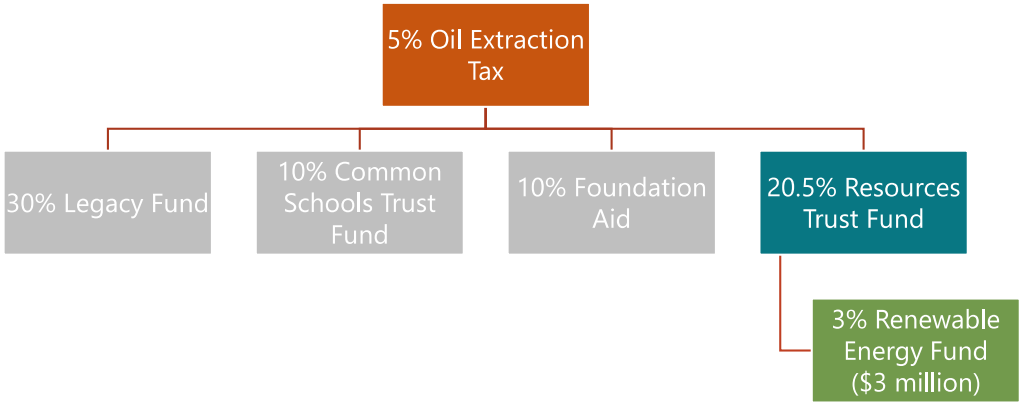
Funding Source:
- **$3 million oil production taxes**

72 Cumulative Projects

13 Active Projects

Cumulative Value:
- **$24.5 million granted**
- **$163.7 million project value**

2023-2025 BIENNIUM APPROPRIATION AND FORECASTED INCOME



Month	OMB Forecast	Actual
August 2023	$588,234	$523,151.02
September 2023	$607,842	$596,920.57
October 2023	$607,842	$660,900.75
November 2023	$588,234	$770,448.24
December 2023	$607,842	$448,579.42
January 2024	$6	$0 (Filled for biennium)

Assumes:

$62-75/bbl

1.1 m bbls/day

REPORT ON PROJECTS COMPLETED

NORTH Dakota
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R-046-056: Electrostatic Lubrication Filtration of Wind Turbine Oil Reservoirs

- $286,234 awarded to UND June 2021
- Demonstrated new filtration technology which cleans and extends the life of wind turbine oil (10,000 gal reservoir)
- Over 90% reduction in size of equipment vs. previously-available technology
- Next Steps: Pursuing commercialization

Figure 15: ELF Gen 1 (left) vs Gen 2 Scaled Down Pelican Case (middle, right)

Renewable Energy Development Program

Grant Round 54 Applications (September 2024)

Proposal Number	Applicant	Application Title	Principal Investigator	Total Project Cost	Amount Requested	Project Duration	Description of Project	Technical Review Score
R-054-A	North Dakota State University	Valorization of DDGS	Clairmont Clementson	$ 491,922.00	$ 245,961.00	2 Years	Develop a bioprocessing method aimed at extracting high-value proteins from corn Distiller's Dried Grains with Solubles (DDGS), a byproduct of ethanol production.	178.33 / 250
R-054-B	NewCarbon Feedstocks, LLC	ACS NewCarbon RNG Project	Matthew Moshier	$ 930,000.00	$ 455,000.00	1 Year	Study sizing and integration of a renewable natural gas project with American Crystal Sugar	154 / 250
R-054-C	NewCarbon Feedstocks, LLC	VBD NewCarbon RNG Project	Matthew Moshier	$ 930,000.00	$ 455,000.00	1 Year	Study sizing and integration of a renewable natural gas project with VanBedaf Dairy	159 / 250
R-054-D	Singularity Energy Technologies	Accelerating the Waste-to-Fuels Commercialization for the Sandwich Gasifier	Dr. Nikhil Patel	$ 978,950.00	$ 486,950.00	2 Years	Scale up and integrate operation of the Sandwich gasification technology to develop a viable customer base and build future commercial-scale facilities	213.50 / 250
				Total Amount Requested	**$ 1,642,911.00**			
				Total Amount Available	**$ 3,189,996.67**			

INDUSTRIAL COMMISSION OF NORTH DAKOTA
RENEWABLE ENERGY PROGRAM

TECHNICAL REVIEWERS' RATING SUMMARY

R-054-A
VALORIZATION OF DDGS

Principal Investigator: Clairmont Clementson
Request for $245,961; Total Project Costs $491,922

TECHNICAL REVIEWERS' RATING SUMMARY
R-054-A
VALORIZATION OF DDGS
Principal Investigator: Clairmont Clementson
Request for $245,961 Total Project Costs $491,922

		Technical Reviewer			
		1A	2A	3A	
Rating Category	Weighting Factor	Rating			Average Weighted Score
1. Objectives	9	4	2	5	33.00
2. Achievability	9	4	4	4	36.00
3. Methodology	7	4	3	4	25.67
4. Contribution	7	3	2	3	18.67
5. Awareness	5	2	3	3	13.33
6. Background	5	3	3	5	18.33
7. Project Management	2	4	3	4	7.33
8. Equipment Purchase	2	5	5	5	10.00
9. Facilities	2	5	4	5	9.33
10. Budget	2	3	3	4	6.67
Average Weighted Score		180	149	206	**178.33**
Maximum Weighted Score					250.00

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 1A (Rating 4)

Perhaps the strongest element of the proposed project is the noted economic and environmental impacts of the proposed effort. Despite not including quantitative targets in the program, qualitatively the objectives align very well with the NDIC REC goals. The project, if successful, has the potential to improve ethanol production sustainability and profitability. Furthermore, it could have job preservation value in the long term. The team provided multiple sections in the proposal that directly addressed this criterion and offered clear discussions of the economic and environmental value of the proposed work.

Reviewer 2A (Rating 2)

The outcomes from this project will be a method for protein extraction from DDGS and properties and/or structure of the extracted proteins. In other words, this project is largely a fundamental study in

laboratory scales. It is too early to see the possible applications of the extracted proteins. In addition, the proposal fails to provide discussions on how the leftover of DDGS after protein extraction be treated, utilized and/or disposed of, and if the economy of this concept of protein extraction from DDGS is justifiable. Thus, the project goal itself is clear but does not show its consistency with the NDIC funding missions of promoting the growth of North Dakota's renewable energy industries thru research, development, marketing, and education.

Reviewer 3A (Rating 5)
Direct alignment with REC goals of co-product utilization. Impacts livestock feed & human food indirectly through soil amendments. Identify value added products.

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 1A (Rating 4)
Standards of success listed in the project lack quantitative goals and are limited to qualitative goals of improvement. The two listed objectives are to (1) optimize extraction methodologies and (2) characterize the extracted DDGS proteins. Associated project milestones are also qualitative, and as such will be difficult to assess as being achieved. Despite the limit of being qualitative, the listed milestones are achievable. The main concern is that without quantitative targets, it is difficult to know if achieved milestones will be of high value or not in realizing the objectives of the project. For example, it would have been valuable if the team would have noted a protein extraction target for the project.

The budget appears fully adequate to support the noted work in the project.

Reviewer 2A (Rating 4)
For this fundamental research with routine methodologies and pre-developed procedures, the timeline and the fund request are sufficient to accomplish the proposed research activities.

Reviewer 3A (Rating 4)
Applicant has a contingency of a % of funds are not available showing project planning initiatives.

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 1A (Rating 4)
To the extent possible within the page limits of the proposal, the team has created a clear high-level plan with sound methodology, as described in their experimental design. One item I found somewhat surprising is that the first step in the selection of extraction techniques is that the team will do a survey/review of literature. One would expect that this would have been done in preparation of a proposal with the best techniques already identified and a down-selected subset proposed to be studied. Otherwise, the methodology seems appropriate. The table beginning on page 9 of the proposal is particularly valuable in that it shows clear consideration for where each technique required in the project is to be carried out and verifies that any necessary equipment or infrastructure is available on site or through a fee for service basis.

Reviewer 2A (Rating 3)
The methodologies and the pre-developed procedures are satisfactorily presented. The facilities and equipment documented are adequate for the proposed work. The methodology, however, is lacking scientifical novelty.

Reviewer 3A (Rating 4)
Very detailed methodology and straight forward approach to mee the specific goals of concentrating protein from extract. States "protein extraction is currently limited," why not focus on this issue? (page 4, paragraph titled Selection of Extraction Techniques).

The project plan calls for identifying a simple and cost-effective means of protein extraction. I imagine that the extraction technique can change the quality and quantity of the protein yield. I am sure this will be covered in the report.

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 1A (Rating 3)
The team clearly articulates the importance of increasing value and local use of corn DDGS. Doing so will improve the viability of ethanol plants in ND, offering increased sustainability and efficiency. As noted elsewhere in this review, the lack of prior/current literature in the proposal limits the ability to fully assess its potential technical value. The team does provide substantial justification of the economic and regional value of the project goals, and this generally aligns well with the NDIC REC goals. As this specific criterion of assessment is specific to the scientific and/or technical contribution, I would have preferred a bit more validation from multiple literature citations, though the one noted paper by Bello from 2023 does directly note the importance of such work.

Reviewer 2A (Rating 2)
Again, this is fundamental research. Its contribution to specifically address the NDIC /REC goals requires further assessment beyond the current research stage. At its current stage, its contribution is limited.

Reviewer 3A (Rating 3)
While characterizing and concentrating corn protein is important to the EtOH industry, the corn wet milling facilities are already separating protein already. My question is how fundamentally different are these proteins in the market place.

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 1A (Rating 2)
There is nearly no reference to prior work in the proposal other than a note about some prior work, "…as documented by Bello et al. (2023),…". This paper includes one of the Co-PIs as a co-author (Hammed). One of the primary limitations of the proposed project is the lack of a sufficient discussion of prior work and existing literature. Not being an expert in protein extraction or DDGS, it is very difficult to validate the level of awareness of the PI of other work and how competitive/relevant the work proposed is as compared to the current status in the field. The one noted publication is directly tied to the work and validates expertise but does not provide sufficient detail on the current status of the field, particular by other groups.

Reviewer 2A (Rating 3)
The proposal does not include a literature review to demonstrate the PIs' awareness on current research activities and published literature in related fields, except citing one previous work by a co-PI and a web report on DDGS production in North Dakota. Per the context of the proposal as discussed in the section of Background/Qualifications, it is assumed that PIs have adequate knowledge in the field.

Reviewer 3A (Rating 3)
Current awareness is apparent in the biographies of the PI and co-PIs. only 2 research references given and one is for the general public. Would have liked to have seen more research references. The lack of other referenced research give a 3/5 rating. If there isn't any more, then state as such.

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 1A (Rating 3)
The PI (Clementson) well positioned to manage the project given that he is a certified Project Management Professional (PMP). He has some post-graduate experience in grain handling, storage, processing and co-product utilization. Though not described the narrative notes he has had involvement in improving the protein concentration extracted from soybean meal – this is directly related to the proposed project scope. Further, one of the Co-PIs (Hammed) is noted to have significant prior contributions in the field of protein extraction from various sources such as soybean, soymeal, and fish skin. The one publication (Bello 2023) is noted that included him as a co-author, validating his expertise in the field.

My general feeling is that the personnel listed have the basic scientific background to carry out the proposed work and taken at face value, seem to have prior experience specifically in protein extraction. Understanding if this is better than average would require a bit more detail and greater number of publications or products noted from the team as evidence.

Reviewer 2A (Rating 3)
The proposal provides adequate discussions on the background and qualifications of the PIs as related to the proposed work, especially one co-PI on the project who has done similar work previously. However, the project PD has expertise in different technical areas. Overall, the PIs' preparation for this project is adequate.

Reviewer 3A (Rating 5)
The PI & Co-Pi's backgrounds are excellent.

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 1A (Rating 4)
Proposal includes a basic Gannt chart of the project milestones over the 2-year duration. The team notes that it will meet b-weekly to assess the project and address any challenges that arise. Given that the PI is certified in PMP, the project is likely to be well managed.

Reviewer 2A (Rating 3)
The proposal has a project management plan in place, and discusses the plan with milestones and schedules, and a financial plan. The proposal provides the means of communications among the PIs.

Reviewer 3A (Rating 4)
Project schedule provided, budget provided, presentation on schedule – does not state to whom. Frequent meeting between the investigation team is planned and stated in the management section.

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 1A (Rating 5)
The project does not include any purchase of equipment and the team will leverage the resources available at external facilities for a fee.

Reviewer 2A (Rating 5)
No purchase of equipment is requested from this proposal.

Reviewer 3A (Rating 5)
Project has reasonable consumables per the project testing plan.

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 1A (Rating 5)
The team provided a very clear list of techniques to be used and where they are available in a table in the proposal. All key items required for the proposed work appear to be in place and/or are accessible through a fee for service that is included in the budget.

Reviewer 2A (Rating 4)
The proposal provides a detailed list of the facilities and equipment, which are notably good for the project and activities.

Reviewer 3A (Rating 5)
NDSU has the facilities and equipment or can easily obtain time on required equipment.

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 1A (Rating 3)
The project budget totals roughly $492k over the 2-year duration. Just over 50% of this comes from cost share primarily from NDSU, meeting the minimum required for the program. Tharaldson Ethanol is providing $2,500 worth of DDGS in support of the project. As noted earlier in this review, the technical value is difficult to assess given the lack of quantitative targets and deeper discussion about the current state-of-the-art.

Reviewer 2A (Rating 3)
The proposed work and expected technical outcome have an average value for the budget requested due to its technical/scientific contribution to and/or economic significance for further development and commercialization. Among the request of approx. $246k, approx. $75k are for operating costs and fees and approx. $170k for personnel to support two graduate students. The matching funds are solely the time contributed by the PIs, with an in-kind support of $2,500 from the industry collaborator.

Reviewer 3A (Rating 4)
There is medium risk and high reward for this project. It is likely that a new value-added product/process can be identified. But it may not be viable in the market place.

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 1A

Overall, the team seems to have the necessary expertise to carry out the proposed work. Strong justification for the value proposition is provided from economic and environmental standpoints. The primary shortcoming in the proposed program is the lack of any quantitative targets. The proposal would have benefitted significantly from a discussion of current scientific literature from this team and others in the field, thus validating the potential technical and scientific merit of the project. I would recommend funding if the team can perhaps provide some further evidence of how the targeted outcomes of the project compare to the current status of the field.

Reviewer 2A

This proposal requests support from NDIC for a study of protein extraction from DDGS and protein characterization at laboratory scales, using routine procedures developed previously by a co-PI. As a fundamental research project, the proposal presents a sound methodology, documents adequately the PIs' capabilities and the facilities/equipment for conducting the project activities. Its significance in contributing to North Dakota's renewable energy industry and sustainable environment, however, is not adequately justified.

As a point to justify the need of this project, the proposal repeatedly states that DDGS is a waste stream/product, on which this reviewer strongly disagrees. DDGS used to be the major product from the corn industry and had/still has tremendous value in the livestock industry and rural economy throughout the US. Up to date, DDGS is nevertheless the targeted co-product, along with the fuel ethanol from corn starch as the other, not just a byproduct and definitely not a waste product. Although the production of DDGS in North Dakota may exceed the needs from livestock industry in the state, alternative measures could be explored but not to extract proteins out of DDGS, because protein extraction will lead to a significantly devalued leftover product which is even more difficult to market, thus becoming truly a waste. The overall economy between the extracted proteins and the unextracted DDGS remains unanswered and needs to be carefully assessed before any conclusion is drawn. Therefore, the justification of the proposal on its alignment to the NDIC funding mission is questionable, and the other claims made in the proposal, such as contributions to the fields of renewable energy, job creation, environment/climate change, etc., are not convincingly supported with analysis.

In summary, the limited merit of this proposed work leads to a low priority for funding, per the NDIC funding missions. It is recommended that this proposal be funded as a fundamental research project, if funds are available in this category by the NDIC program.

Reviewer 3A

Value addition for DDG has been a "low hanging fruit" for some time. Identification of a reasonably efficient and scalable extraction process is the next step after the products can be defined. Consideration should be given to comparison with wet milling protein extraction and characterization.

This project is in line with the REC goal and should be funded.

Renewable Energy Program

North Dakota Industrial Commission

Application

Project Title: Valorization of DDGS

Applicant: North Dakota State University

Principal Investigator: Clairmont Clementson

Date of Application: June 17, 2024

Amount of Request: $245,961

Total Amount of Proposed Project: $491,922

Duration of Project: 2 years

Point of Contact (POC): Amy Scott, Assistant Director Sponsored Programs Administration

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TABLE OF CONTENTS

ABSTRACT

Objective:

Out of about 1.3 million tons of Dried Distiller's Grains with Solubles (DDGS) produced annually by North Dakota ethanol plants only one-tenth (10%) is used for local feeds. The remaining 90% is exported. DDGS exportation is challenged by logistics, flowability, and caking. US Grains Council has identified these issues as major limiting factors for use and profitability derived from DDGS as some railcar operators have limited the use of their railcars for the transport of DDGS. DDGS. Further, in spite of DDGS nutrient richness (30% protein and 40% fiber) it commands a low price. Hence developing technology to increase value and local use will be an opportunity to evade the current logistic challenges and increase the revenue stream. Thereby, improving the viability of North Dakota ethanol plants.

Valorizing DDGS entails adding value for these constituents. This project is intended to develop new process streams, create high value co-products that would increase the profitability-value chain of ethanol plants. The objective of this project is to develop a bioprocessing method aimed at extracting high-value proteins from corn Distiller's Dried Grains with Solubles (DDGS), a byproduct of ethanol production. This initiative is undertaken with the goal of enhancing the sustainability of the ethanol industry.

Expected Results:

The project aims to drive forward the utilization of corn DDGS, marking a substantial transition towards more sustainable and efficient practices within ethanol production and agriculture. By implementing optimized extraction methodologies, a notable increase in protein yields is anticipated. These enhancements are expected to result in statistically significant differences in protein recovery rates compared to current benchmarks, indicating an increase in efficiency that can be quantified.

Moreover, the detailed characterization of the extracted proteins is projected to unveil critical insights into their amino acid profiles, functional properties, and nutritional values. This phase is poised to reveal statistically significant variances in protein quality and functionality, potentially paving the way for new application avenues and influencing market dynamics for DDGS products.

Duration:

Two years

Total Project Cost: $491,922 (NDIC - $245,961, NDSU - $243,461, Tharaldson Ethanol - $2,500)

Participants:

Agricultural Biosystems and Engineering, North Dakota State University:

Clairmont Clementson, Assistant Professor, clairmont.clementson@ndsu.edu, 701-231-1810
Niloy Chandra Sarker, Research Specialist, niloy.sarker@ndsu.edu, 701-231-8602
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PROJECT DESCRIPTION

Objectives:

1. To identify optimized extraction methodologies that maximize protein yield from corn DDGS to reduce waste and enhance the overall sustainability of the ethanol production process.

2. To characterize the amino acid profiles, functional properties, and nutritional values of extracted DDGS proteins, aiming to elucidate the structure-function relationships that govern their utility in various applications.

Methodology

Sample Preparation: DDGS samples will be prepared according to standardized protocols to ensure consistency across all experiments. This will involve milling the DDGS to a uniform particle size of 0.425 – 1 mm and conditioning samples to specific moisture content.

Selection of Extraction Techniques: Extraction techniques will be identified for in-depth investigation following a comprehensive review of literature. This evaluation will encompass traditional methods such as solvent extraction and enzymatic hydrolysis, as well as novel approaches like ultrasound-assisted extraction and pulse electric field processing, which show potential for enhanced efficiency or sustainability. These techniques will be adapted as necessary and explored to identify the most effective methods for extracting high-value proteins from corn DDGS. Our research team, as documented by Bello et al. (2023), has highlighted the promising potential of extracting soybean meal protein using a reusable solvent. Initial experiments have proven successful, significantly increasing the concentrated protein yield. Expanding upon this groundwork, a preliminary study was conducted to DDGS. The simple solvent extraction method, conducted under alkali conditions, facilitates the migration of soluble into the solution in a cost-effective, one-step process. However, protein extraction is currently limited and this project is intended to concentrate the protein content.

For solvent extraction method, DDGS with a particle size of 0.425 – 1 mm will be immersed in varying concentrations of ammonium hydroxide, sodium hydroxide, hydrochloric acid, and water at a ratio of 1:10 (sample-to-solvent). This process will be conducted at different temperatures ranging from 25 - 55 ^{o}C, with continuous shaking for 6 - 12 hours. Subsequently, the mixture will undergo centrifugation at 10,000 g and 25 ^{o}C for 10 minutes to remove insoluble materials. Enzyme aided extraction of protein from DDGS will be carried out following similar process as above except that protease enzymes and 40^{o}C will be used.

Protein Isolation and Purification: Proteins will be isolated from DDGS using the optimized extraction methods identified in Objective 1. Subsequent purification steps, including dialysis or

ultrafiltration, will be employed to ensure the proteins are free from extraction residues, facilitating accurate characterization. The supernatant containing crude protein extracts will be collected and its pH will be adjusted to 4.5 – 5. The protein isolate will be allowed to sediment overnight. The sediment will be collected, washed twice with distilled water, and then centrifuged at 10,000g, 25 ^{o}C for 10 minutes. The protein will be collected onto an aluminum plate and dried at 60 ^{o}C for 12 hours. Protein purification will be achieved through repeated washing, precipitation, and membrane filtration.

Experimental Design:

A full factorial design will be implemented, wherein variables such as solvent type, temperature, pH, enzyme concentration (for enzymatic methods), and time will be systematically varied to evaluate their influence on protein yield. Each extraction will be conducted in triplicate to ensure statistical reliability. Subsequently, samples will be collected for the analysis of protein yield and purity.

Amino Acid Profiling: High-Performance Liquid Chromatography (HPLC) will be employed to analyze the amino acid composition of the purified proteins. This analysis will offer crucial insights into the nutritional quality of the proteins and their potential industrial applications. Furthermore, the amino acid profiles of the DDGS proteins will be compared against established reference protein standards to assess their completeness in essential amino acids.

Functional Properties Assessment: A series of analytical tests will be conducted to examine the functional properties of the DDGS proteins, such as solubility, emulsification capacity, foaming ability, and gelation strength. These properties will be assessed under varying environmental conditions (including changes in pH, temperature, and ionic strength) using spectrophotometry for solubility measurements and rheometry for determining gelation characteristics.

Nutritional Value Determination: The nutritional value of the proteins will be evaluated through *in vitro* digestibility tests, which will simulate the digestion process using simulated gastric and intestinal fluids. Furthermore, the bioavailability of essential nutrients will be analyzed to determine how effectively these nutrients can be absorbed and utilized by the body. This evaluation will provide crucial insights into the overall nutritional quality and potential health benefits of the DDGS proteins.

Structure-Function Relationship Analysis: Mass Spectrometry (MS) and Fourier-Transform Infrared Spectroscopy (FTIR) will be employed to elucidate the molecular structure of the proteins extracted from DDGS. These analytical techniques will provide detailed information about the amino acid sequence, post-translational modifications, and overall structural conformation of the proteins. By uncovering the molecular structure of the proteins, MS and FTIR analyses will facilitate the understanding of the relationship between protein structure and functional properties. This knowledge will guide the modification of protein structures to enhance specific functional attributes, thereby optimizing their suitability for various industrial applications.

Analytical Methods: The extracted proteins will undergo analysis using the Kjeldahl method to measure total nitrogen content, providing a basis for determining protein concentration. Additionally, the Bradford assay will be employed to accurately quantify the protein concentration present in the samples. Further characterization of the purity and composition of the extracted proteins will be conducted using Sodium Dodecyl Sulfate Polyacrylamide Gel Electrophoresis (SDS-PAGE) and High-Performance Liquid Chromatography (HPLC). These analytical techniques will provide insights into the molecular weight distribution, purity, and composition of the proteins, allowing for a comprehensive assessment of their quality and suitability for various applications.

Data Analysis: To assess the efficiency of various extraction techniques, analysis of variance (ANOVA) will be employed to evaluate the significance of differences in protein yield and purity under different extraction conditions. This statistical method will enable the comparison of extraction methods and conditions, providing valuable insights into their effectiveness in isolating proteins from corn DDGS.

Optimization: Based on the outcomes of the statistical analysis, the extraction method(s) demonstrating the highest effectiveness will be identified. These method(s) will undergo further optimization through additional experimentation. Subsequently, the scalability of the optimized method(s) will be evaluated for potential industrial application. Factors including cost-effectiveness, environmental impact, and practical feasibility will be taken into consideration during this assessment process.

Anticipated Results

Key expectations for this study include:

1. Identification of highly efficient extraction methods that significantly increase protein yields while minimizing process waste.

2. Establishment of a comprehensive amino acid profile detailing the composition of DDGS proteins, providing insights into their suitability for various applications such as animal nutrition or human dietary supplementation.

3. Elucidation of key functional properties of DDGS proteins, including solubility, emulsion stability, foaming capacity, and gelation properties, essential for optimizing their use in industries like food processing and biomaterials.

4. Nutritional evaluation to assess the proteins' digestibility and bioavailability, crucial for their incorporation into animal feed formulations to improve feed efficiency and support animal health.

5. Investigation of structure-function relationships of DDGS proteins to guide targeted modifications for enhanced functionality.

6. Promotion of diversified applications of DDGS proteins, including novel uses in bioplastics and other bio-based products.

Ultimately, this project aims to advance the utilization of DDGS proteins and encourage innovation in bioenergy byproduct utilization, leading to sustainable solutions and new opportunities in various industries.

FACILITIES and EQUIPMENT

Facilities:

The research will be conducted at the NDSU Pilot Processing Plant (*moving in summer 2024 to the new Peltier Complex under construction*) includes a large general wet/dry processing high bay laboratory (3,500 ft^2) space, an explosion proof laboratory (400 ft^2), quality control labs (480 ft^2), a bioproducts research laboratory (650 ft^2), and 2 offices. The labs contain ample chemical and sterile, laminar flow hood spaces. Standard utilities include 120, 220 and 440 V power, steam, vacuum, compressed air, distilled water, and 18 mΩ NANOpure water. A walk-in cold room and freezer and an explosion-proof freezer are available for sample storage. The Pilot Processing Plant provides space to faculty, staff and, students for both teaching and research in processing. It also provides space for industrial demonstration and services to local farmers who may need space and equipment.

Between 2020-2024, there were research projects at the Pilot Plant on soy meal protein extraction and characterization which resulted in approximately 4 peer-reviewed publications and many conference presentations. Hence, there are existing equipment to successfully carryout this research.

Equipment:

- Nicolet 6700 FTIR (smart ark, performer, drift accessories)
- UV Spectrophotometer
- Waters High Performance Liquid Chromatography (HPLC)
- Agilent Gas Chromatography
- Shaker water bath, Thermo MaxQ 7000 (3)
- Ultrasonic water bath
- Incubator Oven, Precision
- Gravity Convection Oven, Precision Scientific
- Convection ovens, Binder
- Vacuum Ovens VWR
- Drying Oven with perforated stainless shelfs
- Mettler AB204-S analytic balance 220g Max
- Mettler LJ16 Moisture analyzer
- VWR hotplate stirrers
- Multiwell Hot Plate/ Stirrer
- Digital Thermometers
- Orion A111 pH meter with probe
- Orion 2 star pH meter with probe
- Orion 230A portable pH meter with probe
- Pipet Washer

- Desiccators /drying cabinets
- Pipettes (fixed volume, pos-displacement)
- Bottle Dispensers/Titrators
- Volumetric flasks and glass beakers
- Separatory funnels
- Plastic tubes, bottles, beakers, cylinders
- Plastic Beakers, pipets, Tubes, Bottles
- Syringe & Syringe Accessories (barrels and filters)
- Filtration Accessories (glass filter,funnels, paper, clamps)
- Refrigerator/freezer

Resources:

Data Management: Primary data generated in this project will be digital. Data will be stored through the Center for Computationally Assisted Science and Technology (CCAST) hub at North Dakota State University. CCAST is an academic supercomputing facility made possible in part by NSF MRI Award No. 2019077. CCAST facilities are housed in the Research 1 and Research 2 buildings, both located in NDSU's Research and Technology Park. These are secure facilities, requiring card key access outside of normal business hours. Doors to hallways and rooms within the building are secured at all hours, and access for each room must be approved for each individual requiring access.

Network infrastructure at NDSU is managed and operated by NDSU Information Technology Services (ITS) which also participates in state and national initiatives to provide state-of-the-art networking capabilities to the entire upper-Midwest region. CCAST has a 100Gbps ScienceDMZ connection to the main NDSU router and then directly onto Internet2 for data transfers beyond the campus boundary. There is a 40 Gbps connection to the main NDSU router for communication with internal NDSU equipment. CCAST HPC systems and storage are:

(1) "Thunder" Cluster: This HPC cluster currently has 118 compute nodes (with 3,668 Intel CPU cores and 18.1 TB aggregate usable RAM), 22 GPUs, 2 login nodes, and several management nodes. The compute nodes include 20-core 64GB RAM Intel Ivy Bridge nodes (including 14x MIC nodes with Intel Phi 5110P accelerators), 32-core 1TB RAM (large-memory) Intel Sandy Bridge nodes, 44-core 128GB RAM Intel Broadwell nodes, and 40-core 192GB Intel Cascade Lake nodes, 36-core 192GB Intel Cascade Lake nodes. The 22 GPU cards include 8x Tesla P100 SMX2, 4x Quadro GP100, and 10x GeForce RTX 2080 Ti.

(2) "Thunder Prime" Cluster: This cluster, housed in the same room with Thunder, is the new flagship HPC cluster in the state of North Dakota. It currently consists of 81 compute nodes (with a total of 8,896 AMD CPU cores and 39.7TB aggregate usable RAM), 48 GPUs, 2 login nodes, and several management nodes. The compute nodes include 64-core 256GB RAM AMD EPYC 7662 nodes, 128-core 512GB RAM GPU-ready AMD EPYC 7662 nodes, and 128-core 1TB RAM GPU-ready AMD EPYC 7662 nodes. The GPUs include 11x NVIDIA A100 40GB PCIe, 12x NVIDIA A40 48GB PCIe, 24x NVIDIA A10 24GB PCIe, and 1x NVIDIA A2 16GB PCIe. The new cluster is growing with more compute nodes and GPUs to be added.

(3) Data storage: CCAST provides home, project, and scratch storage space for users. Home and project directories are backed up at regular intervals. Scratch space is not backed up, as it is intended for temporary storage of data being actively used by calculations. Data is hosted on parallel filesystems of 2.2PB storage capacity. In addition, there are a research data archive of 1.6PB for long-term data storage and an IBM tape archival system of over 6PB capacity for data backup. All these systems are expandable.

The HPC clusters and data storage systems at CCAST are housed in a 1,100 sq. ft. HPC server room equipped with 10 rear door heat exchangers (RDHX's) to remove up to 40 kW per rack. The server room can handle up to 500kW of IT load and is expandable to 1,000kW. All the equipment is fed by power that is conditioned by an uninterruptible power supply (UPS) system and backed up by a 2,000kW diesel generator with fuel onsite for 36 hours of runtime at full capacity. The generator is rated for continuous operation and has advanced emission controls for unlimited hours of operation per year.

The PI's research activities are provided 1TB of space within CCAST however for this project it is estimated to require at most 100GB. The data will be held in the CCAST facility for the duration of the project and for five (5) years thereafter. Subsequently, essential data would be retained on cloud storage. Collaborators on the project will be provided access to the data through the project. Access to the data by external sources will be provided as appropriate upon request.

Working with the leadership of the CCAST facility, the PI will ensure the implementation of the Data Management Plan. This resource is available to the project at no cost to North Dakota Industrial Commission.

Techniques to Be Used, Their Availability and Capability:

Technique	**Purpose/Use**	**Availability**	**Capability**
Solvent Extraction	To extract proteins from DDGS.	Available in our laboratories.	Efficiently separates proteins based on their solubility in various solvents, enabling the recovery of high-purity proteins.
Enzymatic Hydrolysis	To break down proteins into peptides and amino acids, enhancing their functionality and digestibility.	Available, requires specific enzymes that will be purchased.	Capable of targeting specific protein bonds, offering precise control over the breakdown process and the resulting functional properties.
Ultrasound-Assisted Extraction (UAE)	To enhance protein extraction efficiency and	Not available, samples will be sent to other	Utilizes ultrasonic waves to disrupt cell structures, improving the release of

	reduce processing time.	laboratories out of state.	proteins with minimal thermal damage.
Pulsed Electric Field (PEF) Processing	To permeabilize cell membranes and enhance protein yield.	Not available, samples will be sent to other laboratories out of state.	Applies short bursts of high voltage to improve cell membrane permeability, facilitating the extraction of proteins.
High-Performance Liquid Chromatography (HPLC)	For characterizing amino acid profiles and protein purity.	Available in our laboratories.	Offers high-resolution separation and quantification of proteins and amino acids, essential for detailed compositional analysis.
Mass Spectrometry (MS)	To further characterize proteins and peptides, providing molecular weight and structural information.	Not available, samples will be sent to other laboratories.	Provides detailed insights into the molecular structure of proteins, enabling the identification of functional properties and potential applications.
Fourier-Transform Infrared Spectroscopy (FTIR)	To assess the functional groups and bonding structures of proteins.	Available in our laboratories.	Allows for the rapid determination of macromolecular structures, aiding in the understanding of protein functionality.
Biochemical Assays	To evaluate the nutritional values of extracted proteins, including their digestibility and content of essential amino acids.	Available, chemicals will be purchased.	Enables the comprehensive assessment of protein quality and its suitability for various applications, from feed to food.
Spectrophotometric Assays (e.g., Bradford Assay)	To measure protein concentration in samples.	Available in our laboratories.	Allows for quick and accurate determination of protein quantities, critical for evaluating extraction efficiency.
SDS-PAGE			

	To separate proteins by molecular weight for purity and profile analysis.	Available in our laboratories.	Provides a visual representation of protein size distribution, assisting in the assessment of purity and integrity.

Environmental and Economic Impacts while Project is Underway:

Environmental Impacts: This project may encounter certain environmental impacts, including resource consumption, chemical use and waste generation, energy use and associated carbon footprint, laboratory emissions, and transportation impacts. These include the utilization of water, energy, and chemicals, which necessitates careful management to minimize environmental footprints. The project's reliance on solvents and enzymes may lead to waste that requires responsible disposal or recycling efforts to prevent environmental contamination. No significant emissions from laboratory processes are anticipated. By integrating, and adhering to environmental management standards, Ultimately, while the project carries some environmental considerations during its execution, the adoption of sustainable practices throughout the project's duration, such as minimizing waste, adopting energy-saving technologies, combined with the long-term benefits of developing sustainable extraction methods, presents a balanced approach towards achieving environmental sustainability and economic growth.

Economic Impacts: While the project involves substantial costs, the potential for generating high-value products from DDGS offers an opportunity for significant economic return. This includes direct profits from the sale of extracted proteins, as well as long-term benefits such as waste reduction and enhanced sustainability in the ethanol production process.

Ultimate Technological and Economic Impacts:

Technologically, this project aims to advance protein extraction methodologies and characterization by utilizing both traditional and novel techniques for improved efficiency and sustainability. This approach has the potential to transform the utilization of agricultural byproducts, establishing new standards for resource efficiency and environmental responsibility in industrial processes. Economically, the project seeks to transform corn DDGS from a low-value byproduct into a high-value commodity, reshaping the value chain of ethanol production. This transformation is anticipated to create new market opportunities, ranging from nutrition to bioplastics, diversifying revenue streams for the ethanol and agricultural industries and reducing reliance on single outputs.

The broader impacts of these technological advancements and economic shifts are expected to drive further research and investment in sustainable practices, leading to job creation, fostering industrial innovation, and contributing to a more resilient and sustainable economic model for corn-ethanol production. Through this project and similar initiatives, the future of industrial

byproduct management appears to be both sustainable and economically beneficial, demonstrating a model where environmental objectives and economic growth complement each other.

Technological Impacts

Innovation in Bioenergy Byproducts Utilization: The development of efficient extraction methodologies for proteins from DDGS represents a significant technological leap in valorizing bioenergy byproducts. This innovation paves the way for the bioenergy sector to transition from a linear to a circular economy model, where waste is minimized, and byproducts are effectively converted into valuable resources.

Advancement in Biofertilizer Production: Converting DDGS proteins into other bio-products such as biofertilizers will introduce a novel, sustainable agricultural input that can significantly reduce the dependency on petroleum. Biofertilizer, for example, has the potential to revolutionize farming practices by offering an environmentally friendly, cost-effective alternative that enhances soil health and fertility.

Cross-sectoral Technological Synergies: This research facilitates cross-sectoral technological synergies between the bioenergy and agriculture sectors. By interconnecting these sectors through innovative utilization of byproducts, it generates new opportunities for integrated technological solutions aimed at addressing sustainability challenges.

Economic Impacts

Creation of New Markets and Revenue Streams: The commercialization of technologies for extracting proteins from DDGS and producing bioproducts from the extracted proteins can unlock new markets and generate additional revenue streams for both the bioenergy and agricultural sectors. This diversification is crucial for enhancing economic resilience and fostering growth.

Job Creation and Economic Development: Implementing the research findings is expected to lead to job creation across multiple stages of the value chain, from research and development to manufacturing, marketing, and application. These jobs contribute to local and regional economic development, particularly in rural areas where bioenergy production and agriculture are key economic activities.

Cost Savings for Farmers: By extracting high-quality proteins from DDGS and its subsequent transformation into valuable products, farmers can significantly reduce their expenditures on conventional feed and fertilizer inputs. Enhanced feed quality from these proteins can lead to improved livestock health and productivity, translating into higher profitability. Additionally, the potential use of extracted proteins in agronomic practices could improve soil health and crop yields, further contributing to the economic and sustainable operations of farms.

Attracting Investment: The technological innovations and market opportunities generated by this research can attract investment from both the public and private sectors. Investment in sustainable technologies and products is critical for accelerating the transition to a green economy and stimulating economic growth.

Leadership and Export Opportunities: Establishing leadership in the technologies developed through this research can position our region and country as global leaders in sustainable bioenergy and agricultural solutions. This leadership can translate into export opportunities for technologies, products, and expertise, further expanding economic impact.

Why the Project is Needed:

North Dakota plays a significant role in the U.S. corn market, contributing to both national corn production and ethanol manufacturing. Ethanol production from corn is a thriving industry in the state, offering an alternative fuel source and bolstering the agricultural sector by creating a demand for surplus corn. However, this process also yields Distillers Dried Grains with Solubles (DDGS), a valuable byproduct primarily utilized as high-protein livestock feed. Approximately 1.3 million tons of DDGS are produced annually in North Dakota's ethanol plants, with a significant portion being exported (ND Ethanol Council, 2024).

To diversify the applications of DDGS and generate additional revenue for the state, while promoting biorenewable systems and sustainable agricultural practices, this study aims to develop a bioprocessing method for extracting high-value proteins from DDGS and characterizing these proteins. The global market for plant-based proteins is expected to witness substantial growth, underscoring the economic potential of enhancing the value of DDGS beyond its conventional use as animal feed. Moreover, optimizing the utilization of DDGS through bioprocessing technologies contributes to waste reduction and resource efficiency, aligning with environmental sustainability goals.

Overall, the development of bioprocessing methods to extract high-quality proteins from DDGS offers numerous benefits, including economic diversification, environmental sustainability, and the harnessing of emerging market opportunities in the plant-based protein sector. The following are broader rationale for developing bioprocessing methods to extract high-quality proteins from DDGS:

i. **Sustainability in Ethanol Production**: the ethanol industry generates vast amounts of DDGS as a byproduct. Currently, the potential of DDGS, particularly its protein content, is not fully utilized. This project will address the urgent need to enhance the sustainability of ethanol production by developing optimized methodologies for extracting proteins from DDGS. This approach aims to reduce waste and create value from byproducts, aligning with global sustainability goals.

ii. **Economic Diversification and Value Creation**: North Dakota's economy, with its strong emphasis on agriculture and energy, stands to benefit significantly from the diversification and value addition provided by this project. By extracting and characterizing high-quality proteins from DDGS, the project can open new markets, create jobs, and stimulate economic growth. This diversification is particularly critical in the face of fluctuating global oil prices and the increasing competitiveness of the agricultural sector.

iii. **Research and Educational Opportunities**: This project offers numerous opportunities for research and education, providing a platform for advancing knowledge in environmental sciences and agricultural technologies. It can foster partnerships between academic institutions, industry, and government agencies, creating a collaborative environment for innovation. Furthermore, the project will serve as a valuable educational tool, preparing students and researchers to tackle future challenges in renewable energy and sustainable agriculture.

iv. **Alignment with Policy and Environmental Goals**: The project aligns with both national and international goals for renewable energy production, waste reduction, and environmental protection. By demonstrating an economically viable model for converting ethanol production byproducts into valuable resources, the project supports policy objectives aimed at promoting sustainability and reducing environmental impacts. This alignment is crucial for securing funding, regulatory support, and public acceptance.

v. **Response to Climate Change**: Addressing climate change requires innovative approaches to reducing greenhouse gas emissions and enhancing carbon sequestration. The project's focus on reusing waste materials (DDGS) to produce valuable products represent an effort to provide an alternative to carbon-intensive agricultural inputs and promoting more sustainable land-use practices. By leveraging the untapped potential of DDGS, the project offers a practical solution to some of the challenges posed by climate change.

Reference

North Dakota Ethanol Council. (2024). Distillers Grains. Accessed: March 29, 2024. https://www.ndethanol.org/distillers-grains#:~:text=North%20Dakota's%20ethanol%20plants%20produce,tons%20of%20distillers%20grain%20annually.

Bello, I., Adeniyi, A., Mukaila, T., Hammed, A. 2023. Optimization of Soybean Protein Extraction with Ammonium Hydroxide (NH4OH) Using Response Surface Methodology. Foods, 12(7), 1515. https://doi.org/10.3390/foods12071515

STANDARDS OF SUCCESS

The Standards of Success for this project are defined by a set of integrated and strategic deliverables aimed at maximizing the value and sustainability of DDGS within North Dakota's ethanol and agricultural sectors. Success will be measured through the development and implementation of efficient, scalable extraction protocols that enhance the quality and yield of proteins from DDGS, alongside a comprehensive characterization of these proteins in terms of amino acid profiles, functional properties, and nutritional values, to uncover their potential applications.

Value to North Dakota: Enhancing the utility of DDGS, this project is poised to significantly boost revenue streams for local farmers and ethanol producers by reducing waste and promoting sustainability practices. By optimizing extraction methodologies to maximize protein yield from DDGS, the proposed study aligns with North Dakota's commitment to renewable energy and agricultural innovation. This effort will contribute to environmental sustainability and cements the state's position as a pioneering leader in sustainable agricultural practices and bioenergy resource management, offering a model for integrating agricultural byproducts into the circular economy.

Public and Private Sector Utilization: The utilization of project findings by both the public and private sectors underscores its broad relevance and potential impact. State and local government agencies with a focus on agriculture and energy are poised to integrate these insights into their policymaking, regulatory frameworks, and educational initiatives, enhancing the governance and support structure for sustainable practices. Meanwhile, in the private sector, ethanol producers, agricultural businesses, and biofertilizer manufacturers stand to directly benefit from the optimized extraction protocols developed through this project. This practical application is anticipated to yield immediate advantages, including cost savings, product diversification, and enhanced sustainability practices, showcasing the project's comprehensive approach to fostering innovation and efficiency across key industry sectors.

Commercialization Potential: The project's commercialization potential extends far beyond the immediate technological advancements in protein extraction from DDGS. These protocols are not just scientific achievements; they represent pivotal opportunities for businesses within and related to the agricultural and bioenergy sectors to innovate and expand their market presence. By developing new product lines or enhancing existing offerings, companies can tap into emerging markets and consumer demands for more sustainable and environmentally friendly products. This could lead to a broader adoption of DDGS-derived products across various industries, including but not limited to, animal feed, agriculture, and bioenergy, driving competitiveness and fostering economic growth.

Advancement of Education, Research and Development (R&D), and Marketing: The project's emphasis on enhancing education, research, development, and marketing within North Dakota represents a multifaceted approach to advancing sustainable energy and agricultural practices while also to cultivating a robust knowledge economy. By facilitating partnerships between academic institutions, research bodies, and industry stakeholders, this initiative serves as a vital conduit for knowledge transfer and innovation. Engaging students in hands-on research projects

directly related to the project will enrich their educational experience and prepare a new generation of professionals equipped with the skills and insights needed to tackle future challenges in renewable energy and sustainable agriculture.

The collaborative nature of these efforts fosters an environment where theoretical knowledge is integrated with practical application, ensuring that the findings and technologies developed through this project have a tangible impact on the industry. Furthermore, the active dissemination of research outcomes through conferences, publications, and workshops plays a crucial role in amplifying North Dakota's contributions to the renewable energy and sustainable agriculture sectors on a national and global scale. This will enhance the state's reputation as a leader in these critical areas and attract investment, talent, and interest nationally, thereby stimulating economic growth.

Job Creation and Preservation: The transformative potential of this project extends deeply into the economic fabric of North Dakota, particularly through its capacity to preserve existing jobs and catalyze the creation of new ones. By introducing new technologies and methodologies for extracting proteins from DDGS and their subsequent conversion into valuable products, the project directly supports the ethanol and agriculture sectors—key pillars of North Dakota's economy.

In the realm of job preservation, the project's advancements ensure that the ethanol production facilities and agricultural operations remain competitive in an increasingly sustainability-conscious market. This competitiveness is crucial for maintaining the viability of these sectors and the jobs they provide, from technicians and engineers in ethanol plants to agronomists and farm workers in the agricultural sector. The introduction of sustainable practices and technologies can lead to increased demand for North Dakota's bioenergy and agricultural products, further securing these jobs.

As the project moves from research and development into the commercialization phase, there will be a need for a wide range of professionals. Scientists and researchers will be essential for continuous innovation, while manufacturing roles will grow to produce the new technologies and products developed through the project. Furthermore, marketing and sales professionals will play a critical role in promoting these innovations, both domestically and internationally, expanding North Dakota's agricultural and energy sectors to new markets and opportunities.

Beyond the direct creation of jobs, this project aligns with the broader mission of promoting sustainable development and energy independence in North Dakota. By doing so, it ensures the long-term prosperity of the state, preserving existing jobs and creating a dynamic, innovative environment that attracts new businesses and talent to North Dakota. This holistic approach to economic development, grounded in sustainability and innovation, positions North Dakota as a forward-thinking leader, ready to meet the challenges and opportunities of the future.

