INDUSTRIAL COMMISSION OF NORTH DAKOTA
RENEWABLE ENERGY PROGRAM

Renewable Energy Council Meeting: Grant Round 52

November 6, 2023, 9:00 am (CT)
Department of Commerce, WSI Boardroom, 1600 E. Century Ave., Suite 1, Bismarck

Click here to join the meeting
+1 701-328-0950,,782295033#

(approximately 9:00 am)

I. Call to Order – *Josh Teigen, Chairman*

II. Administrative Business
   1. **Consideration of June 22, 2023 Meeting Minutes** – *Josh Teigen*
   2. Renewable Energy Program Project Management and Financial Report – *Reice Haase*
   3. Carbon Capture and Utilization Education and Marketing Special Grant Round Update – *Reice Haase*

(approximately 9:30 am)

III. **Consideration of Grant Round 52 Requests** – *Rich Garman*

1. R-052-A – **Smart Holistic Zero Waste Utilization Paradigm (SH0WUP);** Submitted by Surojit Gupta, UND; Total Project Costs: $3,780,360; Amount Requested: $500,000
   a. Technical Reviewer Results
   b. Technical Advisor Recommendations
   c. Applicant Presentation

2. R-052-B – **Prairie Horizon Carbon Management Hub**; Submitted by Kevin Connors, EERC; Total Project Costs: $3,225,000; Amount Requested: $100,000
   a. Technical Reviewer Results
   b. Technical Advisor Recommendations
   c. Applicant Presentation

3. R-052-C – **Use of Bioengineering to Enhance the Agronomic Potential of Camelina**; Submitted by Eric Murphy, CamBioGene; Total Project Costs: $1,151,250; Amount Requested: $500,000
   a. Technical Reviewer Results
   b. Technical Advisor Recommendations
   c. Applicant Presentation

(approximately 11:00 am)

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

V. Tentative Dates and Venue for next Renewable Energy Council Meeting

VI. Other Business

VII. Adjournment

Minutes of the

RENEWABLE ENERGY COUNCIL (REC)

Thursday, June 22, 2023

1:00 pm (CT)

TEAMS Meeting Via Conference/Video Call

ONSITE Location: Bismarck Event Center, Room 103, 315 S. 5th Street, Bismarck, ND 58504

Members Present	Staff Present	Guests Present
Josh Teigen, TEAMS	Reice Haase, NDIC	Jason Laumb, EERC
Gerald Bachmeier	Brenna Jessen, NDIC	Dr. Michael Swanson, EERC
Al Christianson	Rich Garman, Commerce Dept.	Brian LaPlante, TEAMS
Terry Goerger	Joleen Leier, Commerce Dept.	John Schneider, TEAMS
Tony Grindberg		Marlo Anderson, TEAMS
Rodney Holth, TEAMS		

WELCOME & OPENING COMMENTS

Josh Teigen called the Renewable Energy Council (REC) meeting to order at 1:00 pm. Teigen welcomed the members and guests in the meeting room and on the TEAM video/audio platform. Teigen introduced himself and gave a brief history.

APPROVAL OF MINUTES

The minutes from the December 8, 2022, meeting was presented to the board. **It was moved by Grindberg and seconded by Christianson to approve the December 8, 2022, meeting minutes. The motion carried unanimously.**

RENEWABLE ENERGY PROGRAM LEGISLATIVE UPDATE

Reice Haase presented on legislative updates.

2023-2025 Appropriation

$3M was appropriated to the Renewable Energy Council during the last legislative session. The Industrial Commission received two additional FTEs; one for grant management and one for administrative support.

House Bill 1014: Digitization and Grant Management Software

We were approved to purchase new meeting management software.

House Bill 1014: Carbon Capture Education

Appropriated up to $100,000 from the Renewable, Oil and Gas, and Lignite Research funds and they directed you as a Council to make recommendations that would advance carbon capture education. We will discuss recommendations on how to go forward with this project at the fall meeting.

There was a question regarding the grade level of education. Haase stated that expectations in the budget bill are very broad. It states it is for education and marketing.

There was a question to clarify the amount taken out of the REC appropriation. Haase stated they will take $350,000 out of the $3M appropriation. Discussed amount to be taken from all programs since some programs are allotted more than the REC.

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PROJECT MANAGEMENT & FINANCIAL REPORT

17 active projects $4.8 million. Information included in your packets for more detailed information on the projects.

Reice Haase presented the financial report that had been posted on the Industrial Commission/Renewable Energy website. The cash available for comment in your Renewable Energy fund is $1.1M. This is the amount available for the rest of this biennium. There are four requests in front of you today totaling $1.7M. If were to approve all these projects, you would be appropriating money that is coming in next biennium.

REPORT ON GRANT ROUND 51 APPLICATIONS

Four applications were received, four were sent to Technical Reviewers for peer review. Total amount being considered for Round 51 is $1.7M. Rich Garman, of the Commerce Department, presented the Grant Round Requests.

CONSIDERATION OF SPECIAL GRANT ROUND 51 REQUESTS

R-051-A – Integrated Renewable Combined Heat and Power for Ethanol

Principal Investigator: Joshua R. Strege
Project Duration: 18 months
Requesting: $450,000
Total Project Cost: $2,250,000

Reviewers' Ratings

- Fund – 227/250
- Fund – 209/250
- Fund – 218/250
- Average Weighted Score – 218/250

Jason Laumb presented on the project.

Board member expressed the following concerns:

- Availability of biomass in agriculture.
- California market and carbon-free ethanol; are we going to overdo that market?
- California has passed resolutions to get rid of combustion engines; so does that market and premium go away?

Laumb stated they have some of the same concerns. When we did the initial feasibility study, we would only need to collect a fraction of the silver based on amount of corn delivered in one year. Based on averages, you would only need to collect a fraction of the stover based on the amount of corn grain that is delivered to Red Trail during one year. So the farmers that support the ethanol plant with the corn itself would only need a fraction of their stover to support the combined heat power.

Regarding the carbon footprint, there are entities now in Nebraska and Iowa that are pelletizing corn stover that is being harvesting locally. Would have to look at this so it doesn't raise the carbon back up.

LCSF market is a bit of unknown. Have to look at scenarios where if the tax credit is going away; look at other markets.

Board member asked question regarding compressors with 5 megawatts. Laumb stated it would need a larger heat power system. They would look at that in the current study.

Questioned if they used half coal and half corn stover, what data on per ton basis? Laumb stated it's similar per pound to some of the low rank coals.

Also questioned utilizing the California model vs Oregon model.

R-051-B – Clean Hydrogen from High-Volume Waste Materials and Biomass
Principal Investigator: Dr. Michael L. Swanson
Project Duration: 21 months
Requesting: $500,000
Total Project Costs: $2,500,000

Reviewers' Ratings
- Fund – 210/250
- Fund – 184/250
- Fund – 221/250
- Average Weighted Score – 205/250

Dr. Mike Swanson presented on the project.

There was a question regarding the breakdowns of Simon Petri. Swanson stated that's where a lot of the PA and LCA work is being done. They are coming up with cost share and additional funding.

There was a question if EERC can do themselves. They could but it was requested to get an estimate to contract out. Most of this money is coming out of the DOE funding.

There was a question regarding Chad Wocken and EERC leading the hydrogen application and how it ties into that program if funded what values it brings in. Swanson stated the thought would be it would generate additional hydrogen plus carbon capture. Not a lot of information has been put out on that yet. Possibility of green hydrogen and oxygen generation.

R-051-C - DEFC Research and Development
Principal Investigator: Dr. Yang Yang
Project Duration: 2023-2025
Requesting: $346,915
Total Project Costs: $693,832

Reviewers' Ratings
- Funding May be Considered – 168/250
- Funding May be Considered – 150/250
- Fund – 183/250
- Average Weighted Score – 167/250

Brian LaPlante presented on this project.

There was a question regarding the financials. LaPlante clarified the request is for $346,000 to be split over two years.

R-051-D – CarbonConvert
Principal Investigator: Steve Bakken
Project Duration: 1 year
Requesting: $500,000
Total Project Costs: $4,500,000

Reviewers' Ratings
- Do Not Fund – 79/250
- Do Not Fund – 100/250
- Do Not Fund – 127/250
- Average Weighted Score – 102/250

Dave Blair introduced Marlo Anderson who participated on TEAMS. Marlo presented on this project.

CONFLICT OF INTEREST

Conflict of Interest forms were distributed. Members online will need to bring that forward to Reice.

Teigen stated he would entertain a motion to allow those board members that have a conflict of interest the ability to vote. Christianson moved to allow all members the ability to vote. Grindberg seconded the motion. Motion passed unanimously.

DISCUSSION/COMPLETION OF BALLOTS

R-051-A – Integrated Renewable Combined Heat and Power for Ethanol
Project Duration: 18 months
Requesting: $450,000
Total Project Cost: $2,250,000
Conflict of Interest:
Fund: 2 Do Not Fund: 3 Abstain: 0

R-051-B – Clean Hydrogen from High-Volume Waste Materials and Biomass
Project Duration: 21 months
Requesting: $500,000
Total Project Costs: $2,500,000
Conflict of Interest:
Fund: 2 Do Not Fund: 3 Abstain: 0

Minutes of the
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R-051-C - DEFC Research and Development
Project Duration: 2023-2025
Requesting: $346,915
Total Project Costs: $693,832
Conflict of Interest:
Fund: 4 Do Not Fund: 1 Abstain: 0

R-051-D – Carbon Convert
Project Duration: 1 year
Requesting: $500,000
Total Project Costs: $4,500,000
Conflict of Interest:
Fund: 0 Do Not Fund: 5 Abstain: 0

Chairman Teigen entertained motion for the approval of the project recommended for funding. Christianson made a motion to approve Project 3. Bachmeier seconded the motion. Roll call vote all approved.

Chairman Teigen entertained motion for the do not fund project recommendations. Bachmeier moved to not approve the remainder of the projects. Christianson seconded the motion. Roll call vote passed unanimously.

ADMINISTRATIVE BUSINESS

Discussion for Proposed Round 52 Deadline – Monday, October 2, 2023

Proposed dates for next REC Meeting – November 13, 14 or 20, 2023

Reice explained the deadline and meeting date. Garman requested we have at least two weeks between application deadline and meeting date.

After discussion it was determined that the application deadline will be **Monday, October 2, 2023.**

Next REC meeting **Monday, November 6, 2023 (9:00-12:00 noon)**.

OTHER BUSINESS

Board members thanked Reice for the chart of active projects and suggested to add the date the project started.

ADJOURNMENT

Motion made by Christianson and seconded by Grindberg to adjourn the meeting. Teigen adjourned the meeting at 3:16 pm.

RENEWABLE ENERGY PROGRAM PROJECT MANAGEMENT REPORT

Reice Haase, Deputy Executive Director, NDIC

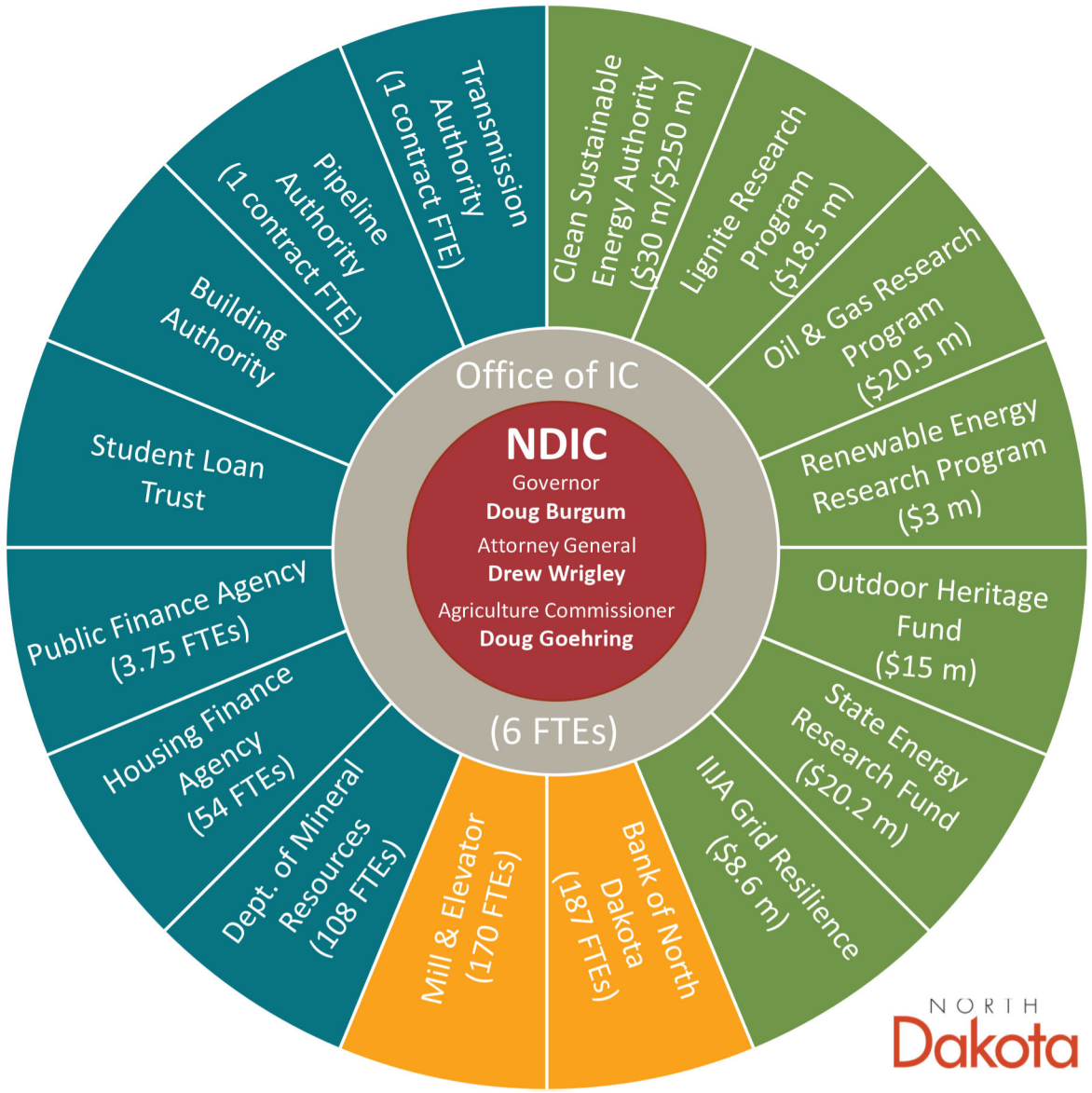
November 6, 2023

renewable ENERGY PROGRAM

NORTH Dakota

Be Legendary.™

Industries, Agencies, and Programs



Legend

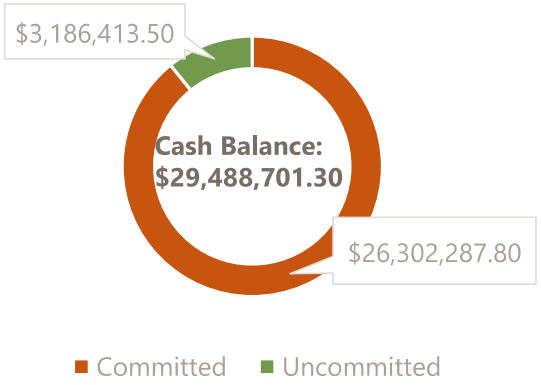
- Commission
- Office of IC
- Agency Role
- Grant Program
- State-Owned Enterprise

Updated to reflect 68th Legislative Assembly changes

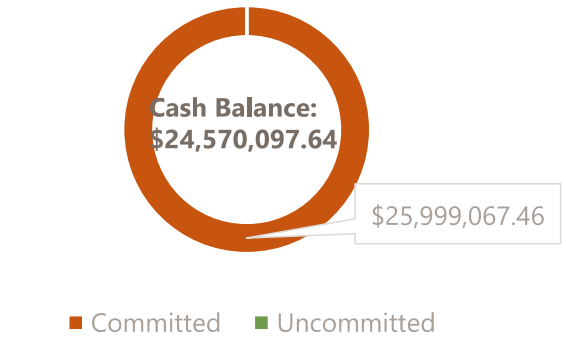
NORTH Dakota Be Legendary.

INDUSTRIAL COMMISSION-MANAGED FUNDS
(AUGUST 31, 2023)

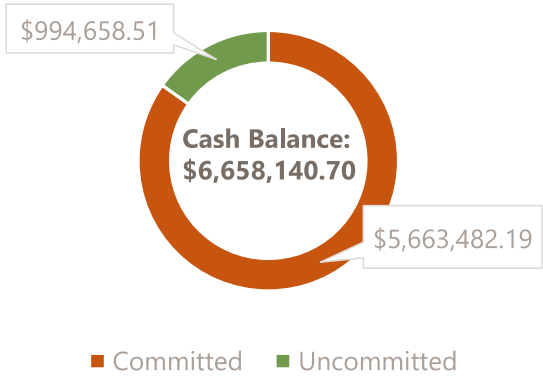
Lignite Research Fund



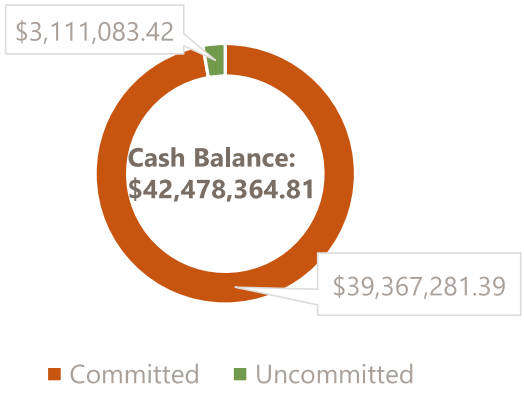
Oil and Gas Research Fund



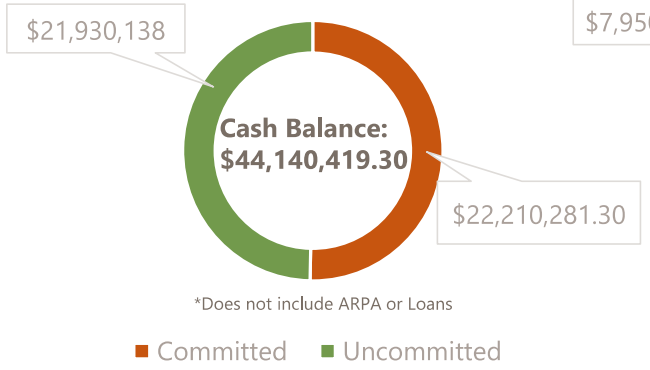
Renewable Energy Fund



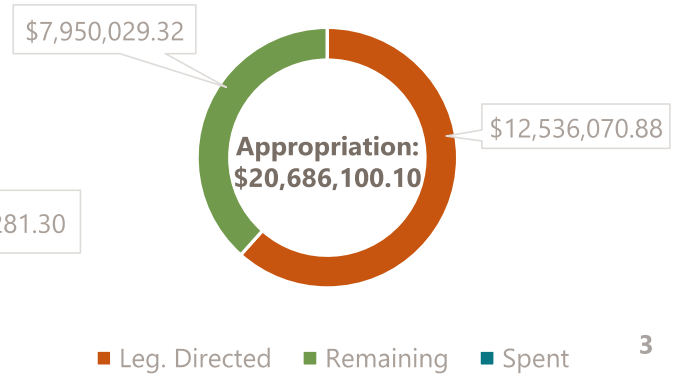
Outdoor Heritage Fund



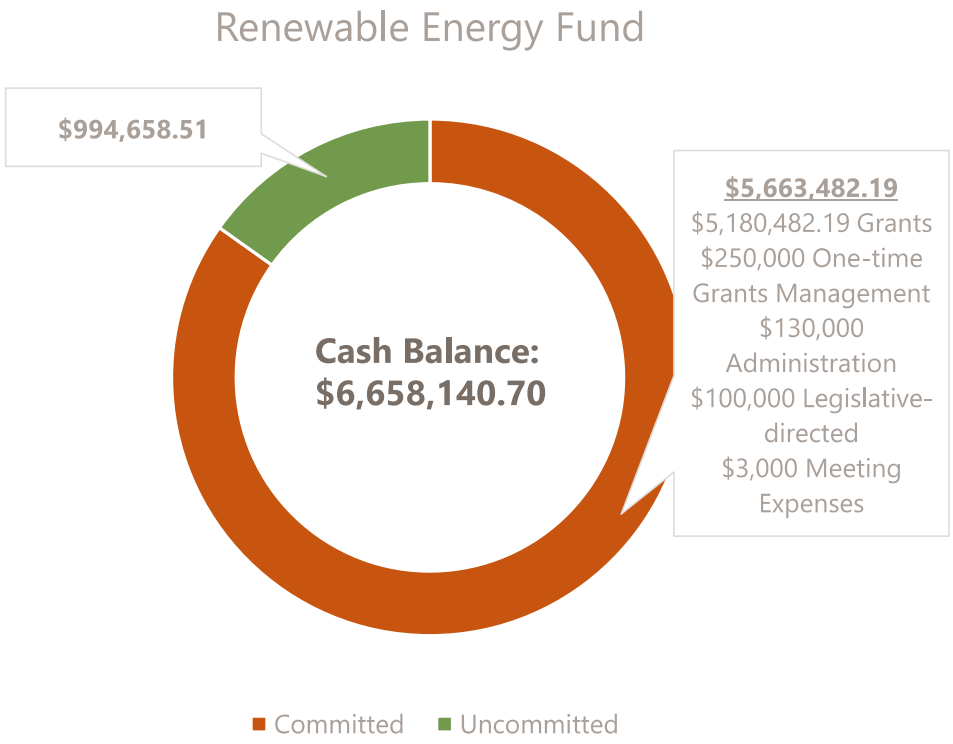
CSEA Fund*



SERC Fund



RENEWABLE ENERGY FUND BALANCE NOVEMBER 6TH, 2023



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

70 Cumulative Projects

18 Active Projects

Cumulative Value:
- **$23.5 million granted**
- **$154.7 million project value**

ACTIVE PROJECTS

18
Active Projects

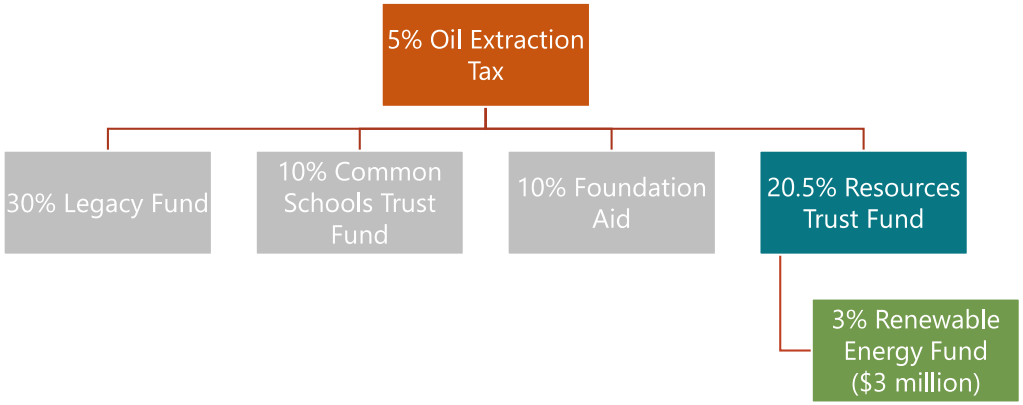
$1.8 Million
Paid To Date

$6.9 Million
Awarded Dollars

$5.1 Million
Payable Dollars

$0.9 Million
Cash Available for Commitment in
Outdoor Heritage Fund

2023-2025 BIENNIUM APPROPRIATION AND FORECASTED INCOME



Month	OMB Forecast	Actual
August 2023	$588,234	$523,151.02
September 2023	$607,842	N/A
October 2023	$607,842	N/A
November 2023	$588,234	N/A
December 2023	$607,842	N/A
January 2024	$6	N/A