Alignment with the Program's Mission: This project uniquely aligns with the mission of promoting renewable energy development and sustainability in North Dakota as it focuses on leveraging ND's rich agricultural and energy resources in a manner that sets a precedent for the rest of the country. By focusing on the extractability and utility of proteins from DDGS, the project

exemplifies a commitment to resource efficiency and the circular economy, principles that are increasingly becoming vital to environmental sustainability and economic resilience.

This commitment extends beyond the immediate environmental benefits of reducing waste and optimizing resource use. It embraces a holistic approach to sustainability that encompasses economic development, technological innovation, and societal well-being. In doing so, the project directly contributes to North Dakota's goal of becoming a leader in renewable energy, demonstrating how agricultural byproducts can be repurposed in ways that benefit the environment, economy, and communities.

In essence, the project embodies a forward-looking approach to renewable energy development, one that integrates economic development with environmental sustainability and social well-being. It is a testament to North Dakota's commitment to leading by example in the transition to a more sustainable and resilient energy future, ensuring that the state remains a vibrant, prosperous, and sustainable place for the next generations.

BACKGROUND/QUALIFICIATIONS

Our research team, as documented by Bello et al. (2023), has highlighted the promising potential of extracting soybean meal protein using a reusable solvent. Initial experiments have proven successful, yielding approximately 70% protein concentrated from the initial 40%.

Summary of qualification and experience

Clairmont Clementson

Clairmont Clementson, the Project Director, is a registered professional engineer (PE) and an Assistant Professor at North Dakota State University (NDSU). His initial professional training was in Mechanical Engineering, focused on mechanized agricultural systems. His graduate study provided a deeper understanding of biological systems and agricultural processes. Coupling these insights provided the foundation for post-graduate studies in grain handling, storage, processing and co-product utilization. The diversity of cereal and grains grown in the Northern Plains provides immense opportunities to contribute to the body of knowledge in this area.

His research is directed towards addressing the effects of climate change on post-harvest operations, and value addition for co-products. During his time at NDSU, he has completed a comprehensive study of the physical characteristics of corn varieties, indicating variances in corn varieties during post-harvest operations. Additionally, he is involved in improving the protein concentration extracted from soybean meal.

He is an active member of the American Society of Agricultural and Biological Engineering (ASABE), currently serving as chair of the PRS 707 – Food and Agricultural Waste Management and Utilization committee. He is also a certified Project Management Professional (PMP) with years of project management experience. These skills will be leveraged to effectively manage this project, ensuring the timely accomplishment of its objectives.

Niloy Chandra Sarker

The Co-PI, Niloy Chandra Sarker is a research specialist and affiliated graduate at North Dakota State University (NDSU). He has worked for the past 10 years at different level of his career on value added agriculture, agricultural product development including renewable energy. He is managing the NDSU pilot plant and extensively involved in bioprocessing research group supervision at NDSU. He has been working with the PD and Co-PDs for last 3.5 years on similar projects and presented research outcome in the form of presentation and peer reviewed journal article. Dr. Sarker is well experienced in every aspect of project management that includes but not limited to experimental design, purchasing supplies though procurement department, experimental, data collection, report writing, and manuscript preparation.

Ademola Hammed

Dr. Ademola Hammed, a research assistant professor and Co-Principal Investigator, holds dual PhDs in biotechnology engineering and bioprocess engineering. His academic and professional journey is marked by significant contributions to the field of protein extraction from various sources such as soybean, soymeal, and fish skin. Dr. Hammed possesses a profound expertise in the physicochemical characterization of proteins, encompassing their biological properties like antioxidant, anti-inflammatory effects, and digestibility.

His research activities extend into exploring and enhancing the functional attributes of proteins derived from both common and unconventional sources. Through his work, Dr. Hammed aims to address critical issues related to food sustainability and nutritional quality, focusing on the efficient utilization of bioresources. His multidisciplinary approach in engineering and biotechnology underpins his innovative strategies in protein science, contributing substantially to the academic community and industry standards. Dr. Hammed's role in his current project involves applying his extensive knowledge and skills to pioneer advancements in protein extraction methodologies and applications, ensuring significant impacts on health and nutrition sectors.

MANAGEMENT

This project will be managed using the five phases of project management: initiation, planning, execution, monitoring and control, and closure. During the initiation phase, the Co-PIs will review institutional procedures and guidelines related to procurement, accounting, and reporting. In the planning phase, the project requirements will be carefully assessed to identify the necessary skill set among graduate students, and an evaluation rubric will be developed for assessing potential candidates. Additionally, the equipment and materials required for experimentation will be determined, and a timeline for procurement and research assistant onboarding will be established.

During the execution phase, experimentation will be conducted according to the outlined methodology. In the monitoring and control phase, the Co-PIs will meet bi-weekly to assess the progress of the project, address any challenges, and explore opportunities to overcome them. Any extraneous circumstances that arise will be resolved during this phase.

Finally, in the closure phase, reports and financial statements will be prepared and presented as necessary for the project.

Milestones	2024				2025							
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Initiation												
Planning												
Execution												
Monitoring and control												
Closure												

TIMETABLE

Please provide a project schedule setting forth the starting and completion dates, dates for completing major project activities, and proposed dates upon which the interim reports will be submitted.

Milestones	2024				2025							
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Develop initial protein extraction methodologies from DDGS.												
Select and optimize the best protein extraction techniques.												
Characterization of extracted proteins												
Reporting and presentation												

BUDGET

Project Associated Expense	NDIC's Share	Applicant's Share (Cash)	Applicant's Share (In-Kind)	Other Project Sponsor's Share
Personnel	91,600	102,621		
Fringe Benefits	2,748	46,685		
Supplies	24,280			2,500
Fees	51,000			
Tuition		26,968		
Indirect Costs	76,333	67,187		
Total	$245,961	$243,461		$2,500

NDIC Share

Two graduate research assistants will be hired for two years at a salary of $22,900/year. The students will conduct research on the bioprocessing of DDGS protein as described in the proposal. Total $91,600.

Fringe benefits for the graduate research assistants is calculated at 3%. Total $2,748.

Supplies needed to carryout the proposed work includes citrate buffer solutions ($750), ultra-filtration membrane ($2,500), size exclusion gel ($2,500), consumables, such as flask, beakers, pipette tips, etc ($4,500), ion exchange gel ($8,880 for six units), NaOH ($1,250), Braford reagent ($750), HCL ($650), and Enzymes ($2,500). Total $24,280.

Fees include: 1) Ultrasound-Assisted Extraction; cost estimated for 75 samples at $150/sample based on current rates at external labs ($11,250). 2) Pulsed Electric Field processing; cost estimated for 75 samples at $130/sample based on current rates at external labs ($9,750). 3) Mass Spectometry performed at University of North Dakota; cost for 250 samples at $120/sample ($30,000). Total $51,000.

Indirect costs are calculated using NDSU's negotiated rate of 45% of modified total direct costs (MTDC). The MTDC is $169,628 x 45%. Total $76,333.

Applicants' share

Clairmont Clementson will lead this effort and devote 20% effort both years for a total salary of $40,289. He will lead the project, coordinate communication with stakeholders, lead Bi-monthly project meetings, and coordinate communication of research findings through reports and briefings. He will also assist with protocol development and evaluation of project data.

Niloy Chandra Sarker will devote 30% effort both years for a total of $36,119. He will procure and maintain material supplies. He will also ensure the maintenance and proper functioning of equipment, provide daily support and equipment training as necessary.

Ademola Hammad will devote 20% effort both years for a total of $26,213. He will conduct laboratory training and protocol guidance to graduate students. He will also coordinate laboratory activities and perform preliminary evaluation of data.

Fringe benefits are calculated at 36% of salary for PI Clementson, 55% for Co-PI Sarker, and 52% for Co-PI Hammed. Total $46,685.

Tuition for graduate students is calculated at $421.39/credit x 16 credits/year for $6,742 per student, per year. Total $26,968.

Indirect costs are calculated using NDSU's negotiated rate of 45% of modified total direct costs (MTDC). The MTDC is $149,306 x 45%. Total $67,187.

Other Sponsor's Share

Tharaldson Ethanol will provide the DDGS at a value of $2,500. See attached letter.

If Less Funding is Available

If 12-18% less funding is available than requested, the project's objectives will still be attainable. If the funding available is reduced by more than 18% of the requested amount, further assessments will be made with the intent of scaling down the project to achieve sufficient insights from the project objectives.

May 21, 2024

RE: Agricultural and Biosystem Engineering, NDSU's Project "Valorization of DDGS"

Dear North Dakota Industrial Commission:

I am writing this in support of the "Valorization of DDGS" for the North Dakota Industrial Commission. My name is Ryan Carter and I am the Chief Operating Officer of Tharaldson Ethanol, Casselton, North Dakota.

This study seeks to diversify the applications of DDGS and generate additional revenue while promoting biorenewable systems and sustainable agricultural practices, offering significant economic return. The broader impacts of these technological advancements and economic shifts are expected to drive further research and investment in sustainable practices, leading to job creation, fostering industrial innovation, and contributing to a more resilient and sustainable economic model for corn-ethanol production. This project aligns with the broader mission of promoting sustainable development and energy independence in North Dakota.

For these reasons, Tharaldson Ethanol is supportive of this project. Should this proposal be funded, we will provide the DDGS for this project, which is estimated at $2,500. This project is intended to develop new process streams and create high-value co-products, thereby increasing the profitability-value chain of ethanol plants.

Please contact me if you have questions about this letter of support.

Sincerely,

Ryan Carter
Chief Operating Officer, Tharaldson Ethanol
Telephone: 7014374000 | 7013473314
Email: rcarter@tharaldsonethanol.com

CONFIDENTIAL INFORMATION

Applicant is not requesting confidentiality.

PATENTS/RIGHTS TO TECHNICAL DATA

Applicant does not have any related patents. NDSU requests a level of confidentiality to safeguard the novelty of the idea and to allow NDSU to publish on the findings.

STATE PROGRAMS AND INCENTIVES

None.

INDUSTRIAL COMMISSION OF NORTH DAKOTA
RENEWABLE ENERGY PROGRAM

TECHNICAL REVIEWERS' RATING SUMMARY

R-054B
ACS NEWCARBON RNG PROJECT
Principal Investigator: Matthew Moshier
Request for $455,000; Total Project Costs $930,000

TECHNICAL REVIEWERS' RATING SUMMARY
R-054-B
ACS NEWCARBON FEEDSTOCKS, LLC
Principal Investigator: Matthew Moshier
Request for $455,000 Total Project Costs $930,000

		Technical Reviewer			
		1B	2B	3B	
Rating Category	Weighting Factor	Rating			Average Weighted Score
1. Objectives	9	4	4	2	30.00
2. Achievability	9	3	4	2	27.00
3. Methodology	7	3	4	3	23.33
4. Contribution	7	2	3	2	16.33
5. Awareness	5	3	3	2	13.33
6. Background	5	4	3	3	16.67
7. Project Management	2	3	3	3	6.00
8. Equipment Purchase	2	5	5	5	10.00
9. Facilities	2	3	3	3	6.00
10. Budget	2	3	2	3	5.33
Average Weighted Score		161	177	124	**154.00**
Maximum Weighted Score					250.00

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 1B (Rating 4)

Produce RNG with sugar beet pulp & tailings at an industrial scale and prove-up technology to a commercially viable system using anerobic digestion. This application appears to aid in obtaining initial engineering and additional financing of the project, i.e. a pre-feed study.
This project is in alignment with the goals of the REC as it finds a beneficial use of an ag by-product to be used as an energy source.

Reviewer 2B (Rating 4)

This proposal aligns with all of the NDIC's goals. Contact with the beet plant have been made along with a tentative agreement.

Reviewer 3B (Rating 2)
The proposed work appears to this reviewer to be a marketing activity to show the value of a proposed project for American Crystal at their Hillsboro plant. It does not appear there is any new technology being developed which is the goal of the NDIC/Renewable Energy Council. Therefore, I am giving the low score noted.

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 1B (Rating 3)
The proposal lays out a time frame and budget that appear to be achievable. The NG interconnection timeframe is very optimistic unless the plan is to sell to ACS directly.

Reviewer 2B (Rating 4)
This proposal is for the investigation of feasibility. The requested funding is for the labor cost of deciphering how best to capture and market the methane from sugar beet processing waste.

Reviewer 3B (Rating 2)
There is limited data included in the budget. Without the number of hours and the individuals involved it is impossible to estimate the potential for success.

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 1B (Rating 3)
The project follows a typical venture capital start-up process. The process will work if the economics are viable. No mention of the inputs into the budget pro-forma. i.e. sales price and carbon credit price.

Reviewer 2B (Rating 4)
The proposed plan is very logical and covers all the bases.

Reviewer 3B (Rating 3)
The methodology noted is good but the lack of details, particularly in the budget and the lack of information identifying contractors is problematic.

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 1B (Rating 2)
There will be very little tech or science achieved with this project, as stated this is a project with a TRL of 9. Unless the team is planning on using a novel process, there is little to gain other than economic justification. Again, at this TRL, there should be some level of payback analysis including pricing and carbon credits.

Reviewer 2B (Rating 3)
Taking waste and producing markable gas may have a significant impact on the owner and surrounding community.

Reviewer 3B (Rating 2)
Since this reviewer does not see any "new" technology being developed I see the scientific or technical contribution as small. In addition, the proposal also states that all data generated will be held by New

Carbon which indicates the information would not be available to assist in development of additional North Dakota projects.

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 1B (Rating 3)

The awareness of the PI and Co-PIs are adequate based on reference and backgrounds of key personnel. They appear to know that more specialized technical people need to be involved.

Reviewer 2B (Rating 3)

The PI appears to have a proven background in project management. However, based on his resume, he is prone to change jobs quite frequently. Consequently, project dedication would be a concern.

Reviewer 3B (Rating 2)

The proposal does not include any details on the technologies to be used or criteria for the selection of technology including vendors.

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 1B (Rating 4)

The PI and Co-PI's have the background to manage this project to their stated goal.

Reviewer 2B (Rating 3)

This project only involves the investigation of methane capture. I have over 40 years of providing and reviewing proposed industrial projects.

Reviewer 3B (Rating 3)

The assembled team includes well educated individuals with significant experience. I am concerned that the team as group has been together for less than a year and therefore has a limited track record in successfully completing similar projects.

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 1B (Rating 3)

Good PM plan & milestone chart. Timetable has missing reference. No communication schedule found. No public final report issuance found.

Reviewer 2B (Rating 3)

The provided management plan appears to be very generic with very little specified (as it was in other proposals by this requestor). However, since this proposal is only for preliminary investigation, it should suffice.

Reviewer 3B (Rating 3)

No comments.

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 1B (Rating 5)
No equipment purchased

Reviewer 2B (Rating 5)
This proposal is only for investigation, so no new equipment is to be purchased.

Reviewer 3B (Rating 5)
No equipment is to be purchased.

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 1B (Rating 3)
No facilities or equipment required other than land agreements that appear to be readily available. Services Only for this portion of the project. Does the team intend to have a ND based engineering firm or office?

Reviewer 2B (Rating 3)
The proposal is only for initial investigation and the existing facilities should be adequate.

Reviewer 3B (Rating 3)
The proposed work is strictly a paper study, and no equipment is to be purchased for this project.

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 1B (Rating 3)
Finding a means to economically produce RNG at various ag processing sites adds flexibility and resiliency to the facility operations. It will not fully replace NG. There is only an in-kind labor match from the applicants.

Reviewer 2B (Rating 2)
It is difficult to quantify "in-kind" value when it is presented as a lump sum without any detail as to how the dollar amount was determined.

Reviewer 3B (Rating 3)
The budget has limited details on the financial commitment from other sources. The proposal states that $475,000 in labor from the proposer is included. No information is given about specific individuals, their time commitments and the tasks they will be involved in. In addition, the main recipient of value besides the proposer is American Sugar and they are not contributing significantly to this effort.

Therefore, although I see value in the proposed activities, I believe the value flows do not match up with the requested funds.

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 1B

Good concept. Need to release economic findings for public use. To buy down the risk of a large enough project that is potentially economically feasible and meets the REC's goals is a good use of funds.

In reviewing R-54-B and R-54-C, these are 2 extremely similar projects. Individually I am recommending funding, however, I would only fund one of the projects and not both. There is not enough value to justify both. If I had to pick one, I'd fund R-54-C, even though 54-B is likely more economically viable due to the scale of the project. If there was a way for ACS to make money by digesting their beet pulp and tailings, they would already be doing it in my opinion.

Reviewer 2B

It is evident that this proposal was, in many places, a "cut and paste" process to fulfil the requirements necessary to request NDIC funding. This proposal could have great potential to utilize waste and make a renewable energy product with an economic benefit. However, as written, I cannot support funding this project due to the "in-kind" ambiguity. Once again, this proposal cited 10 line items as to how the NDIC's funding ($455,000) will be utilized. The budget cites the applicant's contribution as a lump sum ($475,000) with no breakdown on how this number is derived. It would appear that the "in-kind" contribution was selected to cover just over 50% of the total project cost to meet the minimum requirements for NDIC funding. Consequently, I **do not** support this proposal as written.

Reviewer 3B

This reviewer does not support funding of this project in its current form. Although I do believe there is value in the proposed work, The proposer needs to add additional details in the material provided in particular regarding the cost share including the number of hours in each of the tasks noted. Also, there are no letters of commitment from the contractors that would be used to complete the tasks, which includes commitments to complete the work outlines in the proposal. Finally, the proposal includes only general references to technology to be used. More information is required. Finally the proposal states that information generated will be held by New Carbon. In order for the value to flow to the State, access to at least some knowledge gained has to be publicly available.

NewCarbon Feedstocks, LLC
1057 Chadwick Ct.
Aurora, IL 60502
www.newcarbon.energy

July 31, 2024
Mr. Reice Haase
Deputy Executive Director
North Dakota Industrial Commission
State Capitol – 14th Floor
600 East Boulevard Avenue, Department 405
Bismarck, ND 58505-0840

Dear Mr. Haase:

Subject: ACS NewCarbon RNG Project

NewCarbon Feedstocks, LLC ("NewCarbon") is pleased to submit the subject proposal to the North Dakota Industrial Commission Renewable Energy Program.

NewCarbon, a clean energy infrastructure company who develops, owns and operates infrastructure that delivers lifecycle carbon intensity reduction for North America's top industrial, agricultural and energy companies, is collaborating with American Crystal Sugar on the development of a renewable natural gas (RNG) project to harvest biogas from byproducts of sugar beet refining via anerobic digestion, upgrade the gas, and deliver high-quality low-carbon RNG to end users. Successful execution of this Project will result in the creation of new renewable energy jobs, wealth and tax revenues for North Dakota. It will also decrease the carbon intensity of a major North Dakota agricultural cooperative and increase sustainability of a key North Dakota industry thereby preserving existing jobs and production levels.

NewCarbon is committed to completing the Project on schedule and within budget should the Commission approve the requested grant.

The $100 application fee for this proposal is provided through ACH Confirmation Number 503625600. If you have any questions, please contact me by telephone at (312) 718-9519 or by email at omar.khayum@newcarbon.energy.

Sincerely,

Omar Khayum, President
NewCarbon Feedstocks, LLC

Renewable Energy Program

North Dakota Industrial Commission

Application

Project Title: ACS NewCarbon RNG Project

Applicant: NewCarbon Feedstocks, LLC

Principal Investigator: Matthew Moshier

Date of Application: July 31, 2024

Amount of Request: $455,000

Total Amount of Proposed Project: $930,000

Duration of Project: 12 months

Point of Contact (POC): Omar Khayum

POC Telephone: (312) 718-9519

POC Email: omar.khayum@newcarbon.energy

POC Address: 1057 Chadwick Ct., Aurora, IL 60502

TABLE OF CONTENTS

ABSTRACT

NewCarbon, a clean energy infrastructure company who develops, owns and operates infrastructure that delivers lifecycle carbon intensity reduction for North America's top industrial, agricultural and energy companies, is collaborating with American Crystal Sugar Company on the development of a renewable natural gas (RNG) project to harvest biogas from byproducts of sugar beet refining via anerobic digestion, upgrade the gas, and deliver high-quality low-carbon RNG to end users.

Objective: The Project objective is to conduct planning and feasibility activities over 12 months that will study sizing and integration of a renewable natural gas (RNG) project with American Crystal Sugar's Hillsboro, North Dakota beet sugar processing facility. The scope of the planning and feasibility activities include market analysis, community outreach and engagement, pre-FEED engineering study, feasibility studies to determine the availability and cost of utility feedstocks, financial model development and pipeline routing due diligence. **Expected Results:** Successful execution of this Project will support the Renewable Energy Program's (REP's) mission to promote the growth of North Dakota's renewable energy industries through research, development, marketing, and education. Upon completion of the 12-month Project duration, NewCarbon will decide whether to progress to a FEED study and subsequent

development activities based upon meeting the following measurable criteria: (1) signed non-binding customer term sheets, (2) budgetary estimate from an EPC contractor based on the pre-FEED, (3) development of a community benefits plan, and (4) feasibility assessment of the technology achieving a TRL 9. Once operational, the proposed Project will result in the creation of new renewable energy jobs, wealth and tax revenues for North Dakota. It will also decrease the carbon intensity of a major North Dakota agricultural cooperative and increase sustainability of a key North Dakota industry thereby preserving existing jobs and production levels. When it is fully operational the ACS NewCarbon RNG Project will produce approximately 300,000 MMBTU per year of low carbon intensity RNG that will satisfy emerging Midwest low carbon fuel standards (LCFS) and provide for a value-added derivative biofuel suitable for commercial and industrial natural gas customers. The Project will create an estimated 50-75 temporary (12-18 months) construction, engineering, and fabrication jobs and 3-5 new permanent facility/operations jobs. The Project represents a novel integration of sugar beet refining, anaerobic digestion, biogas upgrading and gas delivery which can be replicated at other North Dakota agricultural feedstock and sugar beet processing operations. **Duration:** 12 months, with an anticipated start date of November 1, 2024. **Total Project Cost:** $930,000 with $455,000 from the North Dakota Industrial Commission Renewable Energy Program and $475,000 from NewCarbon Feedstocks, LLC. **Participants:** NewCarbon Feedstocks, LLC and American Crystal Sugar Company.

PROJECT DESCRIPTION

Objectives: The Project objective is to conduct planning and feasibility activities over 12 months that will study sizing and integration of a renewable natural gas (RNG) project with American Crystal Sugar's Hillsboro, North Dakota beet sugar processing facility. The scope of the planning and feasibility activities include market analysis, community outreach and engagement, pre-FEED engineering study, feasibility studies to determine the availability and cost of utility feedstocks, financial model development and pipeline routing due diligence. Particular emphasis will be placed on community outreach and public

engagement activities that will support improved understanding of stakeholder concerns, community attitudes, and public acceptance of RNG.

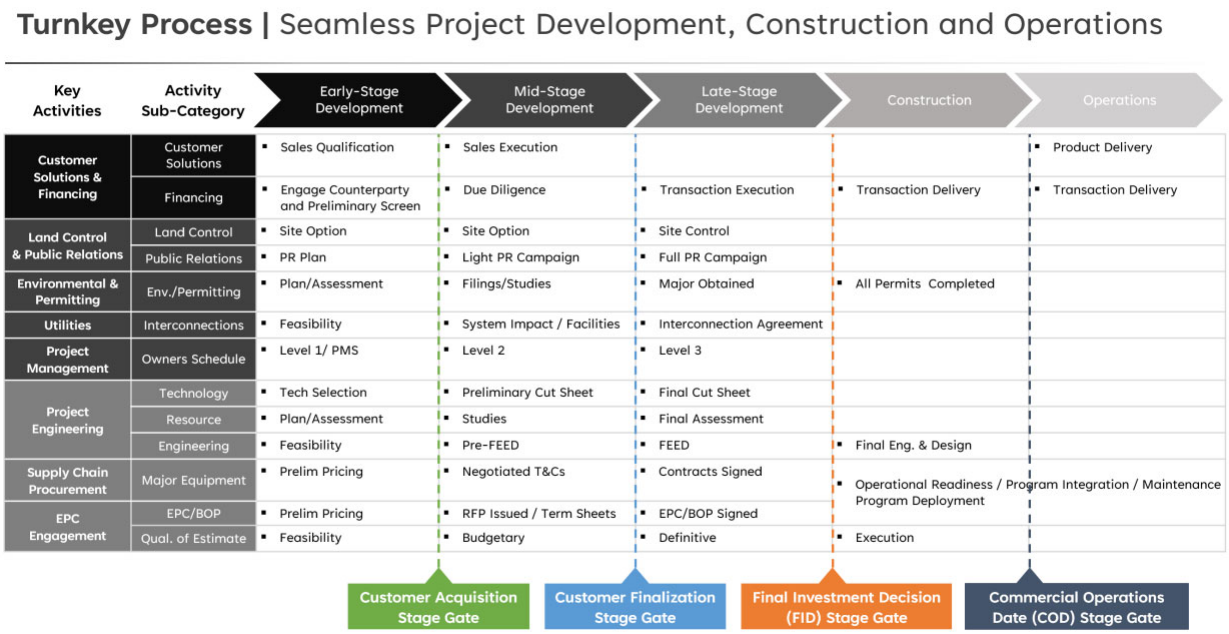
Sugar beet refining is the production of sugar (sucrose) from sugar beets. The process generates significant quantities of both solid and liquid organic byproducts. (Natalia Mioduszewska, 2018) Byproducts of the sugar beet refining process, including sugar beet pulp and sugar beet tailings, are currently used for cattle feed or land applied for beneficial use. This Project will evaluate the design of an industrial scale system to convert these byproducts into raw biogas using anaerobic digestion. The process of anaerobic digestion reduces the amount of methane released during the decomposition of the organic matter and does not reduce the nitrogen and phosphorus nutrient levels. The raw biogas is subsequently upgraded to natural gas pipeline specification which results in lower carbon intensity natural gas when compared to fossil fuel-derived natural gas (Francisco López, Lago Rodríguez, Faraji Abdolmaleki, Galera Martínez, & Bello Bugallo, 2024), hence the term renewable natural gas (RNG). This lower carbon intensity RNG is then delivered to customers either through existing natural gas pipelines or via trucked compressed natural gas. The residual organic matter from the anaerobic digestion process, digestate, is subsequently recycled for agricultural use as a fertilizer. Although sugar production is based on seasonal processing of beets, fresh input substrates can be stored and fed into digesters to maintain a year-round, consistent, biogas production. When it is fully operational the ACS NewCarbon RNG Project will produce approximately 300,000 MMBTU per year of low carbon intensity RNG. This Project will provide a clean energy source from agricultural byproducts and provide a pathway for low carbon competitive sugar production from sugar beets.

Methodology: The Project is organized into eight major tasks. NewCarbon will employ its turnkey project development process to ensure technical, development, and financial

feasibility (see **Error! Reference source not found.**). This process provides multiple stage gates to ensure the Project

follows a rigorous governance process to maximize project viability and risk reduction. During the 12-month duration of the Project, NewCarbon will complete all early-stage development activities and certain mid-stage development activities, such as the pre-FEED study, pursuant to the process in Figure 1 which are vital to producing realistic cost and schedule information and further validate feasibility of the proposed technology and project.

Figure 1: NewCarbon Turnkey Project Development Process



Task 1.0: Market Analysis. The objective of this task is to obtain signed, non-binding customer term sheets from customers for long-term offtake of the RNG product. In terms of market demand for RNG, North Dakota has in-state Biofuels and Sustainable Aviation Fuels facilities which require RNG low carbon feedstock such as RNG to achieve their carbon intensity targets. Many out of state entities are also seeking RNG to meet voluntary or compliance-driven sustainability targets. The scope for Task 1 includes sales and marketing efforts, financial analysis, and execution of commercial transactions. Activities involve developing sales strategies for Renewable Natural Gas (RNG), identifying and reaching

out to prospective customers, engaging with customers to discuss terms and conditions for long-term offtake of RNG and preparing and drafting commercial and legal documents to memorialize offtake agreements.

Task 2.0: Property Due Diligence. The goal of this task is to determine the legal and environmental suitability of the RNG plant site. The scope includes conducting a property title search and assessing the site for any legal or environmental issues that could affect the Project. The project team will optimize the equipment and general plant arrangement, installation, and interconnecting piping of the RNG processing facilities within the existing Hillsboro, North Dakota beet sugar processing facility while anticipating interconnection with utilities adjacent to the Project site.

Task 3.0: Community Outreach and Engagement. This task aims to deliver maximum value to the North Dakota community through effective engagement and communication. The community benefits plan will address community and labor engagement and discuss the creation of high-quality jobs and development of a skilled workforce. Activities include designing and implementing a community outreach strategy and engaging with local stakeholders to communicate Project benefits and gather stakeholder input.

Task 4.0: Engineering Services. The objective is to conduct preliminary front-end engineering and relevant studies to ensure the viability of the facility for RNG production. The scope includes pre-FEED Engineering Study, Lifecycle Assessment (LCA), Biogas Quality Study, Plant Permit Matrix, and Pipeline Permit Matrix. The project team will identify and quantify major material and energy inputs and outputs for a biogas production system. Design analysis includes pressed pulp and tailings reception and washing, size reduction requirements, and design requirements for anaerobic digestion based on high solids content.

Task 5.0: Developer Services. The goal is to perform feasibility studies to determine the availability and cost of utility feedstocks/inputs into the RNG project. The scope includes Electrical, Natural Gas, Wastewater, and Feedwater Interconnection Feasibility.

Task 6.0: Project Pro-Forma/Budget. This task aims to develop a pro-forma model to support offtake pricing and construction financing needs. The pro-forma will leverage the data from the pre-FEED study, biogas and methane production yields, interconnection, land, and financing costs.

Task 7.0: Site Acquisition Planning. The objective is to plan site acquisition for pipeline routing to the interstate pipeline interconnection location.

Task 8.0: Sourcing Project Funding. This task focuses on identifying other funding sources and federal, local, and state tax incentives for renewable natural gas.

Anticipated Results: Successful execution of this Project will support the Renewable Energy Program's (REP's) mission to promote the growth of North Dakota's renewable energy industries through research, development, marketing, and education. Upon completion of the 12-month Project duration, NewCarbon will decide whether to progress to a FEED study and subsequent development activities based upon meeting the following measurable criteria: (1) signed non-binding customer term sheets, (2) budgetary estimate from an EPC contractor based on the pre-FEED, (3) development of a community benefits plan, and (4) feasibility assessment of the technology achieving a TRL 9. Once operational, the proposed Project will result in the creation of new renewable energy jobs, wealth, and tax revenues for North Dakota. The proposed project will also decrease the carbon intensity of a major North Dakota agricultural cooperative and increase sustainability of a key North Dakota industry thereby preserving existing jobs and production levels. When it is fully operational the ACS NewCarbon RNG Project will produce approximately 300,000 MMBTU per year of low carbon intensity RNG that will satisfy emerging Midwest low carbon fuel standard (LCFS) and provide for a value-added derivative biofuel suitable for commercial and industrial natural gas customers. The Project will create an estimated 50-75 temporary

(12-18 months) construction, engineering, and fabrication jobs and 3-5 new permanent facility/operations jobs. The Project represents a novel integration of sugar beet refining, anaerobic digestion, biogas upgrading, and gas delivery which can be replicated at other North Dakota agricultural feedstock and sugar beet processing operations.

Facilities: NewCarbon will be working directly with a large-scale EPC contractor as well as other subcontractors with significant facilities and capabilities for scale up. The NewCarbon team has developed relationships across the energy, engineering, and construction sectors and will augment the NewCarbon capabilities as needed. Using lessons learned from similar pilot projects and analysis and design of the Project site, the project team will determine the feasibility of sugar beet pressed pulp and tailings as a substrate for anaerobic digestion at a commercial scale. During this Project, NewCarbon will be working directly with American Crystal Sugar Company to ensure clear and consistent communication between the two organizations.

Resources: No equipment is expected to be purchased during the initial 12-month planning and feasibility stage. The project participants control the Project and have effective control of the land.

Techniques to Be Used, Their Availability and Capability: The proposed team has committed to the Project and has ensured the availability of key personnel for the time frame of this Project. Any and all relevant publicly available data will be used for the Project. In addition to public resources, NewCarbon has engaged a technology licensor/ equipment provider that has completed and operates a similar project in the EU. The lessons learned from this project is expected to significantly improve the project outcomes.

Environmental and Economic Impacts while Project is Underway: There will be no environmental impact during the initial 12-month planning and feasibility stage. During operations, the RNG project will avoid methane emissions from decomposing sugar beet pulp and tailings while producing low carbon intensity fuel for industry in North Dakota and surrounding regions. Funding through NDIC will help

offset initial development costs of RNG projects in the North Dakota agricultural sector and help develop a potential roadmap for successful project execution of RNG projects at scale.

Ultimate Technological and Economic Impacts: The team believes that as more RNG projects are developed, the costs of the technologies employed will continue to fall and projects such as this will become more economically, socially, and environmentally beneficial. Sugar beet byproducts provide significant potential for RNG production due to high sucrose levels, stable yields across seasons, high dry matter yield, and strong substrate characteristics that stabilize the microbial conversion process. The Project represents a novel integration of sugar beet refining, anaerobic digestion, biogas upgrading and gas delivery which can be replicated at other North Dakota agricultural feedstock processing operations. The Project will create an estimated 50-75 temporary (12-18 months) construction, engineering, and fabrication jobs and 3-5 new permanent facility/operations jobs in North Dakota. The use of sugar beet byproducts for RNG production will contribute to the prosperity of sugar beet farmers and their communities in the North Dakota agricultural landscape.

Why the Project is Needed: This Project will be key to increasing momentum for RNG deployment in the North Dakota agricultural sector. North Dakota is the #2 producer of sugar beets in the United States (ND Department of Agriculture), and this Project is a critical enabler to preserving existing jobs and production levels in this industry while generating information and knowledge that will have the highest probability of bringing new renewable energy companies and industry investment to North Dakota. This Project will address a number of technical and stakeholder needs which can be replicated at other North Dakota agricultural feedstock and sugar beet processing operations. In the technical realm, there are questions about how sugar beet and other agricultural byproducts companies can integrate their operations with anaerobic digestion and subsequent gas upgrading. In the area of public perception, the concept of RNG deployment in North Dakota has been gaining traction and there is an opportunity to educate the public about the beneficial role that the government and private sector play in leveraging

RNG as a means of using our existing and robust natural gas infrastructure to decarbonize our local economy. The technical development and community benefits plan scope in our Project plan will be valuable to all stakeholders as North Dakota continues to pursue carbon reduction strategies and diversify its energy sector. Additionally, the proposed project creates a pathway for low carbon intensity agricultural products allowing North Dakota's agricultural sector to produce products that meet evolving consumer demand.

STANDARDS OF SUCCESS

Upon completion of the twelve-month Project duration, NewCarbon will decide whether to progress to a FEED study and subsequent development activities based upon meeting the following measurable criteria: (1) Signed non-binding customer term sheets, (2) budgetary estimate from an EPC contractor based on the pre-FEED, (3) development of a community benefits plan, and (4) feasibility assessment of the technology achieving a TRL 9. Successful execution of this Project will support the Renewable Energy Program's (REP's) mission to promote the growth of North Dakota's renewable energy industries through research, development, marketing, and education. The proposed Project will result in the creation of new renewable energy jobs, wealth and tax revenues for North Dakota. The project will also decrease the carbon intensity of a major North Dakota agricultural cooperative and increase sustainability of sugar beets, a key North Dakota and US industry, thereby growing existing jobs and production levels.

BACKGROUND/QUALIFICATIONS

NewCarbon will lead and oversee all proposed Project activities. The Principal Investigator (PI) is Matt Moshier (NewCarbon Head of Engineering) who has more than ten years of energy project execution and development experience across the conventional and clean energy sectors, and has completed over $3 billion in capital development, execution, and maintenance work at BP, Williams and TC Energy. The Business Point of Contact (POC) is Omar Khayum (NewCarbon Founder and CEO) who has over 15 years

of experience in the energy domain. Prior to founding NewCarbon, Omar served as the CEO of Annova LNG and held executive and leadership roles at TC Energy, Constellation Energy and Exelon Corporation.

NewCarbon develops, owns, and operates infrastructure that delivers lifecycle carbon intensity reduction. We do this through fit-for-purpose solutions that integrate seamlessly across our customers' value chains. NewCarbon's turnkey infrastructure process makes it easier for customers to reduce lifecycle carbon intensity so they can remain focused on their core businesses.

American Crystal Sugar Company is owned by nearly 2,800 shareholders who raise approximately one-third of the nation's sugar beet acreage in the Red River valley of Minnesota and North Dakota. As the largest beet sugar producer in the United States, the company utilizes innovative farming practices, low-cost production methods, and sales and marketing leadership to produce and sell about 15 percent of America's sugar.

MANAGEMENT

NewCarbon will oversee all tasks, schedule regular internal and external meetings with project participants and contractors and ensure that the Project is conducted using industry best practices in accordance with the project plan (budget, schedule, deliverables, and milestones) and is meeting quality objectives. NewCarbon will keep all partners informed of Project progress, coordinate activities as necessary for the execution of a successful project and will be responsible for timely submission of all project deliverables and transfer of data and products to the project team.

Key Roles:

NewCarbon Feedstocks, LLC: Provides Project director resources, manages the overall Project execution and oversees the contractors and will lead origination effort to sign non-binding term sheet(s) with customers for long-term sale of the RNG.

American Crystal Sugar Company: Provides site specific data and volume and composition of sugar beet byproducts that will feed the anaerobic digestion process.

Contractors: Community Benefits Consultant, Land Control, Environmental/Permitting Consultant, Life Cycle Assessment, Engineering/EPC, Electrical/Water/Pipeline Interconnect Consultant, Financial Modeling Consultant, and OEMs.

Project Duration (12-Month) Go/No-Go Evaluation Point: NewCarbon will decide whether to progress to FEED/Mid-Stage development phase based on the End of Project Goal (SMART).

End of Project Goal: Upon completion of the 12-month Project duration, NewCarbon will decide whether to progress to a FEED study and subsequent development activities based upon meeting the following measurable criteria: (1) Signed non-binding customer term sheets, (2) budgetary estimate from an EPC contractor based on the pre-FEED, (3) development of a community benefits plan, and (4) feasibility assessment of the technology achieving a TRL 9.

TIMETABLE

This Project is proposed to be performed over a 12-month period, with an anticipated start date of November 1, 2024. Quarterly progress reports will be submitted within 30 days after the end of each calendar quarter. **Error! Reference source not found.** depicts the proposed schedule.

Figure 2: ACS NewCarbon RNG Project Schedule

NewCarbon Feedstocks	Year	2024		2025										
ASC RNG Project	Quarters	Q4		Q1			Q2			Q3			Q4	
	# of Months	11	12	1	2	3	4	5	6	7	8	9	10	11
Mid- Stage Development		November	December	January	February	March	April	May	June	July	August	September	October	November
NDIC Grant Award		✓												
Sales Qualification														✓
Engage Fiancing Counterparty and preliminary screen														✓
Site Option														✓
Community Benefits Plan														✓
Pre-FEED Engineering													✓	
Life Cycle Analysis													✓	
Biogas Quality Study			✓											
Permit Matrix													✓	
Electricol Interconnection													✓	
Natural Gas Pipeline Interconnection													✓	
Water/Waste Water Interconnection													✓	
Proforma/ Budget														✓
Pipeline Routing Due Diligence													✓	

BUDGET

The total estimated cost for the proposed work is $930,000, as presented in Table 1. NewCarbon requests $455,000 from the North Dakota Industrial Commission Renewable Energy Program to be matched with $475,000 from NewCarbon Feedstocks, LLC. Budget notes can be found in Appendix D.

Table 1: ACS NewCarbon RNG Project Budget

Project Associated Expense	NDIC's Share	Applicant's Share (In-Kind)	Total Project
Labor (Salaries + Fringe Benefits)		$475,000	$475,000
Travel	$22,000		$22,000
Supplies	$5,000		$5,000
Task 1.0: Market Analysis	$25,000		$25,000
Task 2.0: Property Due Diligence	$5,000		$5,000
Task 3.0: Community Outreach and Engagement	$40,000		$40,000
Task 4.0: Engineering Services	$265,000		$265,000
Task 5.0: Developer Services	$33,000		$33,000
Task 6.0: Project Pro-Forma/Budget	$15,000		$15,000
Task 7.0: Site Acquisition Planning	$40,000		$40,000
Task 8.0: Sourcing Project Funding	$5,000		$5,000
Total	**$455,000**	**$475,000**	**$930,000**

CONFIDENTIAL INFORMATION

No confidential information is included in this proposal.

PATENTS/RIGHTS TO TECHNICAL DATA

It is not anticipated that any patents will be generated during this Project. The rights to data generated will be held NewCarbon Feedstocks, LLC and its affiliates.

STATE PROGRAMS AND INCENTIVES

NewCarbon Feedstocks, LLC has not participated in any programs or incentives from the State in the last 5 years.

APPENDIX A

LETTERS OF SUPPORT

American Crystal Sugar Company

101 North 3rd Street
Moorhead, MN 56560

North Dakota Industrial Commission
State Capitol 14th Floor
600 E. Boulevard Ave. Dept. 405

Bismarck, ND 58505-0840
Phone: (701) 328-3722
Attn: Reice Haase

July 31, 2024

Dear Mr. Haase

To Whom It May Concern,

I am writing this letter to express American Crystal Sugar Company's support of NewCarbon's proposed renewable natural gas (RNG) project at our beet sugar processing facility in Hillsboro, North Dakota.

NewCarbon's innovative food waste to energy project will serve the State of North Dakota and its residents by producing pipeline-grade renewable natural gas from feedstocks abundant in the Red River Valley. The project will allow American Crystal Sugar to convert byproducts of our sugar beet refining process – unprocessed pulp and tailings -- into a value-added advanced biofuel product.

We believe the project meets several stated objectives of the North Dakota Industrial Commission's Renewable Energy Program.

- Promoting efficient economic and environmentally sound development and use of the state's natural resources
- Creating construction and operations jobs in the agricultural/biofuels sector
- Growing the economy, enhancing economic stability and opportunity
- Technology development, innovation and ideation
- Supporting economic growth for agricultural producers

American Crystal Sugar Company generates significant quantities of sugar beet pulp and tailings per year. NewCarbon proposes to develop, construct, and operate an anaerobic digester to produce biogas on site, which will be upgraded to produce pipeline quality renewable natural gas. We support NewCarbon's application to secure grant funding from the North Dakota Industrial Commission Renewable Energy Development Program and other funding sources which will enable them to complete through Phase 1 planning and feasibility tasks of this clean energy project.

NewCarbon is a clean energy infrastructure company who develops, owns and operates infrastructure that delivers lifecycle carbon intensity reduction for North America's top industrial, agricultural and energy companies. Their turnkey infrastructure process makes it easier for partners like American Crystal Sugar Company to reduce lifecycle carbon intensity so we can

American Crystal Sugar Company

101 North 3rd Street
Moorhead, MN 56560

remain focused on what we do best. While delivering on a lower-carbon future, we can attest that NewCarbon takes a collaborative approach to maximizing economic benefits to the local communities in which they operate.

We at American Crystal Sugar are pleased to be collaborating with NewCarbon on this innovative project that creates value through environmentally sound and efficient use of an abundant North Dakota natural resource.

Please do not hesitate to reach out to me if you require any further information. I look forward to witnessing the progress and positive economic impact that NewCarbon will deliver

Thank you for considering my support.

Sincerely,

Josh Kamrud
Business Development and Economic Analysis Manager

APPENDIX B

RESUMES OF KEY PERSONNEL

OMAR KHALID KHAYUM
1057 Chadwick Ct., Aurora, IL 60502 | (312) 718-9519 | omar.khayum@gmail.com | linkedin.com/in/omarkhayum

EDUCATION

The University of Chicago Booth School of Business — **Chicago, IL**
MBA (Honors); Concentrations in Economics, Finance & Entrepreneurship — *September 2007 – June 2009*
- Beta Gamma Sigma

Purdue University — **West Lafayette, IN**
Bachelor of Science, Computer Science (Honors); Minors in Mathematics & Management — *August 2000 – May 2004*
- Phi Beta Kappa, Kappa Sigma, Alpha Kappa Psi

EXPERIENCE

NewCarbon, LLC — **Chicago, IL**
Founder and Chief Executive Officer — *November 2023 – Present*
- Founded a clean energy infrastructure company that delivers lifecycle carbon intensity reduction through fit-for-purpose infrastructure solutions that integrate seamlessly across customers' value chains

Cognitive Concierge, LLC — **Chicago, IL**
Founder and Board Member — *September 2019 – Present*
- Founded a health and wellness company that provides virtual services to families navigating cognitive conditions

MemoryCare Corporation — **Chicago, IL**
Founder and Board Member — *March 2010 – Present*
- Founded a healthcare company that provides Speech, Occupational and Physical Therapy to individuals with cognitive conditions

TC Energy — **Houston, TX**
Vice President – North American Low Carbon Origination and Development — *March 2021 – October 2023*
- Led customer origination for North American power, environmental, natural gas and hydrogen development and trading platform
- Led asset development for North American low carbon platform, including wind, solar, pumped hydro, renewable natural gas, green hydrogen production, blue hydrogen production and carbon capture
- Led asset financing for North American low carbon platform, including strategic equity, project debt and tax equity

Annova LNG — **Houston, TX**
Chief Executive Officer, Annova LNG — *October 2018 – March 2021*
- Led a 6.5 MTPA greenfield liquefied natural gas (LNG) export startup company in Texas
- Led development capital fundraising, project finance debt and equity fundraising and origination of long-term offtake contracts
- Led development activities resulting in FERC and DOE approvals to construct and operate the LNG export facility

Chief Operating Officer, Annova LNG — *September 2017 – September 2018*

Constellation Energy — **Baltimore, MD**
Managing Director – Origination, Constellation Energy — *September 2017 – March 2019*
- Led origination for Constellation's natural gas and LNG trading business

Managing Director – Strategic Projects, Constellation Energy — *January 2017 – August 2017*
- Led establishment of joint venture providing development services to new nuclear power stations in the UK and Japan

Exelon Corporation — **Chicago, IL**
Managing Director – Generation Development, Exelon Generation — *June 2015 – December 2016*
- Led greenfield development for utility scale power generation projects, resulting in financing and construction of over $3 billion of new assets, including over 2.5 GW of natural gas, wind, solar and battery storage capacity across the continental United States

Manager – Generation Development, Exelon Generation — *August 2014 – May 2015*
Manager – Wind Business Development, Exelon Generation — *June 2013 – July 2014*
Manager – Corporate Strategy, Exelon Business Services Company — *November 2012 – May 2013*
Principal Analyst – Corporate Strategy, Exelon Business Services Company — *February 2011 – October 2012*
Senior Analyst – Corporate Financial Planning & Analysis, Exelon Business Services Company — *August 2009 – January 2011*

Diamond Management & Technology Consultants — **Chicago, IL**
Associate and Analyst – Strategy & Marketing Competency — *June 2004 – June 2007*

Matthew William Moshier, MBA, P.E., P.M.P.

Email: mwm5221@gmail.com Phone: 724-825-8406

WORK EXPERIENCE

New Carbon **Chicago, IL**

Head of Engineering March 2024- Present

- Accountable for financial analysis, project management, and engineering for a variety of low carbon products to lower customers carbon intensity in the Midwest
- Submitted five DOE concept papers with customer engagement to EERE to obtain development funding for hard to abate emitters
- Developed financial models to support financing of RNG portfolio on a project and portfolio basis
- Engagement with customers across the carbon lifecycle- from feedstock development to product sale and financing
- Development of term sheets for potential offtake, feedstock supply, and investment

Strata Clean Energy **Chicago, IL**

Senior Director of Engineering October 2023- March 2024

- Led execution of pre-FEED study to determine viability of ammonia production with solid oxide electrolysis
- Served as the technical advisor for stage gated process to drive efficient capital deployment and accountability
- Conducted due diligence across portfolio of electrolysis and ammonia production vendors to determine vendor selection
- Developed siting and deployment strategy to identify potential deep-water ammonia shipping and staged capital deployment
- Led customer engagement in order to commercialize a portfolio of ammonia production facilities
- Created a technoeconomic analysis tool for the leadership team to determine the potential customer cost impact for variety of transportation methods

TCEnergy **Chicago, IL**

Senior Project Manager-Project Development April 2022- October 2023

- Directly managed three employees to meet overall corporate net zero ambitions and drive project development and execution
- Recruited, interviewed, onboarded, and managed multiple employees into the engineering and development group
- Project director for a confidential fully integrated, large scale biofuels facility, with full feedstock supply and offtake
- Managed over 1000 tonne per day (tpd) across 15 FEL studies in various levels of development to develop scope, schedule, and cost to meet customer needs for hydrogen and Carbon Capture Utilization and Storage (CCUS) projects
- Created hydrogen sales and purchase agreement (HSPA) and associated financial and pricing model
- Developed TCEnergy Chemours Joint venture to develop 20 tpd of electrolysis and DOE cost share agreement (Press Release)
- Managed development team to submit four DOE hub applications to receive over $2 Bn in DOE funding
- Executed option to purchase two, 30 tpd liquefaction trains from Plug to support safe harbor investment strategy (Press Release)
- Developed financial and pricing model for green and blue hydrogen as well as capital and operational costs to support
- Executed Life Cycle Analysis across the hubs in order to quantify Carbon Intensity and environmental impact
- Recipient of a DOE loan for $1.3 Bn from the Loans Program Office for Phoenix Hydrogen Hub (Press Release)
- Lead developer for Phoenix Hydrogen Hub (Nikola JV) and key member of due diligence and execution
- Managed multiple Joint Venture (JV) partners and customer engagement with varying levels of ownership
- Developed multiple hydrogen and CO2 pipeline routings and strategies to support hub development and potential offtake
- Negotiated CO2 CCUS sequestration agreement with third party to ensure project bankability
- Lead developer for offtake negotiations for potential biofuels, logistics, and other potential off takers
- Developed hydrogen offtake agreement and pricing structure for customer negotiations in conjunction with JV partners
- Directly involved with the commercial negotiations and financial model development for all projects to ensure engineering perspective is incorporated with main accountabilities for capital and operational expenditures
- Created updated governance structure to ensure viability of project financing and execution for hydrogen and CCUS projects
- Completed due diligence across the hydrogen technology portfolio, including operating and manufacturing site visits
- Developed scope, schedule, and cost for ammonia export terminals to advance hydrogen producing opportunities
- Designed of the metrics spreadsheet to more effectively allow engineering team to provide high level development design criteria to understand feasibility of potential projects for rapid RFP response
- Utilized existing and new data sources to provide recommendations for potential Long Term Supply Agreements for SMR, ATR, Electrolysis, Liquefaction, and biofuels production vendors
- Developed templates to help expedite EPC inputs into financial model, reducing time to pricing for market
- Interviewed and developed recommendation for potential Owners Engineer vendors

BP **Chicago, IL**

Project Manager December 2019 – April 2022

- Directly managed 40+ resources and $11 MM in contractor spend to conduct a 446-mile pipeline inspection- longest in BP history
- Managed a portfolio of $13MM and 60+ resources across the U.S. to complete a high-profile HDD, 65 ILI repairs, reactivation of an idled asset, three active line valve replacements, and multiple ILI inspections
- Conducted multiple FEL studies to shape BPs Net Zero initiative which included multiple confidential Carbon Capture, Utilization, and Storage (CCUS) projects as well as a nationwide DOE funded hydrogen transportation system; presented to senior leadership for investment level decision leading to additional due diligence to align with BP net zero ambitions
- Created financial model to analyze carbon capture projects within the business unit to determine carbon break even pricing
- Optimized in line inspection run to reduce the volume of nitrogen emitted and reduced project spend by $2 MM

- Collaborated with global procurement and leadership teams to develop and implement a change order tracking and feedback system to aggregate contractor non-conformance data for current and future negotiations, ~$1 MM/ year in refunds
- Achieved highest level of internal conformance by implementing a self-verification process to audit project execution and ensure alignment with BP's Stage Gate process and identified future opportunities for KPI development and process improvements
- Established a standardized process for managing projects for pipeline repairs key stakeholder communications
- Utilized Power BI to develop a tool which tracked third party encroachments into pipeline ROW to inform front line operations

Williams Companies Inc. **Pittsburgh, PA**

Project Developer Sr. April 2017 – December 2019

- Lead developer selected to analyze and execute over $2 B of capital projects: gas and condensate gathering, compression, FERC regulated pipelines, gas processing, and fractionation facilities in Ohio River Supply Hub (ORSH)
- Completed commercial deals across gathering and processing business resulting in over $2 B in incremental EBITDA
- Subject matter expert on Processing and Fractionation and expansion capital requirements for multiple M&A deals
- Managed FERC open season process, rate case development, and corporate structure for NGL pipelines
- Presented over $500 MM in proposed capital projects for FY 2017-2019 within capital funding (CAPEX) gated process to senior leadership, board members, and commercial teams to ensure projects meet long term growth strategy
- Developed discounted cash flow models for rate setting purposes for projects with CAPEX less than $150 MM
- Automated and streamlined forecasting model to include commercial scenarios, mitigating contractual risk, and reducing product over/undersell by 15%

Project Engineer III December 2013 – April 2017

- Completed over $650 MM in large capital projects from front end engineering and design (FEED), detailed design, construction support, operations turnover, and post project support
- Managed over $5 MM in engineering contactors, resulting in engineering costs 10% below budget on average
- Provided engineering assistance for construction, including requests for information, commissioning and start-up support, and project deliverable turnover
- Designed, constructed, and commissioned the startup of multiple facilities, including compression, interconnects, pipelines, turbo expander, de-ethanizers, slug catcher, flare, stabilization, frac train, rail bays, and storage tanks
- Developed and ensured efficient execution of multiple company standards for engineering design reviews, Process Hazard Analysis, Layers of Protection Analysis, Management of Changes, Process Safety Startup Review, Alarm Rationalization, Factory Acceptance Tests, and Process Safety Management
- Member of steering committee that developed and implemented companywide standard for API 12F tanks

Pinnacle Asset Integrity Services (PinnacleAIS) **Pasadena, TX**

Project Lead May 2012 – November 2013

- Directly supervised and trained a team of seven consultants on NCRA site-specific procedures in multiple locations
- Oversaw the completion and project reporting of a Mechanical Integrity and Risk Based Inspection program at the National Cooperative Refinery Association (NCRA) Refinery in McPherson, KS
- Managed a total of four project budgets with a gross revenue of $2 MM and gathered data for future proposal bids
- Implemented a companywide best practice for integration of PinnacleAIS Inspection Services with PinnacleAIS Services department for turnaround planning purposes

EDUCATION

Indiana University Bloomington, IN
The Kelley School of Business, MBA, Finance Major August 2023

The Pennsylvania State University University Park, PA
The College of Engineering, Bachelor of Science in Chemical Engineering May 2012

JUSTIN GUTKNECHT
Head of Solutions
NewCarbon LLC
1648 W Division Street, Unit 709, Chicago, IL 60622
312.576.8004 (phone), Justin.Gutknecht@newcarbon.energy

Education and Training

M.B.A., Accounting, Finance, and Strategy, Booth School of Business University of Chicago, 2017.
B.S. Finance, University of Illinois at Urbana-Champaign, 2004.
Chartered Financial Analyst (CFA), 2013–present.

Research and Professional Experience

- Lead structuring of clean energy infrastructure utilizing low carbon feedstocks, fuels and carbon capture technologies by providing commercial guidance to the project development, origination, engineering, and capital markets teams.
- Develop a near and long-term customer-focused decarbonization strategy by deploying energy infrastructure and technologies to achieve lifecycle carbon intensity reduction in manufacturing and production processes.
- Oversee a strategic execution plan incorporating an entire project lifecycle, from conception to commissioning. Include risk mitigation, managing commercial relationships, safety, scheduling, budgeting, and project finance transactional activities.
- Coordinate financing activities, including tax equity and debt financing, provide guidance on financial models, identify risks within contracts, and manage relationships with third-party financiers.

2021–2023: Director, Energy Origination and Development, TC Energy.

- Managed TCE Energy's origination and development of utility-scale renewable power projects and low-carbon infrastructure projects in the United States.
- Supervised a U.S. Origination and Development team covering structured origination, mid-marketing, development, interconnection, permitting and land management functions.
- Led commercial negotiations, development, and execution efforts to establish a U.S. portfolio of wind, solar, hydrogen, clean fuels and carbon capture, transportation and sequestration projects.
- Led Federal and State Hydrogen and Carbon Capture funding opportunities totaling $1 billion, receiving DOE grant awards for projects within the Heartland and ARCH2 Regional Hydrogen Hubs.

2017–2021: Senior Vice President, Finance and Development, Annova LNG.

- Led due diligence, development and execution efforts in multi-phase equity financings with joint venture partners and construction capital fundraising.
- Managed financial advisor, insurance advisor, and outside counsel engagements to support the bankability of terms and conditions of various project contracts and provided structuring advice.
- Led project development activities, including electrical interconnection, wholesale power procurement, dredging, local and state tax incentive negotiations, accounting and tax matters.

2015–2017: Principal, Generation Development Analytics, Exelon Corporation.

- Led financial evaluation and transaction execution support for acquisition and greenfield development of utility scale wind, solar and battery storage generation projects.
- Led development activities for battery storage, including site control, permitting, interconnection, engineering, technology evaluation, and offtake.

2011–2015: Manager, Financial Planning and Analysis, Evraz North America.

- Supervised on-site mill financial managers in monthly forecasting and annual budget processes and consolidated the financial results of the Tubular Product Division.
- Obtained approvals for capital investment projects and provided technical financial support and recommendations on the evaluation of potential alliances, acquisitions, capital investments, and other issues affecting operations.

2004–2011: Senior Financial Analyst, Corporate Development, Telephone and Data Systems Inc.

- Performed valuations for the acquisitions of wireless spectrum and acquisitions.
- Prepared presentations to bond-rating agencies, reviewed credit metric ratios based on rating agency methodologies, and analyzed strategic and financial initiatives to improve capital structure.

Professional Activities

Member, CFA Society of Chicago, 2013–present.

PHILLIP FRANSHAW

4205 Dickson Street, Houston, TX 77007 | (713)253-0690 | phillip.franshaw@newcarbon.energy

EXPERIENCE

NewCarbon—Houston, TX
Co-Founder & Head of Customer Engagement *November 2023—Present*

- Co-founded a clean energy infrastructure company that delivers lifecycle carbon intensity reduction through fit-for-purpose solutions that integrate across customers' value chains
- Lead deal structuring and contract negotiations while working collaboratively with legal, finance, engineering, and construction leads to optimize project economics and mitigate risk

TC Energy Corporation—Houston, TX
Origination Specialist, Power & Energy Solutions *April 2021—November 2023*

- Led customer origination for United States low carbon platform including wind, solar, renewable natural gas, green hydrogen, and sustainable aviation fuel production
- Led deal structuring, negotiations, and execution of contracts to secure mutually beneficial agreements with equity partners, customers, and other project stakeholders

Exelon Corporation—Houston, TX
Senior Vice President & Co-Founder, Annova LNG, LLC *October 2012—March 2021*

- Co-founded a 6.5 MTPA greenfield liquefied natural gas (LNG) export company
- Led origination, structuring, and negotiation of long-term offtake contracts

713 Capital Partners—Houston, TX
Co-Founder & Principal *September 2007—March 2014*

- Co-founded municipal real estate consulting practice providing advisory and development management services

Cockrell Interests Inc.—Houston, TX
Managing Director *September 2003—September 2007*

- Managed a diversified real estate portfolio for a family office
- Led structuring, negotiation, and execution in a portfolio of direct and indirect investments including wholly owned properties, joint ventures, and commingled funds

Hines Interest Limited Partnership—Houston, TX
Project Manager *June 2000—September 2001*

- Managed a global diversified real estate portfolio totaling $2.1billion

The Coca-Cola Company—Atlanta, GA
Business Development Consultant—Houston, TX *September 2001—September 2003*

- Led acquisition structuring, negotiation, and execution of premium juice drink company

Business Development Manager—Atlanta, GA *August 1995—February 1998*

- Led acquisition structuring, negotiation, and execution of bottling assets totaling $2.4 billion

Principal Financial Analyst—Houston, TX *August 1992-August 1995*

- Led restructuring of $2.0 billion operating division

Merrill Lynch Capital Markets—New York City, NY
Equity Trader *August 1986—August 1988*

EDUCATION

The University of Texas at Austin
Master of Business Administration, Finance & International Business *August 1992*

Georgetown University
Bachelor of Arts, English *May 1986*

Brian Lammers
2437 Girard Avenue South
Minneapolis, MN 55405
(612) 518-3798
brian.lammers@newcarbon.energy

Experience

Brian has more than 20 years of experience developing utility-scale renewable power, energy storage and HVDC transmission infrastructure in the United States and Canada. Brian held leadership positions at Exelon, EDP North America and RES Americas. During his career Brian has led origination, development and financing initiatives resulting in investment of more than $6 Billion in low carbon power and energy solutions.

NewCarbon, Chicago, IL
Head of Feedstocks
January 2024 - Present
Founding partner of NewCarbon, a developer, owner and operator of fit-for-purpose solutions for agricultural and industrial customers to lower the lifecycle carbon intensity of their operations.

Advanced Generation Development, Minneapolis, MN
President and Founder
March 2017 – Present

- Originated, developed, and sold a 700 MW wind generation development portfolio to a leading US independent power producer
- Closed 850 MW of wind and solar power purchase agreements for midstream energy client, organized buy-side solicitation, evaluated proposals, led contract negotiations
- Led integration and development of 400 MW solar generation portfolio for power client
- Advisor for site identification and early-stage development of hydrogen production projects, two of which received $1.85 billion in DOE Grant awards
- Led commercial offtake and development efforts for a private equity-backed 2100 MW merchant HVDC transmission project

Renewable Energy Systems, Minneapolis, MN
Vice President, Development
October 2017 – December 2018

- Closed power purchase agreements for 400 MW of wind and solar generation
- Held P&L responsibility for regional origination and development office
- Managed joint venture with leading US IPP resulting in construction of 1 GW of new wind and solar generation

Exelon Generation, Chicago, IL
Managing Director, Renewables and Technology Development
November 2011 - March 2017

- Led development and acquisition of 2 GW of wind and solar generation and battery storage, deploying ~$3 billion in CapEx, and doubling the size of Exelon's renewable generation fleet

EDP Renewables N.A., Minneapolis, MN
Director of Development, Upper Midwest and Northeast U.S.
March 2008 – November 2011

- Completed development of more than 750 MW (~ $1.5 billion) of wind generation
- Responsible for two regional development teams, fifteen staff, a 3 GW project pipeline and $10 million annual budget in the Midwest and Northeastern U.S.

John Deere Finance, Johnston, IA
October 2006 – March 2008

- Led development of 500 MW (~ $1 billion) of U.S. wind power generation projects
- Spearheaded transition from distributed-scale to utility-scale wind generation
- Developed and closed financing for the first multi-megawatt wind farm in Michigan

Gamesa Energy, Philadelphia, PA
September 2004 – October 2006

- Led development of more than 500 MW (~ $1 billion) of US wind generation projects including the largest wind generation project constructed in Pennsylvania
- Opened and managed regional development office

Navitas Energy, Minneapolis, MN
November 1998 – September 2004

- Led origination, development, and completion of 250 MW (~ $500 million) of wind generation
- Supported successful M&A efforts with U.S. and European IPPs

Education

University of Minnesota - Minneapolis, MN
MBA

University of Wisconsin – Madison, WI
Bachelor of Science

Community Involvement

American Red Cross, Twin Cities Chapter – Minneapolis, MN
Board of Directors
June 2023 - Present

City of Lakes Waldorf School, Minneapolis, MN
Secretary, Board of Trustees
Chair, Development Committee
2019 – Present

Clean Grid Alliance (fka Wind on the Wires), Saint Paul, MN
Treasurer and Board Member
2010 – 2021

APPENDIX C

TAX LIABILITY STATEMENT

Industrial Commission

Tax Liability Statement

Applicant:

NewCarbon Feedstocks, LLC

Application Title:

ACS NewCarbon RNG Project

Program:

- ☐ Lignite Research, Development and Marketing Program
- ☑ Renewable Energy Program
- ☐ Oil & Gas Research Program
- ☐ Clean Sustainable Energy Authority

Certification:

I hereby certify that the applicant listed above does not have any outstanding tax liability owed to the State of North Dakota or any of its political subdivisions.

_____

Signature

President

_____

Title

July 31, 2024

_____

Date

APPENDIX D

CITATIONS AND BUDGET NOTES

CITATIONS

ND Department of Agriculture, D. G. (n.d.). Retrieved from https://www.ndda.nd.gov/sites/www/files/documents/files/2023%20ND%20Ag%20brochure.pdf

Natalia Mioduszewska, M. A. (2018). The usefulness of sugar beets for biogas production in relations of the storage time and sugar content. *E3S Web of Conferences*.

Francisco López, A., Lago Rodríguez, T., Faraji Abdolmaleki, S., Galera Martínez, M., & Bello Bugallo, P. (2024). *From Biogas to Biomethane: An In-Depth Review of Upgrading Technologies That Enhance Sustainability and Reduce Greenhouse Gas Emissions*. Retrieved from https://www.mdpi.com/2076-3417/14/6/2342.

BUDGET NOTES

Salaries: Salary estimates are based on the scope of work and prior experience on projects of similar scope. The labor rate used for specifically identified personnel is the current hourly rate for that individual.

Fringe Benefits: Fringe benefits is calculated as 11.6% of gross salary which is calculated as the total of: 6.2% for Employer Social Security Withholding, 1.45% for Employer Medicare Withholding, 0.6% for Employer Federal Unemployment Tax Withholding (FUTA), 0.85% for Employer State Unemployment Tax Withholding (SUI), 2.5% for Paid Leave for All Workers.

Travel: Travel may include site visits, fieldwork, meetings, and conferences. Travel costs are estimated and paid in accordance with OMB Uniform Guidance 2 CFR 200, Section 474. Daily meal rates are based on U.S. General Services Administration (GSA) rates. Other estimates such as airfare, lodging, ground transportation, and miscellaneous costs are based on a combination of historical costs and current market prices. Miscellaneous travel costs may include parking fees, Internet charges, long-distance phone, copies, faxes, shipping, and postage.

Supplies: Supplies include items and materials that are necessary for the research project and can be

directly identified to the project. Supply and material estimates are based on prior experience with similar projects. Examples of supply items are chemicals, gases, glassware, nuts, bolts, piping, data storage, paper, memory, software, toner cartridges, maps, sample containers, minor equipment (value less than $5000), signage, safety items, subscriptions, books, reference materials. General purpose office supplies (pencils, pens, paper clips, staples, Post-it notes, etc.) are included in the Supplies cost.

Communications: Telephone, cell phone, and fax line charges are included in the Supplies cost; however, direct project costs may include line charges at remote locations, long-distance telephone charges, postage, and other data or document transportation costs that can be directly identified to a project. Estimated costs are based on prior experience with similar projects.

INDUSTRIAL COMMISSION OF NORTH DAKOTA
RENEWABLE ENERGY PROGRAM

TECHNICAL REVIEWERS' RATING SUMMARY

R-054-C
VBD NEWCARBON RNG PROJECT
Principal Investigator: Matthew Moshier
Request for $455,000; Total Project Costs $930,000

TECHNICAL REVIEWERS' RATING SUMMARY
R-054-C
VBD NEWCARBON RNG PROJECT
Principal Investigator: Matthew Moshier
Request for $455,000 Total Project Costs $930,000

		Technical Reviewer			
		1C	**2C**	**3C**	
Rating Category	**Weighting Factor**	**Rating**			**Average Weighted Score**
1. Objectives	9	3	4	4	33.00
2. Achievability	9	5	4	3	36.00
3. Methodology	7	2	4	2	18.67
4. Contribution	7	1	3	2	14.00
5. Awareness	5	1	3	3	11.67
6. Background	5	4	3	4	18.33
7. Project Management	2	3	3	3	6.00
8. Equipment Purchase	2	5	5	5	10.00
9. Facilities	2	5	3	3	7.33
10. Budget	2	1	2	3	4.00
Average Weighted Score		146	177	154	**159.00**
Maximum Weighted Score					250.00

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 3)

The proposed project seems to be focused on community outreach, engagement, pre-FEED and feasibility studies, but doesn't mention anything regarding the process or the necessary equipment to collect, transport, filter, clean, and compress the methane.

Reviewer 2C (Rating 4)

This proposal aligns with all of the NDIC's goals.

Reviewer 3C (Rating 4)
Produce RNG from livestock manure using anerobic digestion and gas cleaning procedures. Also produce reusable bedding for livestock and soil amendments. Develop "standard" digestion units. This project meet the goals of a beneficial use of an ag wast to provide a beneficial renewable product, RNG.

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)
Additional information should have been provided regarding the pre-FEED and feasibility studies in order to determine how achievable the studies will be. However, the community outreach and studies for the availability and cost of utility feedstocks is certainly achievable.

Reviewer 2C (Rating 4)
This proposal is for the investigation of feasibility. The requested funding is for the labor cost of deciphering how best to capture and market the methane from dairy cow manure.

Reviewer 3C (Rating 3)
The proposal is achievable given the timeframe and budget. The NG interconnection time frame may be optimistic, but an agreement could be reached.

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 2)
A more detailed scope of the engineering studies (pre-FEED and feasibility) should have been provided.

Reviewer 2C (Rating 4)
The proposed plan is very logical and covers all the bases.

Reviewer 3C (Rating 2)
The project does not layout identifying the attributes of the manure that produces a greater quantity or quality of RNG. As a development project, it follows a typical venture capital process.

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 1)
This is a commodity dependent project. And with natural gas at $1.55/MMBtu, spending $930,000 for community outreach, assessing feedstock availability, and a couple engineering studies seems excessive. Especially when it does not include any pilot projects or equipment. And if/when this project is fully operational only collects 56,000 MMBtu per year, it's equivalent to only $86,800/year at today's natural gas prices. That's 11 years just to cover this portion of the project and doesn't include the costs for any FEED study, pilot projects, or commercial equipment. Plus it sounds like they need natural gas for the "high heat pasteurization" which could be more than the 56,000 MMBtu/yr they would produce.

Therefore, this project does not promote efficient or economic use of North Dakotas renewable resources, create highest potential to create jobs, nor will it add wealth to landowners or agriculture producers.

Reviewer 2C (Rating 3)
Taking waste and producing markable gas may have a significant impact on the owner and surrounding community.

Reviewer 3C (Rating 2)
Some knowledge will be gained on the solids separation and cleaning. However, the process is a proven technology. The economic analysis is the key to the project success if it includes pricing and carbon credits.

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 1)
Very few research or published literature references were provided.

Reviewer 2C (Rating 3)
The PI appears to have a proven background in project management. However, based on his resume, he is prone to change jobs quite frequently. Consequently, project dedication would be a concern.

Reviewer 3C (Rating 3)
The awareness of the PI and Co-PI's are adequate based on references and backgrounds. The developers appear to acknowledge that outside technical specialists need to be involved.

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 4)
All parties have very thorough and impressive resumes in a considerable quantity of endeavors. Not sure if this is a good sign or not.

Reviewer 2C (Rating 3)
This project only involves the investigation of methane capture. I have over 40 years of providing and reviewing proposed industrial projects.

Reviewer 3C (Rating 4)
The developers have the background to manage the project to meet their stated goal.

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 3)
Not overly impressed with the limited details in the project schedule.

Reviewer 2C (Rating 3)
The provided management plan appears to be very generic with very little specified. However, since this proposal is only for preliminary investigation, it should suffice.

Reviewer 3C (Rating 3)
Good PM plan & milestone goals. Financial feasibility has a missing reference. No communication plan found.

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)
There is no equipment to be purchased for this project.

Reviewer 2C (Rating 5)
This proposal is only for investigation, so no new equipment is to be purchased.

Reviewer 3C (Rating 5)
No equipment purchased

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 project is collaborating with the facility, VanBedaf Dairy LLP, so will most likely be available. No additional equipment is to be purchased as part of this project.

Reviewer 2C (Rating 3)
The proposal is only for initial investigation and the existing facilities should be adequate.

Reviewer 3C (Rating 3)
No facilities or equipment required other than land agreements that appear to be readily available. Services Only for this portion of the project.

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 1)
For this single site alone (VanBedaf Dairy), research, engineering, pilot projects, land acquisition, utility access, equipment, construction, commissioning, operations, maintenance, utilities (natural gas, water, electricity), etc. will cost several if not tens of millions of dollars – just to generate maybe $90,000 of equivalent natural gas per year. Unless natural gas prices skyrocket, or RNG can sell for $20-$30/MMBtu – this project will not prove to efficient or economic.

Reviewer 2C (Rating 2)
It is difficult to quantify "in-kind" value when it is presented as a lump sum without any detail as to how the dollar amount was determined.

Reviewer 3C (Rating 3)
Proving that RNG can be produced economically from small to mid sized ag centers is attractive. The NDIC/REC assistance buys down risk and accelerates the development of these project types.

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

In current commodity market, natural gas is extremely inexpensive for the foreseeable future and these types of projects are extremely difficult to justify – even for environmental reasons as methane produced from dairy farms is just ~4.5% of total amount of methane released to the atmosphere.

The benefits just don't outweigh the costs (as outlined in Comment 4 and Comment 10).

Recommendation: Not to fund.

Reviewer 2C

This proposal could have great potential to utilize waste and make a renewable energy product with an economic benefit. However, as written, I cannot support funding this project due to the "in-kind" ambiguity. The proposal cited 10 line items as to how the NDIC's funding ($455,000) will be utilized. The budget cites the applicant's contribution as a lump sum ($475,000) with no breakdown on how this number is derived. It would appear that the "in-kind" contribution was selected to cover just over 50% of the total project cost to meet the minimum requirements for NDIC funding. Consequently, I **do not** support this proposal as written.

Reviewer 3C

Good concept. Need to release economic findings for public use. This project meets the NDIC/REC's goals of advancing renewable energy derived from ag waste by buying down the risk for project developers.

In reviewing R-54-B and R-54-C, these are 2 extremely similar projects. Individually I am recommending funding, however, I would only fund one of the projects and not both. There is not enough value to justify both. If I had to pick one, I'd fund R-54-C, even though 54-B is likely more economically viable due to the scale of the project. If there was a way for ACS to make money by digesting their beet pulp and tailings, they would already be doing it in my opinion.

NewCarbon Feedstocks, LLC
1057 Chadwick Ct.
Aurora, IL 60502
www.newcarbon.energy

July 31, 2024

Mr. Reice Haase
Deputy Executive Director
North Dakota Industrial Commission
State Capitol – 14th Floor
600 East Boulevard Avenue, Department 405
Bismarck, ND 58505-0840

Dear Mr. Haase:

Subject: VBD NewCarbon RNG Project

NewCarbon Feedstocks, LLC ("NewCarbon") is pleased to submit the subject proposal to the North Dakota Industrial Commission Renewable Energy Program.

NewCarbon, a clean energy infrastructure company who develops, owns and operates infrastructure that delivers lifecycle carbon intensity reduction for North America's top industrial, agricultural and energy companies, is collaborating with VanBedaf Dairy LLP on the development of a renewable natural gas (RNG) project to harvest biogas from dairy manure via anerobic digestion, upgrade the gas, and deliver high-quality negative carbon intensity RNG to end users. Successful execution of this Project will add wealth for landowners and agriculture producers to build and maintain a robust rural economy in North Dakota. It will also decrease the carbon intensity of a family-owned farm in North Dakota which will generate information and knowledge that will increase the probability of bringing new renewable energy companies and industry investment to North Dakota's agricultural producers.

NewCarbon is committed to completing the project on schedule and within budget should the Commission approve the requested grant.

The $100 application fee for this proposal is provided through ACH Transaction Number 503625864. If you have any questions, please contact me by telephone at (312) 718-9519 or by email at omar.khayum@newcarbon.energy.

Sincerely,

Omar Khayum, President
NewCarbon Feedstocks, LLC

Renewable Energy Program

North Dakota Industrial Commission

Application

Project Title: VBD NewCarbon RNG Project

Applicant: NewCarbon Feedstocks, LLC

Principal Investigator: Matthew Moshier

Date of Application: July 31, 2024

Amount of Request: $455,000

Total Amount of Proposed Project: $930,000

Duration of Project: 12 months

Point of Contact (POC): Omar Khayum

POC Telephone: (312) 718-9519

POC Email: omar.khayum@newcarbon.energy

POC Address: 1057 Chadwick Ct., Aurora, IL 60502

TABLE OF CONTENTS

ABSTRACT

NewCarbon, a clean energy infrastructure company who develops, owns and operates infrastructure that delivers lifecycle carbon intensity reduction for North America's top industrial, agricultural and energy companies, is collaborating with VanBedaf Dairy LLP on the development of a renewable natural gas (RNG) project to harvest biogas from dairy manure via anerobic digestion, upgrade the gas, and deliver high-quality low-carbon RNG to end users. VanBedaf Dairy is a family-owned farm established in Carrington, North Dakota in 2008 with a focus on providing quality food for as many as possible while maintaining natural resources and minimizing their footprint. The dairy farm manages over 2,300 cows, milking, dry and heifer, and delivers milk to Cass Clay Creamery in Fargo for further processing into dairy products to service North Dakota and the surrounding region. The cow meals at VanBedaf Dairy are community-oriented and primarily consist of haylage, silage, and byproducts like canola meal, corn distillers, wheat middlings, and sugar beet pulp from local manufacturers. VanBedaf Dairy has also made significant investments in cow care, including high-tech ear tag sensors that make regular wireless contact with computers to ensure cow health and safety. **Objective:** The project objective is to conduct planning and feasibility activities over 12 months that will study sizing and integration of a renewable

natural gas (RNG) project with VanBedaf Dairy's Carrington, North Dakota dairy farm. The scope of the planning and feasibility activities include market analysis, community outreach and engagement, pre-FEED engineering study, and feasibility studies to determine the availability and cost of utility feedstocks, financial model development and pipeline routing due diligence. **Expected Results:** Successful execution of this Project will support the Renewable Energy Program's (REP's) mission to promote the growth of North Dakota's renewable energy industries through research, development, marketing, and education. Upon completion of the 12-month Project duration, NewCarbon will decide whether to progress to a FEED study and subsequent development activities based upon meeting the following measurable criteria: (1) signed non-binding customer term sheets, (2) budgetary estimate from an EPC contractor based on the pre-FEED, (3) development of a community benefits plan, and (4) feasibility assessment of the technology achieving a TRL 9. Once operational, the proposed Project will add wealth for landowners and agriculture producers to build and maintain a robust rural economy in North Dakota. The project will also decrease the carbon intensity of a family-owned farm in North Dakota which will generate information and knowledge that will increase the probability of bringing new renewable energy companies and industry investment to North Dakota's agricultural producers. Methane produced from dairy farms is accountable for 4.5% of the total amount of methane released to the atmosphere (Diane Mayerfeld, n.d.). The project will bring the immediate advantage of reducing regional methane from the dairy industry, capturing biogas as a source of renewable fuel, and producing digestate byproducts as a nutrient-rich fertilizer. Additionally, due to the regional importance of the VanBedaf Dairy facility, the project will help support the REP's goals of helping to educate residents of the potential benefit of renewable products and begin stimulating growth in the renewable energy sector. RNG processing facilities will improve manure management and operations on the site that will benefit the surrounding Carrington community. When the project is fully operational the VanBedaf Dairy NewCarbon RNG Project will process approximately 26 million gallons of liquid manure to produce an

estimated 56,000 MMBTU per year of negative carbon intensity RNG that will satisfy emerging Midwest low carbon fuel standards (LCFS) and provide for a value-added derivative biofuel suitable for commercial and industrial natural gas customers (Francisco López, Lago Rodríguez, Faraji Abdolmaleki, Galera Martínez, & Bello Bugallo, 2024). The Project will create an estimated 40-65 temporary (12-18 months) construction, engineering, and fabrication jobs and 3-5 new permanent facility/operations jobs. The majority of Midwest Dairy RNG operating projects have focused on facilities with greater than 5,000 cows. NewCarbon plans to evaluate new turnkey standardized biogas system configurations for dairy farms with animal units between 1,000 to 3,000 cows, which will increase sustainability and economic viability for small to medium sized dairy producers and other Concentrated Animal Feeding Operations (CAFOs), which are more prevalent in North Dakota. Small CAFOs, where resources and space are limited, face unique challenges for manure storage and management. RNG production improves on-farm manure management, significantly reduces greenhouse gas (GHG) emissions in agriculture, provides a new revenue stream, and advances environmental stewardship. The project represents a novel integration of dairy manure handling, anaerobic digestion, biogas upgrading and gas delivery which can be replicated at other North Dakota dairy operations. This project paves a pathway for other dairy operators to begin to implement RNG projects at their own facilities, creating additional revenue streams and helping take a step towards a clean energy economy. **Duration:** 12 months, with an anticipated start date of November 1, 2024. **Total Project Cost:** $930,000 with $455,000 from the North Dakota Industrial Commission Renewable Energy Program and $475,000 from NewCarbon Feedstocks, LLC. **Participants:** NewCarbon Feedstocks, LLC and VanBedaf Dairy LLP.

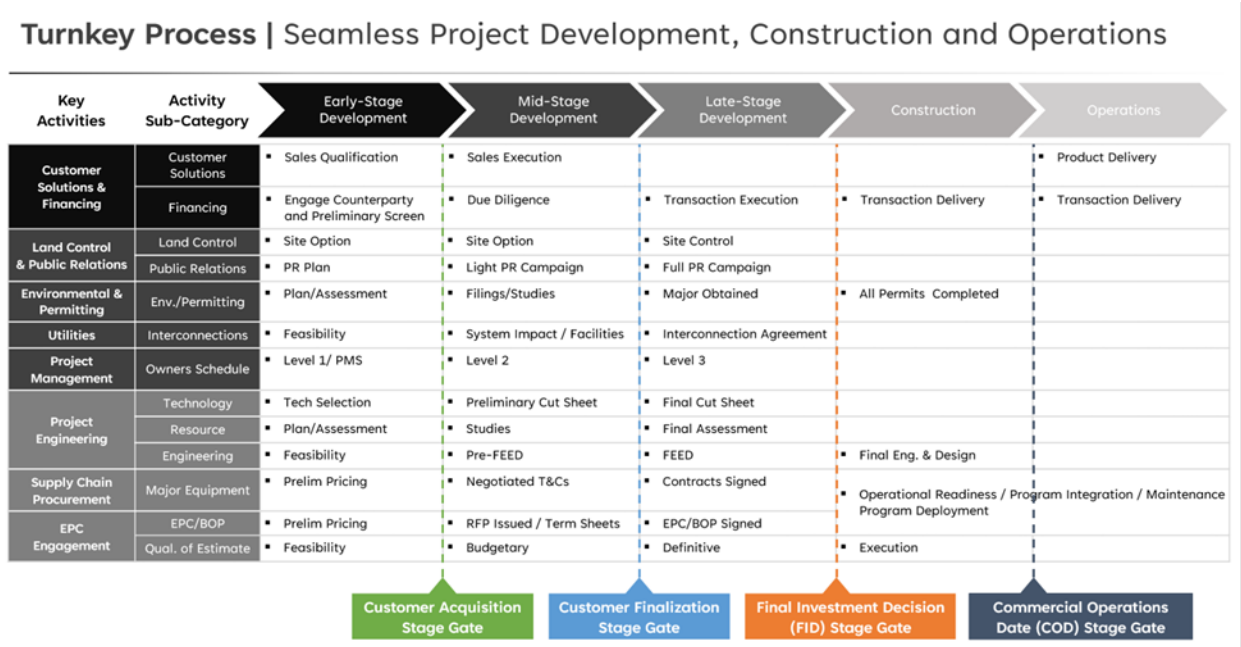
PROJECT DESCRIPTION

Objectives: The project objective is to conduct planning and feasibility activities over 12 months that will study the sizing and integration of a renewable natural gas (RNG) project with the existing dairy to reduce emissions of fugitive methane from manure management at the VanBedaf Dairy farm in

Carrington, North Dakota. The scope of the planning and feasibility activities include market analysis, community outreach and engagement, pre-FEED engineering study, feasibility studies to determine the availability and cost of utility feedstocks, financial model development and pipeline routing due diligence. Particular emphasis will be placed on community outreach and public engagement activities that will support improved understanding of stakeholder concerns, community attitudes, and public acceptance of RNG. The biomethane potential of livestock manure depends on factors such as type of livestock, manure management practices, and the composition of waste. NewCarbon will analyze the consistency of feedstock, moisture content, nutrient content, and other characteristics to improve the efficiency and performance of the conversion process. Manure at VanBedaf Dairy is currently stored in lagoons, where it naturally starts decomposing and releasing methane into the atmosphere, until it can be applied as a fertilizer. The Project will design an RNG processing facility to capture large quantities of manure in anaerobic digesters and use microbial communities to break down the manure into raw biogas. The digesters process and store manure for an average of 25 days, during which time high heat pasteurizes the slurry killing the majority of pathogens. The raw biogas is subsequently upgraded to natural gas pipeline specification which results in negative carbon intensity natural gas when compared to fossil fuel-derived natural gas. This negative carbon intensity RNG is then delivered to customers either through existing natural gas pipelines or via trucked compressed natural gas. A pump system will move the residual organic matter, digestate, from the anaerobic digestion process to a manure solids separator which divides the waste stream into solid and liquid components. The resulting liquid effluent can be pumped through standard irrigation systems for direct application to field crops. The dairy farms will be able to reclaim and recycle the water, thereby improving conservation efforts. When it is fully operational the Project will process approximately 26 million gallons of liquid manure to produce an estimated 56,000 MMBTU per year of negative carbon intensity RNG. The development of a standardized biogas system configuration for small to medium sized CAFOs will improve the

sustainability of North Dakota livestock operations and convert decomposing manure into a valuable product. Anaerobic digestion of dairy manure also reduces odors compared to uncovered manure storage and decreases the risk of nutrient runoff into waterways (Francisco López, Lago Rodríguez, Faraji Abdolmaleki, Galera Martínez, & Bello Bugallo, 2024). **Methodology:** The Project is organized into eight major tasks. NewCarbon will employ its turnkey project development process to ensure technical, development, and financial feasibility (see **Error! Reference source not found.**). This process provides multiple stage gates to ensure the Project follows a rigorous governance process to maximize project viability and risk reduction. During the 12-month duration of the Project, NewCarbon will complete all early-stage development activities and certain mid-stage development activities, such as the pre-FEED study, pursuant to the process in Figure 1 which are vital to producing realistic cost and schedule information and further validate feasibility of the proposed technology and project.

Figure 1: NewCarbon Turnkey Project Development Process



Task 1.0: Market Analysis. The objective of this task is to obtain signed, non-binding customer term sheets from customers for long-term offtake of the RNG product. In terms of market demand for RNG, North Dakota has in-state Biofuels and Sustainable Aviation Fuels facilities which require RNG as a low

carbon feedstock to achieve their carbon intensity targets. Many out of state entities are also seeking RNG to meet voluntary or compliance-driven sustainability targets. The scope for Task 1 includes sales and marketing efforts, financial analysis, and execution of commercial transactions. Activities involve developing sales strategies for Renewable Natural Gas (RNG), identifying and reaching out to prospective customers, engaging with customers to discuss terms and conditions for long-term offtake of RNG and preparing and drafting commercial and legal documents to memorialize offtake agreements.

Task 2.0: Property Due Diligence. The goal of this task is to determine the legal and environmental suitability of the RNG plant site. The scope includes conducting a property title search and assessing the site for any legal or environmental issues that could affect the project. The dairy farm uses sand bedding and separates manure solids mechanically. This process would need to be moved to the digester location and take place after manure has gone through the digester. Sand bedding has caused manure handling challenges for anaerobic digestion as sand can settle in tanks and cause equipment wear. Small amounts of bypass sand can be problematic for effective operations of anaerobic digestion systems. NewCarbon will evaluate mechanical sand-manure separation equipment as anaerobic digestion pre-treatment to recover up to 98% of the sand for reuse, which will improve the dairy operation and increase the total organic solids going into the digester. RNG production can also be affected by technical challenges such as impurities and moisture in the feedstock. NewCarbon will evaluate new technologies to improve the efficiency and effectiveness of RNG production and implement quality control processes in the design basis. The project team will optimize the equipment and general plant arrangement, installation, and interconnecting piping of the RNG processing facilities with the existing Carrington, North Dakota dairy farm.

Task 3.0: Community Outreach and Engagement. This task aims to deliver maximum value to the North Dakota community through effective engagement and communication. The community benefits plan will address community and labor engagement and discuss the creation of high-quality jobs and

development of a skilled workforce. Activities include designing and implementing a community outreach strategy and engaging with local stakeholders to communicate Project benefits and gather stakeholder input.

Task 4.0: Engineering Services. The goal is to conduct preliminary front-end engineering and relevant studies to ensure the facility's viability for RNG production. The scope includes pre-FEED Engineering Study, Lifecycle Assessment (LCA), Biogas Quality Study, Plant Permit Matrix, and Pipeline Permit Matrix. Project team will identify and quantify major material and energy inputs and outputs for a biogas production system. The design analysis will include a closed-loop sand-manure separation system that will rely on minimal water addition to achieve separation and reduce the volume of water fed into the digester. The sand-manure separation system will follow industry best practices in engineering and design to ensure a consistent system operation, and handle manure in an environmentally friendly way.

Task 5.0: Developer Services. The goal is to perform feasibility studies to determine the availability and cost of utility feedstocks/inputs into the RNG project. The scope includes Electrical, Natural Gas, Wastewater, and Feedwater Interconnection Feasibility.

Task 6.0: Project Pro-Forma/Budget. This task aims to develop a pro-forma model to support offtake pricing and construction financing needs. The pro-forma will leverage the data from the pre-FEED study, estimated carbon intensity based on existing dairy operations and proposed equipment installations, interconnection, land, and financing costs.

Task 7.0: Site Acquisition Planning. The objective is to plan site acquisition for pipeline routing to the interconnection location. NewCarbon will design an upgrading system to meet required pipeline specifications and develop a planned pipeline route that will meet safety and regulatory requirements.

Task 8.0: Sourcing Project Funding. This task focuses on identifying other funding sources and federal, local, and state tax incentives for renewable natural gas.

Anticipated Results: Successful execution of this Project will support the Renewable Energy Program's (REP's) mission to promote the growth of North Dakota's renewable energy industries through research, development, marketing, and education. Upon completion of the 12-month Project duration, NewCarbon will decide whether to progress to a FEED study and subsequent development activities based upon meeting the following measurable criteria: (1) signed non-binding customer term sheets, (2) budgetary estimate from an EPC contractor based on the pre-FEED, (3) development of a community benefits plan, and (4) feasibility assessment of the technology achieving a TRL 9. Once operational, the proposed Project will add wealth for landowners and agriculture producers to build and maintain a robust rural economy in North Dakota. The project will also decrease the carbon intensity of a family-owned farm in North Dakota which will generate information and knowledge that will increase the probability of bringing new renewable energy companies and industry investment to North Dakota's agricultural producers. The proposed project will also reduce environmental impacts of dairy feedlot operations while producing a value-added derivative biofuel suitable for commercial and industrial natural gas customers. Processing agricultural waste, such as animal manure, into RNG has significant potential in North Dakota as one of the largest agricultural producers in the United States. When the project is fully operational the VanBedaf Dairy NewCarbon RNG Project will produce approximately 56,000 MMBTU per year of negative carbon intensity RNG that will satisfy emerging Midwest low carbon fuel standards (LCFS) and provide for a value-added derivative biofuel suitable for commercial and industrial natural gas customers. The Project will create an estimated 40-65 temporary (12-18 months) construction, engineering, and fabrication jobs and 3-5 new permanent facility/operations jobs.

Facilities: NewCarbon will be working directly with a large-scale EPC contractor as well as other subcontractors with significant facilities and capabilities in the execution animal waste RNG projects. NewCarbon will be working with contractors who are able to apply best practices for dairy farms using sand bedding with anaerobic digestion systems, which are particularly susceptible to sand settling and

equipment wear, to avoid the design pitfalls from earlier implementations and improve overall system performance. The NewCarbon team has developed relationships across the energy, engineering, and construction sectors and will augment the NewCarbon capabilities as needed. During the course of this Project, NewCarbon will be working directly with VanBedaf Dairy to ensure clear and consistent communication between the two organizations.

Resources: No equipment is expected to be purchased during the initial 12-month planning and feasibility stage. The project participants control the Project and have effective control of the land.

Techniques to Be Used, Their Availability and Capability: The proposed team has committed to the project and has ensured the availability of key personnel for the time frame of this project. Any and all relevant publicly available data will be used for the project.