Assumes:

$62-75/bbl

1.1 m bbls/day

Renewable Energy Development Program

Grant Round 52 Applications (October 2023)

Grant #	Application Title	Applicant	Summary	Principal Investigator	Funding Requested	Total Project Costs	Applicant Match	Category	Conf. Request	Duration	Funding Info
R-052-A	Smart Holistic Zero Waste Utilization Paradigm (SH0WUP) for Resuing Thermosets and Effectively Recovering Fibers via Mechanical, Thermal, Biological, and Chemical Pathways	UND	Recycling used wind turbine blades by three methods: gasification, milled into 3D-printing feedstock, and thermoset polymers	Surojit Gupta	$500,000	$3,780,360	87%	Co-product Utilization	No	3 Years	$3,000,000 DOE cash match, $280,570 in-kind match
R-052-B	Prairie Horizon Carbon Management Hub	EERC	Development of CO_2 storage hub for renewable diesel and hydrogen production facility; Up to 5 m tons/year captured	Kevin Connors	$100,000	$3,225,000	97%	Hydrogen	No	2 Years	$2,500,000 DOE cash match, $625,000 industry cash match
R-052-C	Use of Bioengineering to Enhance the Agronomic Potential of Camelina for Use as a Source for Biofuel Feedstock and Meal for Livestock	CamBioGene	Bioengineering camelina with two generations of growth in a Finland grow facility prior to transport to ND for field trials; Potential feedstock for biofuels and livestock feed; Crop suiting for cold and arid climates	Eric Murphy	$500,000	$1,151,250	57%	Biofuels	No	3 Years	$250,000 private investor cash match, $250,000 federal COVID cash match, $108,000 applicant in-kind match
	Total being considered				**$1,100,000**	**$8,156,610**					

INDUSTRIAL COMMISSION OF NORTH DAKOTA

Doug Burgum
Governor

Drew H. Wrigley
Attorney General

Doug Goehring
Agriculture Commissioner

Memorandum

TO: Doug Burgum, Governor and Chairman
Drew Wrigley, Attorney General
Doug Goehring, Agriculture Commissioner

FR: Reice Haase, Deputy Executive Director

DT: October 31, 2023

RE: Special Grant Round for Carbon Capture and Utilization Education and Marketing

Section 10 of HB 1014 passed by the 68th Legislative Assembly included an appropriation of $300,000 “to contract for carbon capture and utilization education and marketing”. The lignite research fund, oil and gas research fund, and renewable energy development fund are directed to each contribute $100,000 to the effort. The Commission is directed to develop the contract in consultation with each of the fund’s respective research councils.

The next meetings of the respective councils are currently scheduled as follows:

- Renewable Energy Council: November 6th, 2023
- Lignite Research Council: November 9th, 2023
- Oil and Gas Research Council: December 2023

Each research program has a similar process for accepting grant applications, including a similar application, technical review, Council recommendation, and contracting with the Commission. A combined special grant round would facilitate a thorough review of applications and would allow the Commission to efficiently consult with all three councils prior to considering a contract that would meet the legislative intent of HB 1014.

Therefore, I recommend that the Commission authorizes a special grant round of the combined Renewable Energy, Lignite Research and Oil and Gas Research Councils for the purpose of soliciting proposals to conduct carbon capture and utilization education and marketing, during which the Commission would consider for approval only such applications that receive a positive recommendation from all three research councils.

SECTION 10. TRANSFER - FUNDS UNDER THE CONTROL OF THE INDUSTRIAL COMMISSION TO INDUSTRIAL COMMISSION FUND - CARBON CAPTURE EDUCATION. The sum of $300,000, or so much of the sum as may be necessary, included in the appropriation in subdivision 1 of section 1 of this Act, may be transferred from funds under the control of the industrial commission to the industrial commission fund to contract for carbon capture and utilization education and marketing in consultation with the lignite research council, the oil and gas research council, and the renewable energy council. Of the $300,000, the industrial commission may transfer:

1. Up to $100,000 from the lignite research fund;

2. Up to $100,000 from the oil and gas research fund; and

3. Up to $100,000 from the renewable energy development fund.

INDUSTRIAL COMMISSION OF NORTH DAKOTA
RENEWABLE ENERGY PROGRAM

TECHNICAL REVIEWERS' RATING SUMMARY

R-052-A
SMART HOLISTIC ZERO WASTE UTILIZATION PARADIGM (SH0WUP) FOR REUSING THERMOSETS AND EFFECTIVELY RECOVERING FIBERS VIA MECHANCAL, THERMAL, BIOLOGICAL AND CHEMICAL PATHWAYS

Principal Investigator: Surojit Gupta

Request for $500,000 Total Project Costs $3,780,360 (DOE Funding Requested: $3,000,000)

TECHNICAL REVIEWERS' RATING SUMMARY

R-052-A

SMART HOLISTIC ZERO WASTE UTILIZATION PARADIGM (SH0WUP) FOR REUSING THERMOSETS AND EFFECTIVELY RECOVERING FIBERS VIA MECHANCAL, THERMAL, BIOLOGICAL AND CHEMICAL PATHWAYS

Principal Investigator: Surojit Gupta

Request for $500,000 Total Project Costs $3,780,360 (DOE Funding Requested: $3,000,000)

		Technical Reviewer			
		1A	**2A**	**3A**	
Rating Category	**Weighting Factor**	**Rating**			**Average Weighted Score**
1. Objectives	9	3	4	3	30.00
2. Achievability	9	4	3	2	27.00
3. Methodology	7	5	5	3	30.33
4. Contribution	7	4	5	3	28.00
5. Awareness	5	3	1	3	11.67
6. Background	5	3	5	3	18.33
7. Project Management	2	5	3	3	7.33
8. Equipment Purchase	2	5	2	4	7.33
9. Facilities	2	4	4	4	8.00
10. Budget	2	4	3	4	7.33
Average Weighted Score		192	187	147	**175.33**
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 3)

This proposal is to conduct research and development of doing something with wind turbine blades, that are worn beyond their practical use, other than bury them in a landfill. It may lead to additional jobs in North Dakota if the research yields positive results but, for the purpose of this proposal, it produces no additional positions in North Dakota.

Reviewer 2A (Rating 4)

The recycling/reuse of wind turbine blades is critical item for North Dakota as well as the rest of the wind industry and is clearly tied to the NDIC/REC's goals of encouraging energy development, sustainable energy, and job creation.

There is no discussion in the tagging development process to describe the expected distribution among the three levels of damage. Nor is there a discussion what happens to the substrate (although the is a weakly implication that the substrate could be gasified.) This gets back to the benefit of the tagging analysis part of the project; perhaps only a visible inspection at the time of decommissioning would be sufficient to throw the blades in one pile or another.

Reviewer 3A (Rating 3)

If mission proves successful, the results would promote the environmentally sound use of ND's wind energy resources and help ensure economic stability of the wind energy industry were clearly stated.

However, there were no clear statements as to how this mission necessarily creates additional ND jobs, promotes public awareness, or adds wealth for landowners or agriculture producers.

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)

The 3-year research and development scope is well thought out and certainly should be achievable. The DOE grant provides the majority of the resources required for this proposal.

Reviewer 2A (Rating 3)

The goals are most likely achievable if the results of the program are as hoped in the proposal. However, things happen. Reactions may not produce the expected products. The systems may not be able to progress successfully beyond bench scale. If the results are guaranteed, there would be no need for the research.

One possible outcome of research is finding what doesn't work.

Reviewer 3A (Rating 2)

It is the opinion of the review that achieving the desired results are possibly achievable. The method of reliably tagging turbine blades using drones and commercially available drones imaging systems will likely prove difficult if not impossible. Additionally, the costs associated with classifying, cutting, grinding, milling, handling, shipping, converting, gasifying, fiber recovery, and recycling will likely prove considerably more expensive than landfilling.

The economics of this application should be addressed as part of this project.

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 5)

The step by step, multi-phased methodology appears to be well orchestrated among several individuals and sponsors.

Reviewer 2A (Rating 5)

The reviewer hesitates to define the quality of the methodology as well above average, but it is certainly much, much higher than many other projects that have been proposed.

Reviewer 3A (Rating 3)

The methodology as presented is well defined and concise. However, the anticipated costs associated with developing and operating a commercial scale processing facility should be addressed.

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 4)

A means to utilize worn wind turbine blades will preserve the expected life of solid waste landfills in many states, including North Dakota. Though this proposal does not develop any of North Dakota's renewable energy resources, it may address a negative aspect that has arisen from that development. This proposal does fit the NDIC's goal of using new technologies and ideas that will have a positive economic and environmental impact on renewable energy development and production in North Dakota.

Reviewer 2A (Rating 5)

The proposed work and its expected outcome are apparently beyond anything successfully attempted before at least in the United States. The retirement of wind turbine blades will certainly become a major issue for the industry if solutions such as those being investigated here are not successful.

Reviewer 3A (Rating 3)

If the desired objectives are met, there may be a significant contribution to the classification and recycling of wind turbine blades and would promote environmentally sound use of North Dakota's wind energy resources.

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 3)

This is new research so detailed knowledge may be limited but I do understand the process of trials and evaluations. This proposal has been well thought out.

Reviewer 2A (Rating 1)

There was no comment of the PI's awareness of current research or published literature other than a statement that there have been no successful programs. A mention of other DOE projects underway hardly qualifies as a discussion of other research being similar or connected to this research.

Surely there has been past work that has failed to produce successful results or failed to produce economically viable results; such work may not have been published (who publishes failures – though

they should to advance the science) but someone of the PI's stature in the industry would surely be aware of.

Reviewer 3A (Rating 3)
Little literature or other research was referenced in the application.

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 timetable is reasonable and the various individuals involved in the many steps appear to be leading experts in their perspective fields. The coordination of the many groups of participants will probably provide the largest challenge of keeping this research running smoothly.

Reviewer 2A (Rating 5)
Based on the qualifications stated, the project team is well qualified and can be expected to deliver quality results with the minimum of false starts.

Reviewer 3A (Rating 3)
Backgrounds of the investigators is academic and sufficiently covers the necessary disciplines (mechanical, chemical, manufacturing, etc.)

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 5)
Well thought out.

Reviewer 2A (Rating 3)
The project schedule is well developed. The project management plan is in general ok. However, the submittal of annual reports to the NDIC is questionable; the NDIC should not have to request a quarterly report. In addition, a quarterly report which is available a month after the end of the quarter is hardly useful for challenging the pace of the work or the quality of its results. A bi-monthly report available two weeks after the end of the period is more realistic. If work is not being recorded and summarized more frequently than on a quarterly basis the researchers might be considered negligent. There is little to be gained by pulling together three-month's activities to develop a report.

The financial plan shows no tie to the schedule except the concept of "we're going to spend a lot of money and we don't know when it will be except sometime during the project."

Reviewer 3A (Rating 3)
Project management plan is adequate. Milestone chart is adequate, but not extremely well defined.

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 required equipment is listed as in-kind value other than the analytical equipment in the Chemical and Mechanical Engineering Departments at UND. The requested funding from the NDIC is to be used for the purchase of a state-of-the-art 3D printer.

Reviewer 2A (Rating 2)
The use/lease of existing equipment and facilities is well presented. The use of a drone if poorly justified. How many blades will be examined? Can the related imaging systems read a moving blade or is it required to be stationary?

This is a valuable piece of equipment (though price is not detailed); those retains ownership? Is the imaging process available by lease/contract with only the data analysis required by the project team? Could the evaluation and following analysis be performed as well with blades already removed from service?

Reviewer 3A (Rating 4)
Procurement of UAV and various imaging systems is well justified.

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 4)
The facilities and equipment are mostly provided by the University of North Dakota and the other partners cited in this proposal.

Reviewer 2A (Rating 4)
The principal investigators have well identified facilities and equipment that is available for the work except as noted in No. 8. The University of North Dakota has an exceptional system of laboratories to assist in this work.

Reviewer 3A (Rating 4)
Being an engineering research facility, UND is well suited for executing the proposed research.

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 4)
The $3 million dollar grant from the Department of Energy provides the majority of the funding for this proposal. The private industry contribution falls far short of the 50% requirement and is only in-kind contributions. It is not cited in this proposal if the applicant expended any effort in acquiring a private party to aid in this research or not. Perhaps, with the DOE grant, it was not necessary.

Reviewer 2A (Rating 3)
While the positive results of the proposed work could be significant in solving a wind turbine blade disposal problem, the amount of work being performed here and the price involved are of average value. There is much overhead included and minimal laboratory work being performed; it is possible that the investigators would want to propose a further project to verify and expand upon the work they are doing.

Reviewer 3A (Rating 4)
If the DOE funds the requested $3M, there is high value to the level of commitment and outlined work.

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
Other than the salaries of the lead research individuals, not a great amount of detail was provided on how the overall cash flow of this proposal will occur. Perhaps, it was not necessary being all the proposal requests from the NDIC's funding is to purchase a 3D printer. However, I do support the NDIC funding this proposal as the possibility of utilizing worn out wind turbine blades will benefit many locations in many states, including North Dakota.

Reviewer 2A
The project has a high degree of being approved by the NDIC/REC based on Reice Haase's letter of support. In spite of this, I recommend the project be approved.

The result being investigated has yet to be found successful at least in the United States. The project's success (and eventual commercial success) will provide alternatives in the decomposition/destruction of retired wind turbine blades. This will be extremely important to the state of North Dakota and its wind industry.

The financial plan is extremely deficient as noted, and the management plan is somewhat deficient. How can a continual of the work be allowed if research is floundering or going askew; neither would be known until too late to effectively challenge the status. Further, NDIC should receive reports on a timely basis, not on an "as requested basis." There is no paper documentation involved only the transmittal of the published report.

The letters of support from Great River Energy, LM Power, and Strata are gratifying, but would be much more significant if they were accompanied with even modest financial contributions especially for companies that will receive such direct benefits from the project's successful completion.

In the section, "Why the Project Is Needed", there is a citation that ND ranks fourth in the generation of wind energy which statement is irrelevant. The relevant statistic is how many or what proportion of turbines blades are in ND.

Reviewer 3A
The merits of the proposed project may prove extremely beneficial if the desired results can be achieved economically. Developing a method to image, accurately identify, and sort wind turbine blades for recycling, as well as developing methods to recycle damaged blades is needed and is an environmentally preferred method of disposal over burial.

One main flaw of the proposed project is that it does not include developing/analyzing the estimated CAPEX costs for a commercial scale facility or the annual operating and maintenance costs associated with a commercial scale wind turbine blade recycling facility. Ultimately the benefits will need to outweigh the costs for any technology to become commercialized.

Recommendation: It is the recommendation of this Reviewer to fund this project application, but only if the DOE funds the project as well.

Application

Project Title: Smart Holistic Zero Waste Utilization Paradigm (SHOWUP) for Reusing Thermosets and Effectively Recovering Fibers via Mechanical, Thermal, Biological, and Chemical Pathways

Applicant: University of North Dakota

Principal Investigator: Surojit Gupta

Date of Application: 09/28/2023

Amount of Request: $500,000

Total Amount of Proposed Project: Estimated total budget: $3,780,360 (DOE Funding Requested: $3,000,000)

Duration of Project: 3 years

Point of Contact (POC): Surojit Gupta

POC Telephone: (701)777-1632

POC Email: Surojit.gupta@und.edu

Renewable Energy Program

North Dakota Industrial Commission

TABLE OF CONTENTS

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Project Location (s): Department of Mechanical Engineering, University of North Dakota, Grand Forks; Drilling and Completion Lab (DRACOLA), Grand Forks; Grand Forks Landfill location of SET LLC

Acknowledgement: Dr. Anna Crowell for editing the proposal

Appendix A: DOE Award Acceptance, NDIC Support Letter, Support Letters from Strata, GRE and LM Windpower and Commitment Letters from SET-led Consortium of Companies

ABSTRACT

Objectives: We propose interconnective sustainable technologies that will have a transformative effect on blade recycling via a University-Industry-National Lab collaboration. A critical aspect of this call is designing materials with innovative tagging methods and separating the constituents for effective wind blade reuse. We will develop a smart interface to sort blades into different functional components using Artificial Intelligence (AI) and Machine Learning (ML) (Objective-A). Heavily damaged blades will be recycled into Syngas using a propriety Sandwich Gasifier Technology (Objective-B). Medium-damaged blades will be mechanically milled to generate thermoset powder that will be integrated into 3D-printed structures (Objective-C). High-quality wind turbine waste will be recycled into thermoset polymers and fibers using propriety solvent-based (Objective-D) and enzymatic processes (Objective-E). A Life Cycle Analysis (LCA) for the entire process will be performed (Objective-F).

Expected Results: We will establish a holistic approach to increase thermoset and incorporated fiber sustainability and recyclability. Current pyrolysis-based technologies are destructive, destroy the polymeric components, and decrease fiber quality.

Duration: 3 years

Total Project Cost: Estimated total budget: $3,780,360 (NDIC Funding Requested: $500,000)

Participants: Collaborators and institutions (Drs. Gupta and Ji will manage the NDIC cost share grant): **UND:** Co-PI: Yun Ji, Chemical Engineering; Co-PI: Hallie Chelmo, Mechanical Engineering; Co-PI: Beth Klemetsrud, Chemical Engineering; **University of Idaho**: Co-PI: Hasan Jamil; **National Lab Collaborator**: Yingqian Lin, Research Scientist, INL; **Industrial Partners**: Nikhil Patel, President, Singularity Energy Technologies LLC (SET); CEO at Dakota Green Power Co (DGP); Scott Homstad, Tristeel Manufacturing Company; Michael D. Mann, CEO and Founder, MDM Energy Consulting LLC.

PROJECT DESCRIPTION

Objectives: (a) Develop a smart image-based database and design an AI and ML-driven interface to sort and tag windmill waste into different categories, (b) Use heavily damaged blades as a source of Syngas via the gasification process at a 5-ton/day capacity, (c) Recycle thermoset powders to build functional components, such as 3D-printed non-wind turbine components, (d) Develop technology to recycle blades using propriety liquids in a pilot setting, (e) Validate biological agents as an effective medium for recycling green-coded turbine blades, (f) Evaluate all steps holistically to determine overall greenhouse gas emissions and cumulative energy demand for recycled wind turbine blades and overall life cycle analysis.

Methodology and Anticipated Results: We propose an innovative, Smart, Holistic Zero-Waste Utilization Paradigm (SH0WUP) to reuse thermosets and recover fibers effectively with minimal damage by integrating next-generation technologies developed at UND and SET. The integral components of this design paradigm are: (i) Blade wastes, including Offshore Wind (OSW) blades, will be tagged with ultrasonic and image evaluations. We will develop a smart interface to sort blades into functional components using Artificial Intelligence (AI) and Machine Learning (ML). Heavily contaminated damaged blades will be sent to SET for fuel generation product evaluation. ii) The screened system containing fibers and resin will be separated into milled powders and fibers with thermoset residues. The recovered thermoset powders will be used as a recyclable feedstock to develop wear-resistant and hydrophobic coatings and 3D-printed structures for rapid commercialization. Replacing different PTFE-based components is one of the program's inherent challenges. Ice accretion causes an 80% power loss; therefore, ice-phobicity will be quantified using our setup and chiller that can reach -40^{o}C. iii) Fibers containing thermoset residue will be treated with ILs and an enzymatic degradation process. Determining the enzymatic degradation and IL pathways will involve studying the degradation kinetics at different conditions, such as temperature, pH, and humidity, to optimize the degradation process and mechanical behaviors. We will build the first pilot plant of its kind in the U.S. to process and recycle 50 Kg of thermoset

residue per batch. iv) We will assess the process' environmental impacts by examining the degradation products and their potential toxicity. Useful chemical products will be derived from the green treatment process. The left-over fibers will be extracted and integrated with the composites.

Facilities and Resources: MMI and the Department of Mechanical Engineering at UND have the following equipment for Advanced Materials Research: two 3.5" tube furnaces (controlled atmosphere, 1600°C and 1700°C), grinding and polishing equipment, Shimadzu AG-50 Universal Testing Machine (screw driven, 50 kN capacity), high-temperature furnace (< 1600°C and extensometer), and box furnaces. We also have Fused Deposition Modeling (FDM) and Selective Laser Sintering (SLS) printers. The Department of Chemical Engineering (Chem E) has a 500 MHz NMR (Avance 500, Bruker), High-resolution HPLC-MS TOF/ESI/APCI (Agilent G1969A), FTIR spectrophotometers (Perkin-Elmer Spectrum 400), several UV-vis spectrophotometers (Carry 50, Varian Inc.), Beckman Multipurpose Liquid Scintillation Counter Model LS6500, two state-of-the-art gas chromatographs (Agilent 6890N,7890) equipped with autosamplers, and Quadruple MS instruments with EI, CI, and NICI ionization sources (Agilent 5975C). One of the instruments is equipped with a pyroprobe 5200 (CDS Analytical).

The UND Drilling & Completion Lab (DRACOLA) is a state-of-the-art pilot development facility with on-site welders, plumbers, and electricians. Pilot studies for completing Objectives C and D will be located at DRACOLA. We have requested large-scale reactors and ancillaries for the project.

SET Technologies and Tri-Steel Manufacturing will provide access to the current 5-ton/day truck-mounted gasifier as part of the cost share requirements for this proposal.