Environmental and Economic Impacts while Project is Underway: There will be no environmental impact during the initial 12-month planning and feasibility stage. During operations, the RNG project will avoid methane emissions from decomposing dairy manure while producing negative carbon intensity fuel for industry in North Dakota and surrounding regions. Funding through NDIC will help offset initial development costs of RNG projects in the North Dakota dairy sector and help develop a potential roadmap for successful project execution of RNG projects at scale.

Ultimate Technological and Economic Impacts: The team believes that as more RNG projects are developed, the costs of the technologies employed will continue to fall and projects such as this will become more economically, socially and environmentally beneficial. The project represents a novel integration of dairy manure handling, anaerobic digestion, biogas upgrading and gas delivery which can be replicated at other North Dakota agricultural feedstock and dairy operations. The Project will create an estimated 40-65 temporary (12-18 months) construction, engineering, and fabrication jobs and 3-5 new permanent facility/operations jobs in North Dakota. The use of manure for RNG production can

provide a valuable contribution for increasing the prosperity of dairy farmers and their communities in the North Dakota agricultural landscape.

Why the Project is Needed: This Project will be key to increasing momentum for RNG deployment in the North Dakota agricultural sector. Agriculture is one of North Dakota's leading industries, with its dairies producing milk for 593 million 8-ounce servings United States (ND Department of Agriculture). The proposed Project is a critical enabler to growing the low carbon dairy industry and creating energy transition jobs in North Dakota. The design, development and implementation of an anaerobic digestion facility adjacent to VanBedaf Dairy using its manure as a feedstock will capture and beneficially reuse biogenic methane for use in the region. Small and medium sized dairies lack the financial resources to invest in sophisticated manure management systems like anaerobic digestion and biogas upgrading, but the growing demand and value of negative carbon intensity RNG can financially underpin a project with proper engineering and design factoring in best practices for operations. The feasibility study will support the innovation and implementation of biogas production at small to medium sized CAFOs, explore ways to reduce waste, improve sustainable practices in livestock operations in North Dakota, and provide an additional revenue stream for dairy farm operations.

STANDARDS OF SUCCESS

Upon completion of the 12-month project duration, NewCarbon will decide whether to progress to a FEED study and subsequent development activities based upon meeting the following measurable criteria: (1) Signed non-binding customer term sheets, (2) budgetary estimate from an EPC contractor based on the pre-FEED, (3) development of a benefits plan, and (4) feasibility assessment of the technology achieving a TRL 9. Successful execution of this Project will support the Renewable Energy Program's (REP's) mission to promote the growth of North Dakota's renewable energy industries through research, development, marketing, and education. The proposed Project will add wealth for landowners and agriculture producers to build and maintain a robust rural economy in North Dakota.

The proposed Project will also decrease the carbon intensity of a family-owned dairy farm in North Dakota which will generate information and knowledge on innovative ways to handle manure management that will increase the probability of bringing new renewable energy companies and industry investment to North Dakota's dairy industry and other livestock operations.

BACKGROUND/QUALIFICIATIONS

NewCarbon will lead and oversee all proposed project activities. The Principal Investigator (PI) is Matt Moshier (NewCarbon Head of Engineering) who has more than ten years of energy project execution and development experience across the conventional and clean energy sectors, and has completed over $3 billion in capital development, execution, and maintenance work at BP, Williams and TC Energy. The Business Point of Contact (POC) is Omar Khayum (NewCarbon Founder and CEO) who has over 15 years of experience in the energy domain. Prior to founding NewCarbon, Omar served as the CEO of Annova LNG and held executive and leadership roles at TC Energy, Constellation Energy and Exelon Corporation. NewCarbon develops, owns and operates infrastructure that delivers lifecycle carbon intensity reduction. We do this through fit-for-purpose solutions that integrate seamlessly across our customers' value chains. NewCarbon's turnkey infrastructure process makes it easier for customers to reduce lifecycle carbon intensity so they can remain focused on their core businesses. VanBedaf Dairy is a family-owned farm established in Carrington, North Dakota in 2008.

MANAGEMENT

NewCarbon will oversee all tasks, schedule regular internal and external meetings with project participants and contractors and ensure that the project is conducted using industry best practices in accordance with the project plan (budget, schedule, deliverables, and milestones) and is meeting quality objectives. NewCarbon will keep all partners informed of project progress, coordinate activities as necessary for the execution of a successful project and will be responsible for timely submission of all project deliverables and transfer of data and products to the project team.

Key Roles: NewCarbon Feedstocks, LLC: Provides project director resources, manages the overall project execution and oversees the contractors and will lead origination effort to sign non-binding term sheet(s) with customers for long-term sale of the RNG. VanBedaf Dairy LLP: Provides site specific data and volume and composition of dairy manure that will feed the anaerobic digestion process.

Contractors: Community Benefits Consultant, Land Control, Environmental/Permitting Consultant, Life Cycle Assessment, Engineering/EPC, Electrical/Water/Pipeline Interconnect Consultant, Financial Modeling Consultant, and OEMs.

Project Duration (12-Month) Go/No-Go Evaluation Point: NewCarbon will decide whether to progress to FEED/Mid-Stage development phase based on the End of Project Goal (SMART).

End of Project Goal: Upon completion of the 12-month Project duration, NewCarbon will decide whether to progress to a FEED study and subsequent development activities based upon meeting the following measurable criteria: (1) Signed non-binding customer term sheets, (2) budgetary estimate from an EPC contractor based on the pre-FEED, (3) development of a benefits plan, and (4) feasibility assessment of the technology achieving a TRL 9.

TIMETABLE

This Project is proposed to be performed over a 12-month period, with an anticipated start date of November 1, 2024. Quarterly progress reports will be submitted within 30 days after the end of each calendar quarter. **Error! Reference source not found.** depicts the proposed schedule.

Figure 2: VBD NewCarbon RNG Project Schedule

NewCarbon Feedstocks	Year	2024		2025										
ASC RNG Project	Quarters	Q4		Q1			Q2			Q3			Q4	
	# of Months	11	12	1	2	3	4	5	6	7	8	9	10	11
Mid- Stage Development		November	December	January	February	March	April	May	June	July	August	September	October	November
NDIC Grant Award		✓												
Sales Qualification														✓
Engage Fiancing Counterparty and preliminary screen														✓
Site Option														✓
Community Benefits Plan														✓
Pre-FEED Engineering													✓	
Life Cycle Analysis													✓	
Biogas Quality Study			✓											
Permit Matrix													✓	
Electricol Interconnection													✓	
Natural Gas Pipeline Interconnection													✓	
Water/Waste Water Interconnection													✓	
Proforma/ Budget														✓
Pipeline Routing Due Diligence													✓	

BUDGET

The total estimated cost for the proposed work is $930,000, as presented in Table 1. NewCarbon requests $455,000 from the North Dakota Industrial Commission Renewable Energy Program to be matched with $475,000 from NewCarbon Feedstocks, LLC. Budget notes can be found in Appendix D.

Table 1: VBD NewCarbon RNG Project Budget

Project Associated Expense	NDIC's Share	Applicant's Share (In-Kind)	Total Project
Labor (Salaries + Fringe Benefits)		$475,000	$475,000
Travel	$22,000		$22,000
Supplies	$5,000		$5,000
Task 1.0: Market Analysis	$25,000		$25,000
Task 2.0: Property Due Diligence	$5,000		$5,000
Task 3.0: Community Outreach and Engagement	$40,000		$40,000
Task 4.0: Engineering Services	$265,000		$265,000
Task 5.0: Developer Services	$33,000		$33,000
Task 6.0: Project Pro-Forma/Budget	$15,000		$15,000
Task 7.0: Site Acquisition Planning	$40,000		$40,000
Task 8.0: Sourcing Project Funding	$5,000		$5,000
Total	**$455,000**	**$475,000**	**$930,000**

CONFIDENTIAL INFORMATION

No confidential information is included in this proposal.

PATENTS/RIGHTS TO TECHNICAL DATA

It is not anticipated that any patents will be generated during this Project. The rights to data generated will be held NewCarbon Feedstocks, LLC and its affiliates.

STATE PROGRAMS AND INCENTIVES

NewCarbon Feedstocks, LLC has not participated in any programs or incentives from the State in the last 5 years.

APPENDIX A

LETTERS OF SUPPORT

VanBedaf Dairy

6959 2nd Street NE
Carrington, ND 58421

[DATE] 7/25/24

To Whom It May Concern,

I am writing this letter to express VanBedaf Dairy's support of NewCarbon's proposed renewable natural gas (RNG) project at our dairy and the corresponding issues it will address.

VanBedaf Dairy produces approximately 26 million gallons of animal waste per year. NewCarbon proposes a manure management project with anaerobic digestion on site. This manure management project will collect and treat the manure producing approximately 56,000 MMBtu per annum of pipeline quality renewable natural gas. We support NewCarbon's application to secure grant funding from the North Dakota Industrial Commission Renewable Energy Development Program and other funding sources which will enable them to advance through Phase 1 planning and feasibility tasks of this clean energy project.

NewCarbon's proposed project would serve the State of North Dakota and its residents by promoting environmental sustainability. By capturing and upgrading biogas, the project reduces greenhouse gas emissions, avoids watershed contamination, and reliance on fossil fuels, aligning with environmental regulations and improving air quality. This holistic approach reflects a commitment to sustainable development and responsible resource utilization.

NewCarbon is a clean energy infrastructure company who develops, owns and operates infrastructure that delivers lifecycle carbon intensity reduction for North America's top industrial, agricultural and energy companies. Their turnkey infrastructure process makes it easier for partners like VanBedaf Dairy to reduce lifecycle carbon intensity so we can remain focused on what we do best. While delivering on a lower-carbon future, we can attest that NewCarbon takes a collaborative approach to maximizing economic benefits to the local communities in which they operate.

Please do not hesitate to reach out to me if you require any further information. I look forward to witnessing the progress and positive economic impact that NewCarbon will deliver.

Thank you for considering my support.

Sincerely,

Piet van Bedaf
Owner

APPENDIX B

RESUMES OF KEY PERSONNEL

OMAR KHALID KHAYUM
1057 Chadwick Ct., Aurora, IL 60502 | (312) 718-9519 | omar.khayum@gmail.com | linkedin.com/in/omarkhayum

EDUCATION

The University of Chicago Booth School of Business — **Chicago, IL**
MBA (Honors); Concentrations in Economics, Finance & Entrepreneurship — *September 2007 – June 2009*
- Beta Gamma Sigma

Purdue University — **West Lafayette, IN**
Bachelor of Science, Computer Science (Honors); Minors in Mathematics & Management — *August 2000 – May 2004*
- Phi Beta Kappa, Kappa Sigma, Alpha Kappa Psi

EXPERIENCE

NewCarbon, LLC — **Chicago, IL**
Founder and Chief Executive Officer — *November 2023 – Present*
- Founded a clean energy infrastructure company that delivers lifecycle carbon intensity reduction through fit-for-purpose infrastructure solutions that integrate seamlessly across customers' value chains

Cognitive Concierge, LLC — **Chicago, IL**
Founder and Board Member — *September 2019 – Present*
- Founded a health and wellness company that provides virtual services to families navigating cognitive conditions

MemoryCare Corporation — **Chicago, IL**
Founder and Board Member — *March 2010 – Present*
- Founded a healthcare company that provides Speech, Occupational and Physical Therapy to individuals with cognitive conditions

TC Energy — **Houston, TX**
Vice President – North American Low Carbon Origination and Development — *March 2021 – October 2023*
- Led customer origination for North American power, environmental, natural gas and hydrogen development and trading platform
- Led asset development for North American low carbon platform, including wind, solar, pumped hydro, renewable natural gas, green hydrogen production, blue hydrogen production and carbon capture
- Led asset financing for North American low carbon platform, including strategic equity, project debt and tax equity

Annova LNG — **Houston, TX**
Chief Executive Officer, Annova LNG — *October 2018 – March 2021*
- Led a 6.5 MTPA greenfield liquefied natural gas (LNG) export startup company in Texas
- Led development capital fundraising, project finance debt and equity fundraising and origination of long-term offtake contracts
- Led development activities resulting in FERC and DOE approvals to construct and operate the LNG export facility

Chief Operating Officer, Annova LNG — *September 2017 – September 2018*

Constellation Energy — **Baltimore, MD**
Managing Director – Origination, Constellation Energy — *September 2017 – March 2019*
- Led origination for Constellation's natural gas and LNG trading business

Managing Director – Strategic Projects, Constellation Energy — *January 2017 – August 2017*
- Led establishment of joint venture providing development services to new nuclear power stations in the UK and Japan

Exelon Corporation — **Chicago, IL**
Managing Director – Generation Development, Exelon Generation — *June 2015 – December 2016*
- Led greenfield development for utility scale power generation projects, resulting in financing and construction of over $3 billion of new assets, including over 2.5 GW of natural gas, wind, solar and battery storage capacity across the continental United States

Manager – Generation Development, Exelon Generation — *August 2014 – May 2015*
Manager – Wind Business Development, Exelon Generation — *June 2013 – July 2014*
Manager – Corporate Strategy, Exelon Business Services Company — *November 2012 – May 2013*
Principal Analyst – Corporate Strategy, Exelon Business Services Company — *February 2011 – October 2012*
Senior Analyst – Corporate Financial Planning & Analysis, Exelon Business Services Company — *August 2009 – January 2011*

Diamond Management & Technology Consultants — **Chicago, IL**
Associate and Analyst – Strategy & Marketing Competency — *June 2004 – June 2007*

Matthew William Moshier, MBA, P.E., P.M.P.

Email: mwm5221@gmail.com Phone: 724-825-8406

WORK EXPERIENCE

New Carbon **Chicago, IL**

Head of Engineering March 2024- Present

- Accountable for financial analysis, project management, and engineering for a variety of low carbon products to lower customers carbon intensity in the Midwest
- Submitted five DOE concept papers with customer engagement to EERE to obtain development funding for hard to abate emitters
- Developed financial models to support financing of RNG portfolio on a project and portfolio basis
- Engagement with customers across the carbon lifecycle- from feedstock development to product sale and financing
- Development of term sheets for potential offtake, feedstock supply, and investment

Strata Clean Energy **Chicago, IL**

Senior Director of Engineering October 2023- March 2024

- Led execution of pre-FEED study to determine viability of ammonia production with solid oxide electrolysis
- Served as the technical advisor for stage gated process to drive efficient capital deployment and accountability
- Conducted due diligence across portfolio of electrolysis and ammonia production vendors to determine vendor selection
- Developed siting and deployment strategy to identify potential deep-water ammonia shipping and staged capital deployment
- Led customer engagement in order to commercialize a portfolio of ammonia production facilities
- Created a technoeconomic analysis tool for the leadership team to determine the potential customer cost impact for variety of transportation methods

TCEnergy **Chicago, IL**

Senior Project Manager-Project Development April 2022- October 2023

- Directly managed three employees to meet overall corporate net zero ambitions and drive project development and execution
- Recruited, interviewed, onboarded, and managed multiple employees into the engineering and development group
- Project director for a confidential fully integrated, large scale biofuels facility, with full feedstock supply and offtake
- Managed over 1000 tonne per day (tpd) across 15 FEL studies in various levels of development to develop scope, schedule, and cost to meet customer needs for hydrogen and Carbon Capture Utilization and Storage (CCUS) projects
- Created hydrogen sales and purchase agreement (HSPA) and associated financial and pricing model
- Developed TCEnergy Chemours Joint venture to develop 20 tpd of electrolysis and DOE cost share agreement (Press Release)
- Managed development team to submit four DOE hub applications to receive over $2 Bn in DOE funding
- Executed option to purchase two, 30 tpd liquefaction trains from Plug to support safe harbor investment strategy (Press Release)
- Developed financial and pricing model for green and blue hydrogen as well as capital and operational costs to support
- Executed Life Cycle Analysis across the hubs in order to quantify Carbon Intensity and environmental impact
- Recipient of a DOE loan for $1.3 Bn from the Loans Program Office for Phoenix Hydrogen Hub (Press Release)
- Lead developer for Phoenix Hydrogen Hub (Nikola JV) and key member of due diligence and execution
- Managed multiple Joint Venture (JV) partners and customer engagement with varying levels of ownership
- Developed multiple hydrogen and CO2 pipeline routings and strategies to support hub development and potential offtake
- Negotiated CO2 CCUS sequestration agreement with third party to ensure project bankability
- Lead developer for offtake negotiations for potential biofuels, logistics, and other potential off takers
- Developed hydrogen offtake agreement and pricing structure for customer negotiations in conjunction with JV partners
- Directly involved with the commercial negotiations and financial model development for all projects to ensure engineering perspective is incorporated with main accountabilities for capital and operational expenditures
- Created updated governance structure to ensure viability of project financing and execution for hydrogen and CCUS projects
- Completed due diligence across the hydrogen technology portfolio, including operating and manufacturing site visits
- Developed scope, schedule, and cost for ammonia export terminals to advance hydrogen producing opportunities
- Designed of the metrics spreadsheet to more effectively allow engineering team to provide high level development design criteria to understand feasibility of potential projects for rapid RFP response
- Utilized existing and new data sources to provide recommendations for potential Long Term Supply Agreements for SMR, ATR, Electrolysis, Liquefaction, and biofuels production vendors
- Developed templates to help expedite EPC inputs into financial model, reducing time to pricing for market
- Interviewed and developed recommendation for potential Owners Engineer vendors

BP **Chicago, IL**

Project Manager December 2019 – April 2022

- Directly managed 40+ resources and $11 MM in contractor spend to conduct a 446-mile pipeline inspection- longest in BP history
- Managed a portfolio of $13MM and 60+ resources across the U.S. to complete a high-profile HDD, 65 ILI repairs, reactivation of an idled asset, three active line valve replacements, and multiple ILI inspections
- Conducted multiple FEL studies to shape BPs Net Zero initiative which included multiple confidential Carbon Capture, Utilization, and Storage (CCUS) projects as well as a nationwide DOE funded hydrogen transportation system; presented to senior leadership for investment level decision leading to additional due diligence to align with BP net zero ambitions
- Created financial model to analyze carbon capture projects within the business unit to determine carbon break even pricing
- Optimized in line inspection run to reduce the volume of nitrogen emitted and reduced project spend by $2 MM

- Collaborated with global procurement and leadership teams to develop and implement a change order tracking and feedback system to aggregate contractor non-conformance data for current and future negotiations, ~$1 MM/ year in refunds
- Achieved highest level of internal conformance by implementing a self-verification process to audit project execution and ensure alignment with BP's Stage Gate process and identified future opportunities for KPI development and process improvements
- Established a standardized process for managing projects for pipeline repairs key stakeholder communications
- Utilized Power BI to develop a tool which tracked third party encroachments into pipeline ROW to inform front line operations

Williams Companies Inc. **Pittsburgh, PA**

Project Developer Sr. April 2017 – December 2019

- Lead developer selected to analyze and execute over $2 B of capital projects: gas and condensate gathering, compression, FERC regulated pipelines, gas processing, and fractionation facilities in Ohio River Supply Hub (ORSH)
- Completed commercial deals across gathering and processing business resulting in over $2 B in incremental EBITDA
- Subject matter expert on Processing and Fractionation and expansion capital requirements for multiple M&A deals
- Managed FERC open season process, rate case development, and corporate structure for NGL pipelines
- Presented over $500 MM in proposed capital projects for FY 2017-2019 within capital funding (CAPEX) gated process to senior leadership, board members, and commercial teams to ensure projects meet long term growth strategy
- Developed discounted cash flow models for rate setting purposes for projects with CAPEX less than $150 MM
- Automated and streamlined forecasting model to include commercial scenarios, mitigating contractual risk, and reducing product over/undersell by 15%

Project Engineer III December 2013 – April 2017

- Completed over $650 MM in large capital projects from front end engineering and design (FEED), detailed design, construction support, operations turnover, and post project support
- Managed over $5 MM in engineering contactors, resulting in engineering costs 10% below budget on average
- Provided engineering assistance for construction, including requests for information, commissioning and start-up support, and project deliverable turnover
- Designed, constructed, and commissioned the startup of multiple facilities, including compression, interconnects, pipelines, turbo expander, de-ethanizers, slug catcher, flare, stabilization, frac train, rail bays, and storage tanks
- Developed and ensured efficient execution of multiple company standards for engineering design reviews, Process Hazard Analysis, Layers of Protection Analysis, Management of Changes, Process Safety Startup Review, Alarm Rationalization, Factory Acceptance Tests, and Process Safety Management
- Member of steering committee that developed and implemented companywide standard for API 12F tanks

Pinnacle Asset Integrity Services (PinnacleAIS) **Pasadena, TX**

Project Lead May 2012 – November 2013

- Directly supervised and trained a team of seven consultants on NCRA site-specific procedures in multiple locations
- Oversaw the completion and project reporting of a Mechanical Integrity and Risk Based Inspection program at the National Cooperative Refinery Association (NCRA) Refinery in McPherson, KS
- Managed a total of four project budgets with a gross revenue of $2 MM and gathered data for future proposal bids
- Implemented a companywide best practice for integration of PinnacleAIS Inspection Services with PinnacleAIS Services department for turnaround planning purposes

EDUCATION

Indiana University Bloomington, IN
The Kelley School of Business, MBA, Finance Major August 2023

The Pennsylvania State University University Park, PA
The College of Engineering, Bachelor of Science in Chemical Engineering May 2012

JUSTIN GUTKNECHT
Head of Solutions
NewCarbon LLC
1648 W Division Street, Unit 709, Chicago, IL 60622
312.576.8004 (phone), Justin.Gutknecht@newcarbon.energy

Education and Training

M.B.A., Accounting, Finance, and Strategy, Booth School of Business University of Chicago, 2017.
B.S. Finance, University of Illinois at Urbana-Champaign, 2004.
Chartered Financial Analyst (CFA), 2013–present.

Research and Professional Experience

- Lead structuring of clean energy infrastructure utilizing low carbon feedstocks, fuels and carbon capture technologies by providing commercial guidance to the project development, origination, engineering, and capital markets teams.
- Develop a near and long-term customer-focused decarbonization strategy by deploying energy infrastructure and technologies to achieve lifecycle carbon intensity reduction in manufacturing and production processes.
- Oversee a strategic execution plan incorporating an entire project lifecycle, from conception to commissioning. Include risk mitigation, managing commercial relationships, safety, scheduling, budgeting, and project finance transactional activities.
- Coordinate financing activities, including tax equity and debt financing, provide guidance on financial models, identify risks within contracts, and manage relationships with third-party financiers.

2021–2023: Director, Energy Origination and Development, TC Energy.

- Managed TCE Energy's origination and development of utility-scale renewable power projects and low-carbon infrastructure projects in the United States.
- Supervised a U.S. Origination and Development team covering structured origination, mid-marketing, development, interconnection, permitting and land management functions.
- Led commercial negotiations, development, and execution efforts to establish a U.S. portfolio of wind, solar, hydrogen, clean fuels and carbon capture, transportation and sequestration projects.
- Led Federal and State Hydrogen and Carbon Capture funding opportunities totaling $1 billion, receiving DOE grant awards for projects within the Heartland and ARCH2 Regional Hydrogen Hubs.

2017–2021: Senior Vice President, Finance and Development, Annova LNG.

- Led due diligence, development and execution efforts in multi-phase equity financings with joint venture partners and construction capital fundraising.
- Managed financial advisor, insurance advisor, and outside counsel engagements to support the bankability of terms and conditions of various project contracts and provided structuring advice.
- Led project development activities, including electrical interconnection, wholesale power procurement, dredging, local and state tax incentive negotiations, accounting and tax matters.

2015–2017: Principal, Generation Development Analytics, Exelon Corporation.

- Led financial evaluation and transaction execution support for acquisition and greenfield development of utility scale wind, solar and battery storage generation projects.
- Led development activities for battery storage, including site control, permitting, interconnection, engineering, technology evaluation, and offtake.

2011–2015: Manager, Financial Planning and Analysis, Evraz North America.

- Supervised on-site mill financial managers in monthly forecasting and annual budget processes and consolidated the financial results of the Tubular Product Division.
- Obtained approvals for capital investment projects and provided technical financial support and recommendations on the evaluation of potential alliances, acquisitions, capital investments, and other issues affecting operations.

2004–2011: Senior Financial Analyst, Corporate Development, Telephone and Data Systems Inc.

- Performed valuations for the acquisitions of wireless spectrum and acquisitions.
- Prepared presentations to bond-rating agencies, reviewed credit metric ratios based on rating agency methodologies, and analyzed strategic and financial initiatives to improve capital structure.

Professional Activities

Member, CFA Society of Chicago, 2013–present.

PHILLIP FRANSHAW

4205 Dickson Street, Houston, TX 77007 | (713)253-0690 | phillip.franshaw@newcarbon.energy

EXPERIENCE

NewCarbon—Houston, TX
Co-Founder & Head of Customer Engagement *November 2023—Present*

- Co-founded a clean energy infrastructure company that delivers lifecycle carbon intensity reduction through fit-for-purpose solutions that integrate across customers' value chains
- Lead deal structuring and contract negotiations while working collaboratively with legal, finance, engineering, and construction leads to optimize project economics and mitigate risk

TC Energy Corporation—Houston, TX
Origination Specialist, Power & Energy Solutions *April 2021—November 2023*

- Led customer origination for United States low carbon platform including wind, solar, renewable natural gas, green hydrogen, and sustainable aviation fuel production
- Led deal structuring, negotiations, and execution of contracts to secure mutually beneficial agreements with equity partners, customers, and other project stakeholders

Exelon Corporation—Houston, TX
Senior Vice President & Co-Founder, Annova LNG, LLC *October 2012—March 2021*

- Co-founded a 6.5 MTPA greenfield liquefied natural gas (LNG) export company
- Led origination, structuring, and negotiation of long-term offtake contracts

713 Capital Partners—Houston, TX
Co-Founder & Principal *September 2007—March 2014*

- Co-founded municipal real estate consulting practice providing advisory and development management services

Cockrell Interests Inc.—Houston, TX
Managing Director *September 2003—September 2007*

- Managed a diversified real estate portfolio for a family office
- Led structuring, negotiation, and execution in a portfolio of direct and indirect investments including wholly owned properties, joint ventures, and commingled funds

Hines Interest Limited Partnership—Houston, TX
Project Manager *June 2000—September 2001*

- Managed a global diversified real estate portfolio totaling $2.1billion

The Coca-Cola Company—Atlanta, GA
Business Development Consultant—Houston, TX *September 2001—September 2003*

- Led acquisition structuring, negotiation, and execution of premium juice drink company

Business Development Manager—Atlanta, GA *August 1995—February 1998*

- Led acquisition structuring, negotiation, and execution of bottling assets totaling $2.4 billion

Principal Financial Analyst—Houston, TX *August 1992-August 1995*

- Led restructuring of $2.0 billion operating division

Merrill Lynch Capital Markets—New York City, NY
Equity Trader *August 1986—August 1988*

EDUCATION

The University of Texas at Austin
Master of Business Administration, Finance & International Business *August 1992*

Georgetown University
Bachelor of Arts, English *May 1986*

Brian Lammers
2437 Girard Avenue South
Minneapolis, MN 55405
(612) 518-3798
brian.lammers@newcarbon.energy

Experience

Brian has more than 20 years of experience developing utility-scale renewable power, energy storage and HVDC transmission infrastructure in the United States and Canada. Brian held leadership positions at Exelon, EDP North America and RES Americas. During his career Brian has led origination, development and financing initiatives resulting in investment of more than $6 Billion in low carbon power and energy solutions.

NewCarbon, Chicago, IL
Head of Feedstocks
January 2024 - Present
Founding partner of NewCarbon, a developer, owner and operator of fit-for-purpose solutions for agricultural and industrial customers to lower the lifecycle carbon intensity of their operations.

Advanced Generation Development, Minneapolis, MN
President and Founder
March 2017 – Present

- Originated, developed, and sold a 700 MW wind generation development portfolio to a leading US independent power producer
- Closed 850 MW of wind and solar power purchase agreements for midstream energy client, organized buy-side solicitation, evaluated proposals, led contract negotiations
- Led integration and development of 400 MW solar generation portfolio for power client
- Advisor for site identification and early-stage development of hydrogen production projects, two of which received $1.85 billion in DOE Grant awards
- Led commercial offtake and development efforts for a private equity-backed 2100 MW merchant HVDC transmission project

Renewable Energy Systems, Minneapolis, MN
Vice President, Development
October 2017 – December 2018

- Closed power purchase agreements for 400 MW of wind and solar generation
- Held P&L responsibility for regional origination and development office
- Managed joint venture with leading US IPP resulting in construction of 1 GW of new wind and solar generation

Exelon Generation, Chicago, IL
Managing Director, Renewables and Technology Development
November 2011 - March 2017

- Led development and acquisition of 2 GW of wind and solar generation and battery storage, deploying ~$3 billion in CapEx, and doubling the size of Exelon's renewable generation fleet

EDP Renewables N.A., Minneapolis, MN
Director of Development, Upper Midwest and Northeast U.S.
March 2008 – November 2011

- Completed development of more than 750 MW (~ $1.5 billion) of wind generation
- Responsible for two regional development teams, fifteen staff, a 3 GW project pipeline and $10 million annual budget in the Midwest and Northeastern U.S.

John Deere Finance, Johnston, IA
October 2006 – March 2008

- Led development of 500 MW (~ $1 billion) of U.S. wind power generation projects
- Spearheaded transition from distributed-scale to utility-scale wind generation
- Developed and closed financing for the first multi-megawatt wind farm in Michigan

Gamesa Energy, Philadelphia, PA
September 2004 – October 2006

- Led development of more than 500 MW (~ $1 billion) of US wind generation projects including the largest wind generation project constructed in Pennsylvania
- Opened and managed regional development office

Navitas Energy, Minneapolis, MN
November 1998 – September 2004

- Led origination, development, and completion of 250 MW (~ $500 million) of wind generation
- Supported successful M&A efforts with U.S. and European IPPs

Education

University of Minnesota - Minneapolis, MN
MBA

University of Wisconsin – Madison, WI
Bachelor of Science

Community Involvement

American Red Cross, Twin Cities Chapter – Minneapolis, MN
Board of Directors
June 2023 - Present

City of Lakes Waldorf School, Minneapolis, MN
Secretary, Board of Trustees
Chair, Development Committee
2019 – Present

Clean Grid Alliance (fka Wind on the Wires), Saint Paul, MN
Treasurer and Board Member
2010 – 2021

APPENDIX C

TAX LIABILITY STATEMENT

Industrial Commission

Tax Liability Statement

Applicant:

NewCarbon Feedstocks, LLC

Application Title:

ACS NewCarbon RNG Project

Program:

- ☐ Lignite Research, Development and Marketing Program
- ☑ Renewable Energy Program
- ☐ Oil & Gas Research Program
- ☐ Clean Sustainable Energy Authority

Certification:

I hereby certify that the applicant listed above does not have any outstanding tax liability owed to the State of North Dakota or any of its political subdivisions.

_____

Signature

President

_____

Title

July 31, 2024

_____

Date

APPENDIX D

CITATIONS AND BUDGET NOTES

CITATIONS

Francisco López, A., Lago Rodríguez, T., Faraji Abdolmaleki, S., Galera Martínez, M., & Bello Bugallo, P. (2024). *From Biogas to Biomethane: An In-Depth Review of Upgrading Technologies That Enhance Sustainability and Reduce Greenhouse Gas Emissions*. Retrieved from https://www.mdpi.com/2076-3417/14/6/2342.

ND Department of Agriculture, D. G. (n.d.). Retrieved from https://www.ndda.nd.gov/sites/www/files/documents/files/2023%20ND%20Ag%20brochure.pdf

Diane Mayerfeld, W. F. (n.d.). *Methane emissions from livestock and climate change*. Retrieved from University of Wisconsin- Madison: https://cropsandsoils.extension.wisc.edu/articles/methane-emissions-from-livestock-and-climate-change/

USDA. (2023). *2023 STATE AGRICULTURE OVERVIEW*. Retrieved from https://www.nass.usda.gov/Quick_Stats/Ag_Overview/stateOverview.php?state=north%20dakota

BUDGET NOTES

Salaries: Salary estimates are based on the scope of work and prior experience on projects of similar scope. The labor rate used for specifically identified personnel is the current hourly rate for that individual.

Fringe Benefits: Fringe benefits is calculated as 11.6% of gross salary which is calculated as the total of: 6.2% for Employer Social Security Withholding, 1.45% for Employer Medicare Withholding, 0.6% for Employer Federal Unemployment Tax Withholding (FUTA), 0.85% for Employer State Unemployment Tax Withholding (SUI), 2.5% for Paid Leave for All Workers.

Travel: Travel may include site visits, fieldwork, meetings, and conferences. Travel costs are estimated

and paid in accordance with OMB Uniform Guidance 2 CFR 200, Section 474. Daily meal rates are based on U.S. General Services Administration (GSA) rates. Other estimates such as airfare, lodging, ground transportation, and miscellaneous costs are based on a combination of historical costs and current market prices. Miscellaneous travel costs may include parking fees, Internet charges, long-distance phone, copies, faxes, shipping, and postage.

Supplies: Supplies include items and materials that are necessary for the research project and can be directly identified to the project. Supply and material estimates are based on prior experience with similar projects. Examples of supply items are chemicals, gases, glassware, nuts, bolts, piping, data storage, paper, memory, software, toner cartridges, maps, sample containers, minor equipment (value less than $5000), signage, safety items, subscriptions, books, reference materials. General purpose office supplies (pencils, pens, paper clips, staples, Post-it notes, etc.) are included in the Supplies cost.

Communications: Telephone, cell phone, and fax line charges are included in the Supplies cost; however, direct project costs may include line charges at remote locations, long-distance telephone charges, postage, and other data or document transportation costs that can be directly identified to a project. Estimated costs are based on prior experience with similar projects.

INDUSTRIAL COMMISSION OF NORTH DAKOTA
RENEWABLE ENERGY PROGRAM

TECHNICAL REVIEWERS' RATING SUMMARY

R-054-D
ACCELERATING THE WASTE-TO-FUELS COMMERCIALIZATION FOR THE SANDWICH GASIFIER

Principal Investigator: Dr. Nikhi Patel

Request for $486,950; Total Project Costs $978,950

TECHNICAL REVIEWERS' RATING SUMMARY
R-054-D
ACCELERATING THE WASTE-TO-FUELS COMMERCIALIZATION FOR THE SANDWICH GASIFIER
Principal Investigator: Dr. Nikhi Patel
Request for $486,950 Total Project Costs $978,950

		Technical Reviewer				
		1D	2D	3D	4D	
Rating Category	Weighting Factor	Rating				Average Weighted Score
1. Objectives	9	4	4	4	5	38.25
2. Achievability	9	4	4	4	5	38.25
3. Methodology	7	4	4	4	5	29.75
4. Contribution	7	3	4	5	4	28.00
5. Awareness	5	4	4	5	5	22.50
6. Background	5	5	5	4	5	23.75
7. Project Management	2	4	4	4	5	8.50
8. Equipment Purchase	2	4	4	3	5	8.00
9. Facilities	2	4	4	4	5	8.50
10. Budget	2	3	4	4	5	8.00
Average Weighted Score		196	205	210	243	**213.50**
Maximum Weighted Score						250.00

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 1D (Rating 4)

Intention to make clean syngas for subsequent synthetic fuels and/or hydrogen from ND biomasses or wastes, commercialization of the technology, and job creation.

Note that a primary challenge may be economic viability at a relatively small scale that could be limited by feedstock availability at a given location. Voting members of the council may ask for a response to this concern as part of the proposal presentation.

Reviewer 2D (Rating 4)
The proposed project will confirm the performance of the Sandwich Gasifier and integrated systems with multiple waste feedstocks to produce to produce clean and composition-balanced syngas under self-sustained steady-state operation. They will validate the integrated technology and improvement in techno-economics of producing low-cost syngas suitable for direct conversion into sustainable liquid fuels, renewable natural gas, and/or green hydrogen. This is consistent with the goals of the ND Industrial Commission/Renewable Energy Councils goals.

Reviewer 3D (Rating 4)
This proposal outlined quite well how this project would closely follow the NDIC's stated goals.

Reviewer 4D (Rating 5)
The project proposal is exceptionally well written and the objective is stated clearly, precisely, and concisely in the very first sentence. The objective of this proposal is in accordance with the goals and purposes of the NDIC Renewable Energy Council.

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 1D (Rating 4)
Most of the equipment is available and proven, so two years and a budget of $978,950 should be adequate to make the project achievable as planned.

Reviewer 2D (Rating 4)
The proposal has justified the time and budget requested. I believe the approach noted is most likely appropriate to expect the objectives to be achieved.

Reviewer 3D (Rating 4)
The timeline appears to be realistic and achievable. The budget appears to be reasonable.

Reviewer 4D (Rating 5)
Two years to relocate and demonstrate the capabilities of the Sandwich Gasifier is certainly achievable with the suggested approach, schedule, and budget.

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 1D (Rating 4)
The concept and methodology are very sound. Achieving economic viability is the question.

Reviewer 2D (Rating 4)
The methodology noted is well thought out and leads this reviewer to anticipate a positive outcome.

Reviewer 3D (Rating 4)
The methodology certainly appears to be a logical way to accomplish the final objective.

Reviewer 4D (Rating 5)
As stated previously, this proposal is well written and the methodology is clear and concise.

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 1D (Rating 3)

Significant, but the proposal states the system has been proven on many of the target feedstocks in previous tests. Some of the unique targets of this effort include longer duration runs, tailoring the syngas to enable subsequent synthetic fuels production, system integration to improve the process and economics …

Reviewer 2D (Rating 4)

The proposer notes several waste streams that they have identified that could be used as feedstocks for the Sandwich Gasifier. These materials represent a significant environmental challenge and the ability to convert these materials to useful products in an environmentally acceptable manor would be a significant contribution to achieving the goals of the NDIC/Renewable Energy Council.

Reviewer 3D (Rating 5)

This proposal is to take waste products and convert it to energy products in an economical manner.

Reviewer 4D (Rating 4)

Distance (shipping costs) is the single most significant factor to utilizing biomass. If the Sandwich gasifier could be modular, trailer mounted, or truck mounted as the existing prototype – the reactor could be moved to the biomass instead of moving biomass to the reactor. Additionally, small co-ops could be created to pool financial resources and share the CAPEX and operating costs of a centralized processing site.

This proposal ticks nearly all of the check boxes for the NDIC Renewable Energy Council's goal, purposes, and objectives.

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 1D (Rating 4)

Over two decades at the EERC with a focus on biomass conversion systems. Additional awareness shown by paper and references in Appendix E.

Reviewer 2D (Rating 4)

The team assembled is aware of current research activities and the published literature as demonstrated by the information cited in the proposal.

Reviewer 3D (Rating 5)

Dr. Patel (PI) holds the patent on the sandwich gasifier and has authored several papers on as such.

Reviewer 4D (Rating 5)

The principal investigator invented the technology and has patents and IP rights. Working with the EERC, the investigator has considerable knowledge of current research.

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 1D (Rating 5)

The Principal Investigator is the patent holder for the technology with over 18 years of experience with this technology and over two decades of related experience at the EERC. Also supported by a strong team including members that have been involved in significant past R&D projects for North Dakota.

Reviewer 2D (Rating 5)

The assembled team is very well qualified to complete the proposed research.

Reviewer 3D (Rating 4)

I am aware of the gasification process and have provided and reviewed proposed industrial projects for over 40 years.

Reviewer 4D (Rating 5)

The investigator background related to the proposed work is exceptional as they developed the technology. It is this reviewer's opinion that the project participants are well suited to completed the proposed objective.

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 1D (Rating 4)

Good timeline with milestones and Mike Mann is supporting the project management and communication efforts.

Reviewer 2D (Rating 4)

The proposal lays out a set of milestones that should allow the sponsors to follow the progress of the proposed work. I would suggest a change to include a meeting with the sponsors to review and approve the selected equipment prior to purchase. This group should include the technical lead for the Industrial Commission.

Reviewer 3D (Rating 4)

Potential risks have been identified and project responsibilities have been cited in this proposal.

Reviewer 4D (Rating 5)

The layout of this proposal is exceptional and all attributes like milestone chart, schedule, financial plan, qualifications, and mitigations strategies, are clear and well organized.

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 1D (Rating 4)

The primary equipment additions are needed to support the system upgrades for cleaning and tailoring the syngas composition for future synthetic fuels production.

Reviewer 2D (Rating 4)
The proposal includes information that justifies the need to purchase the equipment noted. I believe once the selection process is complete it makes sense to have a meeting of the team to confirm the selections made are appropriate.

Reviewer 3D (Rating 3)
The exact equipment required is ambiguous due to the nature of the project.

Reviewer 4D (Rating 5)
There is not a considerable amount of equipment to be purchased as the majority of the equipment has already been acquired. The $220,000 total for equipment is well justified. The greatest risk to the proposed equipment budget is implementing a CO_2 capture system.

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 1D (Rating 4)
The project focuses on use of the existing 5 ton per day system with upgrades mainly associated with the backend syngas equipment.

Reviewer 2D (Rating 4)
With the purchases noted in the proposal the facilities and equipment for use in the proposed work are very good.

Reviewer 3D (Rating 4)
Facilities have been arranged for and the initially, required equipment has been overhauled for project use.

Reviewer 4D (Rating 5)
The facilities already exist and just need to be relocated and integrated with syngas cleanup systems and CO_2 capture.

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 1D (Rating 3)
Just over 50 percent cost share, with a mix of cash and in-kind. Additional funding is expected by the team that would also support the effort but is not shown as cost share in the budget, so the leveraging of State funding could be higher. The budget seems to be in line with the proposed scope of work.

NDIC will need to review the budget details including the equipment rental value.

Reviewer 2D (Rating 4)
The proposed work includes cost share of 50% for the work outlined in the proposal. The proposer also notes that a second project already funded from a Bioscience Innovation Grant of $150,000 plus cost share of $75,000 has some overlap and was not counted as cost share as was the waving of rent from the Grand Forks landfill of $71,820 per year. These added costs covered with other funds raises the effective cost to ~60%. This results in more cost-effective use of the State funds committed to the Renewable Energy Council's funds.

Reviewer 3D (Rating 4)
The value of this proposal is very good as is the financial committment. The expressed interest of outside municipalities indicates that this process could provide an exceptional renewable energy project that fulfils all of the NDIC's goals.

Reviewer 4D (Rating 5)
It is this reviewer's opinion that the proposal has a very high value relative to the previous work and financial commitment from the Applicant, Xcel, and Tri-Steel. This proposal also has high value to enhance and encourage energy and agricultural development for the State of North Dakota.

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 1D
As a reviewer I feel the technology and the project plan are sound and am supportive of the proposed effort. The project has a strong project team with very good expertise.

Note that a primary challenge may be economic viability at a relatively small scale that could be limited by feedstock availability at a given location. Voting members of the council may ask for a response to this concern as part of the proposal presentation.

Reviewer 2D
Overall, I believe the proposed project represents good value and success in completing this activity offers significant value to the State by working to further the goals of the NDIC/Renewable Energy Council. Therefore, I would recommend this project be funded based on accepting the changes suggested with the milestones noted. In addition, the proposer needs to demonstrate that funding from Xcel Energy is made available and a change is made to their milestone 6 to state the final report is for The NDIC not the Department of Energy.

Reviewer 3D
As written, I **do not** recommend funding this project. This proposal aligns with all the goals stated in the NDIC's mission statement. I believe it is a very worthwhile renewable energy project. This proposal is to upscale a 5 tpd (tons per day) process to a 25 and possibly 50 tpd process which would make the sandwich gasifier (SG) a markable, economical renewable energy process for municipalities. The reason I do not recommend this project as submitted is this:
Dr. Patel has submitted this proposal and holds the patents for the sandwich gasifier. Dr. Patel is currently employed by UND and the EERC. If this upscaling project is successful, Dr. Patel and his companies would realize substantial financial gain (estimated net sales were reported as $30 - $40 million). However, for Dr. Patel to orchestrate his own project, the proposal states that he would be compensated $148,000 (28.2% of the project request) over two years as a consultant (to his own project) regardless of project outcome by the NDIC. This compensation needs to be deleted from this proposal. I do not believe that Dr. Patel should be compensated for his time by the NDIC in making his own product markable. Other than this one issue, this project has great potential as a renewable energy source for the state of North Dakota and would come with my highest recommendation.

Reviewer 4D

This proposal is thorough, well organized, concise and easy to read and understand. The objective is clearly defined and achievable and the potential results are in accordance with the stated goals, purposes, and objectives of NDIC's Renewable Energy Council.

Recommendation: This reviewer recommends funding this proposal

Renewable Energy Program

North Dakota Industrial Commission

Application

Project Title: Accelerating the Waste-to-Fuels Commercialization for the Sandwich Gasifier

Applicant: Singularity Energy Technologies

Principal Investigator: Dr. Nikhil Patel

Date of Application: August 1, 2024

Amount of Request: $486,950

Total Amount of Proposed Project: $978,950

Duration of Project: 24 months

Point of Contact (POC): Dr. Nikhil Patel

POC Telephone: 701-739-8720

POC Email: npatel@singularet.com

POC Address: Center of Innovation
4200 James Ray Drive
Grand Forks, ND 58202

TABLE OF CONTENTS

ABSTRACT

Objective:

The primary objective of this project is to demonstrate and prove the capabilities of the Sandwich Gasifier and integrated systems to produce clean and composition-balanced syngas under self-sustained steady-state operation. We will validate the integrated technology and improvement in techno-economics of producing low-cost syngas suitable for direct conversion into sustainable liquid fuels, renewable natural gas, and/or green hydrogen. The scale-up and integrated operation will fast-track our plan to develop a viable customer base and build future commercial-scale facilities. The Sandwich gasification technology has been proven to produce clean syngas from challenging waste streams with net carbon dioxide equivalent emission reduction, and therefore our integrated setup will provide a marketable waste-to-fuels technology using North Dakota biomass, agriculture/animal wastes and MSW. Job creation and training of a future workforce to support the industry are also important goals.

Expected Results:

This project seeks to generate tangible evidence, data, and insights that will inform decision-making processes regarding the adoption and implementation of the gasifier technology. Ultimately, the goal is to contribute to the development of a more sustainable and environmentally friendly energy sector by enabling the utilization of locally available biomass resources for clean and renewable biofuel and bio-material production. In achieving these goals, this project will demonstrate the performance and efficiency of the Sandwich gasifier in converting North Dakota biomass feedstocks (agricultural waste, manure, municipal solid waste, etc.) into syngas of suitable quality for production of sustainable liquid fuels, renewable natural gas, or green hydrogen. It will provide valuable insights and recommendations for improving the overall efficiency, cost-effectiveness, and sustainability of biomass-to-syngas conversion. This project will contribute to the advancement of renewable energy technologies by showcasing the potential of the Sandwich gasifier in utilizing diverse biomass feedstocks for biofuel production, and advancing the technology towards commercialization. Finally, this project will facilitate the transition towards a more sustainable energy sector by promoting the use of locally available biomass resources for clean and renewable fuel production.

Duration:

Twenty-four months (Suggested: January 1, 2025 – December 26, 2026)

Total Project Cost:

$486,950 is requested from NDIC of the $978,950 total project cost.

Participants:

Dakota Green Power (DGP), Singularity Energy Technologies, LLC (SET), Tri-Steel Manufacturing, Sage Green N.R.G. LLC, MDM Energy Consulting, LLC, Dr. Edwin Olson

PROJECT DESCRIPTION

The primary objective of this project is to demonstrate and prove the capabilities of the Sandwich Gasifier (SG) and integrated systems to produce clean and composition-balanced syngas under self-sustained steady-state operation by a clinker-free system producing gas-to-liquid (GTL), renewable natural gas (RNG) and hydrogen (H_2) quality syngas. Singularity Energy Technology's (SET) Sandwich gasifier has been proven to operate on a range of complex feedstocks, including municipal solid waste (MSW), biodigester waste, high moisture forestry and agricultural wastes including poultry and livestock manure, railroad ties, tires, and other difficult to process waste materials. SET's technology is viable at 25 tons/day, making it ideal for localized use for feedstocks traditionally difficult and expensive to transport. The unique design of the Sandwich gasifier allows clinker-free operation on difficult feedstocks while producing a syngas low in tar. Our strategy for the production of GTL/RNG/H_2-ready syngas includes the use of off-the-shelf sorbents, solvents and technologies and their optimized combinations, thereby minimizing the required development time and improving the overall economics of the system. Understanding the unique characteristics of each feedstock allows tweaking of the gasifier operating conditions and optimization of the backend scrubbing system to obtain the required syngas purity at the lowest cost. The ability to reinject waste streams makes this a near-zero discharge gasifier, including low to negative carbon emissions. Figure 1 provides an overview of the integrated technology, which comprises a waste processing unit, the Sandwich Gasifier, a syngas processing unit and a renewable liquid synthesis system.

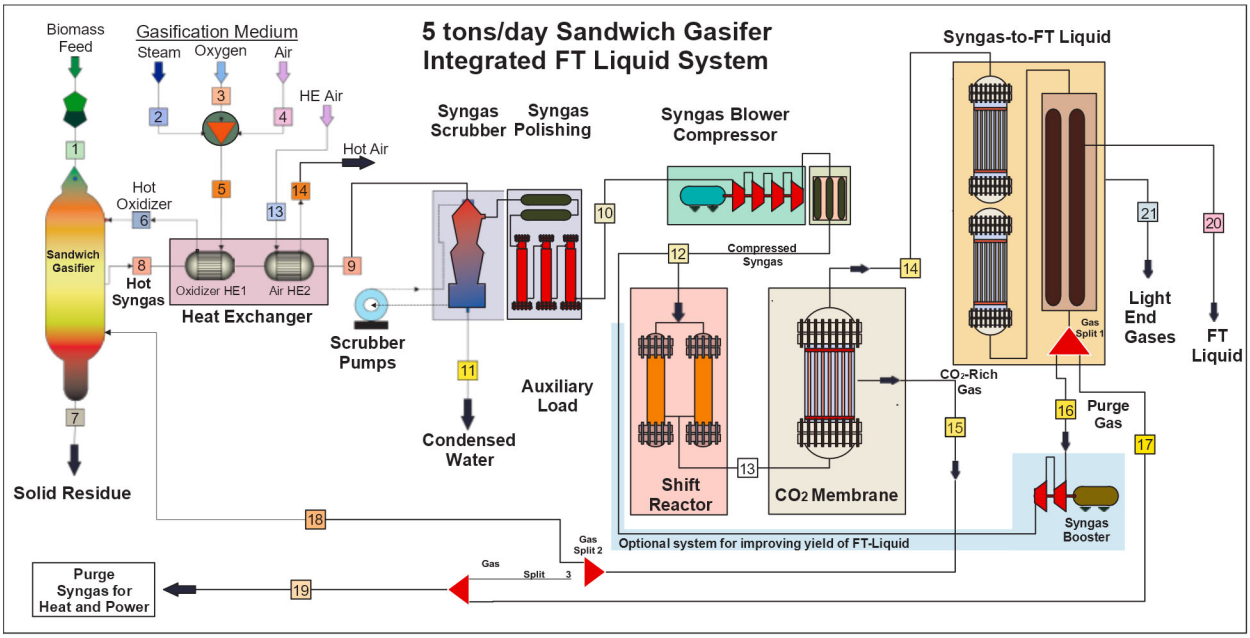


Figure 1: High-Level Process Flow Diagram the integrated Sandwich gasification system

Objectives:

The primary objective of this project is to demonstrate and prove the capabilities of the Sandwich Gasifier (SG) and integrated systems to produce clean and composition-balanced syngas under self-sustained steady-state operation by a clinker-free system producing GTL/RNG/H_2-ready quality syngas. We will validate the integrated technology to meet the stringent syngas purity and composition standards and demonstrate an improvement in techno-economics of producing low-cost GTL/RNG/H_2-ready syngas. Our team's major strength is our ability to integrate additional components into the gasification architecture

at different scales to achieve high-quality liquid-based fuels and intermediates for lubricants and chemicals. Our target is the integration of technically and economically viable gas cleanup technology with the Sandwich gasifier to produce syngas suitable for commercial and near-commercial GTL/RNG/H_2 systems.

The scale-up and integrated operation will fast-track our plan to build future commercial-scale facilities. Our integrated setup will provide a marketable waste-to-fuels technology. The SG technology has been proven to produce clean syngas from challenging waste streams with net carbon dioxide equivalent emission reduction.

Methodology:

Overview: The key technical risk is integrating the Sandwich Gasifier (SG) with a GTL/RNG/H_2 system and associated subsystems. Specifically, our proposed project is designed to address the need for a narrow range of H_2/CO, with near zero concentrations of trace contaminants in syngas for achieving desired conversion, and ensuring high yields and adequate catalyst performance/longevity when using distributed low energy-dense and complex composition feedstocks. The gasifier design philosophy is based on the production of clean syngas with high fuel conversion efficiency while achieving near-zero-effluent discharge from the overall system. Clean syngas is produced by converting complex organics into energy-rich gaseous forms in the hot zones of the gasifier. The near-zero-effluent discharge is achieved by recycling the small fraction of unconverted organics in the syngas into the gasifier hot zones, to ensure production of favorable syngas compositions. One of the main features of the Sandwich gasifier is the unique gas–solid distribution afforded by the second oxidation zone that creates uniformly high-temperatures throughout the reaction chamber. This ensures a higher level of in situ tar and carbon conversion, thereby eliminating the need for secondary carbon/char converters, large syngas scrubbers, waste disposal systems, and extensive syngas processing. When operated according to specifications, downdraft gasifiers (including the first stage of the Sandwich gasifier) produce clean syngas with very low (on the order of 1 g/Nm^3) tar loading.[(1)] The production of low amounts of tar in the downdraft gasifier is due to the long residence time of high-molecular-weight devolatilized gases in a uniform high-temperature zone, which results in thermal conversion to simple short-chain hydrocarbons. SG's second oxidation zone enhances tar reduction and carbon conversion.

Several strategies are utilized to obtain the gas purity and the optimal H_2/CO ratio for liquid-to-gas production. Low temperature and pressure tar removal and acid gas removal is accomplished using conventional scrubbing technology. Tar recycling in the gasifier increases yields and reduces environmental harm from tar disposal. Effluent streams from wet scrubbing filtered through enhanced surface area char produced within the gasifier which are then recycled back into the gasifier, thus minimizing generation of solid as well as liquid waste. The trace impurities removal in packed beds of low temperature sorbent prior to syngas balance allows low pressure operation thus offering low capital cost and ease of operation. Conventional water-gas-shift catalysts further maximize overall yields and produce a syngas with a H_2/CO ratio in the range needed for GTL/RNG/H_2 production. The H_2/CO ratio is fine-tuned by incorporating a bypass and recycle loop in the system. Prior to the GTL/RNG/H_2 processing, CO_2 can be removed from the system via several different commercially available technologies including solvent-based and membrane-based approaches, both of which will be tested during this project. We also propose to recycle a portion of the CO_2 back into the gasifier to be used to help moderate gasifier temperatures

[1] Graham, R.G.; Bain, R. *Biomass Gasification: Hot-Gas Clean-Up*; International Energy Agency, Biomass Gasification Working Group, Dec 21, **1993**; 33–44.

while simultaneously serving to reform a portion of the CO_2 into CO, thereby increasing liquid fuel yields while reducing CO_2 emissions.

The variable compositions of the various waste materials to be tested during this project (and others which are of interest to our commercial clients), and in particular their effects on the Sandwich gasifier's ability to minimize tar and char formation represents a significant challenge. The SG has successfully converted mixed wastes containing plastic waste materials and modifications to the truck-mounted system incorporate design changes suggested from that earlier work. Captured tars are recycled into the gasifier to maintain the near-zero discharge attribute and additional tar removal equipment can be added if needed. Low-cost commercially available gas cleanup systems are available that can be readily integrated into the Sandwich gasification island for the production of GTL-ready syngas.

Innovation and Impacts: The Sandwich Gasifier has overcome two important barriers: cost (figure 2) and reliability (Appendix A). The Sandwich Gasifier design has high heat transfer, isothermicity, scalability, enhanced control over operating conditions, good gas-solid contact, and high specific capacity. The Sandwich Gasifier design is fully scalable, relying on single or multiple modules to accommodate both rural and urban requirements for converting feedstocks to heat, chemicals, and power. The scalable feature of the system allows sizing of the commercial Sandwich gasification technology such that it can be located at or near the feedstock source, enabling zero to near-zero feedstock transportation cost. The system is capable of converting waste on an "as-received" basis without requiring feed densification. The heat integration capability allows the system to tolerate moisture variation while minimizing or completely eliminating energy-intensive feed preparation.

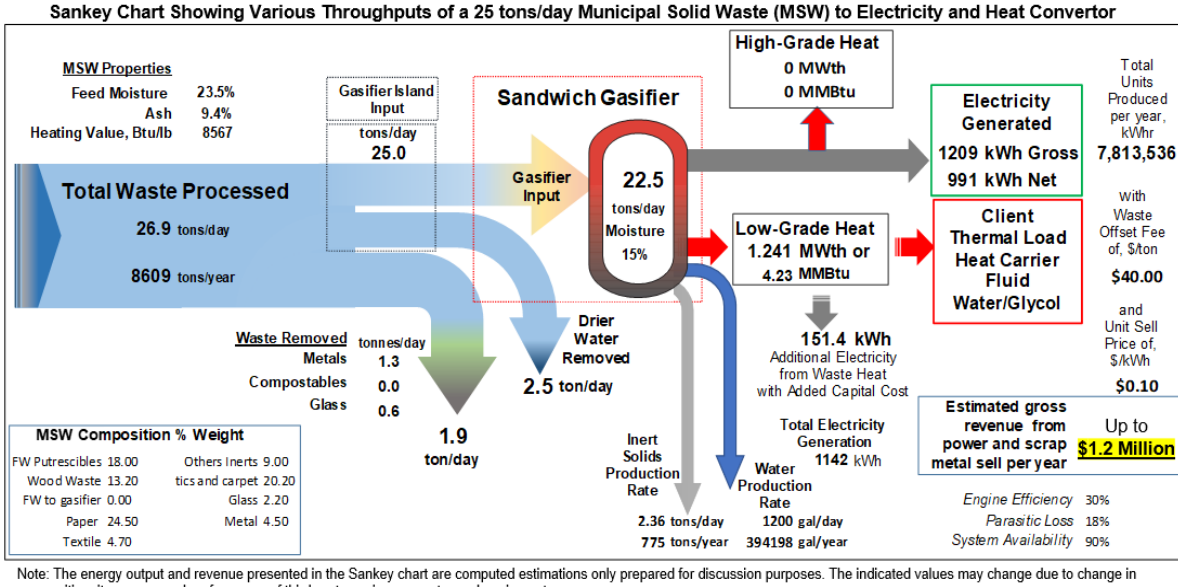


Figure 2. High level material and energy balance showing economic viability of SG technology.

This optimized gasifier significantly reduces the demands on the downstream cleanup system, thereby allowing for significant simplification of the required gas purification equipment. The tar condenser and wet scrubber are effective in removing soluble tars, alkalis, and gas-phase chlorine not captured in the inorganics associated with the ash. The staged low- and high-pressure sorbent removal as presented above operates at low temperature and take advantage of the abilities of newer water-gas-shift catalyst

and CO_2 capture solvents in removal of trace contaminants providing synergies in syngas composition balance and cleaning. Stage two cleaning is also critical in capturing secondary release of sorbent-captured species and aerosols escaping the demister from upstream solvent scrubber. This approach supports cost reduction, ease of operation and GTL/RNG/H_2 catalyst protection goals.

Additionally, we propose to tailor the downstream equipment based upon the specific characteristics of each feedstock, thereby ensuring the necessary equipment is present to produce the desired quality syngas, but not including extra and un-necessary equipment (avoiding the one size fits all feedstock approach), thereby minimizing overall capital and operating costs. Based upon previous studies at the EERC and vendor assurances, we are confident that commercially available sorbents and solvents are available which allows rapid deployment of the integrated system. The high-quality syngas produced from the Sandwich gasifier can be upcycled using Fischer-Tropsch technology.

Anticipated Results:

The outcome of the proposed project will be an optimized and simple waste-to-fuels platform that provides economic GTL/RNG/H_2-ready syngas production from a variety of negative cost (tipping fee generating) wastes that pose significant environmental challenges. SET will work with team member organizations to streamline integration of the SG technology with available commercial or near-commercial subsystems that include:

- Syngas cleanup system to remove trace contaminants detrimental to catalysts such as tar and particulate matter, trace gaseous contaminants including species of sulfur (H_2S, COS and mercaptans), nitrogen (NH_3 and HCN), halogen (HCl), volatile alkali, Si (silane) arsenic and trace volatile organic compounds (VOC's).
    - Condensation of tars by gas cooling followed by wet scrubbing
    - Wet scrubbing for removing tars and soluble inorganic contaminants using conventional and non-conventional solvents that provide recycling options
    - Activated carbon, iron- and zinc-based polishing sorbents for removal of sulfur
    - Zocarbs sorbents to adsorb impurities including sulfur, nitrogen, and trace VOC
- Syngas composition balance by demonstration of integrated water-gas-shift reactor to optimize the H_2/CO ratio.
- CO_2 capture with recycle and H_2 separation technologies to optimize the H_2/CO ratio for increasing yield of fuel production.

Facilities:

The Sandwich gasifier was invented at the Energy and Environmental Research Center (EERC) in Grand Forks, ND by Dr. Nikhil Patel in 2006 (Dr. Patel is the President of SET). The technology's research and deployment efforts have gone through extensive peer review and has benefited from the EERC's long experience and expertise in gasifier development. The EERC Foundation transferred the technology to SET which is the sole owner and licensor of the technologies. Dakota Green Power, of which Dr. Patel is the CEO, is the licensee of the technology with rights to manufacture, commission, and sell these systems to clients. Figure 3 provides a history of the technology development and commercialization efforts for the Sandwich gasifier.

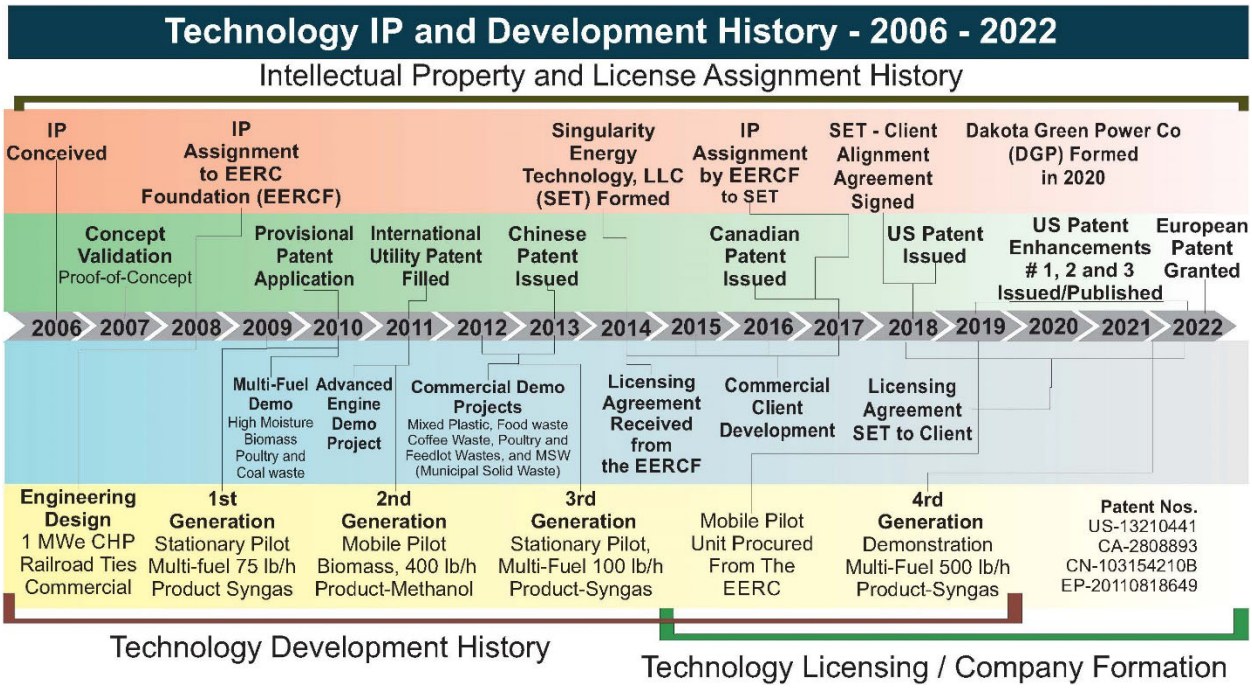


Figure 3. Technology and Intellectual Property Development for the Sandwich Gasifier

The Sandwich gasifier is at a technology readiness level (TRL) of 5. Development has progressed through several scales, including a 2 lb/hr laboratory system operated by the University of North Dakota Institute for Energy Studies (IES), a 70 lb/hr pilot-scale system operated by the EERC, and a 5 ton per day truck mounted system shown in Figure 4, originally built at the EERC and currently owned by Tri-Steel Manufacturing. Many tests, the longest of which was 5 days of continuous steady-state operation, have been performed on a variety of feedstock, including turkey litter, manure, railroad ties, and coffee roaster's waste, including plastic and food processing waste and wet wood on the 70 lb/hr bench-scale system. The 5 TPD truck mounted system has successfully processed railroad ties, shredded tree trimmings, and high-moisture wood waste and produced both electricity and methanol. Various gas cleanup strategies have been employed at these different scales. These tests have illustrated the benefits of the Sandwich gasification concept on challenging feedstocks and led to the enhancements necessary to further optimize the system performance and enable continuous steady-state operation over long periods of time (>10 days). Results from previous testing and justification of the proposed approach are discussed in Appendix A.

Figure 4. Five ton/day truck mounted Sandwich gasifier currently located at Tri-Steel Manufacturing.

Resources:

The current 5 ton/day truck mounted gasifier (see figure 3) owned by Tri-Steel Manufacturing will be relocated to the Grand Forks City Landfill. This system was originally conceived by Dr. Patel while he worked at the EERC. Funding for the original gasifier was provided primarily by the U.S. Department of Energy and Xcel Energy. The unit was mothballed in 2011 due to difficulties in developing sponsors to commercialize the technology. Patents for the technology were transferred to SET and its owner, Dr. Patel. Tri-Steel Manufacturing purchased the truck mounted system from the EERC and invested approximately $1,500,000 to refurbish and enhance the system to its current operating condition. The truck mounted system has been successfully operated on railroad ties, shredded tree trimmings, and high-moisture wood waste. Tri-Steel will provide access to the truck-mounted system to SET for this program and will perform necessary modifications. Steffes Manufacturing, a Grand Forks, North Dakota company can provide ASME stamped pressure vessels. In addition, the EERC has a pilot-scale system and the UND Engineering has a bench-scale system that can be used to support the development efforts if needed. SET/DGE has a three-year, rent-free lease from the City of Grand Forks to use the building that housed the former bailing facility for this and other projects focused on developing and commercializing the Sandwich Gasifier technology.

Techniques to Be Used, Their Availability and Capability:

This project aims to demonstrate the capabilities of the Sandwich Gasifier (SG) and integrated systems in producing uninterrupted, high-quality syngas suitable for gas-to-liquid (GTL) production. The project will integrate a cost-effective gas cleanup technology and assess the techno-economic improvements in producing low-cost GTL/RNG/H_2-ready syngas. By showcasing the potential of the SG system, this project seeks to advance efficient and economically viable GTL/RNG/H_2 production.

In this project, the SET Sandwich Gasifier will be integrated with existing or nearly commercial subsystems, including:

- Syngas cleanup system: Removes harmful contaminants like tar, particulate matter, sulfur species (H_2S, COS, mercaptans), nitrogen species (NH_3, HCN), halogen (HCl), volatile alkali, silane, arsenic, an d trace volatile organic compounds (VOCs). This is achieved through tar condensation by gas cooling, wet scrubbing using conventional and non-conventional solvents, activated carbon, iron- and zinc-based sorbents for sulfur removal, and Zeocarb sorbents for impurity adsorption.
- Syngas composition balance: Demonstrates the use of an integrated water-gas-shift reactor to optimize the ratio of H_2 to CO in the syngas.
- CO_2 capture with recycle and H_2 separation technologies: Utilizes methods to capture CO_2 and separate H_2, aiming to optimize the H_2/CO ratio for increased yield of liquid fuel production.

The following provided details of the five tasks proposed to meet the project objectives.

Task 1: Feedstock Selection and Analysis

MSW will be used as the primary feedstock based upon interest from SET's potential clients (see letters of support in Appendix). Other suitable feedstocks will be identified based on their availability and market demand for disposal and with input from the ND Department of Commerce and Xcel Energy. SET will procure the biomass feedstocks locally and/or from other localities with potential interest to serve as a site(s) for the commercial installation(s). Small representative samples will be subjected to fuel analysis such as proximate, ultimate, dynamic, and differential thermal analysis (TG/DTA) and inorganic analysis. Selected samples will be gasified using a laboratory gasifier. Ash composition analysis will include bulk species and trace metals in the feed material. Data will supplement a request for an extension to the current temporary environmental permit.

Milestone 1: Feedstocks procured and analyzed. Supplemental permit request filed.

Task 2: Syngas Composition Balance Equipment Design, Vendor Selection and Procurement

Task 2 focuses on designing, selecting vendors and procuring equipment that will enable us to achieve syngas composition balance to meet with third-party GTL/RNG vendor syngas specification. This involves selection of the Shift Reactor and catalyst for conversion for achieving targeted H_2/CO ratio in the syngas and a CO_2 Removal System. The sorbents and solvents are selected based upon results from work performed at the Energy and Environmental Research Center (EERC) in conjunction with DOE. The train tested included WGS and removal of sulfur, chlorine, and trace metals (including mercury). The technologies utilized are considered either commercial or near-commercial.[2] An example configuration tested included Johnson Matthey's KATALCO® K8-11 sour shift catalyst, fixed beds for sulfur capture (hydrogen sulfide and carbonyl sulfide) with a regenerable adsorbent (RVS-1, a regenerable zinc oxide-based adsorbent developed by DOE NETL and manufactured by RTI for Süd-Chemie (now Clariant)). High purity (95%+) CO_2 is obtained via the Selexol process using NETL-recommended solvents including ARG2[3].

Included in Task 2 is the procurement and testing of analytical equipment necessary for measuring the primary syngas components and trace concentrations of sulfur and nitrogen species. The procured analytical equipment will be integrated into the syngas production system, ensuring proper connectivity and functionality. Compatibility with existing control systems and data acquisition systems is considered to enable seamless integration and data exchange. The performance of the analytical equipment is evaluated through comprehensive testing and validation.

Upon completion of Task 2 we will have a well-designed and balanced syngas composition system, with the necessary equipment and safeguards in place. This will enable us to achieve our project goals of producing syngas with the desired composition of clean syngas. The efficacy of the process and sorbent will help determine cost effective option for production of syngas of desired composition.

Milestone 2: Syngas cleanup and compositional balancing equipment selected and procured. A HAZOP for system integration completed.

Task 3: 5 TPD System Modification and Commissioning

Task 3 will involve the modification and commissioning of the 5 TPD system at the Grand Forks City Landfill. Data from the feedstock analysis and estimated performance will be used in obtaining necessary permits and drive a thorough HAZOPS review to identify and address any potential hazards. The equipment identified and procured in Task 2 will be installed and commissioned. This includes ensuring proper installation, connectivity, and functionality of the equipment within the syngas production and cleanup system. A commissioning test will be conducted using the baseline feedstock to assess the system's functionality and identify any potential issues or areas for improvement. A set of preidentified sorbents will be utilized during the preliminary commissioning. The necessary preparations will be made for contaminant sampling, including system upgrades, commissioning, and testing. This will ensure accurate and reliable sampling of trace gas contaminants and will enable effective detection and analysis of contaminants in the syngas produced. This task will include optimizing the system for efficient on-site sampling and analysis of trace contaminants in a third-party lab. All prescribed quality control protocols will be adhered to during the sampling. By completing Task 3, the 5 TPD system will undergo necessary modifications and upgrades, ensuring its compatibility with the selected feedstocks and operability of the added syngas balance and cleanup equipment. Preliminary commissioning tests will help verify the

[2] Subtask 2.1 – Pathway to Low-Carbon Lignite Utilization, Topical Report for the Period September 15, 2015 through May 31, 2017. Cooperative Agreement Number DE-FE0024233. May 17, 2017

[3] Biomass Cofiring with Precombustion Carbon Capture Baseline Testing at UND EERC, Final Report. Dec 2021.

system's performance, and the sampling system will be optimized for accurate contaminant sampling. These efforts will contribute to the overall success and efficiency of the syngas production process.

Milestone 3: Syngas cleanup equipment fully integrated and operational on the 5 TPD system. System ready for clean syngas production.

Task 4: Clean Syngas Production with Composition Balance

In Task 4, gasification tests with syngas and measurement of scrubber water contaminants will be conducted in the 5 TPD system. Baseline testing will establish the initial performance and characteristics of the syngas produced. Contaminant sampling and analysis will be carried out to identify and quantify any trace contaminants present in the syngas. The scrubber water generated during the gasification process will undergo treatment using gasifier char or activated carbon to remove contaminants from the water and improve its quality before disposal or reuse, while reinjecting the spent sorbent into the gasifier. Baseline testing provides a comprehensive understanding of the syngas composition and contaminant levels will be obtained through baseline testing and analysis. Additionally, the treatment of scrubber water with gasifier char or activated carbon will help ensure the efficient management of water contaminants, contributing to environmental sustainability and process optimization.

Once the baseline testing is complete, clean syngas production with composition balance will be achieved using the selected feedstocks; Municipal Solid Waste (MSW) and/or a Municipal/Industrial Wood Waste mix; and potentially forestry wastes, poultry waste; and/or biosolids. Gasification tests will involve at least one 8-hour shift and continuous operation for 24 hours for each feedstock. Additionally, a 5-day continuous operation will be performed on a feedstock selected by the client to support commercialization goals. During the tests on the 5 TPD system, the syngas composition will be continuously monitored. This will include the implementation of appropriate sampling methodologies and colorimetric trace-gas detection techniques to ensure accurate measurement and analysis of the syngas composition. By completing Task 4, clean syngas production with composition balance will be achieved for various feedstocks. The gasification tests and continuous monitoring will provide valuable data on the syngas composition, enabling optimization of the process and supporting the commercialization objectives of the project.

Milestone 4: Baseline testing with selected feedstock completed and optimal configuration and operation of syngas equipment determined.

Milestone 5: Clean syngas produced from selected feedstocks for 8-, 24-, and 100- hours operation using the selected feedstocks.

Task 5: Final Report Preparation

In Task 5, the project team will undertake the preparation of the final report and the submission to the North Dakota Industrial Commission (NDIC) and Xcel Energy. The report will encompass the data collected, data analysis, and recommendations for future studies. Additionally, it will feature a technoeconomic of the feedstock-specific technology implementation at a selected location. By completing Task 5, the project team will provide a valuable resource for future studies, providing insights and guidance for further advancements in the field. Additionally, the submission of the final report will signify the successful conclusion of the project and the fulfillment of all obligations.

In addition to the final report, SET will submit quarterly progress reports to the NDIC and Xcel Energy for assessment. These reports will provide updates on the project's progress, outlining the milestones achieved, challenges encountered, and future plans. The progress reports will serve as a means to ensure alignment with the project goals and objectives. Through regular reporting, SET aims to maintain

transparency and accountability in project execution and foster effective communication with both the NDIC and Xcel Energy regarding the project's advancement.

Milestone 6: Final report submitted to and accepted by DOE.

Environmental and Economic Impacts while Project is Underway:

We do not anticipate any significant environmental impacts while the project is underway. The Sandwich gasifier achieves near-zero effluent discharge by injecting the condensed tar and particulate matter (PM) along with a small fraction of water into the reactor hot bed such that the thermodynamics of the reactor temperature profile are not affected. The inert inorganic ash residue removed from the gasifier is the only disposable material generated from the system and will be disposed of at the City Landfill. The produced syngas will be oxidized via a thermal oxidizer or flare and/or used for heating or electricity generation while the project is underway. Solid, liquid, and gaseous effluents will be collected and analyzed before being disposed of in compliance with the environmental permits that will be obtained for this project as a standard procedure. The data generated will be used for reporting and other permit application purposes.

Approximately one hundred tons of biomass will be processed during the testing phase of the project. The volume reduction of the waste coupled with the "green" electricity and fuels produced represent a positive environmental impact of the project.

Ultimate Technological and Economic Impacts:

The technological impact of the Sandwich gasifier is vested in its ability to promote complete waste conversion to produce clean syngas. The robust operational flexibility of the technology means that it can drive down costs for valuable fuel production in rural and urban areas. The system has the potential for higher revenues due to its higher conversion efficiency and improved quality of syngas produced. The Sandwich gasifier's net production is ~850 kWh/ton compared to 500 – 617 kWh/ton for 4 different competing technologies, and 500 kWh/ton for existing combustion-based waste-to-energy plants when using municipal solid waste (MSW) as a comparison.[4]

The Sandwich Gasifier design has high heat transfer, isothermicity, scalability, good control over operating conditions, good gas-solid contact, and high specific capacity. The scalable feature of the system allows the sizing of the commercial Sandwich gasification technology such that it can be located at or near the feedstock source, thus requiring zero to near-zero transportation cost. This feature makes it ideal for remote locations that require low-cost biomass and plastic waste processing systems for valuable fuels production.

Once the technology's commercial operation is demonstrated, DGP is projecting they can manufacture and sell initially up to five systems per year resulting in annual net sales of $30,000,000 - 40,000,000 and development of up to 35-40 high paying jobs. Manufacturing will occur in Grand Forks, ND. Even during the initial growth phase it is anticipated that DGP will generate 24 jobs in its 4th year.

Why the Project is Needed:

[4] Ducharme, C.; "Technical and Economic Analysis of Plasma-Assisted Waste-to-Energy Process", Columbia University, 2010.

The Sandwich gasifier has the potential to provide consistent-quality biomass-derived air-blown and enriched-oxygen/air-blown syngas for liquid fuels production. However, technical risks remain because of a lack of experience for long-term continuous operation and the performance challenges associated with challenging feedstocks that possess elevated and variable moisture, ash, and inorganic content. Further, the strict purity requirements for downstream GTL/RNG/H_2 systems are economically difficult to meet at a small scale for most gasification systems. These risks prevent commercial investment. Potential clients are interested in seeing the operation of a fully integrated system before investing in the technology (see letters of support).

NDIC funding will allow this project team to make the necessary system modifications, achieve step-change improvements to system performance and cost-effectiveness, full integration of the gasifier with gas cleanup systems and demonstrate longer-duration operation. With these three accomplishments, the project team will have the information needed to secure commercial investment to take the next step of scale-up design and fabrication of a first-generation commercial Sandwich gasifier suitable for integration with GTL/RNG/H_2 conversion systems.

The funding provided by NDIC through this grant, coupled with funding that will be raised as cost share commitments will facilitate the market expansion of gasification technologies.

STANDARDS OF SUCCESS

The end of project goal is a technically and economically viable gas cleanup technology integrated with the Sandwich gasifier capable of producing syngas suitable for commercial and near-commercial GTL/RNG/H_2 systems. In accomplishing this goal, this project will produce a gasification system that is fully scalable, relying on single or multiple modules to accommodate both rural and urban requirements for converting feedstocks to heat, chemicals, and power. The sizing of the commercial Sandwich gasification technology is such that it can be located at or near the feedstock source, enabling zero to near-zero feedstock transportation cost. Further, the system will be capable of converting waste on an “as-received” basis without requiring feed densification or drying, minimizing, or completely eliminating energy-intensive feed preparation.

This project will assess the technical and economic viability of the Sandwich gasifier as a reliable and efficient method for converting diverse North Dakota biomass sources, such as municipal solid waste, agricultural and forestry waste, and manure, into high-quality syngas suitable for biofuel synthesis and production of bio-materials. The project seeks to generate tangible evidence, data, and insights that will inform decision-making processes regarding the adoption and implementation of the gasifier technology. Ultimately, the goal is to contribute to the development of a more sustainable and environmentally friendly energy sector by enabling the utilization of locally available biomass resources for clean and renewable biofuel and bio-material production. To meet this broader goal, the following individual goals will have been met.

1. Demonstrate the performance and efficiency of the Sandwich gasifier in converting North Dakota biomass feedstocks (municipal solid waste, agricultural and forestry waste, manure, etc.) into syngas of suitable quality for production of sustainable liquid fuels, renewable natural gas, or green hydrogen.

2. Optimize the operation of the Sandwich gasifier to maximize the conversion efficiency and overall performance.

3. Generate comprehensive data supporting an engineering feasibility study for implementing the gasifier technology.

4. Develop a technoeconomic cost model to assess the economic viability and potential commercialization of the gasification process.

5. Provide valuable insights and recommendations for improving the overall efficiency, cost-effectiveness, and sustainability of biomass-to-syngas conversion.

6. Contribute to the advancement of renewable energy technologies by showcasing the potential of the Sandwich gasifier in utilizing diverse biomass feedstocks for biofuel production.

7. Facilitate the transition towards a more sustainable energy sector by promoting the use of locally available biomass resources for clean and renewable fuel production.

BACKGROUND/QUALIFICIATIONS

The team members and their primary roles of the team are summarized in Table 1. Resumes of key personnel are included in Appendix B.

Table 1. Primary Roles of Project Participants

Team Member	Role
Singularity Energy Technologies LLC	Prime contractor and project lead. Owner of patents. License patent rights to DGP. Input into long-term potential projects.
Dakota Green Power (DGP)	Manufactures Sandwich gasifier systems in partnership with SET and Tri-Steel Manufacturing. Will provide engineering support.
Tri-Steel Manufacturing	Manufacturer of gasifier components through established relationship with DGP and SET. Will provide operations support and perform system modifications.
Sage Green N.R.G.	Provide support for permitting, marketing, and communications
MDM Energy Consulting	Provide support for project management, design, and reporting
Dr. Ed Olson	Develop and implement advanced analytical techniques

Singularity Energy Technologies, LLC (SET) – Dr. Nikhil Patel, founder and President of SET, is the inventor and patent holder for the technology. He will lead the project, serving as the Primary Investigator (PI) to direct the technical and scientific aspects, managing resources, scheduling, and budgets. He will be the point of contact between the EERE and other project participants/sponsors. He has over 25 years of research, development, and technology commercialization experience in waste-to-energy conversion using thermochemical processes involving combustion and partial oxidation or gasification of biomass, coal, and unconventional, difficult-to-burn liquid and solid, industrial, and municipal solid wastes. He spent 23 years working with the Energy and Environmental Research Center (EERC) where he focused on inventing and advancing gasification-based conversion technologies.

Tri-Steel Manufacturing – Mr. Scott Homstad is the Manager/Secretary Treasurer at Tri-Steel Manufacturing Co. Tri-Steel will provide manufacturing services for the required modifications to the system. Tri-Steel will rent the 5 TPD gasifier to the project as in-kind cost share to the project. The company, located in Grand Forks, ND was established in 1962 and serves the upper Midwest as a manufacturer and supplier of agriculture equipment. In an effort led by Mr. Homstad, Tri-Steel procured the current truck-mounted Sandwich gasifier from EERC and has invested into refurbishing and updating the previously mothballed system into a fully operational system.

Dakota Green Power (DGP) - Mr. Scott Homstad serves as the President of Dakota Green Power. Mr. Scott Homstad will assist the PI in the development of the commercialization strategy and identification of potential customers for the integrated biofuels production system. Mr. Homstad and Dr. Patel co-founded Dakota Green Power. Their goal is to serve as a manufacturer of 25, and 50 ton/day Sandwich Gasifier integrated waste-to-energy systems. They have established an engineering team who is responsible for preparing initial piping, instrumentation, and manufacturing drawings and will provide similar engineering support to the project.

Sage Green N.R.G., LLC – Dr. Nicholas Ralston, Director of Sage Green NRG, provides advice and support in business considerations, marketing, networking, and outreach presentations, publications, and communications. He will work performed to comply with environmental permits. Dr. Ralston will also use his expertise to help develop a long-term customer base and establish relationships with potential buyers of the Sandwich gasifier. Dr. Ralston has over 40 years of experience in applied research and has particular expertise in environmental aspects related to energy production.

MDM Energy Consulting LLC – Dr. Michael Mann, founder of MDM Energy Consulting, will provide assistance in design review, developing test plans, meeting project-reporting requirements, and will provide input into the development of commercialization plans and developing the end-user marketing material. He has extensive experience in management of large multi-organizational projects of similar scale and scope during his 40+ years' work in the energy field. While at the University of North Dakota, he served as the principal investigator on a three-phase $12 million project to extract rare earth elements and other critical materials from North Dakota lignite, including the design, construction, and operation of a 12 ton per day pilot plant located in Grand Forks. Previously while at the EERC, he was responsible for the design and installation of their 1-MW transport gasifier and associated hot-gas cleanup unit.

Dr. Edwin Olson – Dr. Edwin Olson, Consultant, will assist in developing comprehensive analytical techniques to measure performance of the gas cleanup modules. He will assist in training personnel in proper sampling techniques and with sample collection during testing. Dr. Olson, an organic chemist by training, spent 16 years in the academic arena before joining the EERC. While at the EERC, he has conducted extensive research programs in the development of novel methods for CO_2 capture and has developed and patented a novel levulinate biorefinery, an algae-to-fuels and chemicals biorefinery, a dual fermentation biorefinery, a biomass pyrolysis biorefinery, a method for preparing polyamines from biomass pyrolysis products.

MANAGEMENT

The team brings together the expertise required to advance our waste-to-fuels technology to commercialization. The project structure is designed to facilitate management of the project by task. Dr. Nikhil Patel, SET President and CEO for DGP will lead the project, serving to direct the technical and scientific aspects, managing resources, scheduling, and budgets, and will be the point of contact between the DOE Project Officer and other project participants/sponsors. SET/DGP will utilize current accounting personnel from Tri-Steel Manufacturing to assist in the cost management of the project, including tracking all costs for each of the project tasks.

Nicholas Ralston, Michael Mann, and Ed Olson have been working with SET, the technology licenser since its inception. For this project, Dr. Ralston will take the lead on maintaining permits. Michael Mann will use his many years of experience in developing and managing large research, development, and demonstration projects to help keep the proposed work on schedule and within budget. Dr. Mann will provide assistance in design review, developing test plans, meeting project reporting requirements. Dr. Olson will use his extensive experience in developing and applying complex analytical techniques to ensure accurate gas analysis around each unit operation.

Project meetings and conference calls with the core project management team will be held, at least, on a biweekly basis to conduct project activities, review project timelines, upcoming milestones/deliverables, costs, and challenges associated with the completion of the project tasks. Microsoft Project management tools will be utilized. Review meetings with sponsors (NDIC and Xcel Energy) will be held quarterly to ensure communication and discussion of accomplishments, plans and management of project risks. Intellectual property management and discussions have been initiated. During the course of the project, any new findings will be promptly documented and patent applications to protect the intellectual property filed as necessary. Discussions with potential commercial sponsors have been initiated regarding further development and scale-up of the technology and will be continued on a semi-annual basis as the project progresses.

A preliminary list of the perceived risks associated with completing the project is summarized in Table 2. Project risks will be continuously analyzed, and appropriate measures taken to address and mitigate said risks. A risk analysis will be included as an agenda item for the monthly project management team meetings and updated during the course of the project. Deviations and corrective actions will be discussed in quarterly reports.

Table 2. Perceived Risks and Mitigation Strategies

Perceived Risk	Risk Rating			Mitigation/Response Strategy
	Probability	Impact	Overall	
	(Low, Med, High)			
Cost/Schedule Risks:				
Plant construction costs exceed budget	Low	Med	Low	Vendor quotes have been obtained for major pieces of equipment. Installation costs based on previous experience. Used equipment can be purchased to help control costs.
Equipment delivery delayed	Low	Med	Med	Long lead times will be identified during design. Extra “flex” time built into schedule. Alternate vendors will be identified.
A crucial activity unexpectedly requires substantial additional funds	Low	Med	Low	Project and task managers will evaluate modifications to reduce cost and still meet project objectives. Additional funding will be sought if necessary. The City of Grand Forks, Grand Forks Regional Economic Development and the State of North Dakota offer programs to provide bridge funding.
Technical/Scope Risks:				
Integration of back-end processing equipment	Low	High	Med	Product gas specifications for various down-stream applications have been reviewed. Current design indicates good compatibility. The gasifier island can be tailored with additional gas cleanup, process recycling, and additional reactors/catalysts added to impact gas quality as needed.
Gas cleanup system not performing to vendor specifications	Med	High	Med	For lower cost sorbents/solvents, residence times will be increased and polishing steps added. If this is not effective, other more expensive (but still commercially available) materials will be tested, followed by the use of near-commercial materials.
Management, Planning, and Oversight Risks:				

Personnel availability	Low	High	Low	Explore options with EERC for a subcontract to supply operators and technicians. Utilize wide range of personnel expertise available at UND including students. Offer competitive internships to upper-level engineering students. Key personnel identified are committed and available at their specified labor hours.
Equipment availability	Low	High	Med	System design maximizes the use of off-the-shelf equipment. Work with engineering firms to identify preferred vendors. Identify long-lead items early in the design effort and initiate ordering. Coordinate manufacturing schedule with Tri-Steel Manufacturing to ensure their schedule can accommodate project needs.
Cost tracking	Low	High	Low	SET/DGP will utilize the accounting services of Tri-Steel Manufacturing's CPA to assist the project manager in tracking costs. Utilization of Project cost tracking system.
ES&H Risks:				
Organic emissions	Moderate	Low	Low	The temperature regime in the Sandwich gasifier is designed to minimize the formation of tars and other organic compounds. Recycle options are available to capture and reprocess organics in the gasifier (capture on activated carbon followed by gasification for example). Additional backend polishing systems will be added if needed.
Fugitive emissions related to feedstock storage	Low	Moderate	Moderate	Facility is located outside the city limits adjacent to the city landfill. Dust control measures such as water spray of storage piles used as needed. Feedstocks stored and fed from truck and or similarly designed feed bin. Train all personnel on the proper handling and use of feed equipment.

TIMETABLE

Table 3 presents an overview of the project schedule and major milestones.

Table 3. Project Schedule and Major Deliverables

	Task	Milestone	Milestone Description	Milestone Verification Process (What, How, Who, Where)	Duration / Months from Start of the Project
1	Feedstock Selection and Analysis	M1	Feedstocks procured and analyzed. Supplemental permit request filed.	Test results submitted to NDIC and summarized in quarterly progress reports	0 - 3
2	Syngas composition balance equipment design and procurement	M2	Syngas cleanup and compositional balancing equipment selected and procured. A HAZOP for system integration completed	Equipment procured and HAZOP of integrated system completed. Final design summarized in quarterly progress reports	0 - 12
3	5 TPD System Modification and Commissioning	M3	Syngas cleanup and composition balance equipment fully integrated on the 5 TPD system	Test results submitted to NDIC and summarized in quarterly progress reports	7 - 14
4	Clean Syngas Production with Composition Balance	M4	Baseline testing with selected feedstock completed and optimal configuration and operation of syngas equipment determined.	Test results submitted to NDIC and summarized in quarterly progress reports	14 - 16
		M5	Clean syngas produced from selected feedstocks for 8-, 24-, and 100- hours operation.	Test results submitted to NDIC and summarized in Final Report	17 - 22
5	Final Report Preparation and Submission	M6	Final report submitted to and accepted by NDIC.	Final report which includes updated economic models, and plant performance (inputs, outputs, yields, etc.) as defined in the deliverable requirements	22 - 24

BUDGET

Project Associated Expense	NDIC's Share	Applicant's Share (Cash)	Applicant's Share (In-Kind)	Xcel Energy Share
Personnel	$249,400	$189,000	$0	$86,250
Equipment	$157,000		$0	$63,000
Supplies	$46,250		$0	$20,500
Contractual	$30,250		$0	$19,750
Other Direct	$4,050		$108,000	$5,500
Total	$486,950	$189,000	$108,000	$195,000

Direct salaries are for a portion of Nikhil Patel, engineers' and the operations/technician salaries required to complete the proposed project. Fringe benefits are included in the personnel costs. The salaries shown as cost share will be contributed by Tri-Steel Manufacturing and SET.

Equipment will be purchased to clean the raw syngas from the gasifier to the purity and composition required to directly convert the syngas to bio-based fuels. This includes a shift reactor, CO_2 removal, solvent and sorbent gas cleanup systems. Analytical equipment to allow measurement and control of the syngas quality will be purchased through a $150,000 grant from the North Dakota Department of Agriculture Bioscience Innovation Grant Program (this $150,000 is not shown on the budget as it is not allowed as cost share towards this application).