Techniques to Be Used, Their Availability and Capability:

Objective A: UND will tag and differentiate drone blades into red (heavily damaged), yellow (matrix damaged), and green (reasonable condition) using ultrasonic, 3D imaging and drone-based imaging. UoI will use a transfer learning approach for pipeline design to detect and classify wind turbine damage using a ML/AI system. DOE will fund the imaging procurement system. **Objective B**: Procure Wind Turbine

Blades (WTB) to create a rejected WTB (R-WTB) sample for SET to analyze. Design, construct, and commission a table-top bench scale test unit to evaluate the preliminary conversion features of rejected WTB using SET's patented gasification process. Operate the 5-ton/day Sandwich gasification system after conducting recommended modifications. **Objective C**: Create recycled thermoset feedstocks from cured adhesives, thermoset components, and yellow-coded blades using mechanical milling, (b) Use Stereolithography (SL) and Selective Laser Sintering (SLS) to fabricate functional composites with recycled thermoset particulates. Design and manufacture non-Wind Turbine component prototypes and test prototype coatings in a pilot setting. Funds are requested from the NDIC for a state-of-the-art 3D printer as a cost share. UND has ball milling and other facilities. **Objective D:** Perform dissolution kinetics, absorption limits, and pathways of different types of thermosets in ILs by varying the chemistry of ILs and different solutions, characterizing recycled monomers/oligomers and fibers through imaging, FTIR, and Zeta-potential measurements. Integrate recycled monomers and fibers into composites and characterize the mechanical and physical behavior of the recycled composites. Design a pilot scale process at a level of TRL-5 using 50 Kg/batch feedstock. The stretch goal is processing 100-500 Kg of feedstock weekly. UND will have the capability to set up a pilot plant with DOE funding. **Objective E**: Explore the biodegradation kinetics and mechanisms at mild conditions (35°C) and design a pilot scale process at a level of TRL-4 with a stretch goal of TRL-5 using lignolytic or similar enzymes. **Objective F:** Complete a holistic LCA for SH0WUP. These results will be integrated into the technology commercialization plan to showcase the technology and inform potential investors on thermoset reutilization "greening.".

Environmental and Economic Impacts While Project is Underway: The project's economic and environmental impacts are: (a) Sending heavily damaged blades to a Sandwich Gasifier (red code). This process is already commercialized and can be potentially scaled up to 5 tons per day within three years. (b) Using medium-damaged blades to generate and recycle thermosets into functional 3D-printed components for non-wind blade structures. (c) Processing the least damaged blades using IL solvents and

a biological recycling process. We used this technology to recycle epoxy in the feasibility study. We propose building an Ionic Liquid-Solvent-based plant in Grand Forks that is based on the experimental data and design paradigm. The innovation aspect is the usage of low Ionic Liquid concentrations in tailored solvents coupled with recyclability to design a state-of-the-art, first-of-its-kind, chemical pilot plant co-located with 3D printing technology as a "bootstrapping" philosophy of entrepreneurship.

Ultimate Technological and Economic Impacts: The proposed technology is based on smart and AI-driven processes that will streamline and sort blades into different categories. Tailored thermoset particles have not been explored as commercially available solid lubricants or integrated into 3D-printed structures. We will integrate these particles into coatings and 3D-printed structures that can be used for non-blade components, such as molds, bushings, towers, and platforms. The synergistic use of ionic solvents and enzymatic degradation will effectively remove fibers from the thermoset matrix with minimal disruption. The recovered fiber process can be extended to Carbon-fibers and used in construction applications. Completely rejected and corroded blades will be analyzed for energy generation. Degradation using ILs and enzymatic processes is a blue-ocean market space, and there are no commercial competitors that can recycle thermosets and fibers at a temperature <200°C in ambient air without using supercritical solvents.

Why the Project is Needed: North Dakota has continuous wind energy resources. Wind energy has doubled in the state from 2016 to 2022. According to the latest data, North Dakota has about 4,300 megawatts of installed wind power generating capacity and a site near Williston is the largest farm and has a 300 megawatts capacity. As a summary, North Dakota ranks fourth in terms of electricity generated from wind energy[1]. Currently, there are no viable solutions for recycling wind turbine blades and only a few disposable sites in North Dakota. North Dakota solid waste management law encourages recycling

[1] https://www.eia.gov/state/analysis.php?sid=ND#:~:text=At%20the%20beginning%20of%202023,came%20online%20in%20early%202021.

wind turbine blades but there are no or limited options[2]. The successful completion of this project will potentially lead to successful recycling of wind turbine blades commercially, boost a new cluster of interconnected technologies which will further boost the state's economy, and will stimulate further development of wind energy in North Dakota.

STANDARDS OF SUCCESS

List of Measurable Deliverables Indicative of Program Success:

Year 1: (a) Protocol for tagging wind blades and sorting them into three major categories, (b) table-top bench scale unit for evaluating the conversion features of WTB, (c) Method to create thermoset feedstocks using mechanical milling, (d) Methods to use SL and SLS to fabricate composites, (e) characterization of monomers/oligomers and fibers, and (f) annual report.

Year 2: (a) R-WTD parametric testing using the bench-scale unit, (b) create an improvement strategy for the sandwich gasification system, (c) comprehensive characterization of physical and mechanical properties of composites, (d) Pilot scale process design process and mini pilot plant, and (e) annual report.

Year 3: (a) Optimized ML/AI system, (b) sandwich gasification system operation at 5 ton/day, (c) non-wind turbine component protypes to replace PTFE-based components, (d) IL-based and 3D printing pilot plants process operating at TRL 5, (e) holistic LCA for SH0WUP, and (f) annual and final report.

Value to North Dakota: Wind energy is a major source of energy in North Dakota[3]. In ND, the renewable energy supports 2,200 jobs, > $22.5 million in annual state and local tax payments, and $8 billion in total capital investments. Wind farm technician is also the fastest growing job opportunity in US[4]. Based on these statistics, we can summarize that the design and development of next generation recycling technologies as a part of this proposal will further stimulate the Wind Energy sector in ND, create more

[2] https://bismarcktribune.com/news/state-and-regional/govt-and-politics/bill-requires-state-ok-for-wind-turbine-blade-disposal-in-north-dakota/article_77fa97f2-9ccc-11ed-ac65-97166ce26501.html
[3] https://windexchange.energy.gov/states/nd
[4] https://bismarckstate.edu/news/wind-energy-boom/

wind energy-based jobs, can be directly integrated with different wind mills and will further ND's vision of commerciable recycling process. Further details are given in the Invest in America sub-section.

Commercialization Pathway via Public Private Partnerships and Potential for Job Creation: We plan to transition all proposed technologies to TRL levels of 5-6. We plan to install two co-existing pilot plants: a 3D printer to create functional components from thermoset waste and a pilot plant based on IL solvent technology, backed by a solid LCA from two independent researchers. These new plants will require personnel from a diverse workforce, creating a significant number of local jobs. We plan to process a ton of waste/batch after successfully completing pilot testing in Year 3. There are 1,500 turbines with 4,500 blades in the northern plains region that will be upgraded soon, creating significant market potential. Existing local companies, such as LM Wind Power, will also be able to benefit from this technology, expanding their market share and workforce, which will create even more local jobs.

Education Component, Invest in America's Workforce, and Job Creation: Two co-existing pilots will be set up on the University of North Dakota campus for 3D printing and the Ionic Solvent-based recycling process. The proposed research will train at least five graduate students, one post-doc, and one research scientist, and will hire electricians, plumbers, and several other technicians. This project will aid in mitigating the wind power-based waste problem in Grand Forks, where LM Wind Power is located. The green energy sector is growing exponentially; therefore, the project can generate job opportunities for U.S. workers in related skilled and semi-skilled categories. Reputable companies, such as Great River Energy, LM Wind Power, and Strata, support the project since they want to leverage this program to create new opportunities in the Northern Plains region. In addition, the SET-led team has many start-ups and small local business-based companies that are active program participants. The project will popularize sustainability research among different stakeholders and expand America's workforce in Wind Energy. The SH0WUP model envisioned in this program will create an ecosystem for recycling Wind Blades and advance the Wind Turbine industry, significantly bolstering local, state, and US economies. The support

of the North Dakota Industrial Corporation (NDIC) will showcase the importance of the proposed research in generating job opportunities, which is a direct investment in America's workforce at the state level.

BACKGROUND/QUALIFICATIONS

University of North Dakota: Dr. Surojit Gupta, Professor and Director of the Materials Manufacturing Initiative (MMI) at the University of North Dakota (UND), will be the PI from UND. Dr. Gupta will manage the project and lead thermoset utilization and IL optimization efforts. He will be the point of contact between the NDIC, EERE, and other project participants/sponsors. Dr. Gupta has over 15 years of experience in fundamental research, technology development, and commercialization. His research has been consistently supported by the DOE, DOD, Navy, NSF, ND Research Council, ND Corn Council, and Department of Agriculture, and he has managed a multi-million-dollar research portfolio.

Dr. Yun Ji, Professor of Chemical Engineering at UND, will be a Co-PI on this project. Dr. Ji has over 15 years of experience in biochemical engineering and biomass utilization and over 50 peer-reviewed publications. She also has experience in proven chemical design and feasibility studies. Dr. Ji will oversee enzymatic degradation, reactor design, quality control, and CMP implementation.

Dr. Bethany Klemetsrud, Assistant Professor at UND, will be a Co-PI on this project. Dr. Klemetsrud has extensive experience conducting life cycle assessments, collaborating with companies such as the Gas Technologies Institute, and participating in several DOE and NETL projects conducting LCAs.

Dr. Hallie Boyer Chelmo is an Assistant Professor at UND and will serve as a Co-PI on this project. Dr. Chelmo will lead studies on the ice-phobicity behavior of coatings.

Mr. Harry Feilen is the Director of Operations at the Drilling and Completion Lab (DRACOLA) and has over 40 years of experience in construction, fabrication, troubleshooting, and repairing equipment experience. Mr. Feilen will work on the development of an IL-based and 3D printing plants.

Singularity Energy Technologies, LLC (SET) – Dr. Nikhil Patel, founder and President of SET, is the inventor and patent holder for the sandwich gasifier technology. Dr. Patel has over 25 years of research,

development, and technology commercialization experience in waste-to-energy conversion using thermochemical processes involving combustion and the partial oxidation or gasification of biomass, coal, and unconventional feedstock. Table 1 summarizes the roles of the team members in the SET-led team.

Table 1: Roles of the Team Members

Team Member	Role
Singularity Energy Technologies LLC	UND prime sub-recipient and Objective B Task 2 lead. Owner of Sandwich Gasification patents
Dakota Green Power	Manufacturer of Sandwich gasifier systems
Tri-Steel Manufacturing	Manufacturer of gasifier components through established relationship with DGP and SET and owner of 5 TPD system
City of Grand Forks	Host site for the 5 TPD system
Sage Green N.R.G.	Provide support for permitting, marketing, and communications
MDM Energy Consulting	Provide support for project management, design, and reporting

MANAGEMENT

We summarized the team member roles in the task summary and the project summary chart in Figure 1. UND is the primary recipient. UoI and SET LLC are sub-contractors of the DOE Grant. We have divided the project into Objectives with hierarchic tasks for better management. Each task will be professionally managed and compiled via individual reports every quarter, where we will determine if the quarterly milestones have been fulfilled.

TIMETABLE

Schedule for Interim Report Submission: An interim report will be submitted to the NDIC annually. Quarterly reports will be available upon request.

Task description summary (Table 2 summarizes the GANTT Chart): The work plan is hierarchically structured to fulfill the following objectives: Task 0.A: PI (Gupta) will manage the project and submit reports. Task 0.B: Co-PI (Ji) will oversee Community Management Plan (CMP) implementation.

Tasks for Completing Objective A: Year 1: Task 1.1: Procure Unmanned Aerial Vehicle (UAV)-based digital, ultrasonic, and optical imaging systems and commence wind blade imaging. Task 1.2: Use a transfer learning approach to ML pipeline design for wind turbine damage detection and classification.

Year 2: Task 1.3: Design and develop a collaborative work environment to streamline research between the partner institutions. Year 3: Tasks 1.4-1.5: Enhance the reinforcement learning techniques and train users.

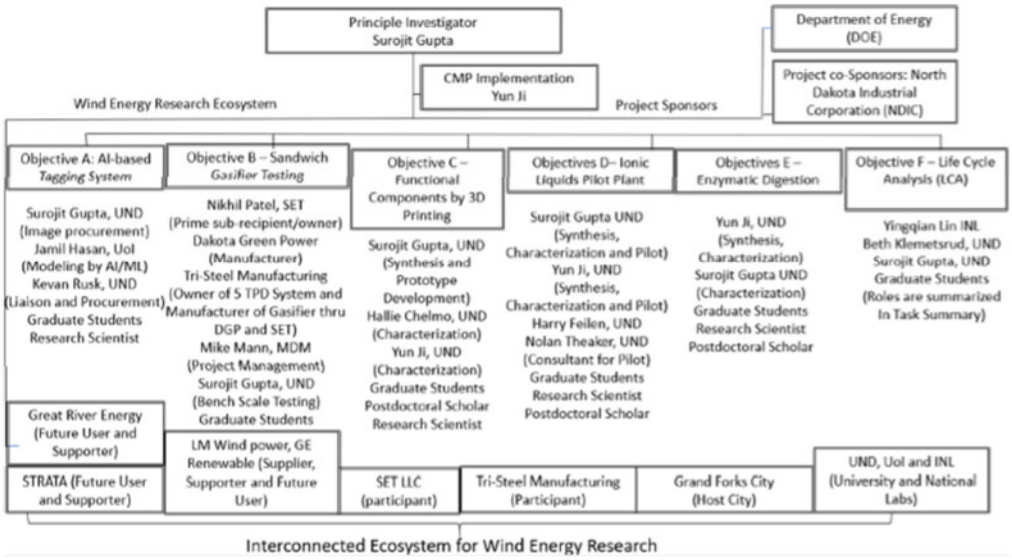


Figure 1: Project Chart summarizing the roles of the PIs

Tasks for completing Objective B: Year 1: Task 2.1: Bench-scale testing of the blade material. Year 2: Task 2.2: Bench-scale testing and 5-ton/day system design modification. Year 3: Task 2.3: 5 ton/day system modification, testing, and reporting.

Tasks for completing Objective C: Year 1: Task 3.1: Mechanically mill wasted cured adhesives and yellow-coded blades to extract thermosets. Task 3.2: 3D-print small-scale coupons using SL. Task 3.3: 3D print small-scale coupons using SLS. Year 2: Task 3.4: Document detailed measurements of the composites' ice phobicity and mechanical, tribological, and microstructural behaviors. Year 3: Task 3.5: Design and manufacture prototype non-wind turbine components in a pilot setting.

Tasks for completing Objective D: Year 1**:** Task 4.1: Procure and validate batch reactors with a daily process capability of 1 Kg of feedstock. Task 4.2: Perform dissolution kinetics, absorption limits, and characterization of different types of thermosets in ILs by varying IL chemistry. Task 4.3: Perform dissolution kinetics of thermosets by making solutions of ILs and solvents with a boiling point >200^{o}C. Year

2: Task 4.5**:** Procure and validate a batch reactor that can process 10 Kg of thermosets per batch. Task 4.6: Integrate recycled fibers and polymers into composites. Year 3: Task 4.7: Procure batch reactors with a processing capability of 50 Kg of thermosets per batch and implement a pilot plant.

Tasks for completing Objective E: Year 1: Task 5.1: Identify promising enzymes and conduct lab-scale experiments at 20g/batch. Task 5.2: Characterize degradation products and explore biological degradation pathways. Task 5.3: Optimize reaction conditions to find the highest bioconversion rate. Year 2: Task 5.4: Conduct experiments with selected enzymes at 100g/batch. Task 5.5: Characterize biodegrading products using analytical instruments. Task 5.6: Explore applications for degraded polymers and recycled fibers.

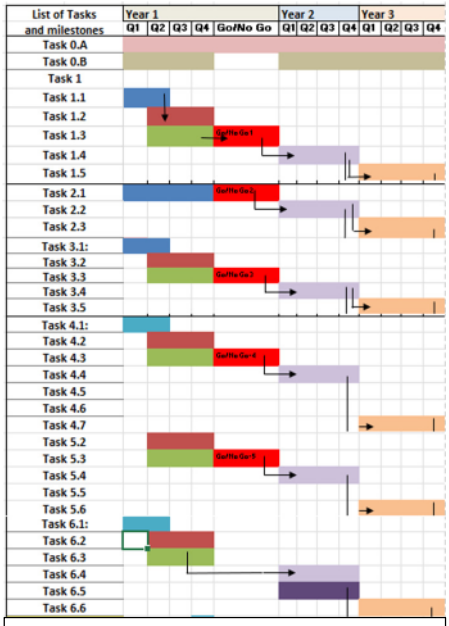


Table 2: GANTT Chart

Year 3: Task 5.7: Conduct experiments at 1 kg per day. Task 5.8: Explore the biodegrading process at a level of TRL-4. Task 5.9: Conduct a techno-economic analysis.

Tasks for completing Objective F: Year 1: Task 6.1: Collect initial life cycle assessment data for wind turbine blade production. Task 6.2: Develop a process model for the proposed recycling system. Task 6.3: INL will develop a baseline process simulation model using Aspen Plus Year 2: Task 6.4: Conduct a sensitivity analysis to reveal the impacts of specific parameters on the system's total footprint. Year 3: Task 6.5: Complete the LCA analysis of SH0WUP holistically.

BUDGET

The DOE has selected this project to receive $3,000,000 in funding after a highly competitive process. Mr. Reice Hasse from the NDIC has kindly issued a support letter of $500,000 to support this project as UND's cost share partner. Table 3 summarizes the NDIC's cost share for this project on a year-by-year basis.

Table 3: NDIC Cost Share

Project Associated Expense	NDIC's Share (Itemized List)	Applicant's Share (Cash)	Applicant's Share (In-Kind)	Other Project Sponsor's Share
1,330,758 (year 1)	$193,845 3D Printer-$81,250; Staff Salary-$79,855; F&A -$32,740	Table 5	Table 5	Table 5
1,043,522 (year 2)	$125,827 Staff Salary: $74,239 DRACOLA Lease: $15,000 F&A:$36,588	Table 5	Table 5	Table 5
1,406,289 (year 3)	$180,328 Staff and PI (s) salary: $92,891 Travel:$5,000; DRACOLA Lease: $15,000; Professional Fees: $15001; F&A: $52,436	Table 5	Table 5	Table 5
Total	$500,000	NA	$25,111	$187,993+67,466

The cost share from the NDIC is vital for successfully completing this project. Tables 4 and 5 list the overall cost share and cost share contributed by different project partners, respectively.

Table 4: Overall cost share

	Federal	Cost Share	Total Costs	Cost Share %
Budget Period 1	$1,062,693	$268,065	$1,330,758	20.14%
Budget Period 2	$821,300	$222,222	$1,043,522	21.30%
Budget Period 3	$1,116,006	$290,283	$1,406,289	20.64%
Total	$2,999,999	$780,570	$3,780,569	20.65%

Table 5: Cost share from different partners

NDIC	Cash	DRACOLA lease; precursor powders for Tasks 3,4, and 5; Research Staff salary for tasks 3 and 4; 3D printer for Task 3	$193,845	$125,827	$180,328	**$500,000**
UND	In Kind	5% of salary and fringe for PI, Co-PIs,	$0	$25,111	$0	**$25,111**
Tri-Steel Manufacturing	In Kind	Labor and equipment rental	$52,393	$48,802	$86,798	**$187,993**
University of Idaho	In Kind	20 % Co-PI salary, associated fringe and F&A	$21,827	$22,482	$23,157	**$67,466**

CONFIDENTIAL INFORMATION and PATENTS/RIGHTS TO TECHNICAL DATA

N/A

STATE PROGRAMS AND INCENTIVES

A. The NDIC Contract No. is FY22-XCVII-242. The title is "Development of Novel Sintered Coal Building Materials." Project length is 10/1/2021 - 2/29/2024; Total amount is $649,407

B. R-050-C – Enhanced Sweep Efficiency for Geothermal Renewable Energy Using Bio-Polymer Supplement, PI: Dongmei Wang, co-PI: Dr. Ji, Funding: $468,877.

C. Drs. Gupta and Ji are also funded by APUC, ND Corn Council, and ND Soybean Council.

UNIVERSITY OF NORTH DAKOTA

September 28, 2023

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

Subject: "Smart Holistic Zero Waste Utilization Paradigm (SH0WUP) for Reusing Thermosets and Effectively Recovering Fibers via Mechanical, Thermal, Biological, and Chemical Pathways," Proposal to the Renewable Energy Program by Dr. Surojit Gupta, Principal Investigator

Dear Mr. Haase:

On behalf of the University of North Dakota, I am pleased to write this letter of transmittal for Dr. Surojit Gupta's proposal on "Smart Holistic Zero Waste Utilization Paradigm (SH0WUP) for Reusing Thermosets and Effectively Recovering Fibers via Mechanical, Thermal, Biological, and Chemical Pathways," for consideration by the NDIC's Renewable Energy Program. Dr. Gupta is an Associate Professor in UND's College of Engineering and Mines, Department of Mechanical Engineering, and is the Principal Investigator for this project. Dr. Gupta is conducting a three-year project with a total requested amount from NDIC of $500,000. The NDIC funding is being requested as a match to the DOE portion of the project, which has been awarded by DOE for $2,899,999 with a start date of 10/1/2023.

Please contact Dr. Gupta with any technical questions about the project at (701) 777-1632 or surojit.gupta@und.edu. If the NDIC selects this proposal for an award, please send any award documents and related communications to Sherry Zeman at sherry.zeman@und.edu for processing on behalf of UND.

The $100 application fee is being handled as an electronic payment by UND and should reach your office in a timely manner. Thank you very much for your consideration of this proposal.

Sincerely yours,

Karen A. Katrinak

Karen A. Katrinak, Ph.D.
Proposal Development Officer / Authorized Organizational Representative
Research & Sponsored Program Development
Division of Research & Economic Development
(701) 777-2505 / Karen.katrinak@und.edu

Industrial Commission

Tax Liability Statement

Applicant:
University of North Dakota

Application Title:
Smart Holistic Zero Waste Utilization Paradigm (SH0WUP) for Reusing Thermosets and Effectively Recovering Fibers via Mechanical, Thermal, Biological, and Chemical Pathways

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.

Karen Katrinak

Signature

Karen Katrinak
Proposal Development Officer

Title

September 28, 2023

Date

Appendix A (Supporting Documents):

1. Evidence of submission of remittance
2. Selection by DOE for the Award
3. Support letter from Mr. Reice Hasse from NDIC
4. Support letters from LM Windpower, STRATA and GRE
5. Commitment letters from SET, MDM and other members of the SET-led consortium

Invoice Summary - Supplier Invoice No. SH0WUP-Gupta 092123 (Doc. No. V3334013)

Supplier Invoice No. SH0WUP-Gupta 092123
Supplier Name INDUSTRIAL COMMISSION,ND

General

Invoice Type	Invoice
Pay Status	Paid
Invoice Number	V3334013
Supplier Invoice No.	SH0WUP-Gupta 092123
Supplier Name	INDUSTRIAL COMMISSION,ND
Invoice Owner	Tonya Parton
Business Purpose	Required Grant Application fee for NDIC proposal-Smart Holistic Zero Waste (SH0WUP)
Invoice Date	9/21/2023
Discount Date	
Due Date	9/21/2023
Terms	0% 0, Net 0
Terms Discount	0.00 USD
Invoice Name	2023-09-25 0399535 01
Bypass Treasury	✗
Invoiced By	Tonya Parton
Match Status	Do Not Match
Invoice Source	Automated
Contains substituted item(s)	✗
Amount Only PO	✗

Addresses

Remit To

Remit To Location List edit

CAPITOL TOWER 14 FLOOR
600 E BOULEVARD AVENUE
BISMARCK, North Dakota 58505

USA
Address Id 1

Bill To

UND PAYMENT SERVICES
TWAMLEY HALL ROOM 409
264 CENTENNIAL DRIVE
STOP 8356
GRAND FORKS, ND
58202-8356
United States

Note/Attachments

External Note ***** Seq: 1 | Payment Ref: 262355 | Payment Date: 2023-09-26

Internal Note *no note*

External Attachments

Internal Attachments

Payment Information

Accounting Date	9/25/2023
F.O.B.	FOB Destination or as per executed agreement
Payment Method	ACH
Payment Record No.	262355

Discount, Tax, Shipping & Handling

Discount, tax, shipping & handling

Allocation	Sum of All	
	Header-level	Sum of lines
Terms Discount	0.00 USD	
Discount	0.00 USD	0.00 USD
Tax 1	0.00 USD	0.00 USD
Tax 2	0.00 USD	0.00 USD

Origin	*no value*
Origin Ref Field	*no value*

Payment Record Date	9/26/2023
Payment Message	*no value*
Hold Check	✗

Shipping	0.00 USD	0.00 USD
Handling	0.00 USD	0.00 USD
Total		100.00 USD

Codes

LINE

Account	Department	Fund - Dept	Project	Program Code
623155 Other Professional Fees	2725 Mechanical Engineering	22619-2725 F&A S Gupta	*no value*	*no value*

Line Item Details

J000103557

		PO Line	Product Description	Catalog No	Size / Packaging	Unit Price	Quantity	Ext. Price
1	✓	1	**Payment Request**			**100.00 USD**	**1**	**100.00 USD**

Business Purpose	Required Grant Application fee for NDIC proposal- Smart Holistic Zero Waste (SH0WUP)
Special Invoice Instructions	None of the above (standard payment by ACH or Check)

PO Number	J000103557
PO Department	*no value*
Substitute Item	✗
Line Match Status	Do Not Match

Matching Summary

	Ordered	Received	Net Invoiced
Quantity:	1	--	1
Ext. Price:	100.00 USD	--	100.00 USD

Related Documents
Invoices: 0 / Credits: 0 / Receipts: 0

External Note	*no note*
Internal Note	*no note*

External Line Attachments

Internal Line Attachments

Discount, tax, shipping & handling

	Line-level
Discount	0.00 USD
Tax 1	0.00 USD
Tax 2	0.00 USD
Shipping	0.00 USD

Contract No.	
Commodity Code	93151517 License or registration fee
WO/CP Number	*no value*

Handling	0.00 USD

Subtotal	**100.00**
Discount	0.00
Tax	0.00
Tax2	0.00
Shipping	0.00
Handling	0.00
Total	**100.00 USD**

ASSISTANCE AGREEMENT

1. Award No.	2. Modification No.	3. Effective Date	4. CFDA No.
DE-EE0011014		10/01/2023	81.086

5. Awarded To	6. Sponsoring Office	7. Period of Performance
University of North Dakota Attn: John Mihelich 4201 James Ray Drive, Stop 8367 Grand Forks ND 582028367	Energy Effcy & Renewable Energy EE-1 U.S. Department of Energy 1000 Independence Avenue, S.W. Washington DC 20585	10/01/2023 through 09/30/2024

8. Type of Agreement	9. Authority	10. Purchase Request or Funding Document No.
☐ Grant ☒ Cooperative Agreement ☐ Other	PL 109-58 EPAct 2005	23EE002985

11. Remittance Address	12. Total Amount	13. Funds Obligated
University of North Dakota Attn: UNIVERSITY OF NORTH DAKOTA TWAMLEY HALL CENTENNIAL DRIVE 264 Centennial Drive, Stop 7306 GRAND FORKS ND 582027306	Govt. Share: $2,900,000.00 Cost Share : $780,570.00 Total : $3,680,570.00	This action: $2,900,000.00 Total : $2,900,000.00

14. Principal Investigator	15. Program Manager	16. Administrator
	Luke Kandris Phone: 720-636-1087	Golden Field Office U.S. Department of Energy Golden Field Office 15013 Denver West Parkway Golden CO 80401

17. Submit Payment Requests To	18. Paying Office	19. Submit Reports To
Payment - Direct Payment from U.S. Dept of Treasury	Payment - Direct Payment from U.S. Dept of Treasury	

20. Accounting and Appropriation Data

05450-2022-31-200835-41010-1009209-0000000-0000000-0000000

21. Research Title and/or Description of Project

Smart Holistic Zero Waste Utilization Paradigm (SHOWUP) for reusing thermosets and effectively recovering fibers via mechanical, thermal, biological,

For the Recipient		For the United States of America	
22. Signature of Person Authorized to Sign		25. Signature of Grants/Agreements Officer Signature on File	
23. Name and Title	24. Date Signed	26. Name of Officer Christina Kouch	27. Date Signed 09/27/2023

ITEM NO. (A)	SUPPLIES/SERVICES (B)	QUANTITY (C)	UNIT (D)	UNIT PRICE (E)	AMOUNT (F)
	UEI: RSWNKK6J8CF3 1. This is a conditional award, comprised of this Assistance Agreement and the Special Terms and Conditions. Upon successful completion of negotiations, this award will be modified to lift its conditional status, to revise the Special Terms and Conditions, and to add additional attachments, such as Attachment 1, Statement of Project Objectives and Milestone Summary Table; Attachment 2, Federal Assistance Reporting Checklist and Instructions; Attachment 3, Budget Information SF-424A; Attachment 4, Intellectual Property Provisions; and Attachment 5, Community Benefits Plan. 2. The award was prepared using the proposed budget information in the Recipient's application. Term 1 of the Special Terms and Conditions states that the Recipient is prohibited from spending Federal funds at this time. DOE will not release the funding obligated by this award until successful completion of negotiations are reached to the satisfaction of the Contracting Officer. Performance against this award is, therefore, at the Recipient's own risk, and payments for costs incurred for Recipient's project will not be made until the parties complete negotiations and the Contracting Officer issues a modification to this award. 3. A representative of the DOE office will contact the Recipient to request additional and/or revised information needed to supplement and clarify the Recipient's application, to complete the negotiations of an amended award. In Block 7 of the Assistance Agreement, the Period of Performance reflects the beginning of the Project Period through the end of the current Budget Period. Additional future DOE funding and additional budget periods are not contemplated under this award. Funding for all awards and future budget periods is contingent upon the availability of funds appropriated by Congress for the purpose of this program and the availability of future-year budget authority. The total amounts reflected in Blocks 12 and 13 of the Assistance Agreement do not include the Continued ...				

CONTINUATION SHEET	REFERENCE NO. OF DOCUMENT BEING CONTINUED	PAGE	OF
	DE-EE0011014	3	3

NAME OF OFFEROR OR CONTRACTOR
University of North Dakota

ITEM NO. (A)	SUPPLIES/SERVICES (B)	QUANTITY (C)	UNIT (D)	UNIT PRICE (E)	AMOUNT (F)
	Federally Funded Research and Development Center (FFRDC) funding amount of $100,000, which was funded directly. DOE Award Administrator: Wilma (Amy) Abalos E-mail: wilma.abalos@ee.doe.gov Phone: 240-562-1338 DOE Project Officer: Luke Kandaris E-mail: luke.kandaris@ee.doe.gov Phone: 720-636-1087 Recipient Business Officer: Karen Katrinak E-mail: Karen.katrinak@und.edu Phone: 701-777-2505 Recipient Principal Investigator: Surojit Gupta E-mail: surojit.gupta@und.edu Phone: 701-777-1632 "Electronic signature or signatures as used in this document means a method of signing an electronic message that-- (A) Identifies and authenticates a particular person as the source of the electronic message; (B) Indicates such person's approval of the information contained in the electronic message; and, (C) Submission via FedConnect constitutes electronically signed documents." ASAP: YES Extent Competed: COMPETED Davis-Bacon Act: NO PI: Gupta, Surojit Fund: 05450 Appr Year: 2022 Allottee: 31 Report Entity: 200835 Object Class: 41010 Program: 1009209 Project: 0000000 WFO: 0000000 Local Use: 0000000				

INDUSTRIAL COMMISSION OF NORTH DAKOTA

Doug Burgum
Governor

Drew H. Wrigley
Attorney General

Doug Goehring
Agriculture Commissioner

May 2, 2023

Dr. Surojit Gupta
Associate Professor
Advanced Materials Research Group
Dept. of Mechanical Engineering
University of North Dakota
243 Centennial Drive
Grand Forks, ND

Re: Support for the proposal entitled "Smart Holistic Zero Waste Utilization Paradigm (SH0WUP) for reusing thermosets and effectively recovering fibers via mechanical, thermal, biological, and chemical pathways" submitted in response to U.S. Department of Energy funding opportunity DE-FOA-0002960

Dear Dr. Gupta,

Please accept this letter of support for the University of North Dakota's (UND) proposal entitled "Smart Holistic Zero Waste Utilization Paradigm (SH0WUP) for reusing thermosets and effectively recovering fibers via mechanical, thermal, biological, and chemical pathways".

The North Dakota Industrial Commission (NDIC) Renewable Energy Program's mission is to promote the growth of North Dakota's renewable energy industries through research, development, marketing, and education. The proposed effort aims to study the integration of smart blade sorting using advanced imaging and machine learning, sandwich gasifiers, recycled thermoset-based structures, and enzymatic-based technologies into a single platform. This scope of work aligns with the Renewable Energy Program's mission.

This project is eligible for up to $500,000 of cash cost share from the Renewable Energy Program. Support is contingent on submittal of a proposal to the NDIC and subsequent proposal approval by both the Renewable Energy Council and the NDIC.

If successful, this project will provide a valuable resource for our nation's renewable energy industry. Thank you for working to advance North Dakota's clean energy goals.

Sincerely,

Reice Haase, Deputy Executive Director

GREAT RIVER ENERGY™

12300 Elm Creek Boulevard
Maple Grove, Minnesota 55369-4718
763-445-5000
greatriverenergy.com

May 16, 2023

Dr. Surojit Gupta
Associate Professor
Department of Mechanical Engineering
University of North Dakota

Re: Letter of Interest in the University of North Dakota application entitled "Smart Holistic Zero Waste Utilization Paradigm (SH0WUP) for reusing thermosets and effectively recovery fibers via mechanical, thermal, biological, and chemical pathways."

Dear Dr. Gupta,

Great River Energy is pleased to provide this letter of interest in support of your team's application to the U.S. Department of Energy to demonstrate a novel technology to cost-effectively reuse materials in end-of-life wind turbine blades.

Great River Energy is a not-for-profit generation and transmission electric cooperative, headquartered in Maple Grove, Minnesota. Together with our 27 member-owner distribution cooperatives and customers, we provide reliable and affordable electricity to 1.7 million people. Great River Energy's power supply portfolio has transformed over the past decade, and our cooperative now has power purchase agreements for the output of nine wind facilities located throughout Minnesota, North Dakota, South Dakota, and Iowa.

Great River Energy believes in the responsible use of natural resources, including maximizing the useful life of materials in wind turbine blades. Based on discussion with members of your team, we feel your technology has significant commercial potential and we plan to follow the progress of your development and demonstration efforts.

We wish you luck in your proposal to the Department of Energy and look forward to following your project going forward.

Sincerely,

GREAT RIVER ENERGY

David Saggau
President and Chief Executive Officer

LM WIND POWER
a GE Renewable Energy business

05/09/2023

DOE Program Manager,

LM Wind Power, a GE Renewable Energy business, would like to support the proposal titled, "Smart Holistic Zero Waste Utilization Paradigm (SH0WUP)" for reusing thermosets and effectively recovering fibers via mechanical, thermal, biological, and chemical pathways".

LM Wind Power is a leading supplier of blades for wind turbines, offering blade development, manufacturing, service, and logistics. Approximately one in five turbines installed around the world are LM Wind Power blades. To keep our leading position LM Wind Power is keen on innovating their product and processes. Key to future sustainable business is the need for manufacturing zero waste blades by 2030. To meet this strategy, it means developing a way to utilize all excess materials from manufacturing.

The proposal is very timely as it envisions a zero-waste paradigm by using a collaborative model to solve a challenging problem of recycling thermoset waste both during manufacturing and post-manufacturing. Research and development of wind turbine research and utilization cluster in the University of North Dakota will be beneficial to us as it will create pathways for thermoset reutilization and recycling which tunes well with our own recycling and sustainability efforts. In addition, there is an urgent requirement of trained manufacturing engineers in the plant. This program has the potential to create pilot facilities and provide work force trained in different aspects of wind blade manufacturing who could join our plant in the future.

We are excited to support this proposal and hope to see results that benefit our world-wide wind power business.

Best Regards,

Tricia Weber
Sr Manufacturing Staff Manager

May 11, 2023

Mr. Kevan Rusk
Director of Business Development
College of Engineering and Mines
University of North Dakota

RE: "Smart Holistic Zero Waste Utilization Paradigm (SH0WUP)

I have genuine interest in the research as described in the proposal entitled, "Smart Holistic Zero Waste Utilization Paradigm (SH0WUP). The reuse of thermosets and effectively recovering fibers via mechanical, thermal, biological, and chemical pathways has great merit.

The proposal is very timely as it envisions a zero-waste paradigm by using a collaborative model to solve a challenging problem of recycling thermoset waste, both during and after manufacturing. We are very interested to evaluate the recycled fibers from the pilot testing for construction-based applications.

The environmental benefits: saving natural resources, using recycled materials, and reducing pollution and greenhouse gas emissions will contribute to the concrete construction industries efforts for building sustainable projects.

Thank you for your consideration in this matter.

Henry Hauge | Director of Technical Services
STRATA CORPORATION
p: 701-277-1432 c: 701-238-6556
e: hank.hauge@stratacorporation.com
102 12th Ave NW | West Fargo, ND 58078

BUILD WITH STRENGTH
A COALITION OF THE NATIONAL READY MIXED CONCRETE ASSOCIATION

SINGULARITY ENERGY TECHNOLOGIES, LLC
WASTE TO ENERGY

DR. NIKHIL PATEL
President

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

May 9, 2023

Dr. Surojit Gupta,
Associate Professor and Director of Materials Manufacturing Initiative (MMI)
Department of Mechanical Engineering
University of North Dakota

Subject: Letter of Commitment from Singularity Energy Technologies in support of the University of North Dakota's response to U.S. Department of Energy DE-FOA-0002960

Dear Dr. Gupta,

I am happy to provide support for your proposed project to the U.S. Department of Energy in response to DE-FOA-0002960. Singularity Energy Technologies (SET) is the inventor of the Sandwich gasifier and has been working diligently the past several years to fully commercialize the technology. SET has developed a strong supporting team over time and continues to work with this team on projects such as that proposed herein. Our team can assist you in meeting the goals of your project, specifically those in support of Objective B as outlined in your proposal.

I have worked closely with you to develop the workplan for Objective B and have read SET's commitments as presented in your final proposal to DOE. We fully support the three subtasks outlined in the proposal, namely Task 2.1 Bench-Scale Testing of the Blade Material; Task 2.2 Bench-Scale Testing and 5 ton/day System Design Modification; and Task 2.3 5 ton/day System Modification, Testing and Reporting. We will perform our tasks in accordance to the attached schedule and milestones. The start date of our work and sub-task timeline will be adjusted as needed to match the start date of your project if an award in made by DOE.

The total cost of the services provided is $939,968. SET will provide a portion of these services to UND as in-kind cost share towards the DOE cost-share requirements. As presented in the attached Budget Justification workbook, this represents a cost to DOE of $751,975 with a cost share commitment from SET (met by our subrecipient Tri-Steel Manufacturing) of $187,993.

We are looking forward to working with you on this important and exciting project.

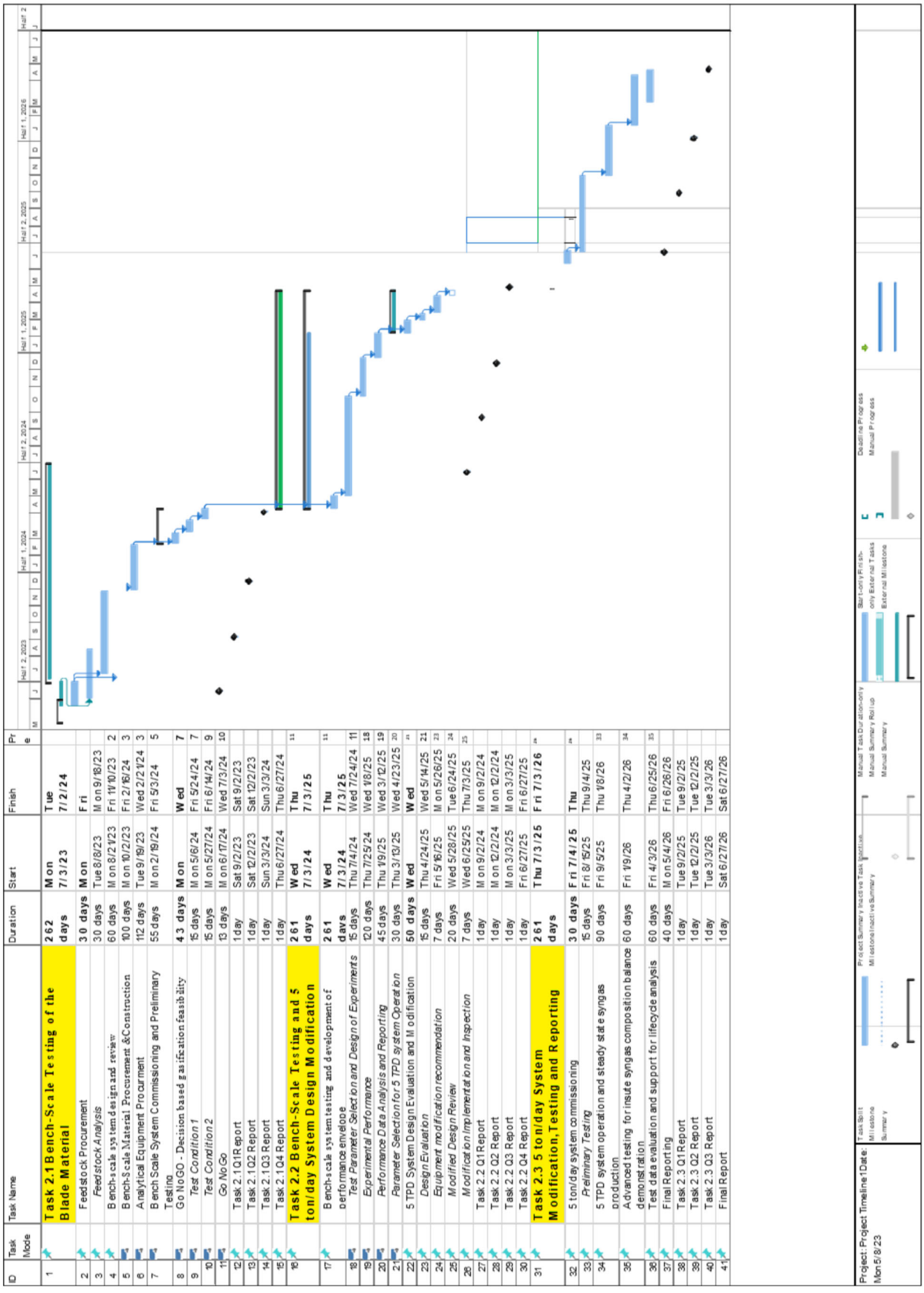
Sincerely,

Nikhil Patel
President, Singularity Energy Technologies, LLC

SINGULARITY ENERGY TECHNOLOGIES, LLC
WASTE TO ENERGY

DR. NIKHIL PATEL
President

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



ID	Task Mode	Task Name	Duration	Start	Finish	Pre
1		**Task 2.1 Bench-Scale Testing of the Blade Material**	**262 days**	**Mon 7/3/23**	**Tue 7/2/24**	
2		Feedstock Procurement	**30 days**	**Mon**	**Fri**	
3		*Feedstock Analysis*	30 days	Tue 8/8/23	Mon 9/18/23	
4		Bench-scale system design and review	60 days	Mon 8/21/23	Fri 11/10/23	2
5		Bench-Scale Material Procurement &Construction	100 days	Mon 10/2/23	Fri 2/16/24	3
6		Analytical Equipment Procurment	112 days	Tue 9/19/23	Wed 2/21/24	3
7		Bench Scale System Commissioning and Preliminary Testing	55 days	Mon 2/19/24	Fri 5/3/24	5
8		Go NoGO - Decision based gasification feasibility	**43 days**	**Mon**	**Wed**	**7**
9		*Test Condition 1*	15 days	Mon 5/6/24	Fri 5/24/24	7
10		*Test Condition 2*	15 days	Mon 5/27/24	Fri 6/14/24	9
11		*Go NoGo*	13 days	Mon 6/17/24	Wed 7/3/24	10
12		Task 2.1 Q1 Report	1 day	Sat 9/2/23	Sat 9/2/23	
13		Task 2.1 Q2 Report	1 day	Sat 12/2/23	Sat 12/2/23	
14		Task 2.1 Q3 Report	1 day	Sun 3/3/24	Sun 3/3/24	
15		Task 2.1 Q4 Report	1 day	Thu 6/27/24	Thu 6/27/24	
16		**Task 2.2 Bench-Scale Testing aad 5 ton/day System Design Modification**	**261 days**	**Wed 7/3/24**	**Thu 7/3/25**	11
17		Bench-scale system testing and development of performance envelope	**261 days**	**Wed 7/3/24**	**Thu 7/3/25**	11
18		*Test Parameter Selection and Design of Experiments*	15 days	Thu 7/4/24	Wed 7/24/24	11
19		*Experimental Performance*	120 days	Thu 7/25/24	Wed 1/8/25	18
20		*Performance Data Analysis and Reporting*	45 days	Thu 1/9/25	Wed 3/12/25	19
21		*Parameter Selection for 5 TPD system Operation*	30 days	Thu 3/13/25	Wed 4/23/25	20
22		5 TPD System Design Evaluation and Modification	**50 days**	**Wed**	**Wed**	21
23		*Design Evaluation*	15 days	Thu 4/24/25	Wed 5/14/25	21
24		*Equipment modification recommendation*	7 days	Fri 5/16/25	Mon 5/26/25	23
25		*Modified Design Review*	20 days	Wed 5/28/25	Tue 6/24/25	24
26		*Modification Implementation and Inspection*	7 days	Wed 6/25/25	Thu 7/3/25	25
27		Task 2.2 Q1 Report	1 day	Mon 9/2/24	Mon 9/2/24	
28		Task 2.2 Q2 Report	1 day	Mon 12/2/24	Mon 12/2/24	
29		Task 2.2 Q3 Report	1 day	Mon 3/3/25	Mon 3/3/25	
30		Task 2.2 Q4 Report	1 day	Fri 6/27/25	Fri 6/27/25	
31		**Task 2.3 5 ton/day System Modification,Testing and Reporting**	**261 days**	**Thu 7/3/25**	**Fri 7/3/26**	
32		5 ton/day system commissioning	**30 days**	**Fri 7/4/25**	**Thu**	
33		*Preliminary Testing*	15 days	Fri 8/15/25	Thu 9/4/25	
34		5 TPD system operation and steady state syngas production	90 days	Fri 9/5/25	Thu 1/8/26	33
35		Advanced testing for insute syngas composition balance demonstration	60 days	Fri 1/9/26	Thu 4/2/26	34
36		Test data evaluation and support for lifecycle analysis	60 days	Fri 4/3/26	Thu 6/25/26	35
37		Final Reporting	40 days	Mon 5/4/26	Fri 6/26/26	
38		Task 2.3 Q1 Report	1 day	Tue 9/2/25	Tue 9/2/25	
39		Task 2.3 Q2 Report	1 day	Tue 12/2/25	Tue 12/2/25	
40		Task 2.3 Q3 Report	1 day	Tue 3/3/26	Tue 3/3/26	
41		Final Report	1 day	Sat 6/27/26	Sat 6/27/26	