Small parts, piping, electrical wiring, etc. is required to support the modifications and upgrades to the system. Supply dollars will be used to procure and ship the various feedstocks to be tested as a part of the program. These dollars are also required to replace the consumables used during proposed tests.

SET has a small work force and relies on consultants to provide expertise needed to support their project. These include Tri-Steel Manufacturing, MDM Energy Consulting LLC, and Sage Green NRG.

Oher direct costs provide analytical support required to obtain detailed characterization of all streams (solid, liquid, and gaseous). This information will be required by potential customers to evaluate our technology and apply for permits. An independent certified laboratory will be used for all critical analysis. Rental of the 5 ton/day gasifier from Tri-Steel Manufacturing is also included in the budget and shown as a part of the cost share. The DOE approved rental rate is $20,000/month. It is estimated that the gasifier would need to be committed to this project for approximately 30% of the time, and therefore the rent was prorated to $6,000/month (30% of $20,000)

No indirect costs are included in this budget.

The applicants share of budget includes salaries paid by Singularity Energy Technologies and Tri-Steel Manufacturing. Xcel Energy has included this project as a part of their Natural Gas Innovation Act (NGIA) filing at a value of $195,000. Final approval from the Commission is expected soon. As noted in the equipment section, SET has received an award for $150,000 from the Bioscience Innovation Grant program. These funds, in addition to the required $75,000 match will be used in support of this project as the goals of the two projects overlap. These dollars are not included in the budget shown above and are not counted as cost share towards this project. This budget also does not include the estimated

value ($71,820/yr) of the lease agreement with the City of Grand Forks. When these costs are included in the budget, NDIC's share of the total project costs are 38%.

A detailed budget is presented in the appendix.

TAX LIABILITY

Singularity Energy Technologies does not have an outstanding tax liability owed to the State of North Dakota or any of its political subdivisions.

CONFIDENTIAL INFORMATION

No confidential information is presented in this application.

PATENTS/RIGHTS TO TECHNICAL DATA

The patented Sandwich gasification technology is owned by SET. The technology was invented at UND's Energy & Environmental Research Center (EERC) by Dr. Patel (founder of SET), and the IP rights were transferred to his company. DGP has permission to use the patented technology and associated technical/design information for the execution of the proposed project. In certain cases, our unique understanding that we would gain from our testing efforts will lead to new procedure design/operation for which we will file domestic and foreign patent applications as necessary. Finally, the performance data and experience we develop with increasing deployment of our technology will represent a competitive advantage and a barrier for new entrants. Patents in the SET portfolio include:

U.S. Patent No. 10,011,792. Date of Patent: July 3, 2018.U.S.

U.S. Patent No. 10,550,343 B2. Date of Patent: February 4, 2020.

U.S. Patent No. 11,220,641. Date of Patent: January 11, 2022.

U.S. Patent No. 11,702,604 B2. Date of Patent: July 18, 2023

Canada Patent No. 2808893. Date of Patent: June 5, 2018.

China Patent No. CN103154210, (issued 2015)

European Patent No. EP2606105, Published on 26th October 2022

European Patent Application, 22199757.0. Divisional from 11818649.3.

STATE PROGRAMS AND INCENTIVES

Title: Support for the Commercialization of the Sandwich Gasifier; 3/2020 – 6/2021; $237,000 (North Dakota Department of Commerce Research ND), $474,000 (Total Project).
Title: Biofuel and Biomaterial Production from North Dakota Biomass using the Sandwich Gasifier; 10/2023 – 6/2025; North Dakota Bioscience Innovation Grant, $150,000 with a $75,000 match.

Transmittal Letter

SINGULARITY ENERGY TECHNOLOGIES, LLC
WASTE TO ENERGY

Dr. Nikhil Patel
Founder and CEO

Suite 201, 4200 James Ray Dr.
Grand Forks, ND 58202
Cell Phone: 701-739-8720
https://www.singularet.com

July 31, 2024

North Dakota Industrial Commission
Attention: Renewable Energy Program
State Capitol – 14th Floor
600 East Boulevard Ave Dept 405
Bismarck, ND 58505-0840

Subject: Singularity Energy Technologies proposal entitled "Accelerating the Waste-to-Fuels Commercialization for the Sandwich Gasifier"

Enclosed, please find an electronic copy of the subject proposal entitled " Accelerating the Waste-to-Fuels Commercialization for the Sandwich Gasifier", which is being submitted to the NDIC Renewable Energy Program.

This proposal seeks to test technology and devise improvements, enabling reliable gasification of renewable feedstocks to produce sustainable liquid fuels, renewable natural gas, and green hydrogen in a reduced carbon emissions context. The proposed work's main benefit is in developing a production technology that is modular giving it the ability to be located in rural or urban settings, close to the feedstock source. The Sandwich gasifier technology can provide flexibility to operations as it can accommodate various feedstocks without pre-blending, which is an important consideration when using biomass and waste materials with changing availability due to seasonal variations.

Successful completion of this project will greatly expand the understanding of how to utilize North Dakota's vast biomass resources, including municipal solid wastes, to produce sustainable liquid fuels, renewable natural gas, and green hydrogen. This will provide the State with options to reduce carbon emissions through renewable feedstock utilization.

If you have any questions, please contact me by telephone at (701) 739-8720 or by e-mail at npatel@singularET.com

Sincerely,

Nikhil Patel
CEO
Singularity Energy Technologies, LLC

Industrial Commission

Tax Liability Statement

Applicant:

NewCarbon Feedstocks, LLC

Application Title:

ACS NewCarbon RNG Project

Program:

- ☐ Lignite Research, Development and Marketing Program
- ☑ Renewable Energy Program
- ☐ Oil & Gas Research Program
- ☐ Clean Sustainable Energy Authority

Certification:

I hereby certify that the applicant listed above does not have any outstanding tax liability owed to the State of North Dakota or any of its political subdivisions.

Signature

President

Title

July 31, 2024

Date

Accelerating the Waste-to-Fuels Commercialization for the Sandwich Gasifier

Application to the NDIC Renewable Energy Program

Appendices

Appendix A – Rationale for Proposed Approach

Appendix B – Resumes of Key Personnel

Appendix C – Letters of Support

Appendix D – Projected Economic Performance of Sandwich Gasification Technology on Various Feedstocks: Customer Acceptance

Appendix E – Example Life Cycle Assessment

Appendix F – Detailed Budget

APPENDIX A

RATIONALE FOR PROPOSED APPROACH

RATIONALE FOR PROPOSED APPROACH

The following subsections first present details on the Sandwich gasifier itself, which is critical to fully meeting the goals of this proposal. Secondly, results from previous testing demonstrating the potential of the integrated system to meet the required specifications while still obtaining near-zero effluent/emissions will be presented.

Gasifier Island: Unlike typical gasifiers which can only maintain gasification temperatures in limited zones, the unique configuration of the Sandwich Gasifier enables it to process feedstocks of varying compositions and moistures while maintaining optimal temperatures for higher syngas qualities and quantities. The Sandwich configuration (see Figure A1) incorporates an endothermic reduction zone sandwiched between two high-temperature oxidation zones, thus maintaining uniform gasification temperatures throughout extended reaction zones. This enables complete gasification of the material, maximizing syngas production while preventing formation of tar residues.

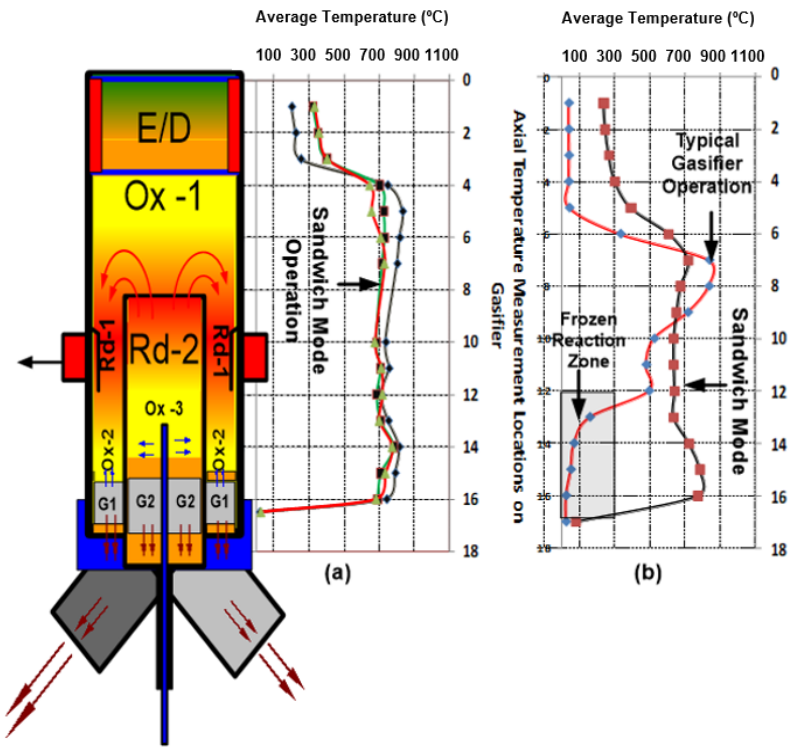


Figure A1. Schematic of the Sandwich Gasifier and its interior temperature profile showing oxidation (Ox) zones where limited combustion occurs and reduction (Rd) zones where syngas forms (gasification) and is extracted. The crucial aspect of the Sandwich Gasifier design is its ability to maintain uniform high temperature zones which increase syngas production efficiency, composition control, and diminishes production of tar and char materials. As seen in (a), this enables the Sandwich Gasifier to process multiple feedstocks with different compositions. As seen in (b) although processing identical fuels, a downdraft gasifier cannot maintain the temperatures required to produce clean syngas. This results in partial gasification and formation of excessive char and tar, degrading efficiency and increasing syngas production costs.
(US PTO 13210441)

The project team has tested a wide variety of fuels at a variety of scales, including the 2 lb/hr laboratory-scale system, the 70 lb/hr bench-scale system, and the 5 ton/day truck-mounted system, with moisture content of the feedstocks tested ranging from 5.6% to 47% and the volatile-to-fixed carbon ratios ranging from 0.26 to 7.9. This shows the ability of the Sandwich gasifier to accommodate feedstocks with a wide and variable range of properties. Figure A2 shows results from the nominal 14-hour tests, demonstrating the uniform temperature distribution in the gasifier and the quality of the syngas produced.

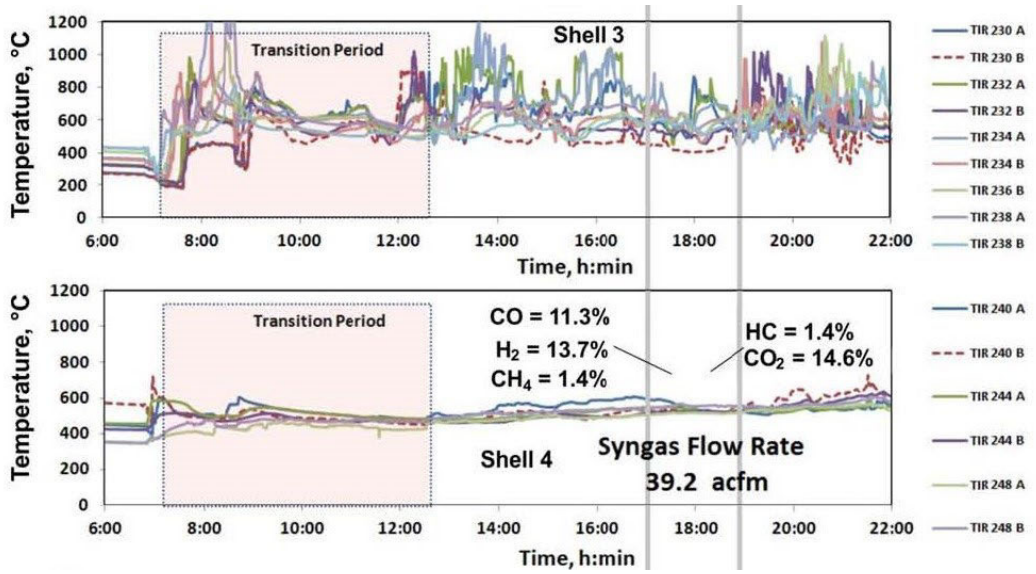


Figure A2. Temperature and syngas compositions for testing with high-moisture white spruce chips

Gas and Effluent Cleanup: To maintain distributed scale operation within the constraints of low capital and operating cost the gasification and the bulk of the syngas cleaning occurs at atmospheric pressure and low-temperature which allows use of conventional carbon-based sorbents. As stated previously, the Sandwich gasifier inherently produces a low-level of tar (<1 g/Nm^3), simplifying the steps required to meet tar specifications. The proposed wet scrubber removes the water-soluble tar species and a portion of the non-water solubles. Results from tar sampling performed during gasification testing of railroad ties show virtually no water-soluble tars with a total tar level in the effluent from the scrubber at approximately 0.2 g/m^3 (~25 ppmv). While this is low, additional tar removal will be necessary to meet the GTL/RNG/H_2 specifications. As discussed in the work scope, this will be accomplished via condensation in a syngas cooler. This cooler (heat exchanger) is designed to accommodate tar buildup on its surfaces. Tar removal will be accomplished via a solvent wash. Two heat exchangers in parallel allows taking one exchanger off line for "tar washing" without disrupting the operation of the system.

Final polishing of the syngas to meet the stringent guidelines for GTL/RNG/H_2 production occurs in two stages, **the first stage** uses a series of sorbent filled packed beds and or solvent columns at room temperature and at close to atmospheric pressure. Since a prior study revealed difficulty in capturing Hg in hot (>200 F) beds, the proposed strategy helps address some of the prior limitations in hot-syngas cleanup. The sorbents and any solvents used will be selected based upon the expected syngas impurities (determined for each feedstock via screening tests). The **second-stage** polishing will occur post syngas-shift and CO_2 scrubbing processes at GTL/RNG/H_2 system operating pressure, prior to syngas preheating. This will allow the system to be optimized choosing only those systems that necessary for the feedstock, but at the same time sufficient to meet the targeted gas composition. For example, arsenate is expected to be a concern for some but not all feedstocks. Likewise, PFAS may be a concern of biosolids and MSW, but not for other biomass feedstocks. Therefore, the recommended treatment system will be optimized for each feedstock to minimize overall cost while still obtaining the required overall removals.

As an example, work has been performed at the Energy and Environmental Research Center (EERC) in conjunction with DOE to develop methods to remove contaminants from syngas to levels suitable for a

hydrogen separation membrane. The warm-gas cleanup train is capable of removing sulfur, particulate, chlorine, and trace metals including mercury at temperatures above 400°F. All of the technologies utilized are considered either commercial or near-commercial in development.[1] The warm-gas cleanup train tested at the EERC can provide WGS reactions and/or removal of sulfur, chlorine, and trace metals (including mercury) at temperatures above 204°C (400°F). The basic principle of the warm gas cleanup train is the utilization of solid catalysts and sorbents in fixed beds at elevated temperature to shift composition of the syngas and remove unwanted contaminants. An example configuration tested included Fixed Beds 1 and 2 loaded with Johnson Matthey's KATALCO® K8-11 sour shift catalyst to provide WGS reactions. Fixed Beds 3 and 4 were used for sulfur capture (hydrogen sulfide and carbonyl sulfide) with a regenerable adsorbent (RVS-1, a regenerable zinc oxide-based adsorbent developed by DOE NETL and manufactured by RTI for Süd-Chemie (now Clariant)). In prior testing, RVS-1 has been demonstrated to reduce sulfur to single-digit ppm levels in the syngas. Fixed Bed 5 is a sulfur polishing bed and was loaded with Clariant ActiSorb® S 2. The two-stage sulfur removal process has been demonstrated to produce H_2S levels below our detection limits of 10 ppb.

CO_2 removal is also an important and can be accomplished using a variety of technologies. We propose to evaluate two approaches, conventional CO_2 scrubbing using NETL recommended solvents such as ARG2[2] and newer membrane separation techniques such as the developed by Membrane Technology and Research LLC.[3] The CO_2 captured can be recycled back into the gasifier where it will be thermally reformed, serving to both increase the yield of liquid product from the GTL conversion and to reduce overall CO_2 emissions. This also has the advantage of better control of the temperature allowing the gasifier to operation at optimal temperature.

Near-Zero Emissions: An important goal of the system is near-zero emissions. Testing has determined the feasibility of organic removal from gasifier condensate water using adsorption on chars produced during gasification of biomass feedstock: two types of char produced in the Sandwich gasifier were investigated.[4] Isotherm data verify that the char produced in the Sandwich gasifier is an effective sorbent for phenolics and other organics in gasifier condensate water present at initially relatively high concentration with final effluent levels <3 mg/L. Other organics (cyclic ketones) are also adsorbed, except for some highly volatile components that may be stripped by air sparging. Further sorption kinetics data are needed to determine the size and optimal configuration of the sorbent beds. These studies are planned as part of the proposed effort.

Testing has also demonstrated that the direct injection of char and tars into the gasifier is a viable method to eliminate the need for secondary treatment and/or disposal of these materials. Reinjection of these materials as a part of the overall process eliminates the production of effluents that could potentially be classified as hazardous wastes, with a favorable result of increased hydrogen yield. The Stage 1 process of syngas production can, thus, attain near-zero effluent discharge, an important benefit of this technology.

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[1] Subtask 2.1 – Pathway to Low-Carbon Lignite Utilization, Topical Report for the Period September 15, 2015 through May 31, 2017. Cooperative Agreement Number DE-FE0024233. May 17, 2017

[2] Biomass Cofiring with Precombustion Carbon Capture Baseline Testing at UND EERC, Final Report. December 2021.

[3] Kniep, J.; Bench-Scale Development of a Transformative Membrane Process for Pre-Combustion CO2 Capture; Final Report for DE-FE0031623, July 27, 2022.

[4] Reference tar-water study

Appendix B – Resumes of Key Personnel

Nikhil Patel

Michael Mann

Nichalos Ralston

Ed Olson

SINGULARITY ENERGY TECHNOLOGIES, LLC
WASTE TO ENERGY

DR. NIKHIL PATEL
Founder & CEO

Suite 201, 4200 James Ray
Dr. Grand Forks, ND 58202
Cell Phone: 701-739-8720
https://www.singularet.com

Principal Area of Expertise

Dr. Patel has 25 years of research and technology development experience in the combustion and gasification of biomass, coal, and unconventional, difficult-to-burn liquid and solid industrial and municipal solid wastes. Dr. Patel currently leads efforts to commercialize mobile truck-mounted and stationary waste conversion technologies. These technologies utilize the patented Sandwich™ gasification process he invented while working at the Energy & Environmental Research Center (EERC).

Dr. Patel joined EERC in 2002 and focused efforts on inventing, developing, and commercializing innovative gasification technologies for distributed energy and Fischer–Tropsch (FT) liquid fuel production. As a research manager and research scientist at the EERC, he led the design, construction, and project management team responsible for implementing gasification-based demonstration and commercialization projects.

Dr. Patel founded Singularity Energy Technologies, LLC, in 2014 to commercialize the Sandwich gasification technology. SET uses the Sandwich gasification technology it owns as a core technology for waste conversion to electricity and FT liquids and chemicals. In 2020 he co-founded and led as CEO of Dakota Green Power Co (DGP), an operating company for manufacturing and deploying SET's Sandwich Gasification technology.

Qualifications

Ph.D. (2001), Aerospace Engineering, Indian Institute of Science, Bangalore,
M.S. (1993) and B.E. (1991), Mechanical Engineering, University of Baroda, Baroda.

Professional Experience

2020–Present: Co-founder & CEO, Dakota Green Power Co (DGP)
2014–Present: Founder & CEO, Singularity Energy Technologies, LLC (SET)
2005–Present: Adjunct Professor, Institute of Energy Studies (IES), Department of Chemical Engineering, UND.
2015–Present: Research Engineer Lead, Distributed Energy Technologies, EERC, UND.
2012–2015: Research Manager, EERC, UND.
2002–2012: Research Scientist, EERC, UND.
2002: Visiting Researcher, EERC, UND.
2000–2002: CSIR Research Associate, Indian Institute of Science, Bangalore, India.
1994–2001: Research Scholar, Indian Institute of Science, Aerospace Engineering Department, Bangalore, India.
1993–1994: Lecturer, University of Baroda, Baroda, India.
1991–1992: Research Assistant, University of Baroda, Baroda, India.
1989: Engineer Trainee, Mukund (Iron and Steel) Ltd., Bombay, India.

Publications and Presentations

Has authored and/or coauthored more than 35 publications and holds four patents, including; IP07-013 – Sandwich Gasification Process for High-Efficiency Conversion of Carbonaceous Fuels to Clean Syngas with Zero Residual Carbon. U.S. Patent No. 10,011,792 (issued 2018), 10,550,343 (issued 2020), US 11,220,641 B2 (Issued 2021), US 17/570,448 (Filed 2021) Canada Patent No. 2808893 (issued 2018), China Patent No. CN103154210, (issued 2015), European Patent Application No. 11818649.3 (Grant fees paid February 2021)

mdm energy consulting, llc

701.215.2900 • mike.mann@mdmenergy.net • thompson, nd

MICHAEL D. MANN, Principal

Principal Areas of Interest and Expertise:

Dr. Michael Mann is the founder and Principal of MDM Energy Consulting LLC. His company was founded in 2015 to provide clients with design services, economic assessments and feasibility studies, formulation and execution of research and development projects, and project management support. He has been working in the energy field since 1981 where he has been involved in developing a wide range of technologies, including energy production from combustion and gasification, wind, and geothermal resources along with energy storage options. He has experience with the extraction of rare earth and other critical materials from coal, brines, and spent catalysts, and has explored options to add value biomass, lignite, and other low-grade carbonaceous materials. Much of his activity focuses on system integration and the development of energy strategies coupling thermodynamics with political, social, and economic factors. Dr. Mann has over 215 publications and has secured over $35 million in research funding during his career.

Qualifications:

Mayville State University	Chemistry, Mathematics	B.A., 1979
University of North Dakota	Chemical Engineering	M.S., 1981
University of North Dakota	Business Administration	M.B.A.,
University of North Dakota	Energy Engineering	Ph.D., 1997

Dr. Mann's ability to develop and manage large research projects while juggling a wide range of other activities was recognized when he was awarded UND's highest honor, the Chester Fritz Distinguished Professorship. He has been awarded UND's highest award for Excellence in Research and the UND Foundation Faculty Scholar Award, recognizing his combined excellence and contributions in teaching, research and service to the university. Dr. Mann helped develop major research centers at UND including SUNRISE, a faculty driven sustainable energy center and the Petroleum Research Education and Entrepreneurship Center of Excellence (PREEC). He was recognized for these efforts when he received UND's Interdisciplinary Collaborative Research Award. He was a primary player in the development of the Institute for Energy Studies.

Professional Experience

2015 – Present: Principal, MDM Energy Consulting, LLC:

Provide support in all phases of client's energy and chemical processing projects. Available to support design of pilot and demonstration systems, develop and implement experimental test plans, analyze data to optimize system design and operation, assist in writing proposals to funding agencies, performing techno-economic analysis and life-cycle analysis, and providing project management support. Technical areas of expertise include integration of energy systems, combustion and gasification technologies, geothermal energy, air pollution control, waste-to-energy systems, and chemical processes.

2009 - 2022: College of Engineering (Associate Dean 2013-14; Associate Dean for Research

2009-13; 2018-2022), University of North Dakota (UND):

Provided advice and support to the Dean in issues related research and development within the college and support academic affairs. Responsible for the implementing the college's major research goals, promoting a culture of research in the college, enhancing research opportunities for faculty and students, and providing administrative oversight for proposal submittal and grant accounting.

2014 –2021: Executive Director, Institute for Energy Studies:

Helped realize the Institute's goal of developing UND into a premier "Energy University" that "inspires the creation of new knowledge to enable the development of revolutionary energy technologies, train the next generation of energy experts, and establish advanced industries required to make affordable emissions free energy technologies a reality". Responsibilities included identifying key technical and economic barriers to the development of secure, affordable, and reliable energy production technologies; identifying proposal opportunities and develops new relationships with potential partners; and drawing from resources across campus building teams to deliver the research, education, and outreach required to meet the needs of public and private partners. Highlights include directing over $12 million in research in rare earth elements resulting in the design and construction of a 12 ton/day pilot processing facility and developing the IES into a go-to research support unit for emerging small businesses.

1999 – 2022: UND Department of Chemical Engineering (Professor, 2006-2022; Chair 2005-13; Associate Professor, 1999-2006):

Developed a reputation as an engaging teacher, excellent researcher, and inspirational leader. Awarded UND's highest honor, the Chester Fritz Distinguished Professorship in 2009 in recognition for his accomplishments in research, teaching, and service. Led the Department to UND's top departmental awards for Excellence in Research in 2005 and 2011 and Excellence in Teaching in 2007. Co-founder of the SUstainable eNergy Research, Infrastructure, and Supporting Education (SUNRISE) group in 2004. SUNRISE now has over 30 faculty participants from 12 different departments and 4 North Dakota Universities with over $20 million in research grants. Served as the primary research advisor for over 30 PhD students and 40 Master's students.

1981-99: UND Energy & Environmental Research Center (Sr. Research Mgr, Advanced Processes and Technologies 1994-99; Research Mgr, Combustion Systems 1985-94; Research Engineer 1981-85):

Activities evolved from hands on research to the development and marketing of ideas and technology. Involved in a wide range of technology development, including energy production from combustion and gasification, wind, and geothermal resources. Highlights include management of over $15 million in research projects; design, installation, and operation of a 1 MWth CFBC; design, installation, and operation of a 250 lb/hr gasifier; development of small power systems for Alaskan villages; and the development of a small-modular fluid-bed combustion system (0.5 to 5 MW)

Nicholas V.C. Ralston
Ph.D. Biomedical Research

Environmental Health Emphasis Area:
My team is working to deploy Smart Waste Converters which use the recently patented Sandwich Gasifier technology. Through a growing network of interested individuals, companies, and government agencies, we are promoting development of projects and proposals to support funding and investment in these crucial additions to commercial and community infrastructure.

Public Health Emphasis Area:
I also lead international efforts to update scientific understanding of the effects of maternal consumption of seafood on child health outcomes. This has grown to include consideration of a broader range of exposures which may affect public health.

Current and Former Positions:

2014-Present; Director, Sage Green NRG (See our website at https://www.sagegreennrg.com/)
Our work increasingly involves deployment of Smart Waste Converter Systems. These systems were patented by Dr. Nikhil Patel, Founder and Director of Singularity Energy Technologies (SET). His advanced approach to gasification minimizes problems which prevented previous technologies from profitably converting mixed wastes into electrical power and/or liquid fuels. His Sandwich gasification technology is the least expensive and most efficient option available to diminish pollution of the land, sea, and air. Sage Green NRG has contributed to major proposals in this area and we are developing regional, nation-wide and international relationships in preparation for deployment of these systems.

My group provides Nutrition Research Guidance as well as Natural Resource Guidance (the origin of the "NRG" in the name of our company). Our public health emphasis is on improving reliability of risk assessments by applying biochemical perspectives to more accurately predict the health effects of nutrients present in ocean fish. Increased maternal intakes of these nutrients are responsible for the ~7.7 point increases in the IQ's of their children. We were funded by the US EPA to develop a more reliably accurate seafood safery criterion which is known as the Health Benefit Value (HBV). Consumption of seafoods and fish with positive HBV's will improve maternal and fetal health while those with negative HBV's would be predicted to put it at risk. To continue our work on the EPA, NOAA, and seafood industry funded projects performed to establish the HBV criterion, we are advising the FAO and WHO organization as well as regulatory agencies of various nations on the importance of adopting this criteria.

2015-Present; Adjunct Faculty, Earth Systems Science & Policy, University of North Dakota
I continue to advise on nutrition in health assessments of risks vs. benefits of maternal fish consumption in studies that have been performed in the Seychelles, Hawaii, Saudi Arabia, Peru, and regularly provide invited keynotes at major meetings. I am developing a Toxicology Forum on selenium-mercury issues and recently authored an invited review, 3 book chapters, and am writing a book that contrasts the risks formerly believed to be associated with mercury exposures from eating certain varieties seafood vs. the notable beneficial effects that have instead been observed among children whose mothers eat ocean fish.

2013-2019; Faculty, Masters in Public Health Program, University of North Dakota
I developed the environmental health core curriculum for the MPH program and taught Environmental Health courses. I obtained funding for and led the "Sustainable Cities Initiative" for multidisciplinary studies involving UND students and faculty interacting with city, state, and federal agencies.

2012-Present; Faculty, Undergraduate Nutrition courses at Grand Forks Air Force Base
Along with other work, I provide nutrition courses to members of the military and their families at the Grand Forks Air Force Base. Many students from UND commonly choose attend these courses.

2005–2016; Health Effects Program Leader, EERC, University of North Dakota
I led research health/environment research groups, advised on mercury studies worldwide and served on EPA Science Advisory Boards as a Mercury Review Panel Member and coordinated/chaired a series of "International Symposia on Selenium-Mercury Interactions" conferences.

2002–2016; Biomedical Research Scientist, EERC, University of North Dakota
My training background in the molecular basis of disease enabled me to identify the biochemical causes and fully define the pathophysiology of mercury toxicity. This led to the "Health Benefit Value" (HBV) criterion which reliably indicates neonatal mercury exposure risks vs. nutritional benefits of maternal fish consumption.

1998–2002; GS-12 Biochemist, Grand Forks Human Nutrition Research Center, USDA
I led the methods development group that created research and laboratory protocols to examine boron and selenium biochemistry/physiology and developed novel methods to quantify molecular binding interactions and examine the significance of selenium in brain metabolism, inflammation, and neurodevelopment.

Education and Training:

1974-1978; Biology, Chemistry, & Earth Science, Mayville State University, Mayville, ND.
Graduated with a B.S. composite major in biology with dual minors in chemistry and earth science.

1989–1995; Fellow, Biomedical Research, Mayo Clinic Graduate School, Rochester MN.
I joined the molecular pathology program at the Mayo Medical Center (Rochester, MN) with rotations in hematology, coagulation, molecular biology, and laser fluorescence spectroscopy prior to my research in thoracic disease. I developed novel methods to quantify inflammatory mediators and characterize the molecular etiology and biochemical pathways which result in the pathogenesis of Byssinosis, an acquired pulmonary disorder.

1995–1998; Fellow, Bowman Gray Medical School, Wake Forest University, Winston-Salem NC.
I discovered the biosynthetic pathway of bis(monoacyl-glyerol) phosphate (BMP), a lysosomal phospholipid that avoids degradation due to its unique sn1:sn1' structure. My work provided stereospecifically tritiated substrates for laboratories around the world and identified the crucial reactions of the biosynthetic pathway that forms BMP.

Publications:
My work has resulted in 2 books, 12 book chapters, >12 documentaries, websites, or online interviews, >80 additional publications, (~40 in research journals, the rest as annual and final project reports for government agencies and other sponsors), >100 platform presentations (>50 were invited keynotes) and I have coordinated and chaired 14 international meetings on the updated understanding of the mercury issue. My group recently finished a book titled "Smart Waste Converters" which describes Sandwich gasifier applications in solving public and environmental health issues. This will be used as a marketing tool and provide background for commercial partner organizations as well as in training seminars to support development and commercial expansion efforts.

Achievements:
As Principal Investigator in public and environmental health studies, I performed >$5,000,000 in research for the US EPA, NOAA, DOE, and industry partners in projects that has dramatically changed how US and international regulatory agencies perceive mercury exposures from maternal seafood and freshwater fish consumption.

My group established a new paradigm for the biochemical mechanisms of toxicity of entire classes of toxic agents and created the Health Benefit Value (HBV) criterion which is the most reliable index of the risks associated with exposures to mercury vs. benefits of nutrient intakes from eating typical varieties of seafoods and freshwater fish.

I currently advise international and national health agencies and most recently gave an invited presentation for the Queen of Spain who has been appointed as FAO's special ambassador for Nutrition to the United Nations.

I provided the keynote presentation "Smart Waste Converters: The Sustainable Solution" for >2,000 attendees at the Karnataka Assocham GEM Chapter meeting: "Towards a Technological and Sustainable Built Environment."

DR. EDWIN S. OLSON
Consultant
223 Circle Hills Dr.
Grand Forks, North Dakota 58201
(701) 772-5403, eolson@gra.midco.net

Education B.A., Chemistry, magna cum laude, St. Olaf College, 1959.
Ph.D., Chemistry and Physics, California Institute of Technology, 1964.
Postdoctoral, University of California, Los Angeles, Laboratory of Nuclear Medicine and Radiation Biology.1964.

Professional Experience
2014 to present" Consultant on energy and environmental issues for ME2C (mercury emissions) and SET (gasification effluents).
2013: Part time work at EERC, UND, following retirement. Provided consultation and analytical services.
1994–2012: Senior Research Advisor, EERC, UND. Conducted extensive research programs in the following areas: 1) Developed new models for mercury-carbon-flue gas interactions and mercury sorption on carbon, resulting in a number of patented mercury control methods for power plant emissions. 2) Developed novel methods for carbon dioxide capture with magnesium and amine reagents4. 3) Developed and patented novel levulinate biorefinery, an algae-to-fuels and chemicals biorefinery, a dual fermentation biorefinery, a biomass pyrolysis biorefinery, a method for preparing polyamines from biomass pyrolysis products. In addition to these research activities, Dr. Olson served as in house consultant to engineers in gasification, pyrolysis, and liquefaction projects.
1988–2002: President, Universal Fuel Development Associates, Inc., Grand Forks, North Dakota. Dr. Olson served as Project Manager for Phase I and II Small Business Innovation Research (SBIR) projects involving water purification, nonaqueous enzymatic solubilization of coal materials, fuel oxygenate synthesis from agricultural materials, and fine-particle catalysts for coal liquefaction.. Also he was project manager for a large U.S. DOE contract involving geotechnical and analytical characterizations of many US power utility byproducts (ash and solid wastes).
1983–1994: Research Supervisor, Process Chemistry and Development, EERC, UND. Dr. Olson performed hydrotreating and catalyst research, coal liquefaction, and gasification research, and analytical methods development.
1980–1983: Research Chemist, Grand Forks Energy Technology Center, DOE, Grand Forks, North Dakota. Dr. Olson developed analytical methods for coal gasification and coal liquefaction products and byproducts in air, water, and fly ash by GC, MS, HPLC, and NMR.
1968–1980: Professor of Chemistry, South Dakota State University. Dr. Olson taught graduate and undergraduate courses in organic, biochemistry, and instrumental analysis. Research projects involved catalyst development, synthesis of antimicrobial heterocyclic compounds, amino acids, and fatty acids.
1977: Professor, University of Notre Dame, South Bend, Indiana. Summer faculty appointment.
1972–1976 summers: Visiting Staff Member, Los Alamos Scientific Laboratory, Los Alamos, New Mexico. Dr. Olson performed synthesis and biosynthesis of labeled amino acids and heterocyclics.
1964-1968: Assistant Professor, Idaho State University Department of Chemistry.

Synergistic Activities: Dr. Olson is past-chair of the American Chemical Society Division of Fuel Chemistry.

Publications: Dr. Olson has over 250 publications and papers and over 25 patents.

Appendix C – Letters of Commitment and Support

Public Works Department
724 North 47th Street
PO Box 5200
Grand Forks, ND 58206-5200

CITY OF GRAND FORKS NORTH DAKOTA

SHARON LIPSH
PUBLIC WORKS DIRECTOR
(701) 738-8740

April 15, 2024

Singularity Energy Technologies
Dr. Nikhil Patel, President
4200 James Ray Drive
Grand Forks, ND 58202

RE: Letter of Support for the Singularity Energy Technologies proposal to the U.S. Department of Energy DE-FOA-0003082

Dear Dr. Patel,

The City has entered into a three-year lease agreement with Dakota Green Power for Phase I, which encompasses a 5 ton/day pilot demonstration of your gasification technology, with the potential of a Phase II expansion to 25 ton/day unit. The City recognizes the potential benefits of your project, particularly in mitigating waste going into the city's landfill and fostering the development of new manufacturing ventures within Grand Forks.

The City Council has approved a three-year lease of space at the City of Grand Forks Landfill, utilizing the building that formerly housed our baling facility. The lease agreement grants you access to 10,260 sq. ft. of space, with a nominal annual lease value of $71,820, provided to you at a token lease rate of $1.00.

We are willing to supporting your project by supplying approved solid waste types for conversion upon request, contingent upon your acquisition of an approved Solid Waste Permit from the North Dakota Department of Environmental Quality. Notably, we recognize your interest in utilizing forestry/tree trimming/wood wastes, which are readily available at the City's inert landfill and will be furnished upon your request.

Furthermore, we are prepared to collaborate with you and Nodak Electric, the local electric cooperative serving the City Landfill, to facilitate the establishment of net-metering arrangements for the produced electricity back into the system.

The City of Grand Forks eagerly anticipates the commencement of your demonstration project.

Sincerely,

Sharon Lipsh
Public Works Director

Xcel Energy®
RESPONSIBLE BY NATURE®

July 29th, 2024

Dr. Nikhil Patel
President, Singularity Energy Technologies, LLC
4200 James Ray Drive
Grand Forks, ND 58202

Subject: Xcel Energy Letter of Support for the Singularity Energy Technologies LLC (SET) proposal to North Dakota Renewable Energy Council

Dear Dr. Patel,

Thank you for sharing your intentions to submit a proposal for a 5 ton/day pilot-scale system to the North Dakota Renewable Energy Council. The work you are proposing aligns with the proposed R&D project within Xcel Energy's Natural Gas Innovation Act (NGIA) filing, which was filed in December 2023 and is currently going through Commission review and approval. Xcel Energy supports SET's proposal which will enable funding to further research technologies that may be able to help support the energy transition towards carbon free resources such as renewable natural gas, bio-methanol and hydrogen which are also of interest to Xcel Energy.

Xcel Energy is a clean and renewable energy leader and was the first utility to establish a goal to provide its customers with carbon-free electricity by 2050 and Net-Zero emissions in the natural gas local distribution company ("LDC") by 2050. For the reviewers of your proposal, Xcel Energy through the NGIA funding plans to support SET's gasification technology advancements. This R&D project will assess the technical and economic viability of the Sandwich gasifier as a reliable and efficient method for converting Minnesota's diverse biomass resources into high-quality syngas suitable for production of renewable natural gas or hydrogen as well as useful biomaterials such as biochar. Xcel Energy supports the North Dakota Renewable Energy Council funding to help advance SET's technology as having the potential to help Xcel Energy lead the clean energy transition and meet the company's long-term carbon free 2050 goals.

We wish you luck with your submission to the Renewable Energy Council and are looking forward to working with you on the first phase of our NGIA project after commission review and approval.

Sincerely,

Kathryn Valdez
AVP, Corporate Planning & Carbon Free Technology
Xcel Energy

Tristeel Manufacturing Company
3001 N Washington St
Grand Forks, ND 58208
1-800-279-2689
www.tristeelmfg.com

July 29, 2024

Dr. Nikhil Patel
President, Singularity Energy Technologies
4200 James Ray Drive
Grand Forks, ND 58202

Subject: Letter of Commitment for the Singularity Energy Technologies proposal to the ND Renewable Energy Program

Dear Dr. Patel,

I am happy to provide support for your proposed project to Singularity Energy Technologies' proposal to North Dakota's Renewable Energy Program. As one of Grand Forks' major farm equipment manufacturers and the owner of the 5-ton/day truck-mounted system, we can assist in all aspects of your project. We will provide labor to help complete your proposed project goals. Based upon your input, we will provide approximately $115,000 in labor towards your project as a mix of engineers, technicians, and operators to best meet the needs of your project. Tri-Steel Manufacturing is committing this amount as an in-kind cost share towards the NDIC cost-share requirements. We will also provide full rent-free access to the 5 TPD truck-mounted system as an in kind cost share equivalent to $108,000.

Sincerely,

Scott Homstad

Tristeel Manufacturing Co.

Grand Forks Region ECONOMIC DEVELOPMENT

April 4, 2024

Dr. Nikhil Patel
President, Singularity Energy Technologies
4200 James Ray Drive
Grand Forks, ND 58202

Subject: Letter of Support for the Singularity Energy Technologies proposal to the U.S. Department of Energy DE-FOA-0003082

Dear Dr. Patel,

The Grand Forks Region Economic Development Corporation (Grand Forks Region EDC) would like to express its strong interest and support for your proposal to the U.S. Department of Energy to build a 25 ton/day pilot facility demonstrating your Smart Gasifier technology. The Grand Forks Region EDC's mission is to expand economic opportunity through industry growth and diversification. Energy and environment is one of our key targeted sectors when prioritizing business development, along with the programmatic opportunities defined by our partners at the University of North Dakota. In result, our organization actively explores state and local opportunities that can be resourceful for the improvement of waste disposal concerns while simultaneously creating economic opportunities for the community. We are aware of the potential tax credits that may be generated using your technology. The ability to see a fully integrated pilot-scale system in operation producing electricity and liquid fuels would provide confidence from key state and local stakeholders to invest in this fascinating technology you have demonstrated with us through your company.

We hope you are successful in obtaining funding for this important demonstration and look forward to continuing to work with you as you fully commercialize your exciting technology.

Sincerely,

Kevin S Hatcher

Kevin Hatcher
Business Development Manager
Grand Forks Region Economic Development Corporation

HydroCarb1

04/14/2024

Dr. Nikhil Patel
President, Singularity Energy Technologies
4200 James Ray Drive
Grand Forks, ND 58202

Subject: Letter of Support for the Singularity Energy Technologies proposal to the U.S. Department of Energy DE-FOA-0003082

Dear Dr. Patel,

HydroCarb1would like to express its strong interest in and support for your proposal to the U.S. Department of Energy to build a 25 ton/day pilot facility demonstrating your Smart gasification technology. As you know from our discussions, HydroCarb1 is exploring opportunities that can deal with plastic waste disposal concerns in our area while simultaneously creating economic opportunities for the community. As we discussed, we are considering a facility to process 25-75 tons/day of plastic waste to produce electricity and fuels. The facility would be located in the St Cloud, MN area and operated by HydroCarb1. We are also aware of the potential tax credits that may be generated using your technology. The ability to see a fully integrated pilot-scale system in operation producing electricity and liquid fuels would provide us with the confidence needed to invest in your technology.

We hope you are successful in obtaining funding for this important demonstration and look forward to continuing to work with you as you fully commercialize your exciting technology.

Sincerely,

Jeff Grunenwald
CEO HydroCarb1
612-224-1004

ALAKAHI GLOBAL

Date April 3, 2024

Dr. Nikhil Patel
President, Singularity Energy Technologies
4200 James Ray Drive
Grand Forks, ND 58202

Subject: Letter of Support for the Singularity Energy Technologies proposal to the U.S. Department of Energy DE-FOA-0003082

Dear Dr. Patel,

Alakahi Globlal Inc would like to express our strong interest in and support for your proposal to the U.S. Department of Energy to build a 25 ton/day pilot facility demonstrating the ability of Smart gasification technology to produce methanol and hydrogen from a wide range of waste materials and biomass. As you know from our discussions, *Alakahi Global Inc* is exploring opportunities to deal with waste disposal concerns in our area while simultaneously creating economic opportunities and reducing greenhouse gas emissions. As we discussed, we are considering a facility to process *25* tons/day of *disposable waste* to produce *electricity* and talking with additional parties located in Maui Hawaii, Oahu Hawaii, and Africa that are interested in Smart gasification as a solution to their waste and energy issues. The first facility we are interested in developing would be located in *Kahalui, Maui* and operated by *Alakahi Global Inc.* We are also aware of the potential tax credits that may be generated using your technology. The ability to see a fully integrated commercial-scale system producing electricity and liquid fuels from various forms of biomass and waste materials would certainly enhance the confidence of future investors in your technology.

We hope you are successful in obtaining funding for this important demonstration project and look forward to continuing to work with you and your exciting technology.

Sincerely,

Dr. Nate Makaiwi
President and CEO of Alakahi Global Inc.
Las Vegas, NV
drnate@civilityglobal.com

Dr. Stacen Makaiwi
Vice President and COO of Alakahi Global Inc.
Las Vegas, NV
drstacen@civilityglobal.com

CITY OF
Belle
Fourche
SOUTH DAKOTA

April 8, 2024

Dr. Nikhil Patel
President, Singularity Energy Technologies
4200 James Ray Drive
Grand Forks, ND 58202

Subject: Letter of Support for the Singularity Energy Technologies proposal to the U.S. Department of Energy DE-FOA-0003082

Dear Dr. Patel,

The City of Belle Fourche would like to express its strong interest in and support for your proposal to the U.S. Department of Energy to build a 25 ton/day pilot facility demonstrating your Smart gasification technology. As you know from our discussions, The City of Belle Fourche is exploring opportunities that can deal with waste disposal concerns in our area while simultaneously creating economic opportunities for the community. As we discussed, we are considering a facility to process 125 tons/day of sorted municipal solid waste to produce heat, electricity, and sustainable methanol. The facility would be located in Belle Fourche, South Dakota and operated by the City. We are also aware of the potential tax credits that may be generated using your technology. The ability to see a fully integrated pilot-scale system in operation producing electricity and liquid fuels would provide us with the confidence needed to invest in your technology.

We hope you are successful in obtaining funding for this important demonstration and look forward to continuing to work with you as you fully commercialize your exciting technology.

Sincerely

Ryan Reeves
Landfill Superintendent
SWANA Certified MOLO
City of Belle Fourche

511 Sixth Avenue | Belle Fourche, SD 57717
www.bellefourche.org
P: 605.892.2494 | F: 605.892.2784

ENVIRA
SMART ENERGY

03 April 2024

Dr. Nikhil Patel
President, Singularity Energy Technologies
4200 James Ray Drive
Grand Forks, ND 58202

Subject: Letter of Support for the Singularity Energy Technologies proposal to the U.S. Department of Energy DE-FOA-0003082

Dear Dr. Patel,

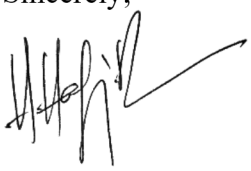
Envira Smart Energy would like to express our strong interest in and support for your proposal to the U.S. Department of Energy to build a 25 ton/day pilot facility demonstrating the ability of Smart gasification technology to produce methanol and hydrogen from a wide range of waste materials and biomass.