Dr. Edwin S. Olson

Phone: 701 330 2522
Email: eolson@gra.midco.net

May 7, 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 University of North Dakota in response to U.S. Department of Energy DE-FOA-0002960

Dear Dr. Patel,

I am happy to provide support for your proposed project to the University of North Dakota's proposal to the U.S. Department of Energy in response to DE-FOA-0002960. 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 to provide consulting support in chemistry at a fee of $1000 for budget period one and $2000 each for budget periods two and three ($5000 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 S. Olson
Principal Scientific Advisor
Singularity Energy Technologies, LLC

mdm energy consulting, llc

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

May 7, 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 University of North Dakota in response to U.S. Department of Energy DE-FOA-0002960

Dear Dr. Patel,

I am happy to provide support for your proposed project to the University of North Dakota's proposal to the U.S. Department of Energy in response to DE-FOA-0002960. 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 development and execution of your testing campaign and support with report writing.

I am committing one month of my time per year for a total of 519 hours in support of your proposed project in accordance to the attached budget. 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

mdm energy consulting, llc

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

Support for Singularity Energy Technologies proposal to the University of North Dakota in response to U.S. Department of Energy DE-FOA-0002960.

Budget Period 1: 173 hours at $150/hr for a total of $25,950
Budget Period 2: 173 hours at $150/hr for a total of $25,950
Budget Period 3: 173 hours at $150/hr for a total of $25,950

Total Cost: $77,850

Note: Any travel costs will be paid directly by SET or UND

May 8, 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 University of North Dakota in response to U.S. Department of Energy DE-FOA-0002960

Dear Dr. Patel,

I am happy to provide support for the University of North Dakota's project proposal to the U.S. Department of Energy in response to DE-FOA-0002960. I will use my connections and expertise to procure the windmill blades required for the proposed work, provide support developing analytical protocols, analyzing data, report writing, and will use my connections to develop relationships with long-term customers and identify potential buyers of your technology.

I will commit 12% of my time per year for each of the annual budget periods at a fee of $10,000 per year ($30,000 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,

Dr. Nicholas Ralston
Director, Sage Green NRG
Nick.Ralston@SageGreenNRG.com
218-791-2838

May 7, 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 University of North Dakota in response to U.S. Department of Energy DE-FOA-0002960

Dear Dr. Patel,

I am happy to provide support for your proposed project to the University of North Dakota's proposal to the U.S. Department of Energy in response to DE-FOA-0002960. My experience over the years educating, as well as learning from, entrepreneurs, strategists, and family business leaders, provide me with an excellent background to assist you with the development of a strong business plan for your technology.

In consideration of my time, I accede to a fee of $2500 per year ($5000 total) for each of budget periods two and three. 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,

Sanjay Goel

Sanjay Goel, PhD
3700 Ruemmele Rd Apt 300
Grand Forks ND 58201

INDUSTRIAL COMMISSION OF NORTH DAKOTA
RENEWABLE ENERGY PROGRAM

TECHNICAL REVIEWERS' RATING SUMMARY

R-052-B
PRAIRIE HORIZON CARBON MANAGEMENT HUB
Principal Investigator: Kevin C. Connors
Request for $100,000 Total Project Costs $3,225,000

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		Technical Reviewer				
		1B	**2B**	**3B**	**4B**	
Rating Category	**Weighting Factor**	**Rating**				**Average Weighted Score**
1. Objectives	9	2	4	5	5	36.00
2. Achievability	9	4	5	3	4	36.00
3. Methodology	7	2	4	3	5	24.50
4. Contribution	7	1	5	4	5	26.25
5. Awareness	5	4	5	1	5	18.75
6. Background	5	3	5	4	5	21.25
7. Project Management	2	4	4	2	5	7.50
8. Equipment Purchase	2	5	5	5	5	10.00
9. Facilities	2	3	5	3	5	8.00
10. Budget	2	3	4	4	4	7.50
Average Weighted Score		140	230	174	239	**195.75**
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 2)

Of the six goals and purposes listed in the Mission Statement of the North Dakota Industrial Commission Renewable Energy Council, this proposal may only meet the goal of promoting public awareness if the collection and storage of carbon dioxide qualifies as a renewable energy industry. Otherwise, this proposal is seeking funding for only 3.1% of the total projected cost of this project mostly for public relations and clerical work.

Reviewer 2B (Rating 4)
The objectives are very clear. The general project deliverables are a local well-bore integrity study, preliminary engineering study for underground storage for products such as CO2 storage, and to provide community outreach/engagement.

These project objectives are consistent with the NDIC/REC overall goals.

Reviewer 3B (Rating 5)
The NDIC/REC goals are directly aligned with this project. ND will benefit greatly from the eventual development of this work.

Reviewer 4B (Rating 5)
The primary objective of this proposed effort is to provide technical assistance and engagement for a prospective large-scale CO2 storage hub, with emphasis on community outreach and public engagement activities that will support better understanding of the social landscape of the region in which the storage hub would be developed. As the two sources identified are an existing renewable diesel facility and a proposed Hydrogen production facility. This clearly is consistent with the goals 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 1B (Rating 4)
Though it is not exactly clear how this requesting funding specifically will be utilized for this project, the cited time table seems reasonable and the proposal is well funded by other sources.

Reviewer 2B (Rating 5)
The timeline appears to be achievable within the proposed budget.

Reviewer 3B (Rating 3)
The outreach is the largest unknown from a scope perspective. It could be that community reaction will require more effort than expected. Of course, the outreach could just be terminated without a full understanding of the effort required in moving forward.

Reviewer 4B (Rating 4)
The proposed approach I believe will most likely lead to a successful project. The budget is highly leveraged with the NDIC only providing $100,000 of a Budget of over $3.2 million with the other funds already committed from federal and industrial sources. This reinforces my belief that the budget is sufficient for a successful project.

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 2)
The proposal is unclear as to how the requested funding will be utilized and what cannot be accomplished if the funding is not provided.

Reviewer 2B (Rating 4)
The methodology appears to be in place to achieve the stated goals of the proposal.

Reviewer 3B (Rating 3)
The methodology appears to be adequate for the work that is involved. The methodology is sound and addresses the issues expected. It does not address new issues that may arise during the outreach phase.

Reviewer 4B (Rating 5)
The proposer in this project is the EERC. This group is widely accepted as the "authority" on the opportunity for CO2 geologic storage in this region. With that in mind, I am very confident that the methodology noted will lead to a successful project.

4. The scientific and/or technical contribution of the proposed work to specifically address North Dakota Industrial Commission/Renewable Energy Council goals will likely be: 1 – extremely small; 2 – small; 3 – significant; 4 – very significant; or 5 – extremely significant.

Reviewer 1B (Rating 1)
There does not appear to be any scientific and/or technical contributions cited in this proposal.

Reviewer 2B (Rating 5)
The feasibility study, specifically the wellbore integrity analysis will provide additional CCUS opportunities in the SW region on ND but also to other oil & gas producing areas. The community outreach proposed address deficiencies in recent CO2 transportation projects.

Reviewer 3B (Rating 4)
The contribution of the proposed work addresses the goals the of the NDIC/REC. How the actual work actually results in the expected benefits is yet to be determined.

Reviewer 4B (Rating 5)
The Governor of the state of North Dakota has established a goal of being carbon neutral by 2030. In addition, the state strongly endorses an all of the above energy strategy. To achieve both of these goals the state must explore and exploit carbon storage. That is exactly what this project does for the state and the country.

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 4)
I spent several years designing, installing and operating a carbon capture system at a coal fired power plant.

Reviewer 2B (Rating 5)
The PI's of this project have superior knowledge of the current research activity.

Reviewer 3B (Rating 1)
There is no evidence cited to establish the PI's awareness of current related research activity or published literature or other research that is yet unpublished.

Reviewer 4B (Rating 5)
The team assembled is widely accepted as world class when it comes to design of safe and effective storage of CO2. Their work has already noted that North Dakota has what is considered ideal geology for safe and effective storage. They are a major source of the published literature in this field.

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 3)
I have interfaced with media in the past when it comes to carbon capture projects and power plant construction. I have participated with governmental task forces in the USA and foreign countries when it involved carbon capture and storage.

Reviewer 2B (Rating 5)
As stated above in section 5, the PI's have the experience and resources to complete the goals of the proposal.

Reviewer 3B (Rating 4)
Those participating appear to have backgrounds that can adequately support this work. It would be helpful to know of past work of the participants in community outreach that addressed unexpected input from stakeholders.

Reviewer 4B (Rating 5)
The assembled staff has demonstrated the knowledge necessary for the proposed work.

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 4)
All of the cited tasks in this proposal are well described and illustrated on a timeline along with the individual responsible.

Reviewer 2B (Rating 4)
Project mgt. plan included who is doing what and why along with a general proposed timeline. Internal and extern meetings are planned, but no schedule is given or stated they will be done on an as-needed basis. Additionally, a budget is included, but there is no proposed spend schedule.

Reviewer 3B (Rating 2)
There is a schedule though it can hardly be called a milestone schedule. A bar chart that runs from beginning to end is not acceptable. There is no detail involved.

Similarly, there is no financial plan other than the source of funds. Expenditures are not tied to the (non-existent) milestones. Nor is a cash flow offered.

Also, no management plan is offered other than a reporting schedule which is also inadequate.

Surely the Department of Energy requires more detail that is present here.

Reviewer 4B (Rating 5)
The proposal includes a detailed set of milestones that will allow the sponsors to monitor the progress of the proposed work. Plans for communication within the team and to the sponsors is noted.

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 is to be purchased.

Reviewer 2B (Rating 5)
No Equipment to be purchased.

Reviewer 3B (Rating 5)
No comments.

Reviewer 4B (Rating 5)
No equipment will 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)
There is not any research conducted within the scope of this proposal. The facilities to be utilized are existing at the time of the proposal.

Reviewer 2B (Rating 5)
The EERC has the facilities and equipment available to perform the tasks stated in the proposal.

Reviewer 3B (Rating 3)
The physical requirements of the proposed work appear to be well met based on the description of the proposal.

Reviewer 4B (Rating 5)
The EERC is widely respected as a leading expert in carbon storage and has the facilities as well as staff to successfully complete a project such as the one proposed here.

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)
The private financial support is more than six times the amount requested which readily meets the requirements of the NDIC. The projected and technical outcome is poor as this proposal does not involve any research.

Reviewer 2B (Rating 4)
The long-term data analyses on well-bore integrity could be invaluable. It may also serve as a blueprint for other areas of oil & gas production for alternate uses. The education/outreach and portion of the

project could pave the way for additional projects for the region with respect to public expectations management.

Additionally, the project does have a high amount of federal and private funds compared to the NDIC request.

Reviewer 3B (Rating 4)
The successful results of the project provide high value and are an integral part of any large project being undertaken. The unsuccessful results also have value in showing limitations that were unknown.

Reviewer 4B (Rating 4)
The proposed activity is estimated to cost $3,250,000. Of this total the team as requesting $100,000 from the NDIC/Renewable Energy Council. The level of cost share offers excellent value 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 1B
This public relations and record searching project is well funded by other sources and has support from high-ranking political individuals in North Dakota. So, from the political aspect, it will be difficult to turn down this proposal. However, consideration should be given to the incompleteness of this request. The proposal outlines the overall project but does not give any indication why the funding from the NDIC is necessary. The proposal does not fulfil any of the goals and purposes cited in the mission statement of the NDIC. The proposal fails to meet any of the grant priority bullet points of the NDIC. Because this proposal fails to illustrate why support from the NDIC is necessary and it has very little to do to help meet the goals and purposes of the NDIC, I am recommending the NDIC does not fund this proposal.

Reviewer 2B
The merits of the project are that it has the potential to provide the framework for significant investment in ND underground storage resources by making the energy output of the state's resources (both legacy and renewable) more marketable to the general US & global population.

The proposal did not state the source of the CO2 or other injectable projects.

Reviewer 3B
I recommend the project for approval.

There are significant deficiencies in the proposal (see the specific comments above) that would suggest the proposal be not endorsed. However, base on previous work with the DoE, those deficiencies are likely address in the DoE application.

It is unfortunate that the PIs feel it unnecessary to offer reports on a more timely basis to allow for the constructive review of the project status and the need for adjustments.

Reviewer 4B

This reviewer strongly recommends funding for the proposed project "Prairie Horizon Carbon Management Hub". As stated earlier in my comments, in order to achieve the Governor's goal of carbon neutrality by 2030 with an all of the above strategy, the state must aggressively exploit carbon storage with the tremendous geologic storage options available in the state. This project will be critical to the carbon management required to achieve the carbon neutrality goal established by the governor.

In addition, the recent announcement of the EERC success in receiving a nearly $1 B award for a Hydrogen Hub that included funding for the Hydrogen production facility in North Dakota. This is for the hydrogen facility discussed as "proposed "in this proposal.

With that award and successful completion of this activity, the pieces will be in place for nearly $2 billion in North Dakota for a hydrogen production facility in North Dakota with a very low carbon footprint!

Energy & Environmental Research Center
15 North 23rd Street, Stop 9018 • Grand Forks, ND 58202-9018 • P. 701.777.5000 • F. 701.777.5181
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October 2, 2023

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: EERC Proposal No. 2024-0035 Entitled "Prairie Horizon Carbon Management Hub"

The Energy & Environmental Research Center (EERC) of the University of North Dakota (UND) is pleased to submit the subject proposal to the North Dakota Industrial Commission Renewable Energy Program.

The EERC, a research organization within UND, an institution of higher education within the state of North Dakota, is not a taxable entity; therefore, it has no tax liability. The EERC 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 262355. If you have any questions, please contact me by telephone at (701) 777-5236 or by email at kconnors@undeerc.org.

Sincerely,

DocuSigned by:
Kevin Connors
1D14EF7CF3CD456...

Kevin C. Connors
Assistant Director for Regulatory Compliance
and Energy Policy

Approved by:

DocuSigned by:
Brian Kalk
C7560BF2E06C43B...
for

Charles D. Gorecki, CEO
Energy & Environmental Research Center

c: Karen Tyler, North Dakota Industrial Commission

Renewable Energy Program

North Dakota Industrial Commission

Application

Project Title: Prairie Horizon Carbon Management Hub

Applicant: Energy & Environmental Research Center (EERC), University of North Dakota; *EERC Proposal No. 2024-0035*

Principal Investigator: Kevin C. Connors

Date of Application: October 2, 2023

Amount of Request: $100,000

Total Amount of Proposed Project: $3,225,000

Duration of Project: 24 months

Point of Contact (POC): Kevin C. Connors

POC Telephone: (701) 777-5236

POC Email: kconnors@undeerc.org

POC Address: 15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

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ABSTRACT

The project team has defined a regional carbon management (CM) hub area in southwestern North Dakota—the Prairie Horizon Carbon Management Hub (PHCMH)—with a prospective stacked CO_2 storage resource of at least 100 million tonnes (Mt). Two stationary CO_2 sources with a combined annual total emission of over 5 Mt are identified as potential contributors to the CO_2 storage hub. The sources include an existing renewable diesel facility and a planned H_2 production facility. The PHCMH is needed to catalyze meaningful investment in new, clean H_2 energy technology that can diversify North Dakota's economy, leverage and expand use of North Dakota's vast natural and agricultural resources, and materially reduce the carbon intensity of the state's economy.

Objective: The primary objective of this proposed effort is to provide technical assistance and engagement for a prospective large-scale CO_2 storage hub, with emphasis on community outreach and public engagement activities that will support better understanding of the social landscape of the region in which the storage hub would be developed. **Expected Results:** The project will support the Renewable Energy Program's (REP's) mission to foster the development of renewable energy and related industrial use technologies through research, development, demonstration, and commercialization. The proposed

project will provide the technical assistance and stakeholder engagement for a large-scale CO_2 storage hub with emphasis on improved understanding of stakeholder concerns, community attitudes, and public acceptance of carbon capture, utilization, and storage associated with the existing renewable diesel facility and a planned H_2 production facility. The proposed hub would store CO_2 captured from these two facilities and would assist in the commercial deployment of clean H_2 energy that can diversify North Dakota's economy, leverage existing energy resources, create sustainable jobs, and reduce the environmental footprint of energy production and use in the region and beyond.

Duration: 24 months, with an anticipated start date of November 1, 2023. **Total Project Cost:** $3,225,000, with $100,000 from the North Dakota Industrial Commission Renewable Energy Program, up to $625,000 in cash cost share from Prairie Horizon Hydrogen (Marathon Petroleum Corporation and TC Energy), and $2.5M from the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL). **Participants:** North Dakota Industrial Commission Renewable Energy Program, UND EERC, Marathon Petroleum Corporation, TC Energy, DOE NETL, and UND Nistler College of Business and Public Administration.

PROJECT DESCRIPTION

Introduction: The Energy & Environmental Research Center (EERC) has worked in collaboration with Marathon Petroleum Corporation (MPC) and TC Energy (TCE) to leverage U.S. Department of Energy (DOE) funds to help facilitate carbon reduction strategies across their portfolio, which includes energy transport, petroleum refining, renewable fuel manufacture, and hydrogen production. MPC and TCE, partnering as Prairie Horizon Hydrogen, are conducting a front-end engineering design (FEED) for a clean hydrogen (H_2) production facility and assessing the opportunity for a regional H_2 hub. This proposed project would assess the viability of a carbon dioxide (CO_2) storage hub to support Prairie Horizon Hydrogen's decarbonization goals.

North Dakota is an ideal candidate for this proposed project. As of September 2023, the North Dakota Industrial Commission (NDIC) has approved five CO_2 storage facility permit applications (one for the Red Trail Energy [RTE] ethanol plant, two for Minnkota Power Cooperative's Project Tundra, one for Dakota Gasification Company's Great Plains Synfuels Plant, and one for Blue Flint Sequester Company, LLC), with an additional permit application pending. Several other announced projects will be pursuing CO_2 storage permits to manage emissions from existing ethanol plants and a coal-fired power plant as well as a H_2 production hub that is in the early planning stages of development. In addition to being a key technology in addressing global CO_2 emissions, carbon capture, utilization, and storage (CCUS) will provide significant economic opportunities for the state of North Dakota. Deployment of CCUS technology is an emerging opportunity that has the potential to create tens of thousands of skilled, high-paying jobs in the state while securing the future of North Dakota's energy and agriculture economies.

Objectives: The primary objective of this proposed effort is to provide technical assistance and stakeholder engagement for a prospective large-scale CO_2 storage hub, with emphasis on community outreach and public engagement activities that will support improved understanding of stakeholder concerns, community attitudes, and public acceptance of CCUS. The project team has defined a regional carbon management (CM) hub area in southwestern North Dakota—the Prairie Horizon Carbon Management Hub (PHCMH)—with a prospective CO_2 stacked storage resource of at least 100 million tonnes (Mt). The proposed hub would store CO_2 captured from an existing renewable diesel facility and a planned H_2 production facility, further decarbonize both renewable diesel and hydrogen, strengthen demand for oil-seed crops, and create a framework for future carbon storage in North Dakota.

Although CCUS deployment has momentum in North Dakota, a variety of technical, policy, and stakeholder engagement aspects still need to be addressed. In the technical realm, there are questions about how operators can optimize CO_2 storage and account for potential pressure impacts from neighboring projects. From a policy standpoint, outstanding questions focus on how mineral rights and

pore space rights can be reconciled in areas where both CO_2 storage and oil and gas production are technically feasible. Other questions about federal policies and regulations will come into play for CCUS development on federal lands. In the area of public perception, the concept of CCUS deployment in North Dakota has recently been getting more attention in the media, highlighting knowledge gaps and misconceptions regarding the safety and effectiveness of CCUS, the role of government in its development and regulation, and the overall benefits of CCUS for all North Dakota citizens.

With these factors in mind, the project team proposes to conduct activities to 1) thoroughly examine local, state, and federal policies, as well as legal frameworks, that may be applied to questions of mineral rights and pore space ownership; 2) engage stakeholders through the development and implementation of a community benefits plan (CBP) that supports public engagement and dialogue activities, including providing technical assistance and resources to communities related to CM; and 3) address technical issues that could facilitate the eventual deployment of the PHCMH.