As you know from our discussions, Envira Smart Energy is exploring opportunities to deal with waste disposal concerns in our area while simultaneously creating economic opportunities and reducing greenhouse gas emissions. As we discussed, we are considering a facility to process 50 tons/day of Municipal Solid Waste to produce Electricity/Methanol. Meanwhile we are talking with parties located in New Mexico and Antigua and Barbuda that are interested in Smart gasification as a solution to their waste and energy issues. The first facility we are interested in developing would be in The City of Rio Communities, NM.

We are also aware of the potential tax credits that may be generated using your technology. The ability to see a fully integrated commercial-scale system producing electricity and liquid fuels from various forms of biomass and waste materials would certainly enhance the confidence of future investors in your technology.

We hope you are successful in obtaining funding for this important demonstration project and look forward to continuing to work with you and your exciting technology.

Sincerely,



Hafiz Hassan
Co-founder
ENVIRA
SMART ENERGY
Hafiz@EnviraSmart.com
www.EnviraSmart.com

THE CITY OF Fargo FAR MORE

Division of Solid Waste

2301 8th Avenue North
Fargo, North Dakota 58102
Phone: 701-241-1449
Fax: 701-241-8109

April 5, 2024

Dr. Nikhil Patel
President, Singularity Energy Technologies
4200 James Ray Drive
Grand Forks, ND 58202

Subject: Letter of Support for the Singularity Energy Technologies proposal to the U.S. Department of Energy DE-FOA-0003082

Dear Dr. Patel,

The City of Fargo, North Dakota Solid Waste Department would like to express its strong interest and support in your proposal to the U.S. Department of Energy to build a 25 ton/day pilot facility demonstrating your Smart gasification technology. As you know from our previous discussions, The City is exploring opportunities that can assist with waste disposal concerns in our area while simultaneously creating economic opportunities for the community. As we discussed, we are considering a facility to process 700 tons/day of sorted municipal solid waste to produce a beneficial byproduct such as process heat, electricity, or other sustainable fuels. The facility would be located in Fargo, North Dakota and operated by the City. We are also aware of the potential tax credits that may be generated using your technology. The ability to see a fully integrated pilot-scale system in operation producing electricity and liquid fuels would assist in building the confidence needed to potentially invest in your technology.

We hope you are successful in obtaining funding for this important demonstration and look forward to continuing to work with you as you fully commercialize your exciting technology.

Sincerely

Scott Olson, PE
Solid Waste Utility Director
City of Fargo

Solid Waste Facilities

Incinerator
708 8th Street NW
PO Box 179
Fosston, Minnesota 56542
(218) 435-6501 Telephone
(218) 435-6619 Fax
ESA: jon.steiner@co.polk.mn.us
Facility Mgr: ron.larson@co.polk.mn.us

Landfill
Located: Gentilly, Minnesota
PO Box 179
Fosston, Minnesota 56542
(218) 281-5419
Accountant: julie.mathison@co.polk.mn.us
Secretary: debbie.kappedal@co.polk.mn.us

April 4, 2024

Dr. Nikhil Patel
President, Singularity Energy Technologies
4200 James Ray Drive
Grand Forks, ND 58202

Subject:: Singularity Energy Technologies
DoE Proposal - DE-FOA-0003082
Letter of Support

Dear Dr. Patel,

The Polk County (MN) Resource Recovery Facility (Polk RRF) located in Fosston, MN strongly supports your proposal to the U.S. Department of Energy (DoE) to build a 25 ton/day pilot facility demonstrating your Smart gasification technology. As you may be aware, the MN legislature – and various activist groups – are currently attempting to force the pre-mature closure of the Hennepin Energy Recovery Center (HERC) in Minneapolis, MN. The HERC is the largest MSW waste-to-energy (WTE) facility in MN. This development has all WTE facilities in the state, including Polk RRF, closely monitoring the outcome of that initiative and any ramifications to other WTE's. As a result, all WTE's are evaluating possible alternatives should that effort expand.

Polk RRF currently utilizes an advanced Material Recovery Facility (MRF) which processes both MSW and Single Stream Recyclables from the region. The MRF processes the MSW to provide a clean fuel for the WTE portion of the Plant. Polk RRF has had numerous conversations with you regarding the MRF and its potential impact upon your system. The continued evaluation of both a MRF on your system and demonstration of your system's potential to be incorporated into a system such as Polk RRF's provides benefits to both interests. As a result, we have a keen interest in furthering that evaluation process.

Polk RRF hopes that your effort to attain the DoE support will be realized as it would be of benefit to Polk and other MN-based WTE's in determining if a system such as yours would be a viable alternative to our current integrated waste management systems. Please keep us informed as your project moves forward.

Sincerely

Jon D. Steiner
Env. Svs. Admin.
Polk County, MN

John Deere Intelligent Solutions Group
4101 19th Avenue North
Fargo, ND 58102

Brij N. Singh, Ph.D., IEEE Fellow
John Deere Technical Fellow - Power Electronics Engineeirng
John Deere Region 4 Manager External Relationships
SinghBrijN@JohnDeere.com

June 15, 2023

Dr. Nikhil Patel
President, Singularity Energy Technologies, LLC
Suite 201, 4200 James Ray Dr, Grand Forks, ND 58202

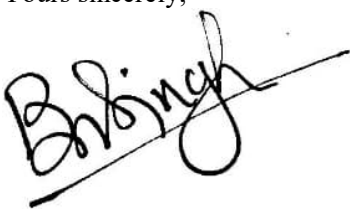
RE: Letter of Interest - Integration of John Deere Technology with Sandwich Gasifier for Biofuel and Biomaterial Production in North Dakota's Farming Community

Dear Dr. Patel,
We sincerely appreciate your introduction of Dakota Green Power and Singularity Energy Technologies, LLC's Sandwich gasification technology. After carefully reviewing your technology and considering its potential application to our customer base in the agriculture sector, we recognize the strong synergy between your gasification technology and our mission. Specifically, we acknowledge its capability to effectively process a wide range of agricultural waste, including manure, and harvesting residues. Moreover, the generation of gaseous and liquid fuels from these waste streams, which can be used to fuel generator sets, aligns with end-use requirements for equipment manufactured by the John Deere. Additionally, your technology offers an attractive pathway for our customers to reduce their carbon footprint, granting us a significant marketing advantage over existing commonly used alternatives.

John Deere would like to express keen interest in the commercial implementation of Sandwich Gasification technology. We fully support your application to the Bioscience Innovation Grant Program (BIG) administered by the North Dakota Department of Agriculture, as this project will facilitate client demonstrations of the technology. Establishing a demonstration facility in Grand Forks would provide us with an ideal platform to develop and test our engine technology using fuels derived from actual waste products at a commercial scale. As part of the project team in capacity of advisory role, which amounts to in-kind support with no cost and resource commitments, we intend to provide engineering know-how for assessment of quality of the biofuels and their suitability for internal combustion engines. Our expertise can guide the process optimization of your system, maximizing the benefits in terms of output fuel quality. Subject to budgetary constraints and resource availability, we may consider donating an engine to the project for direct integration with your system. Furthermore, we envision utilizing your facility as a host site for future research endeavors.

Please do not hesitate to contact me at 701-552-8516 or SinghBrijN@JohnDeere.com if you have any questions or require further information. We look forward to continuing our support to your project.

Yours sincerely,



Brij N. Singh, Ph.D., IEEE Fellow
John Deere Technical Fellow - Power Electronics Engineeirng
Region 4 Manager External Relationships

October 1, 2023

Dr. Nikhil Patel
President, Singularity Energy Technologies
4200 James Ray Drive
Grand Forks, ND 58202

Subject: Letter of Commitment for the Singularity Energy Technologies proposal to the ND Renewable Energy Program

Dear Dr. Patel,

I am happy to provide support for your proposed project to Singularity Energy Technologies' proposal to North Dakota's Renewable Energy Program. I will use my connections and expertise to procure the required biomass for the proposed work, provide support in developing analytical protocols, analyzing data and report writing, and in using my connections to help develop long-term relationships with customers and identifying potential buyers of your technology.

I am committing 100 hours of my time at a fee of $150 per hour ($15,000 total). I have reviewed your proposal and detailed budget and agree with the allocation of my time between tasks and the roles as described in the Project Management Plan.

Sincerely,

Nicholas Ralston
Director, Sage Green NRG

mdm energy consulting, llc

701.215.2900 • mike.mann@mdmenergy.net • thompson, nd

October 1, 2023

Dr. Nikhil Patel
President, Singularity Energy Technologies
4200 James Ray Drive
Grand Forks, ND 58202

Subject: Letter of Commitment for the Singularity Energy Technologies proposal to the ND Renewable Energy Program

Dear Dr. Patel,

I am happy to provide support for your proposed project to Singularity Energy Technologies' proposal to North Dakota's Renewable Energy Program. I feel the experience I gained during my 18 years working with the Energy & Environmental Research Center and the 23 years with the College of Engineering and Mines provide me with an excellent background to assist you with the overall project management of your proposed efforts, including input into your final design, providing oversight for the construction of your system, and developing and executing your testing campaign.

I am committing 133 hours of me time at a fee of $150 per hour ($20,000 total). I have reviewed your proposal and detailed budget and agree with the allocation of my time between tasks and the roles as described in the Project Management Plan.

Sincerely

Michael D. Mann

Michael D. Mann
Principal
MDM Energy Consulting LLC

Dr. Edwin S. Olson
Principal Scientific Advisor

Phone: 701 330 2522
Email: eolson@gra.midco.net

October 1, 2023
Dr. Nikhil Patel
President, Singularity Energy Technologies
4200 James Ray Drive
Grand Forks, ND 58202

Subject: Letter of Commitment for the Singularity Energy Technologies proposal to the ND Renewable Energy Program

Dear Dr. Patel,

I am happy to provide support for your proposed project to Singularity Energy Technologies' proposal to North Dakota's Renewable Energy Program. I feel the experience I gained during my many years working with the Energy & Environmental Research Center provide me with an excellent background to assist you with development and implementation of a strong analytical plan.

I am committing 133 hours of my time at a fee of $150 per hour ($20,000 total). I have reviewed your proposal and detailed budget and agree with the allocation of my time between tasks and the roles as described in the Project Management Plan.

Sincerely

Edwin Olson

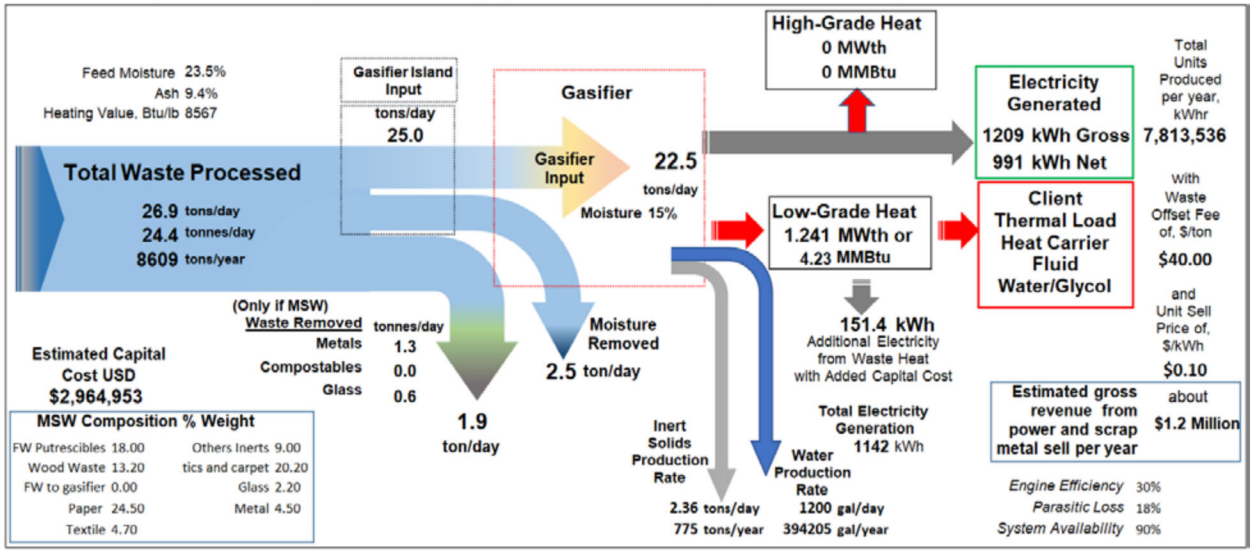
Edwin S. Olson
Principal Scientific Advisor
Singularity Energy Technologies, LLC

Appendix – Projected Economic Performance of Sandwich Gasification Technology on Various Feedstocks: Customer Acceptance

SET and DGP have developed a set of models to estimate the economic performance of the Sandwich Gasifier for various fuels and end-use applications. The model allows projections to be made based upon the characteristics of the fuel and economic factors including tipping fees, electricity and fuel prices, and other major cost/revenue streams. The examples are provided here to show that the Sandwich gasifier has good economic potential and hence the ability to generate a client base.

The Sankey Chart below is an example prepared for an interested client.

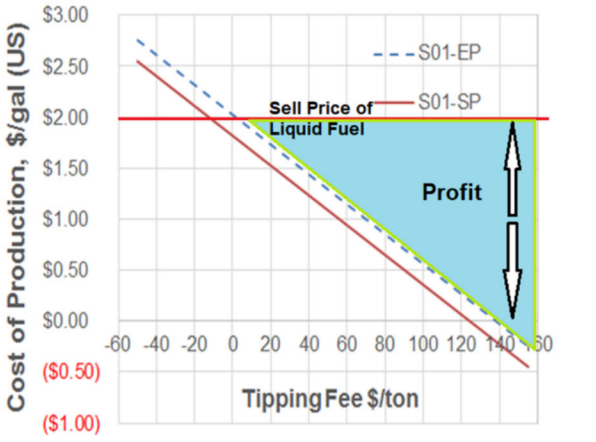
Sankey Chart Showing Various Throughputs of a 25 tons/day MSW to Electricity and Heat Convertor



SET also shows clients the potential areas of profit based upon the primary variables of interest. In the example below, the profitable region for production of crude diesel fuel versus tipping fee, and including the benefit of generating electricity on-site is shown.

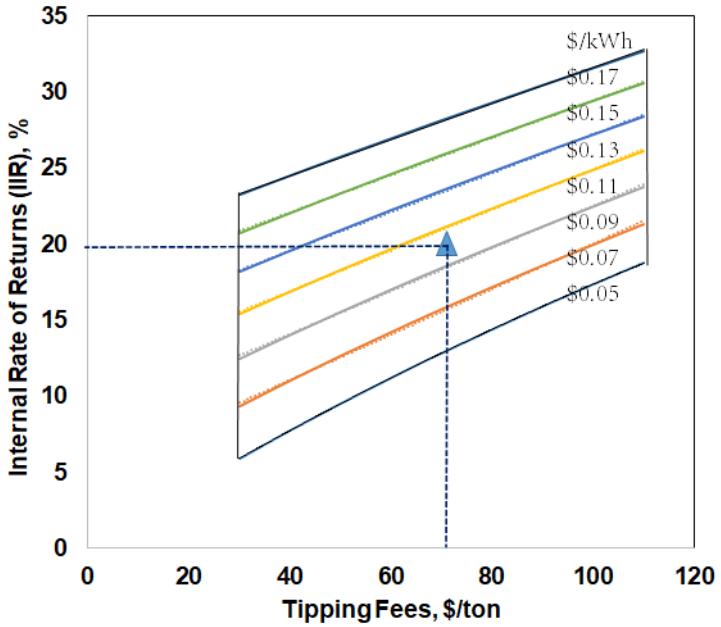
Capital Cost and Revenue Generation Opportunity
Stationary System 20 tons/day MSW-to-Crude Diesel Fuel
(an example for discussion purposes only)

SET Technology Model	S01-EP	S01-SP
	Electricity Purchased	Self-Sustained Operation
System Capital Cost, $	$3,194,165	$3,549,519
Direct Operating, $/year	$413,016	$277,971
Cost of Debt		
Interest Rate for Borrowing Capital	6.50%	6.50%
Debt Loading (10 yr), $/year	$444,323	$493,755
Revenue from Tipping Fees		
Tipping Fee Rate ($/ton)	35	35
Tipping Fee Revenue , $/year	$217,175	$217,175
Production, gal/year		
Crude Diesel Production	424,422	424,422
Production Cost, $		
Zero Debt	$0.97	$0.65
Gallon Debt-Loaded (first 10yr)	$2.02	$1.82
Debt Loaded With Tipping Fee	$1.51	$1.31



SET SINGULARITY ENERGY TECHNOLOGIES, LLC
WASTE TO ENERGY

SET also provides an indication of the potential return on investment for its clients. As an example, the plot below shows a positive internal return on investment even at tipping fees as low as $20/ton at an electricity selling price of $0.05/kWh. This particular customer was receiving a $70/ton tipping fee with an electricity selling price of $0.10/kWh, showing a potential IRR of 20%.



The table below shows potential gross revenues for a variety of different feedstocks of interest to potential clients.

Feedstock Type	MSW # 2	MSW # 1	RR Ties #3	RR Ties #2	Turkey Litter # 1
Gasifier Island Input tons/day	25.0	25.0	25.0	25.0	25.0
Total Waste Processed, tons/day	29.5	26.9	25.0	25.0	25.0
Feed Composition and Energy Content					
Feed Moisture	34%	23%	17%	32%	33%
Ash	6%	9%	2%	2%	17%
Heating Value, Btu/lb	8171	8567	7786	6790	4114
Pre-Gasification Product Removed					
Metals, tons/day	1.1	1.3	0.0	0.0	0.0
Glass, tons/day	3.4	0.6	0.0	0.0	0.0
Post-Gasification Inert Solids and Water Production					
Inert Solids, tons/day	1.45	2.36	0.46	0.44	4.32
Water Production Rate, gal/day	1069	1200	1458	1186	887
Energy Production					
Gross Electricity, kWh	1153	1209	1098	958	580
Net Electricity, kWh	945	991	901	786	476
Low Grade Heat, MMBtu	4.04	4.23	3.85	3.36	2.03
Estimated Annual Gross Revenue from Sell of Electricity and Byproducts					
$/annum	$ 1,188,322	$ 1,196,282	$ 1,038,633	$ 947,792	$ 845,800
Earning Rate: Electricity = $ 0.1/kWh, Tipping Fees= $40/ton, Metal = $150/ton, Fertilizer = $100/ton					

Also of importance is the quality of the liquid that can be produced from the syngas. The table below presents a fuel specification for a fuel generated from syngas using the technology provided by BGTL, Inc. Based upon the syngas compositions generated from testing on the EERC pilot-scale system and on testing performed at Tri-Steel on the 5-ton/day system we expect a fuel of similar quality will be produced.

Sample ID	FISCHER TROPSH REACTOR
Sample Type	Fuel
Report Date	2/6/2018

U.S. OilChek®
Fuel Oil Report

US Lubricants

179946-0001

Labcode	*Sample Date*	*Receipt Date*	*Oil Type*	*Vis @ 40 / 100C*	*Degrees F*		*Percent*		*Particulate*	*Microbe*	*Color*	*API*	*Distillation Data Degrees F*													*BTU/gal*
					VI	*Cloud*	*Water*	*Sulfur*																		
					Flash	*Pour*	*Solids*	*Ash*	*Halogens*	*Stability*	*AF*	*Lb/gal*	*IBP*	*5%*	*10%*	*20%*	*30%*	*40%*	*50%*	*60%*	*70%*	*80%*	*90%*	*95%*	*EP*	*Cetane*
				2.4		-12						35.4														
2048315	1/30/2018	2/5/2018			135							7.059	267	364	397	433	459	479	499	518	539	565	598	627	646	46.0

Sample Date	*Wear Metals (ppm)*										*Contaminant Metals (ppm)*				*Additive Metals (ppm)*					
	Iron	*Aluminum*	*Chrome*	*Copper*	*Lead*	*Tin*	*Cadmium*	*Silver*	*Nickel*	*Titanium*	*Silicon*	*Sodium*	*Boron*	*Potassium*	*Barium*	*Calcium*	*Magnesium*	*Molybdenum*	*Phosphorus*	*Zinc*
1/30/2018																				

Comment:

Specific Gravity 0.8478
Copper Corrosion 1a
Fuel tested within expected ranges for parameters analyzed.

Report To:

ZHIJUN JIA
COMPREX LLC
1740 EISENHOWER DR
DE PERE, WI 54115

Results may now be viewed electronically on our website

www.usoilchek.com

Or sent via email

U.S. OilChek
422 S Washington St
Kimberly, Wi. 54136
Phone 920-831-8839 / 800-490-4903 Fax 920-788-0102

Appendix E – Example Life Cycle Assessment

The Singularity Energy Technology (SET) Sandwich Gasification Process for Manure-to-Energy Conversion:

A Comparative Understanding of CO2e Equivalent Emissions

One of the main features of the Sandwich gasifier is the gas-solid distribution that creates a larger and more uniform high-temperature zone in the gasifier (see Figure 1). This feature ensures a higher level of in situ tar and carbon conversion, thereby eliminating the need for secondary carbon/char converters, large syngas scrubbers and waste disposal systems, and extensive syngas processing. When used to process waste materials into energy, the Sandwich gasifier provides a substantial CO_{2e} reduction/credit as compared to competing technologies. This report provides data showing net CO_{2e} emissions of negative (-) 768 kg CO_2 per ton of manure gasified. Analysis of other potential feedstocks shows net CO_{2e} emission reductions in a similar range.

1. A typical Sandwich configuration consists of at least one **endothermic reduction zone** sandwiched between two high-temperature **oxidation zones.**
2. The reduction zone in the gasifier produces and extracts the syngas. This is an endothermic reaction zone requiring heat transfer from the higher-temperature zones of the gasifier.
3. The patented configuration ensures near-complete waste conversion and augments reduction zone temperature to promote clean syngas production with high efficiency.

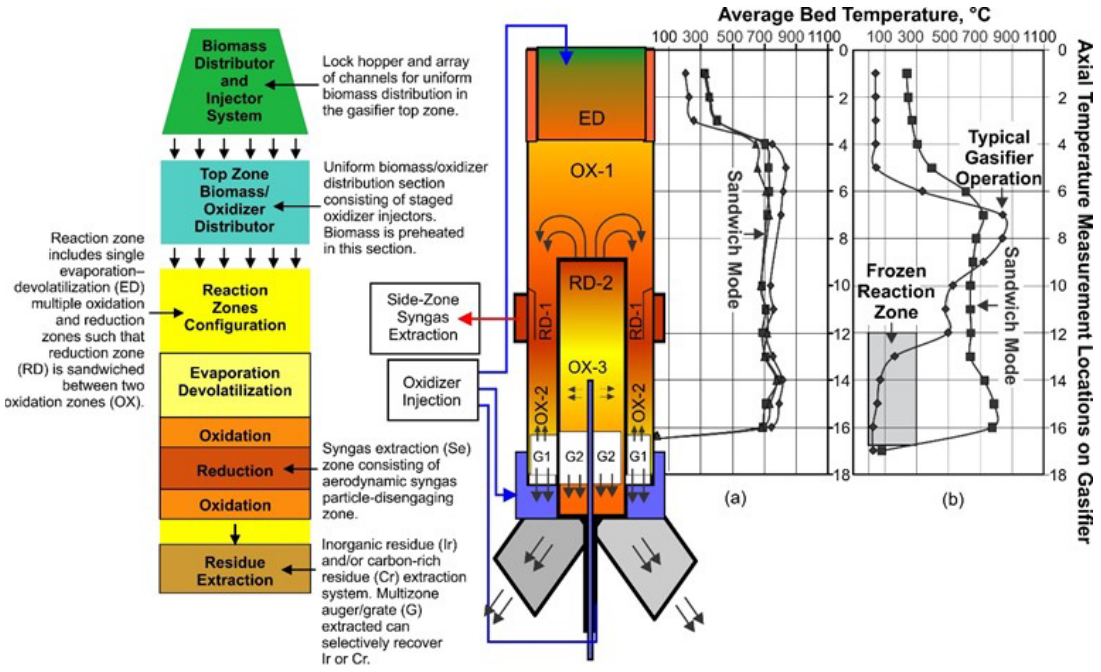


Figure 1. Sandwich gasifier, showing oxidation and reduction zones and the advantage of a uniform axial temperature profile versus the low-conversion "frozen reaction zone" present in typical downdraft gasifiers (oxidation is shown as OX and reduction as RD).

Innovation and Impacts

Current State of the Art – Gasification Processes

For processing residues such as wet manure, competitors of the Sandwich gasifier take two forms: biological methods, such as composting facilities and waste digesters that currently use manure to generate methane as a direct-use fuel or for electricity generation, and thermal methods, such as gasifiers that convert manure to a synthesis gas fuel.[1] Composting facilities and digesters are commercially available and familiar; however, each has significant challenges. Digesters are biological systems that can be negatively impacted by environmental conditions such as cold weather. Additionally, they achieve relatively poor conversion efficiencies compared to gasification, and the waste biosolids generated from digesters add to their overall cost and life cycle impacts.[2] Composting and land application are simple processes, but face limitations to their widespread use due to excessive nutrient runoff and negative impacts on water quality. In the Mid-Atlantic region, such water quality issues have resulted in prohibiting land application of animal waste. Gasifiers represent an emerging technology for power generation from manure that—when compared to biological methods—more quickly treat waste; are more compact; reduce odors, biological oxygen demand, remove pharmaceutical compounds; and eliminate sludge.[3] Several companies claim to market gasifiers that process manure for energy production, such as Ecoremedy® for heat and steam generation[4]; Mavitec Green Energy, which advertises a gasifier to produce steam, electricity, hot water, or hot air but appears to currently demonstrate only heating and drying applications[5]; and BGP International, which also claims heat, steam, or electricity generation but does not disclose any commercial application on its website.[6] As explained earlier, the advanced-design Sandwich gasifier confers performance advantages in manure-to-power applications when compared with other gasifier designs.

A schematic of the Sandwich gasifier and two variations of typical downdraft gasifiers depicting the location of reaction zones with respect to the fuel feed (from the top) and syngas discharge (from the bottom) are illustrated in Figure 2. These gasifiers—Imbert, stratified downdraft gasifier, and Sandwich gasifier – are differentiated based on the distinct temperature profiles achieved as a result of their respective design and operating features. In all three, the pyrolysis zone is located upstream of the oxidation zone, and the reduction zone is located downstream of the oxidation zone. The devolatilized products leaving the pyrolysis zone pass through a high-temperature zone

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[1] eXtension. Treatment Technologies for Livestock and Poultry Manure, 2015. http://articles.extension.org/pages/8855/treatment-technologies-for-livestock-and-poultry-manure (accessed June 2018).

[2] Gonzaga, J.A.; Biona, J.B.M.M. Application of Energy Return on Investment (EROI) Analysis to Biogas Production. Presented at the DLSU Research Congress, De La Salle University, Manila, Philippines, Mar. 6–8, 2014.

[3] Cantrell, K.; Ro, K.; Mahajan, D.; Anjom, M.; Hunt, P.G. Role of Thermochemical Conversion in Livestock Waste-to-Energy Treatments: Obstacles and Opportunities. *Ind. Eng. Chem. Res*. **2007**, *46*, 8918–8927.

[4] Ecoremedy, LLC. Agricultural Waste to Energy, Biochar, and Nutrients, 2017. http://ecoremedyllc.com/agricultural-waste-to-energy-biochar-and-nutrients/ (accessed June 2018).

[5] Mavitec Green Energy. Gasification. www.mavitecgreenenergy.com/gasifications/ (accessed June 2018).

[6] BGP International. About BGP International. www.bgpint.com/about.1/ (accessed June 2018).

formed by the partial oxidation of devolatilized products and char. The products of combustion and unconverted devolatilized hydrocarbons leaving the oxidation zone react with unconverted char in the reduction zone located downstream of the oxidation zone.

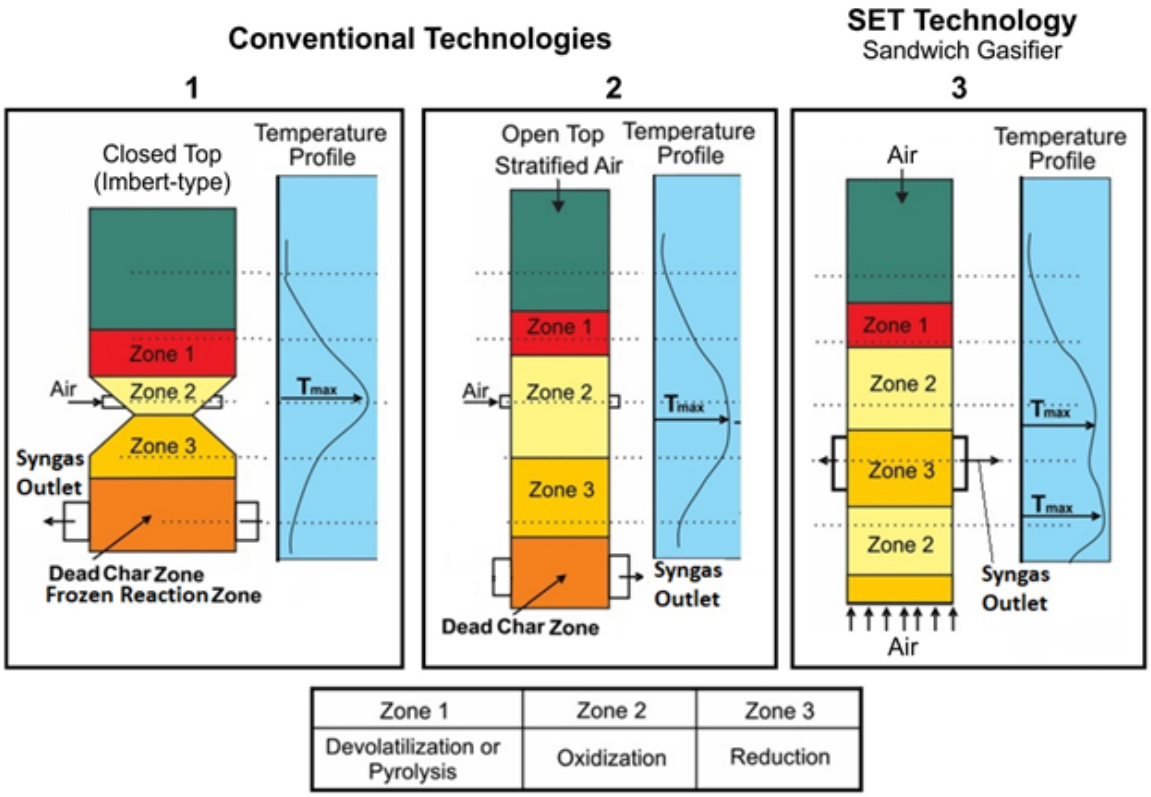


Figure 2. Schematic of downdraft gasifier: 1) Imbert-type, 2) classical stratified, and 3) Sandwich gasifier.

The Imbert downdraft gasifier (Figure 2) has a characteristic constriction near the oxidation zone which limits particle size and fuel ash content. High-ash feedstock, such as railroad ties, tested by the EERC in a commercially purchased downdraft gasifier of this type, failed in operation due to clinker formation near the constriction[7]. This constriction provides the oxidation zone stability and prevents movement. This is a World War II-era technology that was commonly used for powering automobiles during that time. It was therefore designed to utilize quality dry wood, which was affordable at the time. The stratified downdraft has no constriction; however, zone stability is established by maintaining specific oxidizer (air) and fuel throughput. The single oxidation zone achieves a narrow peak temperature, resulting in smaller but similar challenges with high-ash feedstock as was demonstrated in the Imbert-type gasifier.

Competitive Advantage of Sandwich Gasifier

As shown in Figure 2, the conventional downdraft gasifiers are unable to maintain adequate heat transfer to the reduction zone, particularly if the moisture content of the feedstock increases. This

causes the temperatures in conventional systems to diminish and waste conversion ceases. In contrast, the reduction zone temperature in the Sandwich gasifier is maintained by heat transfer from the additional oxidation zone located after the reduction zone and before the residue extraction zone. This configuration promotes complete waste conversion, produces clean syngas with an improved composition, and tolerates variations in moisture and energy content of the waste feedstocks, including nonreactive or poorly-reactive feedstocks that can be problematic in conventional gasifiers.

Air, oxygen-enriched air, pure oxygen, or steam mixed with air or oxygen are potential oxidizers that can be used in all downdraft gasifiers to achieve self-sustained gasification. However, if the exothermic heat profile is not achieved because of insufficient exothermic oxidation, possibly due to high moisture or a high fraction of inert material in the fuel, the reduction zone temperature can drop, reducing the carbon conversion rate and adversely impacting syngas composition and flow rate. The additional oxidation zone in the Sandwich gasifier depicted in Figure 5, and the direct heat transfer from both the top and bottom of the reduction zone augments the reduction zone temperature, thus improving syngas composition, flow rate, carbon conversion, and overall efficiency of the gasifier.

In a Sandwich gasifier, as shown in Figure 2, with solids moving from top to bottom, the characteristic second oxidation zone located near the bottom converts energy-dense dry solids (char) into additional heat for the reduction zone. This is the reason the sandwiched reduction zone achieves higher temperature and is less prone to variations in feed moisture that cause conversion challenges in conventional gasifiers. Figure 3 is a comparison of published heating value and tar concentration data from clean, low-ash wood in a conventional downdraft gasifier vs. results from a more difficult manure gasification test in a Sandwich gasifier. These graphs show that a much-higher-heating-value syngas was produced with low tar concentration (sampled prior to performing any tar scrubbing unit operations), compared to the conventional downdraft gasifier concentrations after their syngas had been processed through a scrubber system. The tar concentrations observed in the Sandwich gasifier were not as severely impacted by the higher moisture in the manure feedstock.

Sandwich Gasifier as GHG Emission Mitigation Technology

The main greenhouse gases which absorb heat and contribute to climate change and are methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2). Biomass CO_2 emissions are considered climate-neutral, so the gasification of any compostable biomass (which might otherwise have released CH_4) into syngas or liquid fuels which release CO_2 would accomplish net reductions in greenhouse gases.

The high nitrogen (N), phosphorous (P), and potassium (K) contents of poultry litter make it desirable for fertilizer as the production of these nutrients is energy-intensive and consumes considerable resources. However, the traditional disposal pathway of direct land application of

poultry litter has large environmental footprint due to issues such as eutrophication, spreading of pathogens, antibiotic residue accumulation, and greenhouse gas (GHG) emissions among others.

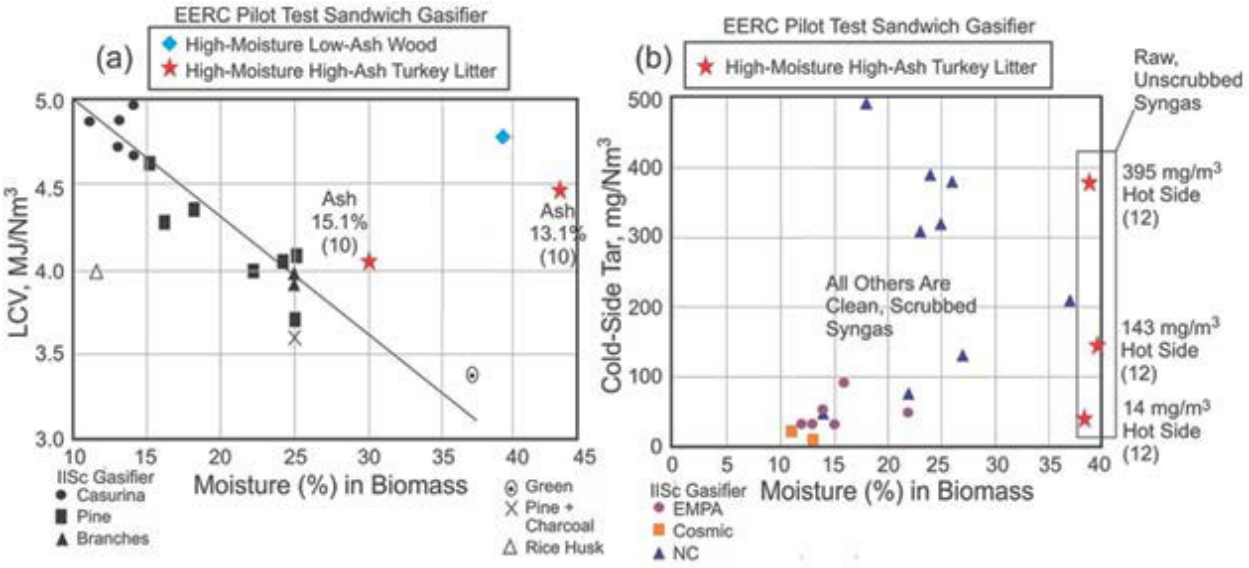


Figure 3. Comparison of Sandwich gasifier syngas heating value (a) and sampled outlet tar concentrations (b) to other commercially available downdraft gasifiers (figure modified from the Indian Institute of Science [IISc] LCV [lower caloric value]; EMPA, cosmic, and NC are other gasifier companies.)[7,8,9,10,11]

Production of N_2O during manure storage and treatment requires nitrification-denitrification of ammonia nitrogen that forms or is present in the wastes. For N_2O to be produced, it must be in an aerobic system where ammonia is converted to nitrites (nitrification). If these nitrites enter an anaerobic decomposition period (become saturated or deeply buried), they can be converted to N_2O (denitrification). This occurs in dry manure management systems which will initially provide aerobic conditions that can be followed by saturation to create the anaerobic conditions necessary

[7] Patel, N.M. *Advances in Gasification for DH Production: Year 3 – Activity 1.6 –Development of a National Center for Hydrogen Technology®*; Topical Report for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No.DE-FC26-05NT42465; Energy & Environmental Research Center: Grand Forks, ND, May 2011.

[8] Patel, N.M. *Pilot-Scale Demonstration of Heat and Power Production from High-Moisture Biomass*; Final Report U.S. Army Construction Engineering Research Laboratories (CERL) under Cooperative Agreement W9132T-08-2-0014, Phase III, Task 2.3 Development of Modular Systems for Distributed Fuels and Energy, Jan 2012.

[9] Uniqueness of IISc Biomass Gasification Technology. http://cgpl.iisc.ac.in/site/Portals/0/Main%20Page/UniquenessOfIIScGasificationTechnology.pdf (accessed May 10, 2019).

[10] Dasappa1, S.; Paul, P.J.; Mukunda, H.S.; Rajan, N.K.S.; Sridhar, G.; Sridhar, H.V. Biomass gasification technology – a route to meet energy needs, Special Section: Application of S&T to Rural Areas Current Science, vol. 87, no. 7, 10 Oct. 2004.

[11] Zygarlicke, C.J.; Hurley, J.P.; Aulich, T.R.; Folkedahl, B.C.; Strege, J.R.; Patel, N.M.; Swanson, M.L.; Martin, C.L.; Olson, E.S.; Oster, B.G.; Stanislowski, J.J.; Nyberg, C.M.; Wocken, C.A.; Pansegrau, P.D. *EERC Center for Biomass Utilization® 2008–2010: Phases I–III*; Final Technical Report for U.S. Department of Energy Cooperative Agreement No. DE-FG36-08GO88054; EERC Publication 2015-EERC-08-02; Energy & Environmental Research Center: Grand Forks, ND, Aug 2015.

for N_2O production and emissions to occur. The amounts of N_2O released will depend on the duration of exposure to aerobic and anaerobic conditions in the system used, whether wet-dry cycling occurs, and how long each aerobic/anaerobic encounters last. In the case of a Sandwich gasifier, the manure can be converted without requiring an extended period of storage thus preventing uncontrolled and undesired decomposition of organic matter. Both CH_4 and N_2O releases to the environment can be significantly reduced or prevented using a Sandwich gasifier. The temperature-controlled conversion of manure into clean syngas and high-efficiency removal of ammonia in the wet scrubber prevents nitrogen emission. The captured ammonia is converted as sellable liquid fertilizer such as ammonium sulfate in an integrated process. Other valuable inorganics such as phosphorous and potassium can also be reacquired from the process for their reuse as recovered fertilizer. The clean syngas is devoid of any sulfur and other trace gases after the syngas is passed through the sorbent beds. When the syngas is used in an internal combustion engine generator, the NOx is reduced by an order of magnitude as compared to when fed with hydrocarbon fuels. This extends the duration of catalytic NOx converters used to treat the engine exhaust. Since the syngas engine exhaust is relatively clean, there is an opportunity to utilize low-cost CO_2 capture technology. The small-scale CO_2 production can support its local use. Thus, the process can become a sink for GHG emissions.

For a comparative understanding of GHG emissions from the Sandwich gasifier with competing processes utilizing manure, a side-by-side comparison of their GHG emissions is provided in Figure 4. Table 1 provides the calculated emission numbers based on previously observed test data and manure composition used in the Sandwich gasifier. As shown in Table 1, the net CO_2 emission is negative (-) 786 kg/ton of manure processed using gasification. The dry matter (DM) including combustible organics and inorganics or ash is 0.735. Since the data for the competing methods reported in reference 12 considered manure with a DM of 0.6, the Sandwich gasifier emission data was recalculated for a DM value of 0.6 for presentation in the plot.

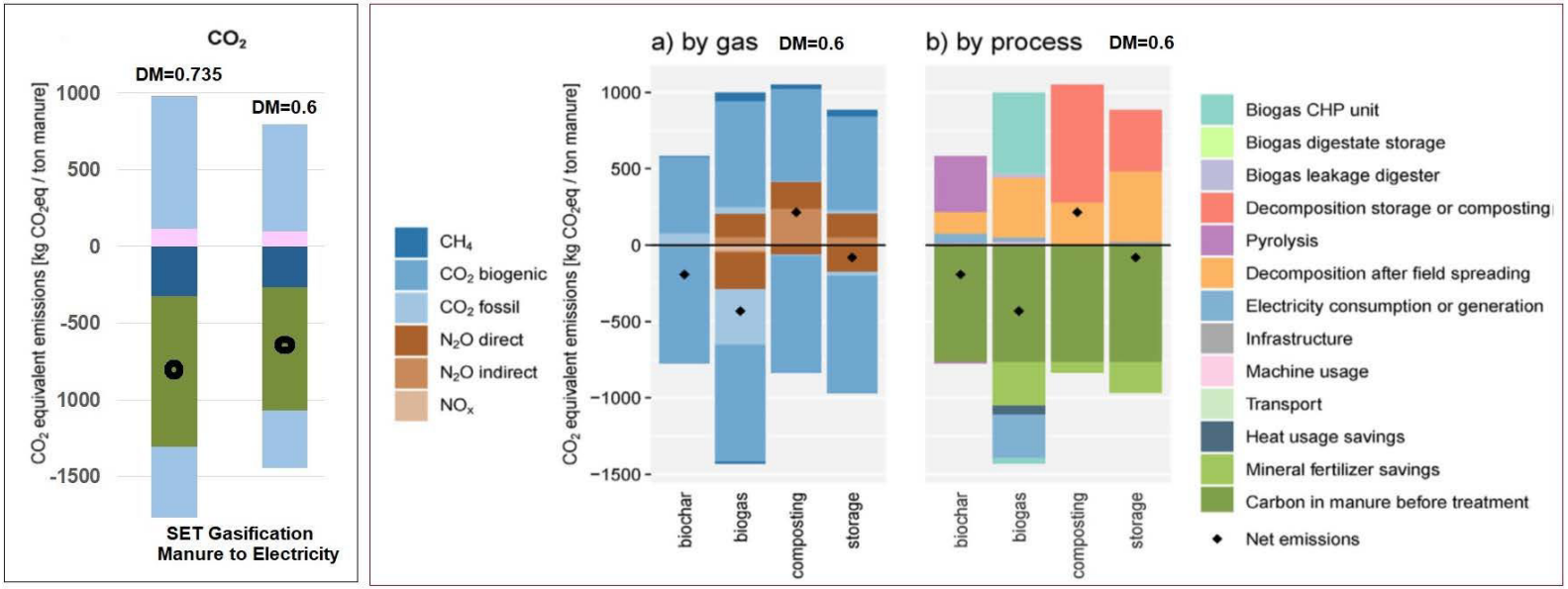
The main assumptions in the SET gasifier emission data calculations are.

1. The category “Carbon in Manure before Gasification” accounts for the organic carbon bound in the manure, which has previously been removed from the atmosphere through plant photosynthesis as in reference 12.
2. The nitrogen in the manure is converted to NH_3 and is removed in the high-efficiency wet scrubber. Therefore, the contribution of the fuel N_2O is neglected in the calculation. The data however includes thermal NOx equivalent CO_2 is included in the data based on previous engine generator NOx emission.
3. The emission from the closed manure storage bin is diverted to the wet scrubber and is fully captured. The holding period is short and therefore fugitive N emission is negligibly small.
4. The net electricity produced offsets the CO_2 equivalent and is considered to have a negative contribution.

5. The low-grade heat is used in the farm which offsets the use of propane and thus equivalent CO_2 emission reductions are accounted.
6. The emission offset accomplished due to the recovered fertilizer is not considered for lack of data. However, the effect on emissions would be negative and contribute to the GHG sink.
7. The embedded energy in steel usage in the 25 tons/day system is estimated to be 2.66 kWe for stainless steel usage of 50 tons. The CO_2e is estimated to be 2 kg/ton of manure.
8. The composition of the manure in reference 12 is similar at an equivalent DM.
9. The CH_4 emission is not considered since organic matter decomposition is prevented by the Sandwich gasification process.
10. Pre-combustion and/or post-combustion CO_2 capture are plausible options using Sandwich gasifiers and CO_2e would be greatly reduced by the implementation of CO_2 capture technology.