Methodology: The project will be organized into five tasks. The task structure is identical to that in the matching proposal that was awarded by DOE's Office of Fossil Energy and Carbon Management (FECM).

Task 1 – Project Management and Reporting

This effort is expected to require significant oversight by EERC personnel throughout the project duration to coordinate each part of the overall study so that results from each task best inform the next. Task 1 will include all reporting to project sponsors, including quarterly reports and the final report. Results will be provided in project reports and meetings with NDIC and will be shared at one or more technical conferences.

Task 2.0 – Community Benefits Plan

Task 2 work will focus on compliance with the mandatory components of the leveraged DOE funding and will address them in a manner that is most relevant and meaningful for North Dakota communities, businesses, and workforce. The CBP contains four actionable sections: Community and Labor

Engagement; Investing in Job Quality and a Skilled Workforce; Diversity, Equity, Inclusion, and Accessibility (DEIA); and Justice40 (J40) Initiative. The subtasks discussed in Task 2.0 each have a unique community or stakeholder focus but are all components of the overarching CBP and will be implemented concurrently. This approach will not only maximize efficiency and use of materials and resources but also provide consistent trustworthy messaging to enhance existing community relationships and foster new ones. A project webpage hosted on the EERC website will be developed and will incorporate principles of DEIA and environmental justice while providing project objectives, status, fact sheets, project partners, and contact information.

Key elements of public engagement will be listening sessions and a stakeholder network. Through listening sessions, the project team anticipates learning about stakeholder needs and concerns. Perceived risks expressed in these sessions will be integrated into Subtask 4.4 and will guide future messaging and materials development. The project team will work toward developing a network of stakeholder representatives to guide and advise project activities, build trustworthy relationships, and help engage the public.

Subtask 2.1 – Community and Labor Engagement (CLE) – This subtask will include all activities necessary to execute the Community and Labor Engagement section of the CBP. This subtask will include in-depth social characterization of the project area in the context of the greater region; identifying audiences, including communities with environmental justice concerns, disadvantaged communities, and tribes; developing messaging goals and content; selecting methods for engaging stakeholders (e.g., media campaigns, one-on-one contact, listening sessions, open houses, etc.); strategies for incorporating stakeholder feedback; materials development; developing a timeline for implementation of the plan; and creating a system for tracking engagement outcomes and gauging impact.

Subtask 2.2 – Investing in Job Quality and a Skilled Workforce – This subtask will include all activities necessary to execute the Investing in Job Quality and a Skilled Workforce section of the CBP.

Subtask 2.3 – Diversity, Equity, Inclusion, and Accessibility – This subtask will include all activities necessary to execute the DEIA section of the CBP. The DEIA subtask includes the actions that will be implemented throughout the project to foster a welcoming and inclusive environment; support people from groups traditionally underrepresented in STEM (science, technology, engineering, and math) and/or applicable workforces; advance equity; and encourage the inclusion of individuals from these groups in future phases of the project.

Subtask 2.4 – Justice40 – This subtask will include all activities necessary to execute the J40 section of the CBP. The J40 subtask will consist of two parts. Part 1 will begin with an in-depth energy and environmental justice assessment (EEJA) that will assess the project benefits and impacts. Learnings from the EEJA will be used to inform and develop Part 2, the J40 implementation strategy that will describe actions the project team will take to maximize benefits and minimize negative impacts in areas identified in the EEJA.

Task 3.0 – Regional Technology Transfer and Engagement

Subtask 3.1 – Technology Transfer – Work in Subtask 3.1 will inform and educate stakeholders about CCUS technologies. Nontechnical challenges to CCUS deployment in the region will be identified and assessed. A carbon hub advisory team (CHAT) will be formed to discuss key CCUS topics and guide engagement efforts. Developments from the CHAT will provide industry and regulatory stakeholders with tools to inform decision-making. The outcomes of this subtask will be transferred to stakeholders through meetings, presentations, and webinars. Developed materials will be shared with project sponsors to support its broader program goals. These activities will be planned in coordination with project partners and subject to their approval.

Subtask 3.2 – State and Federal Government Engagement – Subtask 3.2 will engage and inform state and federal government stakeholders about CCUS technologies and project development. Nontechnical challenges to CCUS deployment in the region, addressed in Task 4.0, will be identified and assessed. The

outcomes of this subtask will be transferred to stakeholders through meetings, presentations, and webinars. Developed materials will be shared with project sponsors. These activities will be planned in coordination with project partners and subject to their approval.

Task 4.0 – Technical and Nontechnical Challenges

Work in Task 4.0 will focus on identifying technical and nontechnical challenges for the prospective PHCMH, including conducting a feasibility study, investigating legacy well integrity in the project area, identifying and addressing pore space competition, and conducting a risk assessment.

Subtask 4.1 – Road Map to Prove Feasibility – This subtask will evaluate the PHCMH from the perspective of a prefeasibility study. Criteria for DOE's CarbonSAFE (Storage Assurance Facility Enterprise) Phases II and III will be used as the standard for comparison in evaluating the feasibility of the PHCMH. The project team will review and identify existing datasets within the defined project area to inform recommendation for additional data acquisition, such as acquiring additional seismic data and the location of a stratigraphic test well, aka the well of knowledge. A report (deliverable) will be developed with recommendations for a commercial project developer to collect all necessary data, including the location of stratigraphic test well and a well coring, testing, and sampling program to ensure compliance with North Dakota CO_2 storage facility permitting requirements. New and existing datasets can be used to inform final project design (i.e., number and location of injection wells and monitoring wells) and incorporated into a geologic model needed for meeting computational simulation requirements.

Subtask 4.2 – Legacy Well Integrity – Efforts in this subtask will be directed toward a legacy wellbore integrity assessment. This assessment will characterize the 400+ existing wellbores from the standpoint of long-term CO_2 storage security. The inventory of wells will be classified in a manner that will provide future hub developers with a foundational knowledge of wellbore mitigation challenges that may lie ahead (deliverable).

Subtask 4.3 – Pore Space Competition – As pore space resource demand increases, there will be increasing chances for a CO_2 storage developer to encounter competition for the subsurface storage resource. A paper (deliverable) will be developed to discuss the various types of storage opportunities (e.g., short-term vs. long-term), by-product to be stored (e.g., CO_2, H_2, saltwater, methane), formation types (e.g., nonproductive oil-bearing, geothermal resource), and associated laws and regulations in the broader area surrounding the PHCMH.

Subtask 4.4 – Risk Assessment – Activities within this subtask will be directed to conducting a risk assessment in conjunction with the engagement activities in Tasks 2.0 and 3.0. The goal will be to catalog risks identified by the area stakeholders. Risk identification will be conducted to identify both technical and nontechnical risks that may prevent or hinder potential candidate storage reservoirs within the hub area from serving as commercial CO_2 storage sites. Once the risk assessment has been completed, a risk treatment strategy will be formulated. Risk treatment includes several different strategies for negative risks, including avoidance, transfer, mitigation, and acceptance, and for positive risks, including exploitation, sharing, enhancing, and acceptance. Communication is necessary during every step of the risk assessment process to assure stakeholders that the identified risks are being addressed formally and suggested mitigation strategies are vetted during public engagement sessions. A report (deliverable) describing the identified risks and mitigation strategies will be submitted.

Task 5.0 – Regional Infrastructure Development

Work in Task 5.0 will evaluate regional infrastructure development by assessing potential transportation and infrastructure needs in the project area as well as identifying regional scale-up challenges and developing site readiness factors for the hub.

Subtask 5.1 – CO_2 Pipeline Rights-of-Way (ROWs) – This subtask will acquire available datasets that relate to land surface use and ownership within the broader study area to identify pertinent geopolitical characterization, environmentally sensitive areas, and various existing ROWs (including pipelines). This

information will be used to identify conflicts or opportunities for project development within the study area and summarized in a report (deliverable).

Subtask 5.2 – Site-Readiness Factors – The project team will create a prototype template (deliverable) for documenting site-readiness factors for commercial development of a carbon storage facility or hub. Site-readiness factors will be guided by the development of a commercial deployment matrix that will encompass CO_2 transport, utilization, and storage.

Anticipated Results: The proposed project will support North Dakota's vision to develop and deploy large-scale commercial CO_2 storage projects that reduce environmental impacts and increase the sustainability of energy production. The proposed project will provide the information needed for the project team to confidently invest in commercial deployment of clean H_2 energy that can diversify North Dakota's economy, leverage existing energy resources, and create sustainable jobs.

Facilities: The EERC research complex comprises 254,000 ft^2 of laboratories, fabrication facilities, technology demonstration facilities, and offices. The EERC has established working relationships with over 1300 clients, including federal and state agencies, universities, energy exploration and production companies, utilities, research and development firms, equipment vendors, architecture and engineering firms, chemical companies, and other organizations in all 50 states and 53 countries.

Resources: As a result of a long history of exploration and production in North Dakota, extensive oil and gas datasets are available. Most notably, the datasets are publicly available for free from NDIC with data from over 30,000 wells. These datasets consist of both spatial and tabular databases. Other available data (for free and/or purchase) include seismic surveys (2D and 3D), geophysical well logs, core data, water quality data, groundwater well locations, and water salinity.

The North Dakota Geological Survey's Wilson M. Laird Core and Sample Library is located less than 1 mile from the EERC. The climate-controlled facility currently houses over 375,000 feet of core and 30,000 boxes of drill cuttings obtained from oil and gas wells, which represents about 75% of the cores

cut in the North Dakota portion of the Williston Basin and about 95% of the samples collected. Use of the facility is free of charge.

No equipment is expected to be purchased for this project.

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. The NDIC Oil and Gas Division provides online access to all geophysical logs related to deep well drilling in North Dakota. Any and all relevant publicly available data will be used for the project.

Environmental and Economic Impacts while Project Is Underway: Funding through NDIC will help offset initial development costs of CO_2 storage projects, and incentives such as 45Q will provide tax credits that make CO_2 capture, transportation, and storage economically viable. The project team believes that as more CCS projects are developed, the costs of the technologies employed will continue to fall and projects such as this will become more economically and socially attractive.

Ultimate Technological and Economic Impacts: The proposed project will support North Dakota's vision to develop and deploy large-scale commercial CO_2 storage projects that reduce environmental impacts and increase the sustainability of energy production. The proposed project will provide the information needed for the project team to confidently invest in commercial deployment of clean H_2 energy that can diversify North Dakota's economy, leverage existing energy resources, and create sustainable jobs.

Why the Project Is Needed: Although CCUS deployment has momentum in North Dakota, a variety of technical, policy, and stakeholder engagement aspects still need to be addressed. In the technical realm, there are questions about how operators can optimize CO_2 storage and account for potential pressure impacts from neighboring projects. From a policy standpoint, outstanding questions focus on how mineral rights and pore space rights can be reconciled in areas where both CO_2 storage and oil and gas production are technically feasible. Other questions about federal policies and regulations will come into play for CCUS development on federal lands. In the area of public perception, the concept of CCUS

deployment in North Dakota has recently been getting more attention in the media, highlighting knowledge gaps and misconceptions regarding the safety and effectiveness of CCUS, the role of government in its development and regulation, and the overall benefits of CCUS for all North Dakota citizens. The questions and challenges being addressed by this project will be valuable to all stakeholders as North Dakota continues to pursue carbon reduction strategies for our energy and agricultural sectors and the diversification of our economy that will follow.

STANDARDS OF SUCCESS: Ultimately, this project will be considered successful if the project activities can 1) promote public engagement and support in North Dakota, 2) promote regional technology transfer, 3) address key technical and nontechnical challenges by advancing critical knowledge and capabilities, and 4) evaluate regional infrastructure challenges and needs. Accomplishment of this project and subsequent investments enables the commercial deployment of clean H_2 energy technology in North Dakota, resulting in economic and environmental benefits consistent with REP goals.

BACKGROUND/QUALIFICATIONS: The EERC will lead the proposed project. The principal investigator (PI) and lead for Task 1.0 is Mr. Kevin Connors, Assistant Director for Regulatory Compliance and Energy Policy at the EERC. Mr. Connors will handle project management, planning, and reporting activities. He will ensure successful completion of the project on schedule and budget, coordinate and direct consultant activities, and ensure transfer of data and products to project sponsors. Ms. Charlene Crocker, EERC Senior Research Scientist and Outreach Team Lead, will lead Task 2.0 and be responsible for updating and implementing the CBP along with coordinating public engagement and support. Ms. Katherine Anagnost, EERC Senior Regulatory and Permitting Specialist, will lead Task 3.0 and be responsible for overall regional technology transfer, managing the advisory team (CHAT), and engagement. Mr. Wesley Peck, EERC Assistant Director for Subsurface Strategies, will lead Task 4.0 and be responsible for leading the technical and nontechnical challenges investigation. Mr. Kyle Glazewski, EERC Principal Analyst and Data/GIS Team Lead, will serve as Task 5.0 lead and direct the regional

infrastructure evaluation. Dr. Sheila Hanson, Associate Professor of Entrepreneurship & Management at the University of North Dakota (UND) Nistler College of Business & Public Administration, is a psychologist who will conduct social science research under Task 2.0. MPC and TCE will be providing cost share. Representatives of MPC, TCE, and REP will serve on the CHAT to guide CBP implementation and engagement activities. In addition, MPC and TCE will lead governmental, tribal, and public engagement efforts; they will also have final approval on all aspects of stakeholder engagement activities.

MANAGEMENT: The EERC will oversee all tasks, schedule regular internal and external meetings with project participants, and ensure that the project is conducted using acceptable scientific methodologies and practices in accordance with the project plan (budget, schedule, deliverables, and milestones) and is meeting quality objectives. The EERC 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.

TIMETABLE: This project is proposed to be performed over a 24-month period, with an anticipated start date of November 1, 2023. Quarterly progress reports will be submitted within 30 days after the end of each calendar quarter. Figure 1 depicts the proposed schedule.

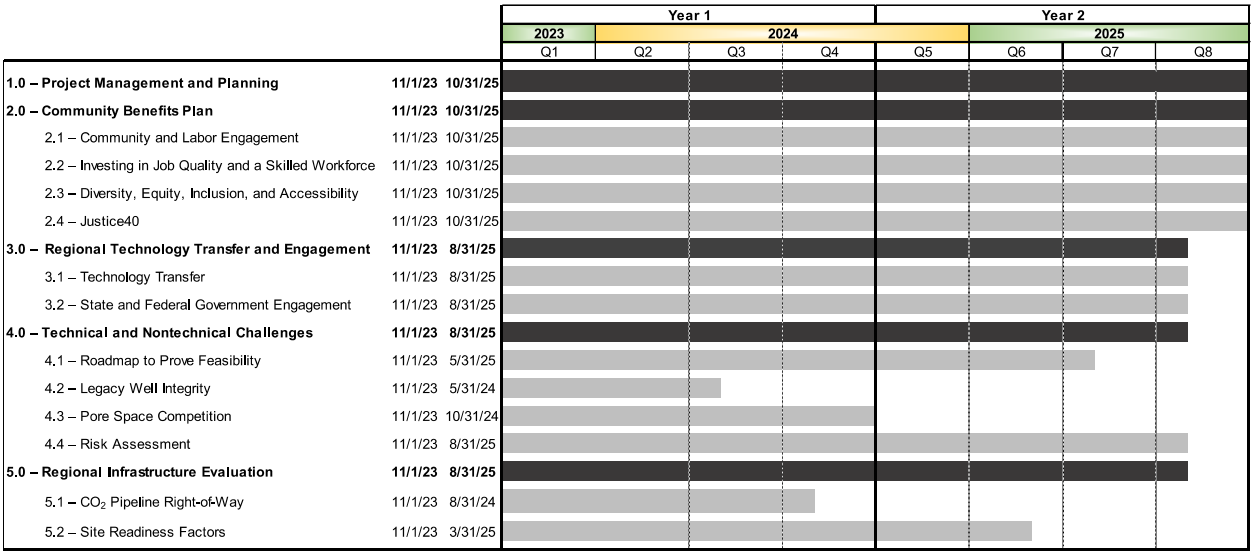

Figure 1. Proposed project schedule.

BUDGET: The total estimated cost for the proposed work is $3,225,000, as presented in Table 1. The EERC requests $100,000 from REP to be matched with $2,500,000 from DOE's FECM and up to $625,000 cash cost share from MPC and TCE. A letter of support is provided in Appendix A. Budget notes can be found in Appendix C.

Table 1. Budget Breakdown

Project Associated Expense	NDIC Share (Cash)	DOE Share (Cash)	Industry Share (Cash)	Total Project
Labor	$66,200	$1,366,309	$337,167	$1,769,676
Travel	$0	$174,346	$10,000	$184,346
Supplies	$0	$5,610	$0	$5,610
Subcontractor - TBD Graphic Design	$0	$30,000	$0	$30,000
Subcontractor - TBD Workshop Partner	$0	$8,000	$0	$8,000
Communications	$0	$6,456	$5,000	$11,456
Printing & Duplicating	$25	$2,131	$1,500	$3,656
Food	$0	$1,475	$0	$1,475
Rent & Leases - Venue	$0	$2,800	$2,600	$5,400
Honorarium	$0	$4,800	$0	$4,800
Laboratory Fees & Services				
Document Production Services	$0	$54,812	$34,358	$89,170
Engineering Services Fee	$0	$2,600	$0	$2,600
Geoscience Services Fee	$0	$2,940	$0	$2,940
Total Direct Costs	$66,225	$1,662,279	$390,625	$2,119,129
Facilities & Administration	$33,775	$837,721	$234,375	$1,105,871
Total Project Costs	**$100,000**	**$2,500,000**	**$625,000**	**$3,225,000**

TAX LIABILITY: The EERC is a business unit within UND, which is a state-controlled institution of higher education and is not a taxable entity; therefore, the EERC has no tax liability.

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 technical data generated will be held jointly by the EERC and project sponsors.

STATE PROGRAMS AND INCENTIVES: A listing of EERC projects funded by NDIC in the last 5 years can be found in Appendix D.

APPENDIX A

LETTERS OF SUPPORT

February 10, 2023

Mr. Kevin C. Connors
Assistant Director for Regulatory Compliance and Energy Policy
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Subject: Cost Share Commitment for EERC Proposal Entitled "Liberty Carbon Management Hub"; U.S. Department of Energy's Funding Opportunity Announcement No. DE-FOA-0002799

Dear Mr. Connors:

MPLX Operations LLC (together with its affiliates, "MPLX") and TC Energy Development Holdings Inc. ("TCEDH") are writing to express our cost share commitment and support for the efforts of the Energy & Environmental Research Center ("EERC") to secure funding through the U.S. Department of Energy's Regional Initiative to Accelerate Carbon Capture, Utilization, and Storage (CCUS) Deployment: Technical Assistance for Large-Scale Storage Facilities and Regional Carbon Management Hubs funding opportunity DE-FOA-0002799 ("Funding Opportunity").

The EERC's proposed project, the Liberty Carbon Management Hub, will investigate the potential for a carbon management hub near Dickinson, North Dakota. MPLX, TCEDH, and the EERC are in the process of evaluating the development of the Liberty Hydrogen Hub ("LHH") in North Dakota as a related complementary project. The separately-funded LHH will advance critical development scope to progress consummation of a large-scale project that would be a major infrastructure investment in clean hydrogen production, storage and transportation along with carbon capture and sequestration to result in low-carbon energy solutions. With MPLX, TCEDH, and EERC partnered on the LHH, the investigation of the Liberty Carbon Management Hub and the related public engagement will further the development of carbon capture and storage for the LHH.

We plan to explore strategic partnerships with various entities who currently serve the region in industrial and energy solutions through these unique hubs. The Liberty Carbon Management Hub, along with the LHH, will allow local industries to advance their sustainability goals in reducing CO_2 emissions while continuing to meet the nation's energy demands. With financial incentives such as grants and the 45Q tax credit, we strive to demonstrate that a strong business case exists to undertake a larger exciting opportunity with further development and deployment as outlined in EERC's proposal responsive to the Funding Opportunity.

MPLX is a diversified, large-cap master limited partnership that owns and operates midstream energy infrastructure and logistics assets and provides fuels distribution services. MPLX's assets include a network of crude oil and refined product pipelines; an inland marine business; light-product terminals; storage caverns; refinery tanks, docks, loading racks, and associated piping; and crude and light-product marine terminals. MPLX also owns crude oil and natural gas gathering systems and pipelines as well as natural gas and natural gas liquids (NGL) processing and fractionation facilities in key U.S. supply basins.

TCEDH is an indirect wholly-owned subsidiary of TC Energy Corporation, a premier North American energy infrastructure company with a network of wholly-owned natural gas pipelines that extends more

than 57,900 miles and moves approximately 25% of natural gas in North America and is one of the continent's largest providers of gas storage with approximately 653 billion cubic feet of storage capacity. A growing independent power producer, TC Energy Corporation has investments in over 4,200 MW of power generation in North America, including Bruce Power (one of the largest nuclear facilities in North America). TC Energy Corporation also moves approximately 20% of Alberta crude oil to U.S. markets through one of North America's largest oil delivery systems with a 3,000-mile pipeline network.

As outlined in the Funding Opportunity, and in support of the EERC's proposal, MPLX and TCEDH commit to provide combined cash cost share of at least twenty percent (20%) of the allowable costs associated with EERC's proposal related to the Liberty Carbon Management Hub, totaling $625,000.

We believe the investigation of carbon capture and storage for the complimentary hydrogen production hub meets the DOE's objective to safely and equitably accelerate the deployment of CCUS. We look forward to working with DOE, EERC, and other project partners to further the development of this exciting work.

TC Energy Development Holdings Inc.

DocuSigned by:
Corey Hessen
7A1ADE4ADA02465...
By: Corey N. Hessen
Title: President

DS TH DS JG

DocuSigned by:
Omar Khayum
2FA6FDB5A9B84F5...
By: Omar Khayum
Title: Vice President

MPLX Operations LLC

By: David R. Heppner
Title: Senior Vice President

WA
Approved as to Form

June 26, 2023

SENT VIA ELECTRONIC MAIL

Sheryl Eicholtz-Landis
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, North Dakota 58202-9018
slandis@undeerc.org

SUBJECT: Selection of Application for Negotiation Under Funding Opportunity Announcement Number DE-FOA-0002799, Regional Initiative to Accelerate Carbon Capture, Utilization, and Storage (CCUS) Deployment: Technical Assistance for Large-Scale Storage Facilities and Regional Carbon Management Hubs

Dear Sheryl Eicholtz-Landis:

We are pleased to provide this update on your application. The Office of Fossil Energy and Carbon Management within the Department of Energy (DOE) has completed its evaluation of your application submitted in response to the subject Funding Opportunity Announcement (FOA). The application below has been recommended by the Office of Fossil Energy and Carbon Management for negotiation of a financial award (*Note: This notification does not guarantee Federal Government funding, as funding will only be obligated upon completion of successful negotiations.*)

Application: Liberty Carbon Management Hub, Kevin Conners, GRANT13801150

DOE has embargoed any public announcement of your selection until further notice. You must refrain from making any public announcements – through press releases, social media, or any other public communication platform – until DOE has made the selection announcement. At the time of the announcement, we will provide you with a link to the announcement and inform you that the embargo has officially been lifted via subsequent email. You will then be free (and encouraged) to announce your selection for negotiation leading to an award publicly.