Table 1: GHG Emissions from SET Gasification Process

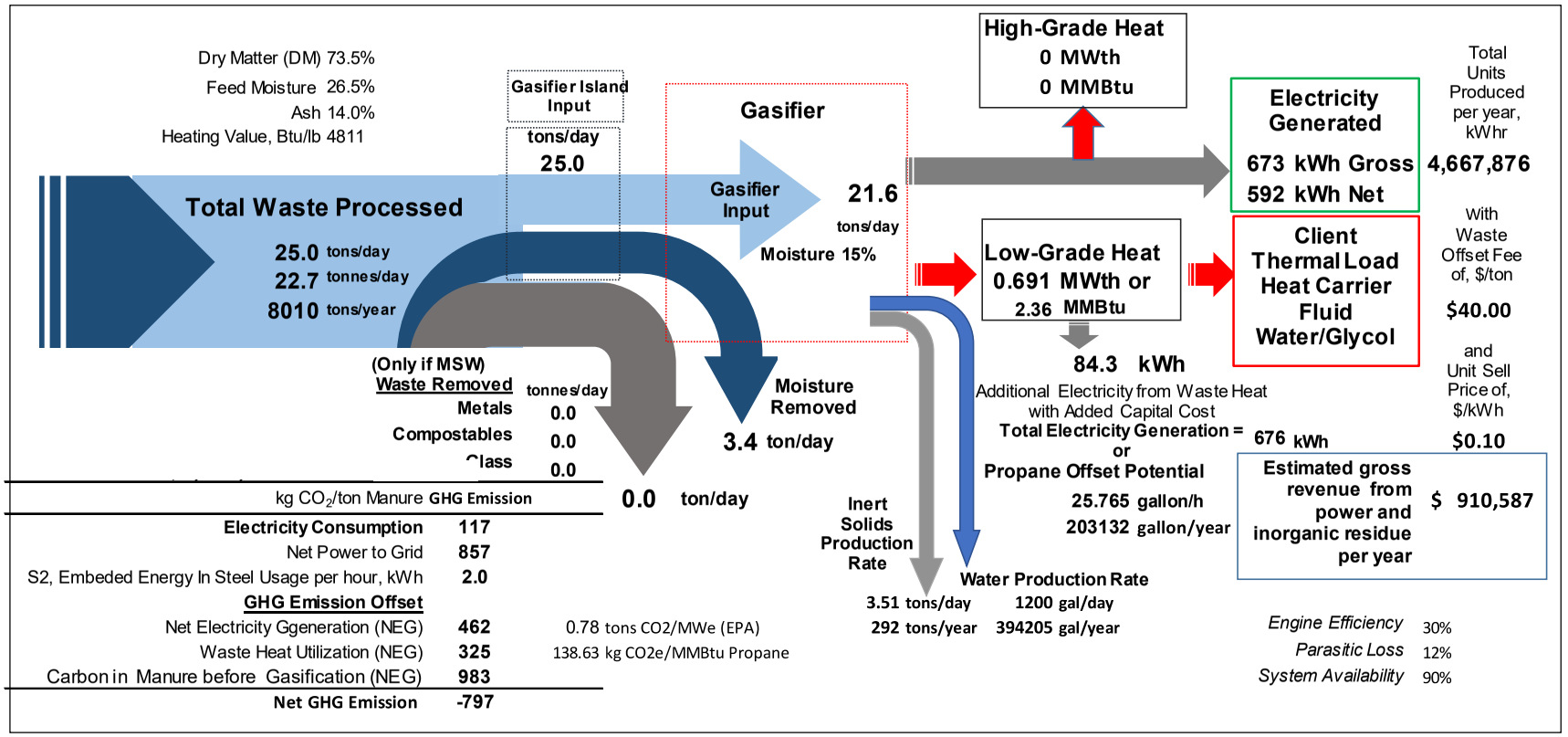
kg CO_2/ton Manure	GHG Emission	
Electricity Consumption	**117**	
Net Power to Grid	**857**	
S2, Embeded Energy In Steel Usage per hour, kWh	**2.0**	
Thermal Nox -engine exhaust with catalytic convertor	**8.8**	
GHG Emission Offset		
Net Electricity Ggeneration (NEG)	**462**	0.78 tons CO2/MWe (EPA)
Waste Heat Utilization (NEG)	**325**	138.63 kg CO2e/MMBtu Propane
Carbon in Manure before Gasification (NEG)	**983**	
Net GHG Emission	**-786**	



12. Kreidenweis, U,; Breier, J.; Herrmann, C,; Libra J,; Prochnow, A. *Greenhouse gas emissions from broiler manure treatment options are lowest in well-managed biogas production*, Journal of Cleaner Production 280. p. 124969, 2021.

Figure 4: Emissions for the SET poultry manure gasification process and the four competing treatment options differentiated according to the process causing the emissions provided Kreidenweis et. al.

Sankey Chart Showing
Various Throughputs of a 25 tons/day Turkey Manure to Electricity and Heat Convertor



Unconverted Carbon (Char)	0.92%
% Carbon in Residue	1.90%
% Carbon as per Analysis,	1.89%

Mineral Fertilizer kg/h	132.7			
K	27.8	Total Nitrogen, kg/h	33.2	
P	30.7	NH3 (Max) kg/h	40.3614	
Mg	12.1	(NH4)2SO4, kg/h	156.578	
Ca	49.0	K2SO4, kg/h	61.9849	

2NH3 + H2SO4 = (NH4)2SO4
2K + H2SO4 = K2SO4 + H2

Approximate weight of steel used in the system =	50 tonnes
S2, Embeded Energy In Steel Usage per hour =	2.66 kWh
(DOE requirement of EORI is 5) EROI (Q/(S1+S2) =	8.068
S1 = 673 EROI (Q1/(S1+S2) =	9.078
GHG - gCO2 e /kWh Gross =	1508 g/kWe
GHG - gCO2 e/kWh Net =	1714 g/kWe
GHG - gCO2 e /kWh Gross MAX =	1340 g/kWe
GHG - gCO2 e/kWh Net MAX =	1500 g/kWe

Energy Return on Investment (EROI)

The EROI value exceeds DOE's requirements of a minimum value of 5. The scalable feature of the system allows the sizing of the Sandwich gasification technology such that it can be located at the feedstock source requiring zero to near-zero transportation cost. This is a big advantage over larger systems where biomass transportation costs negatively impact project economics. The system is capable of converting waste on an "as-received" basis, without requiring feed densification. Also. the ability of the system to tolerate moisture variation besides heat integration capability minimizes completely any energy-intensive feed preparation. The embodied energy cost for the system (S2) therefore, is minimal for the system and is assumed to be restricted only to the energy expenditure considered for the stainless steel (or steel) used in the technology. For the scaled 25-tpd Sandwich gasifier, S2, is conservatively estimated to be 2.66 kWh. (see Table 2) This value was derived by using embedded energy values for steel extracted from Argonne National Lab's GREET model, an estimate of 50 tonnes of steel in a commercial gasification system, and the calculation methodology described by the University of Michigan[13] The electricity consumption in the process is estimated to be less than 12% of the gross electricity production. These preliminary EROI values based on high-level information are already greater than 5, with values ranging from 8.1 to 9.1 (See Table 3)

Table: 2: Embedded Energy in Steel Usage in 25 TPD system

S2, Embedded Energy In Steel Usage per hour, kWh	**2.66**
Embeded Energy in Stainless Steel Used in the Commercial System	
Approximate Weight of Steel Used in the System, tonnes	50
*Energy Consumption in New Stainless Steel, MJ/tonne	35309
*Energy Consumption in Stainless Steel Conversion, MJ/tonne	30187
Total Energy Consumption, MJ/tones	65496
Energy Offset End Life Recovery (Same as New Steel), MJ/tonnes	35309
Net Consumption of Energy in Steel, MJ/tonnes	30187
Total Embeded Energy in the Steel of the Commercial System, MJ	**1509350**
Total Duration of System Operation	
Useful Life of the System, years	20
Operation per Year (Availability), %	90%
Total Duration of Operation, h	157680

Table 3: Energy Return on Investment for 25-TPD high- moisture and high-ash feedstock (manure) conversion System

Energy Return On Investment (EROI)	
Q Gross Electricity Output, kWh e	672.8
Q1 Gross Electricity from Waste heat	757.1
S1 conversion energy input into the process, kWh e	80.74
S2, Embodied Energy, KWh e	2.66
EROI (Q/(S1+S2) =	**8.1**
EROI (Q1/(S1+S2) =	**9.1**

Definitions

(e.g., less than or equal to five dry tons of feedstock/day). Applicants must develop technologies that reduce the levelized cost of energy (LCOE) by at least 25% and provide a justified benchmark for the state-of-the-art as part of their application.

Helpful Equations:
LCOE:

$$LCOE = \frac{Total\ Life\ Cycle\ Costs}{\sum_{t=1}^{N} \frac{System\ Energy\ Output}{(1+i)^t}} = \frac{\sum_{t=1}^{N} \frac{After\ Tax\ Cash\ Flow}{(1+i)^t}}{\sum_{t=1}^{N} \frac{System\ Energy\ Output}{(1+i)^t}} = \frac{\$}{kWh\ \ or\ MMBtu}$$

In addition, by the end of the project, technologies must be capable of exceeding an Energy Return on Investment (EROI) of 5.

EROI:

$$EROI = \frac{Energy\ Output}{Energy\ Input} = \frac{Q}{S_1 + S_2}$$

Where:
Q = rate of energy output (kWh/analysis period) for the entire energy production system
S_1 = the conversion energy input into the process (kWh/analysis period)
S_2 = is the embodied energy in the various items the energy production system uses (kWh/analysis period)
i = the discount rate
t = the year
N = the system lifetime in years

Appendix F – Detailed Budget

Instructions and Summary

OMB Control Number: 1910-5162
Expiration Date: 04/30/2025

Award Number:
Award Recipient: Singularity Energy Technologies

Date of Submission: 1-Aug-24
Form submitted by: Singularity Energy Technologies
(May be award recipient or sub-recipient)

Please read the instructions on each worksheet tab before starting. If you have any questions, please ask your EERE contact!
Do not modify this template or any cells or formulas!

1. If using this form for award application, negotiation, or budget revision, fill out the blank white cells in workbook tabs a. through j. with total project costs.
2. Blue colored cells contain instructions, headers, or summary calculations and should not be modified. Only blank white cells should be populated.
3. Enter detailed support for the project costs identified for each Category line item within each worksheet tab to autopopulate the summary tab.
4. The total budget presented on tabs a. through i. must include both Federal (DOE) and Non-Federal (cost share) portions.
5. All costs incurred by the preparer's sub-recipients, contractors, and Federal Research and Development Centers (FFRDCs), should be entered only in section f. Contractual. All other sections are for the costs of the preparer only.
6. Ensure all entered costs are allowable, allocable, and reasonable in accordance with the administrative requirements prescribed in 2 CFR 200, and the applicable cost principles for each entity type: FAR Part 31 for For-Profit entities; and 2 CFR Part 200 Subpart E - Cost Principles for all other non-federal entities.
7. Add rows as needed throughout tabs a. through j. If rows are added, formulas/calculations may need to be adjusted by the preparer. Do not add rows to the Instructions and Summary tab. If your project contains more than three budget periods, consult your EERE contact before adding additional budget period rows or columns.
8. ALL budget period cost categories are rounded to the nearest dollar.

BURDEN DISCLOSURE STATEMENT

Public reporting burden for this collection of information is estimated to average 24 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Office of Information Resources Management Policy, Plans, and Oversight, AD-241-2 - GTN, Paperwork Reduction Project (1910-5162), U.S. Department of Energy 1000 Independence Avenue, S.W., Washington, DC 20585; and to the Office of Management and Budget, Paperwork Reduction Project (1910-5162), Washington, DC 20503.

SUMMARY OF BUDGET CATEGORY COSTS PROPOSED

The values in this summary table are from entries made in subsequent tabs, only blank white cells require data entry

Section A - Budget Summary

	Federal	Cost Share	Total Costs	Cost Share %	Proposed Budget Period Dates
Budget Period 1	$313,000	$321,000	$634,000	50.63%	1/01/2025-12/31/2025
Budget Period 2	$173,950	$171,000	$344,950	49.57%	01/01/2026-12/31/2026
Budget Period 3	$0	$0	$0	0.00%	
Total	$486,950	$492,000	$978,950	50.26%	

Section B - Budget Categories

CATEGORY	Budget Period 1	Budget Period 2	Budget Period 3	Total Costs	% of Project	**Comments** (as needed)
a. Personnel	$308,000	$216,650	$0	$524,650	53.59%	
b. Fringe Benefits	$0	$0	$0	$0	0.00%	
c. Travel	$0	$0	$0	$0	0.00%	
d. Equipment	$220,000	$0	$0	$220,000	22.47%	
e. Supplies	$42,500	$24,250	$0	$66,750	6.82%	
f. Contractual						
Sub-recipient	$0	$0	$0	$0	0.00%	
Contractor	$27,500	$22,500	$0	$50,000	5.11%	
FFRDC	$0	$0	$0	$0	0.00%	
Total Contractual	$27,500	$22,500	$0	$50,000	5.11%	
g. Construction	$0	$0	$0	$0	0.00%	
h. Other Direct Costs	$36,000	$81,550	$0	$117,550	12.01%	
Total Direct Costs	$634,000	$344,950	$0	$978,950	100.00%	
i. Indirect Charges	$0	$0	$0	$0	0.00%	
Total Costs	$634,000	$344,950	$0	$978,950	100.00%	

Additional Explanation (as needed):

a. Personnel

INSTRUCTIONS - PLEASE READ!!!

1. List project costs solely for employees of the entity completing this form. All personnel costs for subrecipients and contractors must be included under f. Contractual.
2. All personnel should be identified by position title and not employee name. Enter the amount of time (e.g., hours or % of time) and the base hourly rate and the total direct personnel compensation will automatically calculate. Rate basis (e.g., rate negotiated for each hour worked on the project, labor distribution report, state civil service rates, etc.) must also be identified.
3. If loaded labor rates are utilized, a description of the costs the loaded rate is comprised of must be included in the Additional Explanation section below. DOE must review all components of the loaded labor rate for reasonableness and unallowable costs (e.g. fee or profit).
4. If a position and hours are attributed to multiple employees (e.g. Technician working 4000 hours) the number of employees for that position title must be identified.
5. Each budget period is rounded to the nearest dollar.

SOPO Task #	Position Title	Budget Period 1			Budget Period 2			Budget Period 3			Project Total Hours	Project Total Dollars	Rate Basis
		Time (Hrs)	Hourly Rate ($/Hr)	Total Budget Period 1	Time (Hrs)	Hourly Rate ($/Hr)	Total Budget Period 2	Time (Hrs)	Hourly Rate ($/Hr)	Total Budget Period 3			
1	Sr. Engineer **(EXAMPLE!!!)**	2000	$85.00	$170,000	200	$50.00	$10,000	200	$50.00	$10,000	2400	$190,000	
2	Technicians (2)	4000	$20.00	$80,000	0	$0.00	$0	0	$0.00	$0	4000	$80,000	
				$0			$0			$0	0	$0	
1	Patel	80	$200.00	$16,000			$0			$0	80	$16,000	Standard conuslting rate
	Engineer	0	$57.50	$0			$0			$0	0	$0	Standard conuslting rate
	Technicians/Operators	120	$50.00	$6,000			$0			$0	120	$6,000	Standard conuslting rate
				$0			$0			$0	0	$0	
2	Patel	160	$200.00	$32,000			$0			$0	160	$32,000	Standard conuslting rate
	Engineer	600	$57.50	$34,500			$0			$0	600	$34,500	Standard conuslting rate
	Technicians/Operators	600	$50.00	$30,000			$0			$0	600	$30,000	Standard conuslting rate
				$0			$0			$0	0	$0	
3	Patel	160	$200.00	$32,000	80	$200.00	$16,000			$0	240	$48,000	Standard conuslting rate
	Engineer	1000	$57.50	$57,500	400	$57.50	$23,000			$0	1400	$80,500	Standard conuslting rate
	Technicians/Operators	2000	$50.00	$100,000	800	$50.00	$40,000			$0	2800	$140,000	Standard conuslting rate
				$0			$0			$0	0	$0	
4	Patel			$0	160	$200.00	$32,000			$0	160	$32,000	Standard conuslting rate
	Engineer			$0	500	$57.50	$28,750			$0	500	$28,750	Standard conuslting rate
	Technicians/Operators			$0	1000	$50.00	$50,000			$0	1000	$50,000	Standard conuslting rate
				$0			$0			$0	0	$0	
5	Patel			$0	100	$200.00	$20,000			$0	100	$20,000	Standard conuslting rate
	Engineer			$0	120	$57.50	$6,900			$0	120	$6,900	Standard conuslting rate
	Technicians/Operators			$0	0	$50.00	$0			$0	0	$0	Standard conuslting rate
				$0			$0			$0	0	$0	
				$0			$0			$0	0	$0	
				$0			$0			$0	0	$0	
				$0			$0			$0	0	$0	
	TOTAL PERSONNEL	**4720**		**$308,000**	**3160**		**$216,650**	**0**		**$0**	**7880**	**$524,650**	

Additional Explanation (as needed): The labor rates include fringe benefits. Personnel used for the project will be a combination of SET and Tri-Steel Manufacturing employees.

b. Fringe Benefits

INSTRUCTIONS - PLEASE READ!!!

1. Fill out the table below by position title. If all employees receive the same fringe benefits, you can show "Total Personnel" in the Labor Type column instead of listing out all position titles.
2. The rates and how they are applied should not be averaged to get one fringe cost percentage. Complex calculations should be described/provided in the Additional Explanation section below.
3. The fringe benefit rates should be applied to all positions, regardless of whether those funds will be supported by Federal Share or Recipient Cost Share.
4. Each budget period is rounded to the nearest dollar.

Labor Type	Budget Period 1			Budget Period 2			Budget Period 3			Total Project
	Personnel Costs	Rate	Total	Personnel Costs	Rate	Total	Personnel Costs	Rate	Total	
EXAMPLE!!! Sr. Engineer	$170,000	20%	$34,000	$10,000	20%	$2,000	$10,000	20%	$2,000	$38,000
			$0			$0			$0	$0
			$0			$0			$0	$0
			$0			$0			$0	$0
			$0			$0			$0	$0
			$0			$0			$0	$0
TOTAL FRINGE	**$0**		**$0**	**$0**		**$0**	**$0**		**$0**	**$0**

A federally approved fringe benefit rate agreement, or a proposed rate supported and agreed upon by DOE for estimating purposes is required at the time of award negotiation if reimbursement for fringe benefits is requested. Please check (X) one of the options below and provide the requested information if not previously submitted.

_____ A fringe benefit rate has been negotiated with, or approved by, a federal government agency. A copy of the latest rate agreement is/was included with the project application.*

___X___ There is not a current federally approved rate agreement negotiated and available.**

*Unless the organization has submitted an indirect rate proposal which encompasses the fringe pool of costs, please provide the organization's benefit package and/or a list of the components/elements that comprise the fringe pool and the cost or percentage of each component/element allocated to the labor costs identified in the Budget Justification.

**When this option is checked, the entity preparing this form shall submit an indirect rate proposal in the format provided in the Sample Rate Proposal at https://www.energy.gov/eere/funding/downloads/sample-indirect-rate-proposal-and-profit-compliance-audit, or a format that provides the same level of information and which will support the rates being proposed for use in the performance of the proposed project.

Additional Explanation (as necessary): Please use this box (or an attachment) to list the elements that comprise your fringe benefits and how they are applied to your base (e.g. Personnel) to arrive at your fringe benefit rate. SET does not have an approved fringe benefit rate. Fringe benefits are therefore not included as a cost item.

c. Travel

INSTRUCTIONS - PLEASE READ!!!

1. Identify Foreign and Domestic Travel as separate items. Examples of Purpose of Travel are subrecipient site visits, DOE meetings, project mgmt. meetings, etc. Examples of Basis for Estimating Costs are past trips, travel quotes, GSA rates, etc.
2. All listed travel must be necessary for performance of the Statement of Project Objectives.
3. Only travel that is directly associated with this award should be included as a direct travel cost to the award.
4. Federal travel regulations are contained within the applicable cost principles for all entity types.
5. Travel costs should remain consistent with travel costs incurred by an organization during normal business operations as a result of the organizations written travel policy. In absence of a written travel policy, organizations must follow the regulations prescribed by the General Services Administration.
6. **Columns G, H, I, J, and K are total per trip per traveler.**
7. The number of days is inclusive of day of departure and day of return.
8. Recipients should enter City and State (or City and Country for International travel) in the Depart from and Destination fields.
9. Each budget period is rounded to the nearest dollar.

SOPO Task #	Purpose of Travel	Depart From	Destination	No. of Days	No. of Travelers	Lodging per Traveler	Flight per Traveler	Vehicle per Traveler	Per Diem Per Traveler	Cost per Trip	Basis for Estimating Costs
	Domestic Travel	**Budget Period 1**									
1	**EXAMPLE!!!** Visit to PV manufacturer			2	2	$250	$500	$100	$80	$1,860	Current GSA rates
										$0	
										$0	
										$0	
										$0	
	International Travel										
										$0	
	Budget Period 1 Total									**$0**	
	Domestic Travel	**Budget Period 2**									
										$0	
										$0	
										$0	
										$0	
	International Travel										
										$0	
	Budget Period 2 Total									**$0**	
	Domestic Travel	**Budget Period 3**									
										$0	
										$0	
										$0	
										$0	
	International Travel										
										$0	
	Budget Period 3 Total									**$0**	
	TOTAL TRAVEL									**$0**	

Additional Explanation (as needed): The gasification component of this work is an important piece to the overall success of the project. It is unique from the other components and would require personnel from SET to fully discuss the applicaiton of the gasification component to windmill blades and to answer any substantive questions regarding the technology.

d. Equipment

INSTRUCTIONS - PLEASE READ!!!

1. Equipment means tangible personal property (including information technology systems) having a useful life of more than one year and a per-unit acquisition cost which equals or exceeds the lesser of the capitalization level established by the non-Federal entity for financial statement purposes, or $5,000. Please refer to the applicable Federal regulations in 2 CFR 200 for specific equipment definitions and treatment.

2. List all equipment below, providing a basis of cost (e.g. contractor quotes, catalog prices, prior invoices, etc.). Briefly justify items as they apply to the Statement of Project Objectives. If it is existing equipment, provide logical support for the estimated value shown.

3. During award negotiations, provide a contractor quote for all equipment items over $50,000 in price. If the contractor quote is not an exact price match, provide an explanation in the additional explanation section below. If a contractor quote is not practical, such as for a piece of equipment that is purpose-built, first of its kind, or otherwise not available off the shelf, provide a detailed engineering estimate for how the cost estimate was derived.

4. Each budget period is rounded to the nearest dollar.

SOPO Task #	Equipment Item	Qty	Unit Cost	Total Cost	Basis of Cost	Justification of need
Budget Period 1						
3,4,5	**EXAMPLE!!!** Thermal shock chamber	2	$70,000	$140,000	Contractor Quote - Attached	Reliability testing of PV modules- Task 4.3
2	Compressor and tank	1	$50,000	$50,000		Compressed gas storage during system operation
2	Shift reactor and catalyst	1	$65,000	$65,000		
2	CO2 system and solvent	1	$60,000	$60,000		
2	Heat exchangers	3	$5,000	$15,000		
2	Pumps	4	$2,500	$10,000		
2	Misc parts and shipping	1	$20,000	$20,000		
	Budget Period 1 Total			$220,000		
Budget Period 2						
				$0		
				$0		
				$0		
				$0		
				$0		
				$0		
	Budget Period 2 Total			$0		
Budget Period 3						
				$0		
				$0		
				$0		
				$0		
				$0		
				$0		
	Budget Period 3 Total			$0		
	TOTAL EQUIPMENT			**$220,000**		

Additional Explanation (as needed):

e. Supplies

INSTRUCTIONS - PLEASE READ!!!

1. Supplies are generally defined as an item with an acquisition cost of $5,000 or less and a useful life expectancy of less than one year. Supplies are generally consumed during the project performance. Please refer to the applicable Federal regulations in 2 CFR 200 for specific supplies definitions and treatment. A computing device is a supply if the acquisition cost is less than the lesser of the capitalization level established by the non-Federal entity for financial statement purposes or $5,000, regardless of the length of its useful life.

2. List all proposed supplies below, providing a basis of costs (e.g. contractor quotes, catalog prices, prior invoices, etc.). Briefly justify the need for the Supplies as they apply to the Statement of Project Objectives. Note that Supply items must be direct costs to the project at this budget category, and not duplicative of supply costs included in the indirect pool that is the basis of the indirect rate applied for this project.

3. Multiple supply items valued at $5,000 or less used to assemble an equipment item with a value greater than $5,000 with a useful life of more than one year should be included on the equipment tab. If supply items and costs are ambiguous in nature, contact your DOE representative for proper categorization.

4. Add rows as needed. If rows are added, formulas/calculations may need to be adjusted by the preparer.

5. Each budget period is rounded to the nearest dollar.

SOPO Task #	General Category of Supplies	Qty	Unit Cost	Total Cost	Basis of Cost	Justification of need
Budget Period 1						
4,6	**EXAMPLE!!!** Wireless DAS components	10	$360.00	$3,600	Catalog price	For Alpha prototype - Task 2.4
				$0		
3	Feedstock procurement and transport	1	$2,500.00	$2,500	Past experience and verbal quotes	Provides the required feedstock for testing as proposed
2,3	Piping, fittings, electrical, misc supplies to prepare site and to make modifications to the 5 TPD system	1	$14,000.00	$14,000	Past experience, catalog prices	Modificaitons are required to the current 5 TPD system to allow the addition and installation of the various gas cleeanup systems including rerouting piping, electrical and controls
2,3	Piping, tubing, fittings, electrical, insulation, heat tape, misc supplies to install syngas balance equipment and gas analyzers	1	$20,000.00	$20,000	Past experience, catalog prices	This includes all materials required to install the CO2 solvent system and shift reactor.
3	Hand held gas analyzers	4	$250.00	$1,000	Catalog price	Safety
3	Initial charges of solvents/sorbents/catalysts	1	$5,000.00	$5,000	Estimated based upon current price and quantities required	Provides the initial charge of materials for the syngas cleanup train, shirt reactor, and CO2 removal system.
				$0		
	Budget Period 1 Total			**$42,500**		
Budget Period 2						
4	Feedstock procurement and transport	2	$2,500.00	$5,000	Past experience and verbal quotes	Provides the required feedstock for testing as proposed
3,4	Consumable supplies(glassware, solvents, sorbents, fittings, etc.) and repair/replacement parts	1	$10,000.00	$10,000	Experience / Catalog	Materials consumed during the testing are replaced. It is expected that minor repairs and replacment will be needed.
				$0		
3,4	Calibration and purge gases	4	$750.00	$3,000	Calibration and purge gases	Required for calibrating on-line gas analyzers
3,4	55 gallon drums	10	$250.00	$2,500	Estimate	Intermediate storage of various products and wastes
3,4	Charcoal	1	$2,500.00	$2,500	Estimate	Required for cold startup
3,4	Bottled gases	1	$1,250.00	$1,250	Estimate	Required for purge, calibration, and batch tests
3,4	Rental / Truck Mounted System11	0	$5,000.00	$0		
	Budget Period 2 Total			$24,250		
Budget Period 3						
				$0		
				$0		
				$0		
				$0		
				$0		
				$0		
				$0		
				$0		
	Budget Period 3 Total			$0		
	TOTAL SUPPLIES			**$66,750**		

Additional Explanation (as needed):

f. Contractual

INSTRUCTIONS - PLEASE READ!!!

1. The entity completing this form must provide all costs related to subrecipients, contractors, and FFRDC partners in the applicable boxes below.

2. Subrecipients (partners, sub-awardees): Subrecipients shall submit a Budget Justification describing all project costs and calculations when their total proposed budget exceeds either (1) $250,000 or (2) 25% of total award costs. These subrecipient forms may be completed by either the subrecipients themselves or by the preparer of this form. The budget totals on the subrecipient's forms must match the subrecipient entries below. A subrecipient is a legal entity to which a subaward is made, who has performance measured against whether the objectives of the Federal program are met, is responsible for programmatic decision making, must adhere to applicable Federal program compliance requirements, and uses the Federal funds to carry out a program of the organization. All characteristics may not be present and judgment must be used to determine subrecipient vs. contractor status.

3. Contractors: List all contractors supplying commercial supplies or services used to support the project. For each Contractor cost with total project costs of $250,000 or more, a Contractor quote must be provided. A contractor is a legal entity contracted to provide goods and services within normal business operations, provides similar goods or services to many different purchasers, operates in a competitive environment, provides goods or services that are ancillary to the operation of the Federal program, and is not subject to compliance requirements of the Federal program. All characteristics may not be present and judgment must be used to determine subrecipient vs. contractor status.

4. Federal Funded Research and Development Centers (FFRDCs): FFRDCs must submit a signed Field Work Proposal during award application. The award recipient may allow the FFRDC to provide this information directly to DOE, however project costs must also be provided below.

5. Each budget period is rounded to the nearest dollar.

SOPO Task #	Subrecipient Name/Organization	Subrecipient Unique Entity Identifier (UEI)	Purpose and Basis of Cost	Budget Period 1	Budget Period 2	Budget Period 3	Project Total
2,4	**EXAMPLE!!!** XYZ Corp.		Partner to develop optimal lens for Gen 2 product. Cost estimate based on personnel hours.	$48,000	$32,000	$16,000	**$96,000**
							$0
							$0
							$0
							$0
							$0
							$0
			Sub-total	**$0**	**$0**	**$0**	**$0**

SOPO Task #	Contractor Name/Organization	Purpose and Basis of Cost	Budget Period 1	Budget Period 2	Budget Period 3	Project Total
6	**EXAMPLE!!!** ABC Corp.	Contractor for developing robotics to perform lens inspection. Estimate provided by contractor.	$32,900	$86,500	$0	**$119,400**
1-5	Sage Green LLC	Feedstock procurement, support in developing analytical protocols, analyzing data and report writing	$7,500	$7,500		**$15,000**
1-5	MDM Energy Consulting LLC	Support in developing test plans, interpreting data, and report writing	$10,000	$10,000		**$20,000**
2,3,4	Electrical Contractor	Grid connection, wiring equiment	$10,000	$5,000		**$15,000**
						$0
						$0
		Sub-total	**$27,500**	**$22,500**	**$0**	**$50,000**

SOPO Task #	FFRDC Name/Organization	Purpose and Basis of Cost	Budget Period 1	Budget Period 2	Budget Period 3	Project Total
						$0
						$0
		Sub-total	**$0**	**$0**	**$0**	**$0**

TOTAL CONTRACTUAL	**$27,500**	**$22,500**	**$0**	**$50,000**

Additional Explanation (as needed): SET does not have a dedicated engineering staff. Tri-Steel Manufacturing will provide eningeering support on an as-needed basis at a loaded rate of $80/hr. It is estimated that SET will require 300 hours of engineergin time for Task 1 to support operation of the bench-scale system; 700 hours for Task 2 to for operation of the bench-scale system and to support the shakedown and commissioning of the truck-mounted system; and 1750

g. Construction

PLEASE READ!!!

1. Construction, for the purpose of budgeting, is defined as all types of work done on a particular building, including erecting, altering, or remodeling. Construction conducted by the award recipient is entered on this page. Any construction work that is performed by a contractor or subrecipient should be entered under f. Contractual.

2. List all proposed construction below, providing a basis of cost such as engineering estimates, prior construction, etc., and briefly justify its need as it applies to the Statement of Project Objectives.

3. Each budget period is rounded to the nearest dollar.

Overall description of construction activities: Example Only!!! - Build wind turbine platform

SOPO Task #	General Description	Cost	Basis of Cost	Justification of need
Budget Period 1				
3	EXAMPLE ONLY!!! Three days of excavation for platform site	$28,000	Engineering estimate	Site must be prepared for construction of platform.
	Budget Period 1 Total	**$0**		
Budget Period 2				
	Budget Period 2 Total	$0		
Budget Period 3				
	Budget Period 3 Total	$0		
	TOTAL CONSTRUCTION	**$0**		

Additional Explanation (as needed):

h. Other Direct Costs

INSTRUCTIONS - PLEASE READ!!!

1. Other direct costs are direct cost items required for the project which do not fit clearly into other categories. These direct costs must not be included in the indirect costs (for which the indirect rate is being applied for this project). Examples are: tuition, printing costs, etc. which can be directly charged to the project and are not duplicated in indirect costs (overhead costs).

2. Basis of cost are items such as contractor quotes, prior purchases of similar or like items, published price list, etc.

3. Each budget period is rounded to the nearest dollar.

SOPO Task #	General Description and SOPO Task #	Cost	Basis of Cost	Justification of need
			Budget Period 1	
5	**EXAMPLE!!!** Grad student tuition - tasks 1-3	$16,000	Established UCD costs	Support of graduate students working on project
3	Rental charge for 5 TPD truck-mounted system	$36,000	6 months rent at $6,000/month (30% of the nominal rental rate)	SET will require the use of the truck-mounted system to perform the propsed work. It is estimated that SET will use the system for approximately 30% of its availability, and therefore the rate charged is 30% of the normal rate of $20,000/month.
	Budget Period 1 Total	$36,000		
			Budget Period 2	
3,4	Rental charge for 5 TPD truck-mounted system	$72,000	12 months rent at $6,000/month (30% of the nominal rental rate)	SET will require the use of the truck-mounted system to perform the propsed work. It is estimated that SET will use the system for approximately 30% of its availability, and therefore the rate charged is 30% of the normal rate of $20,000/month.
3,4	Ultimate, proxiimate, ash analysis	$1,000	4 samples at $250	Analysis of feedstock
3,4	Fuel, Tar, and Residual Anlaysis	$1,500	10 samples at $150/sample	Determine concentrations for baseline tests / assist with process optimization
3,4	Certifed Analysis of Process Streams	$2,000	10 samples at $200/sample	Determine concentrations for baseline tests / assist with process optimization / support permitting requirements
3,4	TCLP analysis	$2,000	2 samples at $1000 each	Verify solid wastes are non-hazardous
3,4	RCRA metals analysis	$2,000	2 samples at $1000 each	Verify solid wastes are non-hazardous
3,4	Wastewater analysis	$1,050	3 samples at $350 each	Generate data for wastewater disposal
	Budget Period 2 Total	$81,550		
			Budget Period 3	
	Budget Period 3 Total	$0		
	TOTAL OTHER DIRECT COSTS	**$117,550**		

Additional Explanation (as needed):

i. Indirect Costs

INSTRUCTIONS - PLEASE READ!!!

1. Fill out the table below to indicate how your indirect costs are calculated. Use the box below to provide additional explanation regarding your indirect rate calculation.

2. The rates and how they are applied should not be averaged to get one indirect cost percentage. Complex calculations or rates that do not do not correspond to the below categories should be described/provided in the Additional Explanation section below. If questions exist, consult with your DOE contact before filling out this section.

3. The indirect rate should be applied to both the Federal Share and Recipient Cost Share.

4. NOTE: A Recipient who elects to employ the 10% de minimis Indirect Cost rate **cannot claim resulting costs as a Cost Share contribution, nor can the Recipient claim "unrecovered indirect costs" as a Cost Share contribution.** Neither of these costs can be reflected as actual indirect cost rates realized by the organization, and therefore are not verifiable in the Recipient records as required by Federal Regulation (§200.306(b)(1)).

5. Each budget period is rounded to the nearest dollar.

	Budget Period 1	Budget Period 2	Budget Period 3	Total	Explanation of BASE
Provide ONLY Applicable Rates:					
Overhead Rate	0.00%	0.00%	0.00%		*Example: Labor + Fringe*
General & Administrative (G&A)	0.00%	0.00%	0.00%		*MTDC*
FCCM Rate, if applicable	0.00%	0.00%	0.00%		
OTHER Indirect Rate	0.00%	0.00%	0.00%		
Indirect Costs (As Applicable):					
Overhead Costs				**$0**	
G&A Costs	$0	$0	$0	**$0**	
FCCM Costs, if applicable				**$0**	
OTHER Indirect Costs				**$0**	
Total Indirect Costs Requested:	**$0**	**$0**	**$0**	**$0**	

	BP1	BP2	BP3
Personel	308000	216650	0
Fringe	0	0	0
Travel	0	0	0
Supplies	42500	24250	0
Contract1	7500	7500	0
Contract2	10000	10000	0
Contract3	10000	5000	0
Contract4	0	0	0
SubRecip1	0	0	0
Other	36000	81550	0
MTDC	414000	344950	0

A federally approved indirect rate agreement, or rate proposed (supported and agreed upon by DOE for estimating purposes) is required if reimbursement of indirect costs is requested. Please check (X) one of the options below and provide the requested information if it has not already been provided as requested, or has changed.

_____ An indirect rate has been approved or negotiated with a federal government agency. A copy of the latest rate agreement is included with this application and will be provided electronically to the Contracting Officer for this project.

_____ The organization does not have a current, federally approved indirect cost rate agreement and has provided an indirect rate proposal in support of the proposed costs.

__X____ This organization has elected to apply a 10% de minimis rate in accordance with 2 CFR 200.414(f).

Provide an explanation of how your indirect cost rate was applied.

*Additional Explanation (as needed): *IMPORTANT: Please use this box (or an attachment) to further explain how your total indirect costs were calculated. If the total indirect costs are a cumulative amount of more than one calculation or rate application, the explanation and calculations should identify all rates used, along with the base they were applied to (and how the base was derived), and a total for each (along with grand total).*

Cost Share

PLEASE READ!!!

1. A detailed presentation of the cash or cash value of all cost share proposed must be provided in the table below. All items in the chart below must be identified within the applicable cost category tabs a. through i. in addition to the detailed presentation of the cash or cash value of all cost share proposed provided in the table below. Identify the source organization & amount of each cost share item proposed in the award.

2. Cash Cost Share - encompasses all contributions to the project made by the recipient, subrecipient, or third party (an entity that does not have a role in performing the scope of work) for costs incurred and paid for during the project. This includes when an organization pays for personnel, supplies, equipment, etc. for their own company with organizational resources. If the item or service is reimbursed for, it is cash cost share. All cost share items must be necessary to the performance of the project. **Contractors may not provide cost share.** Any partial donation of goods or services is considered a discount and is not allowable.

3. In Kind Cost Share **-** encompasses all contributions to the project made by the recipient, subrecipient, or third party (an entity that does not have a role in performing the scope of work) where a value of the contribution can be readily determined, verified and justified but where no actual cash is transacted in securing the good or service comprising the contribution. In Kind cost share items include volunteer personnel hours, the donation of space or use of equipment, etc. The cash value and calculations thereof for all In Kind cost share items must be justified and explained in the Cost Share Item section below. All cost share items must be necessary to the performance of the project. If questions exist, consult your DOE contact before filling out In Kind cost share in this section. Contractors may not provide cost share. Any partial donation of goods or services is considered a discount and is not allowable.

4. Funds from other Federal sources MAY NOT be counted as cost share. This prohibition includes FFRDC sub-recipients. Non-Federal sources include any source not originally derived from Federal funds. Cost sharing commitment letters from subrecipients and third parties must be provided with the original application.

5. Fee or profit, including foregone fee or profit, **are not allowable** as project costs (including cost share) under any resulting award. The project may only incur those costs that are allowable and allocable to the project (including cost share) as determined in accordance with the applicable cost principles prescribed in FAR Part 31 for For-Profit entities and 2 CFR Part 200 Subpart E **-** Cost Principles for all other non-federal entities.

6. NOTE: A Recipient who elects to employ the 10% de minimis Indirect Cost rate **cannot claim the resulting indirect costs as a Cost Share contribution.**

7. NOTE: A Recipient **cannot claim "unrecovered indirect costs"** as a Cost Share contribution, **without prior approval.**

8. Each budget period is rounded to the nearest dollar.

Organization/Source	Type (Cash or In Kind)	Cost Share Item	Budget Period 1	Budget Period 2	Budget Period 3	Total Project Cost Share
ABC Company **EXAMPLE!!!**	Cash	Project partner ABC Company will provide 20 PV modules for product development at the price of $680 per module	$13,600			**$13,600**
						$0
						$0
Tri-Steel Manufacturing	In-Kind	Rental for 5-ton/day truck mounted system	$36,000	$72,000		**$108,000**
Xcel Energy	Cash	Support provided through Xcel Energy's Natural Gas Innovation Act (NGIA) filing,	$195,000	$0	$0	**$195,000**
SET	Cash	Salary	$40,000	$34,000		**$74,000**
Tri-Steel Manufacturing	Cash	Salary	$50,000	$65,000		**$115,000**
						$0
						$0
						$0
						$0
		TOTAL COST SHARE	**$321,000**	**$171,000**	**$0**	**$492,000**
		Cost Share Percentage per Budget Period	**50.6%**	**49.6%**	**0.0%**	

Total Project Cost: $978,950 **Total Project Cost Share Percent: 50.3%**

Additional Explanation (as needed):

CHAPTER 54-63
RENEWABLE ENERGY COUNCIL

54-63-00.1. Definitions.

As used in this chapter, "advanced biofuel" means fuel derived from renewable biomass and includes:

1. Biofuel derived from cellulose, hemicellulose, or lignin;
2. Biofuel derived from sugar and starch other than ethanol derived from corn kernel starch;
3. Biofuel derived from waste material, including crop residue, other vegetative waste material, animal waste, food waste, and yard waste;
4. Diesel-equivalent fuel derived from renewable biomass, including vegetable oil and animal fat;
5. Biogas, including landfill gas and sewage waste treatment gas, produced through the conversion of organic matter from renewable biomass;
6. Butanol or other alcohols produced through the conversion of organic matter from renewable biomass; and
7. Other fuel derived from cellulosic biomass.

54-63-01. Renewable energy council - Composition.

The industrial commission shall consult with the renewable energy council in matters of policy affecting the administration of the renewable energy development fund.

1. The renewable energy council consists of:
   a. The commissioner of commerce or the commissioner's designee.
   b. A member with a substantial interest in the agriculture industry appointed by the governor.
   ~~c. A member with a substantial interest in the biodiesel industry appointed by the governor representing biodiesel interests.~~
   ~~d.~~c. A member with a substantial interest in the biomass industry appointed by the governor representing biomass interests.
   ~~e.~~d. A member with a substantial interest in the wind industry appointed by the governor representing wind interests.
   ~~f.~~e. A member with a substantial interest in the ethanol industry appointed by the governor representing ethanol interests.
   ~~g.~~f. ~~A~~ Two members with a substantial interest in advanced biofuel ~~and~~ or sugar-based biofuel, appointed by the governor.
2. Subject to subsection 6, the terms of office for members of the council are three years but of those first appointed, two serve for one year, two serve for two years, and two serve for three years.
3. The commissioner of commerce shall serve as chairman.
4. The council shall have at least one regular meeting each year and such additional meetings as the chairman determines necessary at a time and place to be fixed by the chairman. Special meetings must be called by the chairman on written request of any three members. Four members constitute a quorum.
5. The council shall recommend to the industrial commission the approval of grants, loans, or other financial assistance necessary or appropriate for funding, research, development, marketing, and educational projects or activities and any other matters related to this chapter.
6. Members of the council serve at the pleasure of the governor.

54-63-02. Access to council records.

1. Materials and data submitted to, or made or received by, the council or industrial commission, to the extent that the council or industrial commission determines the materials or data consist of trade secrets or commercial, financial, or proprietary information of individuals or entities applying to or contracting with the commission or

receiving council or industrial commission services under this chapter, are subject to section 44-04-18.4.

2. a. A person or entity must file a request with the council or industrial commission to have material designated as confidential under subsection 1. The request must contain any information required by the council or industrial commission and must include at least:
   (1) A general description of the nature of the information sought to be protected.
   (2) An explanation of why the information derives independent economic value, actual or potential, from not being generally known to other persons.
   (3) An explanation of why the information is not readily ascertainable by proper means by other persons.
   (4) A general description of a person or entity that may obtain economic value from disclosure or use of the information, and how the person or entity may obtain this value.
   (5) A description of the efforts used to maintain the secrecy of the information.
   b. The fact that a request has been made is exempt.
3. The information submitted pursuant to subsection 2 is confidential. The council or industrial commission shall examine the request and determine whether the information is relevant to the matter at hand and is a trade secret under the definition in section 47-25.1-01 or 44-04-18.4. If the council or industrial commission determines the information is either not relevant or not a trade secret, the council or industrial commission shall notify the requester and the requester may ask for the return of the information and request within ten days of the notice. If no return is sought, the information and request are a public record.
4. The names or identities of independent technical reviewers on a project or program and the names of council members making recommendations are confidential, may not be disclosed by the council, and are not public records subject to section 44-04-18 or section 6 of article XI of the Constitution of North Dakota.

54-63-03. Industrial commission powers.

1. The industrial commission may:
   a. Make grants or loans, and provide other forms of financial assistance as necessary or appropriate, to qualified persons for funding research, development, marketing, and educational projects or activities, feasibility studies, applied research and demonstrations, venture capital investments, and low-interest loans and loan buydowns to foster the development of renewable energy, including wind, biofuels, biomass, solar, hydroelectric, geothermal, and hydrogen, that is produced from the foregoing renewable energy sources. Any financial assistance that the commission awards to a project must not be the project's sole support. Any financial assistance the commission awards must be conditioned on the assurance that the applicant or a third party will support the project by either monetary or nonmonetary means. The amount of this additional support is at the commission's discretion.
   b. Provide incentives for multifeed facilities to process corn ethanol, cellulosic ethanol, canola biodiesel, and soy biodiesel.
   c. Provide incentives for scaleable technologies.
   d. Provide incentives to increase research and utilization of renewable energy coproduct utilization for livestock feed, human food products, and industrial use technologies.
   e. Execute contracts and all other instruments necessary or convenient for the performance of its powers and functions under this chapter.
   f. Accept aid, grants, or contributions of money or other things of value from any source, to be held, used, and applied to carry out this chapter, subject to the conditions upon which the aid, grants, or contributions are made, including aid, grants, or contributions from any department, agency, or instrumentality of the United States for any purpose consistent with this chapter.

g. Establish interest buydown programs for equipment needed for production, harvest, storage, and transport under the special private lands open to sportsmen pilot program for native grass stands.
h. Fund technical assistance from the university system and private entities to producers.
i. Establish incentive programs that have as their purpose demonstrating to the agriculture community the commercial feasibility of producing, harvesting, storing, and delivering biomass feedstock. The program may include providing funds to producers of perennial biomass crops, including native grasses, so that such producers have an income during the time needed for these plants to mature and become ready for harvest.
j. Provide incentives to support research and demonstration projects and obtain matching grants for projects involving advanced biofuels and sugar-based biofuels.

2. The industrial commission may contract with the department of commerce to provide technical assistance to the renewable energy council and the industrial commission to carry out and effectuate the purposes of this chapter, including pursuit of aid, grants, or contributions of money or other things of value from any source for any purpose consistent with this chapter. The department may contract with a public or private third party to provide any or all of the technical assistance necessary to implement the purposes of this chapter.

54-63-04. Renewable energy development fund - Continuing appropriation.

The renewable energy development fund is a special fund in the state treasury. All funds in the renewable energy development fund are appropriated to the industrial commission on a continuing basis for the purpose of carrying out and effectuating this chapter. Interest earned by the fund must be credited to the fund.