Receipt of this letter does not authorize you to commence with performance of the project. DOE makes no commitment to issue an award and assumes no financial obligation with the issuance of this letter. Applicants do not receive an award until award negotiations are complete and the Contracting Officer executes the funding agreement. Only an award document signed by the Contracting Officer obligates DOE to support a project.

The award negotiation process may take up to **180** days. You must be responsive during award negotiations (*i.e., provide requested documentation*) and meet the stated negotiation

deadlines. Failure to submit the requested information and forms by the stated due date, or any failure to conduct award negotiations in a timely and responsive manner, may cause DOE to cancel award negotiations and rescind this selection. DOE reserves the right to terminate award negotiations at any time for any reason.

Please complete the following items and submit to DOE no later than July 12th, 2023:

- Pre-Award Information Sheet (attached);
- Copy of indirect rate agreement(s) for you and any sub-recipient(s), if applicable;
- Updated environmental questionnaire(s), as applicable (available at: Environmental Questionnaire).

If your organization, including any subrecipient or contractor, anticipates involving foreign nationals (FNs) in the performance of the award, your organization is required to provide a list of all FNs planned to participate on the award along with basic information about each. You must download and complete the "Foreign National Participation Document" located at https://www.netl.doe.gov/business/business-forms/financial-assistance under Post Selection Forms/Information and submit the completed document to basicinfo@netl.doe.gov with a courtesy copy to the assigned Project Manager (PM) and Contract Specialist.

Upon receipt of the completed "Foreign National Participation Document," we will create a secured file sharing drop box folder(s) for **FNs in Principal Investigator (PI)/Co-PI roles and for FNs from countries identified on the U.S. Department of State's list of State Sponsors of Terrorism located at https://www.state.gov/state-sponsors-of-terrorism/ for submission of additional information.** The additional information will NOT be required for any of the other FNs planned to participate on the award, and therefore, a folder(s) will not be created.

As part of the requirement to submit additional information for PIs/Co-PIs and for FNs from countries identified as State Sponsors of Terrorism, your organization must ensure completion of the "Foreign National Participation **Data** Document" also located at https://www.netl.doe.gov/business/business-forms/financial-assistance. The document and all required attachments must be uploaded to the secured file sharing drop box folder(s) provided by DOE's FN Request Coordinator. The assigned PM will contact the appropriate FN Data Entry POC in the event there are issues with the submission.

Please note that all FNs identified on the "Foreign National Participation Document," **except for FNs from countries identified on the U.S. Department of State's list of State Sponsors of Terrorism, are authorized to commence work as of the award effective date unless determined otherwise by DOE.** FNs from countries identified on the U.S. Department of State's list of State Sponsors of Terrorism are **NOT** permitted to participate on the award until written authorization is received from the Contracting Officer.

The Contracting Officer will notify your organization of DOE's decision regarding participation of FNs from countries identified on the U.S. Department of State's list of

State Sponsors of Terrorism. The DOE reserves the right to request additional information or deny participation of any FN at any time.

Please provide the requested documents to the attention of Ursula Drake, who is the Contract Specialist from the Finance and Acquisition Center handling the administrative portion of your application. Ms. Ursula Drake can be reached at ursula.drake@netl.doe.gov. Johnathan Moore is the DOE Project Manager from the Project Management Division handling the technical portion of your application and can be reached at 304-285-0297 or johnathan.moore@netl.doe.gov.

Sincerely,

ANGELA HARSHMAN

Digitally signed by ANGELA HARSHMAN
Date: 2023.06.26 15:03:57 -04'00'

Angela Harshman
Contracting Officer
Finance and Acquisition Center

cc: FOA File
Basicinfo@netl.doe.gov
kconnors@undeerc.org
johnathan.moore@netl.doe.gov
ursula.drake@netl.doe.gov

February 10, 2023

Mr. Kevin C. Connors
Assistant Director for Regulatory Compliance and Energy Policy
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Corey N. Hessen
President
TC Energy Development Holdings Inc.
700 Louisiana Street
Suite 1300
Houston, TX 77002

RE: Letter Agreement – Conditions for EERC's Proposal

All:

MPLX Operations LLC ("MPLX") is pleased to offer this letter agreement to the Energy & Environmental Research Center ("EERC") and TC Energy Development Holdings Inc. ("TCEDH") in furtherance of the EERC's grant application titled *"Liberty Carbon Management Hub"* (the "Proposal") in response to the U.S. Department of Energy ("DOE") Regional Initiative to Accelerate Carbon Capture, Utilization, and Storage (CCUS) Deployment: Technical Assistance for Large-Scale Storage Facilities and Regional Carbon Management Hubs funding opportunity DE-FOA-0002799.

The Proposal aligns with the interests of MPLX and TCEDH, including the EERC's stated intent to advance critical development toward a large-scale project in North Dakota involving clean hydrogen production, storage and transportation coupled with carbon capture and sequestration ("Scope of Work"). MPLX and TCEDH are providing a cost share commitment letter associated with the Proposal, and this letter includes a commitment of twenty percent of allowable costs associated with the Proposal up to $625,000. Such commitment is conditioned on the following items:

(i) The EERC's final Proposal project plan being acceptable to MPLX and TCEDH;
(ii) DOE's award of the Proposal; *and*
(iii) The EERC's grant to MPLX and TCEDH and its affiliates of all licenses, authorizations, and similar rights, including rights to any intellectual property, related to the Scope of Work under the Proposal as those granted to the DOE under any cooperative agreement contemplated by the FOA or any third party.

MPLX looks forward to joining TCEDH and the EERC in this effort.

Sincerely,

David R. Heppner
Senior Vice President

WA
Approved as to Form

[acknowledgement page follows]

Acknowledged and agreed to as of the date first written above:

TC Energy Development Holdings Inc.

DocuSigned by:
Corey Hessen
7A1ADE4AD902455...

By: Corey N. Hessen
Title: President

DocuSigned by:
Omar Khayum
2FA6FDB5A9B64F5...

DS TH DS JG

By: Omar Khayum
Title: Vice President

Energy & Environmental Research Center

By: Kevin C. Connors
Title: Assistant Director for Regulatory Compliance and Energy Policy

INDUSTRIAL COMMISSION OF NORTH DAKOTA

February 6, 2023

Mr. Kevin C. Connors
Assistant Director for Regulatory Compliance and Energy Policy
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Subject: Support for EERC Proposal Entitled "Liberty Dakota Carbon Management Hub"

Dear Mr. Connors:

Please accept this support letter for the Energy & Environmental Research Center's (EERC's) proposed project to investigate the geologic storage of CO_2 in western North Dakota in response to U.S. Department of Energy's Regional Initiative to Accelerate Carbon Capture, Utilization, and Storage (CCUS) Deployment: Technical Assistance for Large-Scale Storage Facilities and Regional Carbon Management Hubs Funding Opportunity Announcement DE-FOA-0002799.

The mission of the North Dakota Industrial Commission's Renewable Energy Program (REP) is to promote the growth of North Dakota's renewable energy industries through research, development, marketing, and education. The development and deployment of CCUS in pursuit of achieving zero or negative CO2 emissions for a renewable diesel facility aligns well with the REP's mission and goals.

This project would be eligible for a cash cost share of up to $100,000 from the REP. Availability of this cost share is contingent upon submission of a proposal to the Renewable Energy Council, approval by the Council and the Industrial Commission, and the execution of a mutually negotiated agreement of acceptable terms and conditions with all project sponsors. REP funds will comprise of nonfederal dollars and would not be used as federal match on any other project.

We hope that DOE gives careful consideration to this project, as there is significant need for projects that promote the continued development and support of renewable fuels. Again, we express our interest and support of the proposed project and look forward to working with the EERC, DOE, and the entire team.

Sincerely,

Reice Haase

Deputy Director, North Dakota Industrial Commission

JOHN HOEVEN
NORTH DAKOTA
338 RUSSELL SENATE OFFICE BUILDING
TELEPHONE: (202) 224-2551
FAX: (202) 224-7999
hoeven.senate.gov

United States Senate
WASHINGTON, DC 20510

COMMITTEES:
AGRICULTURE
APPROPRIATIONS
ENERGY AND NATURAL RESOURCES
INDIAN AFFAIRS

February 6, 2023

Mr. Kevin C. Connors
Assistant Director for Regulatory Compliance and Energy Policy
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Subject: Support for EERC Proposal Entitled "Liberty Carbon Management Hub"

Dear Mr. Connors:

I am writing to express my support for the application submitted by the Energy & Environmental Research Center (EERC) to the U.S. Department of Energy's Regional Initiative to Accelerate Carbon Capture, Utilization, and Storage (CCUS) Deployment: Technical Assistance for Large-Scale Storage Facilities and Regional Carbon Management Hubs funding opportunity (DE-FOA-0002799).

After nearly 15 years, we have successfully placed North Dakota at the forefront of energy development. Our state not only serves as an energy powerhouse for our nation, but we are also leading the way in innovative new technologies, like carbon capture, utilization, and storage (CCUS), which will empower the United States to continue utilizing all of our abundant energy resources with better environmental stewardship. In particular, we:

- Developed and passed through the North Dakota legislature, a regulatory framework for long-term carbon sequestration in the state.
- Established trust funds for state oversight and for long-term liability.
- Secured approval from the Environmental Protection Agency to give North Dakota regulatory primacy over Class VI wells.

These are among the critical elements that set our state apart in making geologic sequestration a reality, and the EERC has been a central player throughout these efforts. Now, under this proposal, the EERC will accelerate the commercial deployment of CCUS in North Dakota as well as continue to inform and educate through public outreach and support.

Accordingly, I hope this application receives favorable consideration. Please keep me informed of the review process, and feel free to contact my office with any updates or inquiries you may have.

Sincerely,

John Hoeven
U.S. Senator

KEVIN CRAMER
NORTH DAKOTA

SUITE 330
HART BUILDING
WASHINGTON, DC 20510
202-224-2043

United States Senate

COMMITTEES
ARMED SERVICES
BANKING, HOUSING, AND URBAN AFFAIRS
THE BUDGET
ENVIRONMENT AND PUBLIC WORKS
VETERANS' AFFAIRS

February 6, 2023

Mr. John A. Harju
Vice President for Strategic Partnerships
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear John:

Subject: Support for EERC Proposal Entitled "Liberty Carbon Management Hub"

I am writing to express my support for the Energy & Environmental Research Center's (EERC's) efforts to secure funding through the U.S. Department of Energy's Regional Initiative to Accelerate Carbon Capture, Utilization, and Storage (CCUS) Deployment: Technical Assistance for Large-Scale Storage Facilities and Regional Carbon Management Hubs funding opportunity DE-FOA-0002799.

As you know, I have been relentless in my support for our state's all-the-above energy industry and for the world-class energy research across multiple disciplines undertaken by the EERC. I have introduced and worked on multiple pieces of legislation to encourage research, development, and implementation of CCUS technologies.

North Dakota is among the nation's premier states in energy production and environmental conservation. I am a proponent of development and production of all of the state's energy resources—conventional and renewable—and believe North Dakota's energy research and policies should serve as a model for the rest of the country. The EERC's proposed efforts will accelerate the commercial deployment of CCUS in North Dakota, which will lead to an expansion of the opportunities for our nation's energy industries, and further inform and educate with public outreach and support.

I am a strong advocate for the work being done at the EERC and remain supportive and committed to the opportunities being pursued, including this geologic carbon storage project, and the promise they provide for the state of North Dakota and the nation.

Sincerely,

Kevin Cramer
United States Senator

KELLY ARMSTRONG
AT-LARGE, NORTH DAKOTA

ENERGY AND COMMERCE COMMITTEE

CONSUMER PROTECTION AND COMMERCE
ENERGY

Congress of the United States
House of Representatives
Washington, DC 20515

WASHINGTON OFFICE:
1740 LONGWORTH HOUSE OFFICE BUILDING
WASHINGTON, DC 20515
(202) 225-2611

DISTRICT OFFICES:
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FARGO, ND 58103
PHONE: (701) 353-6665

U.S. FEDERAL BUILDING
220 E ROSSER AVE., ROOM 228
BISMARCK, ND 58501
(701) 354-6700

ARMSTRONG.HOUSE.GOV

February 7, 2023

Mr. John A. Harju
Vice President for Strategic Partnerships
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear Mr. Harju:

Subject: Support for EERC Proposal Entitled "Liberty Carbon Management Hub"

I write to express my support for the Energy & Environmental Research Center's (EERC's) efforts to secure funding through the U.S. Department of Energy's Regional Initiative to Accelerate Carbon Capture, Utilization, and Storage (CCUS) Deployment: Technical Assistance for Large-Scale Storage Facilities and Regional Carbon Management Hubs funding opportunity DE-FOA-0002799.

In my role as North Dakota's lone member of the U.S. House of Representatives, I have the privilege to showcase our state's vibrant energy resources and those enterprises who lead their environmentally responsible production and development. I am particularly proud of my frequent opportunities to highlight the ongoing leadership of the EERC in formulating an economically viable low-carbon future for our nation and world.

This project will examine the potential for a carbon storage hub in western North Dakota along with the important work of public outreach and support. I am confident that this will further propel North Dakota's leadership in the pursuit of long-term energy solutions.

I strongly support the EERC's efforts, which will lead to exciting opportunities for the state of North Dakota and the nation in resolving near- and long-term energy challenges.

Sincerely,

Kelly Armstrong
Congressman

NORTH Dakota | Governor Doug Burgum

Be Legendary.™

February 3, 2023

Mr. John A. Harju
Vice President for Strategic Partnerships
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear John:

Subject: Support for EERC Proposal Titled "Liberty Carbon Management Hub"

We strongly support the Energy & Environmental Research Center's (EERC's) efforts to secure funding through the U.S. Department of Energy's Regional Initiative to Accelerate Carbon Capture, Utilization, and Storage (CCUS) Deployment: Technical Assistance for Large-Scale Storage Facilities and Regional Carbon Management Hubs funding opportunity DE-FOA-0002799.

North Dakota has a long history of responsible energy development and environmental leadership. We commend the EERC for its long-term commitment to making geologic storage and utilization of carbon dioxide a viable option in our quest for low-carbon solutions.

North Dakota's energy industries are global leaders in energy development and production. They continue to implement long-term strategies that provide meaningful and abundant contributions to our nation's energy needs. The project proposed by the EERC will accelerate the safe and socially equitable deployment of CCUS within our state by establishing an experienced technical team and providing technical and community outreach and information sharing.

We strongly support the efforts of the EERC and look forward to the exciting opportunities this work will bring to the state of North Dakota and our country in resolving our energy challenges.

Regards,

Doug Burgum
Governor

NORTH DAKOTA
PETROLEUM
COUNCIL

100 West Broadway, Ste. 200 | P.O. Box 1395 | Bismarck, ND 58501-1395
701.223.6380 | ndpc@ndoil.org | www.NDOil.org

February 1, 2023

Mr. Kevin C. Connors
Assistant Director for Regulatory Compliance and Energy Policy
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear Mr. Connors:

Subject: Support for EERC Proposal Entitled "Liberty Carbon Management Hub"

The North Dakota Petroleum Council (NDPC) is pleased to submit this letter of support for the team being assembled by the Energy & Environmental Research Center (EERC) to accelerate the commercial deployment of CCUS in western North Dakota in response U.S. Department of Energy's Funding Opportunity Announcement No. DE-FOA-0002799.

NDPC's mission is to promote and enhance the discovery, development, production, transportation, refining, conservation, and marketing of oil and gas in North Dakota, South Dakota, and the Rocky Mountain region; to promote opportunities for open discussion, lawful interchange of information, and education concerning the petroleum industry; to monitor and influence legislative and regulatory activities on the state and national level; and to accumulate and disseminate information concerning the petroleum industry to foster the best interests of the public and industry.

NDPC provides support to the more than 500 members it represents who are involved in all aspects of the oil and gas industry including oil and gas production, refining, pipeline, mineral leasing, consulting, legal work, and oilfield service activities in North Dakota, South Dakota, and the Rocky Mountain region. I would be pleased to provide outreach advisement for this proposed project.

We strongly encourage consideration of the EERC proposal and look forward to the results of this important project.

Sincerely,

Ron Ness
President

WESTERN DAKOTA ENERGY ASSOCIATION

February 1, 2023

Mr. Kevin C. Connors
Assistant Director for Regulatory Compliance and Energy Policy
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear Mr. Connors:

Subject: Support for EERC Proposal Entitled "Liberty Carbon Management Hub"

The Western Dakota Energy Association is a membership organization comprised of the cities, counties, and school districts in the energy-producing region of western North Dakota. WDEA is pleased to provide the EERC with this letter of support for the proposed studies to investigate a commercial-scale geologic carbon storage hub in western North Dakota in response to the U.S. Department of Energy's Funding Opportunity DE-FOA-0002799.

WDEA's advocacy goals include ensuring a solid economic future for our communities, strong infrastructure which promotes safety for our citizens, and sensible management of our natural resources to ensure their viability for generations to come.

North Dakota is at the forefront of energy development and production, investigating long-term strategies that incorporate all the state's energy resources – traditional and emerging – to meet the nation's growing energy demand in an environmentally responsible manner. The project proposed by the EERC will investigate the potential for a carbon management hub in North Dakota, leading to expanded opportunities for the state's energy industries, its communities, and its citizens.

We look forward to working with the EERC team on this important project.

Sincerely,

Geoff Simon
Executive Director

Western Dakota Energy Association
1661 Capitol Way, Bismarck ND 58501
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APPENDIX B

RESUMES OF KEY PERSONNEL

KEVIN C. CONNORS
Assistant Director for Regulatory Compliance and Energy Policy
701.777.5236 (phone), 701.777.5181 (fax), kconnors@undeerc.org

Education and Training
B.S., Geology, University of Montana, 2009.

Research and Professional Experience
November 2021–Present: Assistant Director for Regulatory Compliance and Energy Policy, Energy & Environmental Research Center (EERC), University of North Dakota (UND), Grand Forks, ND. Works with a multidisciplinary team of scientists, engineers, and business professionals to integrate legal and regulatory policy, permitting, economics, and tax perspectives with applied research related to incremental oil recovery, unconventional oil recovery, and CO_2 capture and geologic storage. He also manages the Plains CO_2 Reduction (PCOR) Partnership focused on commercial deployment of carbon capture, utilization, and storage (CCUS).

July 2019–October 2021: Principal Policy & Regulatory Strategist, EERC, UND. Worked with a multidisciplinary team of scientists, engineers, and business professionals to integrate legal and regulatory policy, economics, and tax perspectives with applied research related to incremental oil recovery, unconventional oil recovery, and CO_2 capture and geologic storage.

November 2018–June 2019: Principal Consultant Drilling and Well Operations, Equinor Energy, Austin, TX. Worked as a regulatory advisor for Equinor's Williston Basin Bakken asset securing federal and state permits to drill, advising Equinor stakeholders on regulatory issues, and maintaining compliance in a multi-jurisdictional regulatory environment. Worked on special projects with Equinor's research and technology teams as the lead regulatory advisor in developing solutions to gas flaring and CO_2 emissions in the Bakken.

October 2010–October 2018: North Dakota Industrial Commission Oil and Gas Division, Bismarck, ND.
October 2015–October 2018: Pipeline Program Supervisor. This position was created by the North Dakota Legislature to develop North Dakota's first Underground Gathering Pipeline Program to improve pipeline integrity. The development of the pipeline program included administrative rule making, hiring and managing office and field staff, developing a data management system (database), and meeting with industry leaders and academic researchers. Mr. Connors created guidance documents for program staff, regulatory inspectors, and the regulated community; testified before the North Dakota Legislature; and presented at public events throughout western North Dakota.
July 2011–October 2018: CCS Supervisor. This position was created by the North Dakota Legislature to provide a timely response to the U.S. Environmental Protection Agency (EPA) rules relating to the geologic sequestration of CO_2 (Class VI). Mr. Connors successfully led North Dakota's efforts to obtain Class VI primacy for the state of North Dakota. He gained expertise in the EPA Underground Injection Control (UIC) Program and North Dakota's geologic storage of CO_2 statutes and authored and adopted North Dakota's CO_2 storage rules through the administrative rule-making process. In this position, he participated in the North Dakota Carbon Dioxide Storage Workgroup, testified before the North Dakota Administrative Rules Committee, authored publications, and presented at technical conferences on carbon capture and storage regulatory frameworks. He also has expertise in North Dakota's pore space amalgamation process for CO_2 storage and gas storage. In 2018, he developed guidelines for gas storage in North Dakota. The guidance document was intended to provide a pathway forward for permitting and storing Bakken produced gas to mitigate flaring.
October 2013–October 2015: UIC Supervisor. Administered the North Dakota Class II UIC Program. As UIC Supervisor, he issued over 100 UIC permits, revised and updated program technical guidelines, evaluated regulatory filings, performed technical evaluations of UIC permit applications, and processed well completion reports, workover reports, and various other regulatory filings. He prepared and

submitted quarterly reports to EPA as part of the UIC program primacy agreement between North Dakota and EPA. Mr. Connors created a regulatory comparison table using North Dakota Statutes and regulations in comparison to the Bureau of Land Management (BLM) proposed rules on hydraulic fracturing. The regulatory comparison was key evidence in the state of North Dakota's lawsuit against the BLM.

October 2010–July 2011: Petroleum Engineer. Conducted enforcement and compliance inspections in the field during a time of increasing oil and gas activity.

January–September 2010: Wellsite Geologist, Weatherford. Provided geological services for the drilling and completion of horizontal wells in the Bakken and Three Forks Formations.

Relevant Publications

Warmack, M.P., Azzolina, N.A., Nakles, D.V., Peck, W.D., Connors, K.C., Lagorin, W., Lagorin, T., Blumenthal, T., Hanslik, J., and Shendye, R., 2022, Pipeline cost and CO_2 transport considerations based on three hypothetical pipelines in the PCOR Partnership Initiative region: White paper for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FE0031838 and North Dakota Industrial Commission Contract Nos. FY20-XCI-226 and G-050-96, Grand Forks, North Dakota, Energy & Environmental Research Center, February.

Burton-Kelly, M.E., Azzolina, N.A., Connors, K.C., Peck, W.D., Nakles, D.V., and Jiang, T., 2022, Risk-based area of review estimation in overpressured reservoirs to support injection well storage facility permit requirements for CO_2 storage projects: Paper presented at the 16th International Conference on Greenhouse Gas Control Technologies (GHGT-16), Lyon, France, October 23–27, 2022. DOI: /10.2139/ssrn.4274259.

Connors, K.C., Peck, W.D., Sorensen, J.A., Hamling, J.A., and Gorecki, C.D., 2022, PCOR Partnership—breaking down the barriers in CCUS: Paper presented at the 16th International Conference on Greenhouse Gas Control Technologies (GHGT-16), Lyon, France, October 23–27, 2022.

Kay, J.P., Laumb, J.D., Peck, W.D., and Connors, K.C., 2021, Matching capture technologies with point sources in the PCOR partnership region: White paper for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FE0031838, Grand Forks, North Dakota, Energy & Environmental Research Center, December.

Leroux, K.M., Ayash, S.C., Crossland, J.L., Livers-Douglas, A.J., Crocker, C.R., Connors, K.C., Hamling, J.A., and Willett, D., 2021, First North Dakota CCS project—advancing North Dakota ethanol economics: Paper presented at 15th Greenhouse Gas Control Technologies Conference (GHGT-15), virtual, March 15–18, 2021. DOI: 10.2139/ssrn.3812021.

Peck, W.P., Battle, E.P., Suedel, K.B., Glazewski, K.A., Connors, K.C., Sorensen, J.A., Hamling, J.A., Steadman, E.N., and Harju, J.A., 2021, PCOR Partnership atlas, 6th ed.: Prepared for the U.S. Department of Energy National Energy Technology Laboratory and the PCOR Partnership Initiative, Grand Forks, North Dakota, Energy & Environmental Research Center, 109 p.

Synergistic Activities

- Member, CCUS Legal and Regulatory Subgroup, 2021–present
- Member, Ground Water Protection Council Class VI Workgroup, 2021–present
- Member, Nebraska Oil and Gas Conservation Commission Rules Committee, 2021
- For the CarbonSAFE-North Dakota Phase II project, developed storage facility-permitting timeline for North Dakota's Class VI UIC program and incorporated the timeline into a general CO_2 storage project schedule.
- At the EERC, integrating legal and regulatory policy, economics, and tax perspectives with applied research related to incremental oil recovery, unconventional oil recovery, and CO_2 capture and geologic storage and developing Class VI UIC permitting strategies for commercial CO_2 storage in North Dakota.

CHARLENE R. CROCKER
Senior Research Scientist, Outreach Team Lead
701.777.5018 (phone), 701.777.5181 (fax), ccrocker@undeerc.org

Education and Training

B.S., Chemistry, University of North Dakota, 1994.
B.A., French, Colby College, Waterville, ME, 1986.

Research and Professional Experience

2002–Present: Senior Research Scientist, Outreach Team Lead, EERC, UND. Ms. Crocker's responsibilities include managerial and principal investigator duties for projects related to public outreach and scientific research. With respect to outreach, this included the development of public outreach programs for CO_2 sequestration, water, and fish advisories and the development of CO_2 sequestration public outreach materials, water quality education, and a water-based geoscience education program and outreach activities for middle and high school students. Research responsibilities included projects related to development of sorbents for emission control strategies in fossil fuel-fired energy systems; projects related to environmental management and air quality; collaborating with other scientists on the development of carbon-based flue gas sorbents, particulate matter (PM) sampling, evaluation of bioassessment tools, fish consumption survey development, proposal and report writing, data analysis, presentation of results, and budget tracking; developing PM-sampling protocols; and directing the activities of student assistants. Specific roles and activities include the following:

- Outreach Task Lead for the U.S. Department of Energy (DOE)–North Dakota Industrial Commission (NDIC)–Red Trail Energy (RTE)-funded Phase III Integrated Carbon Capture and Storage for North Dakota Ethanol Production project. Activities include public outreach materials development and support for research and fieldwork associated with project activities in Stark County, North Dakota.
- Outreach Task Lead and team member for the North Dakota CarbonSAFE Phase II project, funded by DOE, NDIC, Minnkota Power Cooperative, Basin Electric Power Cooperative, BNI Energy, North American Coal, and ALLETE Clean Energy. Activities include public outreach materials development and support for research and fieldwork associated with project activities in central North Dakota.
- Outreach Team member for the Wyoming CarbonSAFE Phase II project, funded by DOE, Basin Electric Power Cooperative, et al. Activities include public outreach materials development and consulting for research and fieldwork associated with project activities in central North Dakota.
- Program Coordinator and student supervisor for the EERC Energy Hawks internship program, funded by the State Energy Research Center at the EERC. Activities include development and implementation of an energy literacy syllabus for a multidisciplinary team of graduate and undergraduate students during a 10-week internship; supervision of student activities; and guidance in the development of white papers focused on value-added energy topics for North Dakota.

1994–2002: Research Chemist, EERC, UND. Ms. Crocker's responsibilities included managing projects relating to environmental management and air quality; collaborating with other scientists on fish consumption survey development, PM sampling, corrosion of ceramic and alloy materials, coal ash, water purification, and surface decontamination research; proposal and report writing, data analysis, presentation of results, and budget tracking; developing PM sampling protocols; participating in development of a water-based geoscience education program and outreach activities for school children; directing activities of student assistants; developing and implementing analytical methods employing LIBS. Previous duties performed in the Analytical Research Laboratory focused on water quality and energy-related analyses. Responsibilities included preparing and analyzing ultratrace element samples in aqueous and inorganic media using AAS, ICP, and IC; recording and disseminating

analytical results and quality control checks; performing research on ultratrace elemental analysis of mercury using AFS; and preparing reagents and solutions.

1993–1994: Research Assistant, EERC, UND. Ms. Crocker's responsibilities included preparing and analyzing ultratrace element samples in inorganic media; performing research on ultratrace element analysis of mercury in air using AFS; and preparing reagents and solutions.

1990: Naturalist, Deep Portage Conservation Reserve, Hackensack, Minnesota. Ms. Crocker's responsibilities included planning and conducting environmental education programs for children and adults; evaluating curriculum; and organizing lending of educational learning stations.

1988–1990: Sanctuary Manager, Wetlands, Pines & Prairie Audubon Sanctuary, Warren, Minnesota. Ms. Crocker's responsibilities included planning and conducting environmental education programs; organizing chapter meetings; publishing the Sanctuary newsletter; and performing administrative tasks.

1988: Park Ranger/Interpreter, Boston Harbor Islands State Park, Boston, Massachusetts. Ms. Crocker's responsibilities included interpreting natural and human history; developing special programs and leading walking tours of the islands; and conducting school programs.

Relevant Publications

Crocker, C.R.; Krueger, N.M. Energy and CO_2 Management: Carbon Capture and Storage. Presented at 2023 Lignite Education Seminar, Bismarck, ND, June 13, 2023.

Crocker, C.R.; Leroux, K.M.; Massmann, N.M.; Crossland, J.L.; Manthei, M.M.; Glazewski, K.A.; Daly, D.J.; Hamling, J.A. Public Outreach Package for Carbon Capture and Storage in North Dakota; Task 5 Deliverable D3 for North Dakota Industrial Commission Contract No. R-038-047; EERC, Feb 2020.

Daly, D.J.; Crossland, J.L.; Crocker, C.R. Glazewski, K.A.; Massmann, N.M.; Peck, W.D. North Dakota CarbonSAFE Updated Outreach Plan Phase II, May 2019.

Crocker, C.R.; Daly, D.J. Low-Carbon Energy for North Dakota [documentary short]; Dambach, B.; Olien, M., Site Producers; Prairie Public Broadcasting (PPB): Fargo, ND, and EERC, 2019.

Crocker, C.R.; Daly, D.J. Coal: Engine of Change [DVD]; Dambach, B.; Steadman, E.N., Executive Producers; PPB and EERC, 2018.

Daly, D.J.; Crocker, C.R.; Crossland, J.L.; Massmann, N.M.; Peck, W.D. North Dakota Integrated Carbon Storage Complex Feasibility Study; Deliverable D3 (Outreach Toolkit) for DOE Cooperative Agreement (CA) DE-FE0029488; EERC: Grand Forks, ND, Feb 2018.

Daly, D.J.; Crossland, J.L.; Crocker, C.R.; Gorecki, C.D. Outreach Action Plan; Plains CO_2 Reduction (PCOR) Partnership Phase III Task 2 Deliverable D11 (Update 2) for DOE National Energy Technology Laboratory CA DE-FC26-05NT42592; EERC Publication 2016-EERC-09-02; March.

Daly, D.J.; Crocker, C.R.; Gorecki, C.D. Regionwide Outreach in a Project-Level World – Lessons from the PCOR Partnership. *Energy Procedia* **2017**, *114*, 7224–7236.

Crocker, C.R.; Daly, D.J.; Dambach, B.; Pearson, B.; Anderson, D. A Collaboration among PPB, Classroom Teachers, and the PCOR Partnership to Produce Classroom-Ready CCS lessons. Presented at the International Workshop on Public Education, Training, and Community Outreach for Carbon Capture, Utilization, and Storage, Decatur, IL, July 30, 2014.

Synergistic Activities

Outreach Team Lead (Oct 2018–present)/member of ND CarbonSAFE team (Phases II and III) since inception in June 2017, developing and implementing project outreach plan, facilitating Outreach Advisory Board, developing outreach materials, engaging educators and K–12 to post-secondary students on CCS, and providing input and guidance to project timelines, budgets, and objectives.

Outreach Team Lead (Jan 2019–Nov 2021)/member of RTE Ethanol CCS project since 2017, developing and implementing project outreach plan; developing outreach materials; handling media, talking points, and logistics for county commission appearances; preparing landowner packets and public notices for seismic surveys, environmental sampling events, and research results; overseeing logistics, preparing advertising, and developing materials for community open houses; and providing input and guidance to project timelines, budgets, and objectives.

Outreach Team member for Regional Carbon Sequestration Partnerships (RCSP) Initiative's PCOR Partnership Program since inception in 2003.

Associate Producer and Cowriter for seven CCS-related public television documentaries—*Coal: Engine of Change, The Bell Creek Story: CO_2 in Action, Global Energy and Carbon: Tracking Our Footprint, Managing Carbon Dioxide: The Geologic Solution, Out of the Air – Into the Soil: Land Practices That Reduce Atmospheric Carbon Levels, Reducing Our Carbon Footprint: The Role of Markets, Nature in the Balance: CO_2 Sequestration.*

Codeveloped 20 CBPs, six outreach plans, 23 outreach posters, numerous fact sheets, general public and educator and student presentations, and a website focused on aspects of CCS and CCS projects.

KATHERINE K. ANAGNOST
Senior Regulatory and Permitting Specialist
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Education and Training

B.S., Legal Assistance, Moorhead State University, 1992.

Research and Professional Experience

2021–Present: Senior Regulatory and Permitting Specialist, Energy & Environmental Research Center (EERC), University of North Dakota (UND), Grand Forks, ND. Ms. Anagnost works with a multidisciplinary team of scientists, engineers, and business professionals to integrate permitting, regulatory, legal, policy, economics, and tax perspectives with technical information and applied research related to geologic CO_2 capture utilization and storage (CCUS), power generation, emissions reduction, and renewable energy systems. Ms. Anagnost currently supports the Plains CO_2 Reduction (PCOR) Partnership Initiative to Accelerate CCUS Deployment as the technology transfer task lead. In this role she informs and educates stakeholders about CCUS technologies and project development, with particular emphasis placed on issues related to infrastructure development strategies and regulatory frameworks. Ms. Anagnost supports public and industry outreach efforts through development of products and website content to inform and educate about the opportunities associated with CCUS.

2015–2021: NERC Compliance Coordinator, Minnkota Power Cooperative (MPC), Grand Forks, ND. Ms. Anagnost coordinated with technical and support teams to establish, maintain, and demonstrate compliance with corporate requirements and North American Electric Reliability Corporation (NERC) regulations. She spearheaded the effort to bring comprehensive Critical Infrastructure Program regulatory compliance to the Milton R. Young Generating Station within the scheduled implementation timeframe; coordinated a multidisciplinary team in the development of a new Critical Infrastructure Program regulatory supply chain risk management program within the required implementation time frame; achieved expedited industry consensus to regulatory modifications as participating member (and first MPC employee) on a NERC Standard Drafting Team, and served (as the first MPC employee) on a North American Transmission Forum peer review team.

2009–2015: Research Specialist/Project Manager, EERC, UND. Ms. Anagnost worked for the PCOR Partnership, one of seven regional partnerships funded by the U.S. Department of Energy's National Energy Technology Laboratory Regional Carbon Sequestration Partnership Program, to assess the technical and economic feasibility of capturing and storing (sequestering) CO_2 emissions in the northern Great Plains and adjacent areas. In this capacity, she facilitated the development of project plans for research data, presentations, technical reports, peer-reviewed articles, and proposals for projects involving CO_2 sequestration technologies. Her work also included development, management, and dissemination of market-oriented materials for programs focused on CO_2 sequestration, including public outreach and education via print, video, and web forums.

2006–2009: Contracts Officer, EERC, UND. Ms. Anagnost's responsibilities included preparing, reviewing, negotiating, and administering sponsored research agreements, in-kind agreements, subcontracts, hotel agreements, and confidentiality agreements in accordance with federal and nonfederal contractual requirements, government and university regulations and policies, and EERC policies; disclosing intellectual property (IP) to research sponsors, including government agencies; tracking important contractual and U.S. Patent and Trademark Office compliance dates associated with IP; and effectively communicating and maintaining daily contact with research sponsors, agency representatives, UND employees, and EERC employees via telephone, email, and/or letter.

1994–2006: Legal Assistant, MPC. Ms. Anagnost's responsibilities included assisting legal counsel in the representation of Minnkota and six distribution cooperative member-owners, including drafting corporate governance documents, assisting with environmental matters including compliance with polychlorinated biphenyl use, storage, disposal, and recordkeeping, preparing and submitting federal

environmental reports for proposed cooperative construction activities; coordinating with engineering consultant and technical department supervisors on the preparation and organization of Spill Prevention Control and Countermeasures (SPCC) Plans; reviewing federal regulations and determining potential impacts and/or ensuring compliance; writing articles for corporate publications; and leading the Minnesota member-owner utilities compliance with the Conservation Improvement Program, created to provide improved awareness and adoption of energy efficient technologies and reduced energy costs for Minnesota households. In this role, she worked with regional Community Action Agencies on development of energy conservation measures benefitting low-income households.

Relevant Publications

Connors, K.C.; Nakles, D.V.; Anagnost, K.K.; McKenzie, S.L.; Stevens, C.R.; Hunt, J.E.; Regorrah, J.G.; Peck. E.N.; Olsen, C.M.; Livers-Douglas, A.J. *Regulatory Frameworks and Permitting Considerations for Geologic Storage of Carbon Dioxide in the PCOR Partnership Region*: Plains CO_2 Reduction (PCOR) Partnership Initiative Task 5 Deliverable 8a for North Dakota Industrial Commission Contract Nos. FY20-XCI-226 and G-050-96; EERC Publication 2023-EERC-01-04; Energy & Environmental Research Center: Grand Forks, ND, Jan 2023.

Anagnost, K.K., Peck, W.D., Regorrah, J.G., Livers-Douglas, A.J., Connors, K.C., and Mikula, S.R., 2022, North Dakota CarbonSAFE Phase III—permitting geologic storage of carbon dioxide: North Dakota CarbonSAFE Phase III Topical Report Task 5 Deliverable 6 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FE0031889, Grand Forks, North Dakota, Energy & Environmental Research Center, September.

Gorecki, C.D.; Harju, J.A.; Steadman, E.N.; Romuld, L.; Hamling, J.A.; Sorensen, J.A.; Botnen, L.S.; Daly, D.J.; Jensen, M.D.; Peck, W.D.; Smith, S.A.; Klapperich, R.J.; Anagnost, K.K.; Votava, T.J. *Annual Assessment Report*; Plains CO_2 Reduction (PCOR) Partnership Phase III Task 12 Deliverable D57 (Oct 1, 2013 – Sept 30, 2014) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592; EERC Publication 2015-EERC-02-04; Energy & Environmental Research Center: Grand Forks, ND, Feb 2015.

Gorecki, C.D.; Steadman, E.N.; Harju, J.A.; Hamling, J.A.; Sorensen, J.A.; Peck, W.D.; Daly, D.J.; Jensen, M.D.; Klapperich, R.J.; Ayash, S.C.; Anagnost, K.K. Implementing Carbon Capture and Storage: An Overview of the Plains CO_2 Reduction Partnership. Presented at the 10th CO_2GeoNet Open Forum, San Servolo Island, Venice, Italy, May 11–12, 2015.

Gorecki, C.D.; Hamling, J.A.; Sorensen, J.A.; Peck, W.D.; Daly, D.J.; Jensen, M.D.; Klapperich, R.J.; Ayash, S.C.; Anagnost, K.K.; Steadman, E.N.; Harju, J.A. Implementing Carbon Capture and Storage: An Overview of the Plains CO_2 Reduction Partnership. Presented at the 14th Annual Carbon Capture, Utilization & Storage Conference, Pittsburgh, PA, April 28 – May 1, 2015.

Crocker, C.R.; Crossland, J.L.; Chimote, S.A.; Daly, D.J.; Anagnost, K.K.; Gorecki, C.D.; Steadman, E.N.; Harju, J.A. *Public Site Updates*; Plains CO_2 Reduction (PCOR) Partnership Phase III Task 2 Deliverable D13 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592; EERC Publication 2014-EERC-09-06; Energy & Environmental Research Center: Grand Forks, ND, July 2014.

Synergistic Activities

- Ms. Anagnost currently serves as the President and Vice President of Education (2022–2023) of the Powerhouse Toastmasters Club No. 9663. This club was organized in 1993, and boasts multiple Distinguished Club Program awards for meeting membership prerequisites and goal achievement. She previously held the offices of Treasurer (2021–2022) and Vice President of Education (2019–2021).
- Ms. Anagnost was awarded the club Toastmaster of the Year in 2020 in recognition of dedicated and distinguished service.

WESLEY D. PECK
Assistant Director for Subsurface Strategies
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Education and Training

M.S., Geology, University of North Dakota, 1992. Thesis: The Stratigraphy and Sedimentology of the Sentinel Butte Formation (Paleocene) in South-Central Williams County, North Dakota.
B.S., Earth Science, North Dakota State University, 1987.

Research and Professional Experience

2020–Present: Assistant Director for Subsurface Strategies, Energy & Environmental Research Center (EERC), University of North Dakota (UND), Grand Forks, ND. Leads efforts in subsurface resource development with emphasis on Williston and Powder River Basins. Serves as principal investigator (PI) on multiyear U.S. Department of Energy (DOE)-sponsored North Dakota CarbonSAFE Phase III Characterization and Permitting project. Served as task lead and PI for regional geologic characterization component of Plains CO_2 Reduction Partnership (PCOR) Partnership Program, focused on CO_2 storage in central North America. Led full-CO_2-chain techno-economic investigation in North Dakota linking lignite mining and electric generation to CO_2 EOR. Expertise includes geology, geologic storage of CO_2, CO_2 enhanced oil recovery (EOR), and geographic information systems (GIS).

2015–2019: Principal Geologist, EERC, UND. Involved in subsurface resource development with emphasis on Williston and Powder River Basins. Served as PI on multiyear DOE-sponsored North Dakota CarbonSAFE Feasibility project. Served as task lead and PI for regional geologic characterization component of PCOR Partnership Program. Led full-CO_2-chain techno-economic investigation in North Dakota linking lignite mining and electric generation to CO_2 EOR.

2011–2015: Research Manager, EERC, UND. Oversaw staff of geologists and GIS specialists involved with oil and gas research activities in Williston Basin as well as regional geologic characterization activities associated with PCOR Partnership.

1991–2011: Research Scientist, EERC, UND. Oversaw major EERC GIS activities, served as task lead for regional characterization component of PCOR Partnership, and wrote reports and proposals.

1989–1991: Graduate Research Assistant, EERC, UND. Acquired and managed geologic data related to Cretaceous and Tertiary geology of Williston Basin. Assisted in collection of Cretaceous and Tertiary fossils and stratigraphic information in western North Dakota and eastern Montana.

Relevant Publications

Warmack, M.P., Azzolina, N.A., Nakles, D.V., Peck, W.D., Connors, K.C., Lagorin, W., Lagorin, T., Blumenthal, T., Hanslik, J., and Shendye, R., 2022, Pipeline cost and CO_2 transport considerations based on three hypothetical pipelines in the PCOR Partnership Initiative region: White paper for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FE0031838 and North Dakota Industrial Commission Contract Nos. FY20-XCI-226 and G-050-96, Grand Forks, North Dakota, Energy & Environmental Research Center, February.

Warmack, M.P., Azzolina, N.A., Nakles, D.V., Peck, W.D., Kurz, B.A., and Hamling, J.A., 2022, Balancing CO_2 pipeline infrastructure challenges: Poster presented at the AAPG Carbon Capture, Utilization, and Storage Conference, Houston, Texas, March 28–30, 2022.

Peck, W.D., Ayash, S.C., Klapperich, R.J., and Gorecki, C.D., 2019, The North Dakota integrated carbon storage complex feasibility study: International Journal of Greenhouse Gas Control, v. 84, p. 47–53. DOI: 10.1016/j.ijggc.2019.03.001.

Bosshart, N.W., Azzolina, N.A., Ayash, S.C., Peck, W.D., Gorecki, C.D., Ge, J., Jiang, T., and Dotzenrod, N.W., 2018, Quantifying the effects of depositional environment on deep saline formation CO_2 storage efficiency and rate: International Journal of Greenhouse Gas Control, v. 69, p. 8–19.

Bosshart, N.W., Pekot, L.J., Wildgust, N., Gorecki, C.D., Torres, J.A., Jin, L., Ge, J., Jiang, T., Heebink, L.V., Kurz, M.C., Dalkhaa, C., Peck, W.D., and Burnison, S.A., 2018, Best practices for modeling and simulation of CO_2 storage: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 9 Deliverable D69 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2018-EERC-03-13, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

Daly, D.J., Crocker, C.R., Crossland, J.L., Massmann, N.M., and Peck, W.D., 2018, North Dakota integrated carbon storage complex feasibility study: Deliverable D3 (outreach toolkit) for U.S. Department of Energy Cooperative Agreement No. DE-FE0029488, Grand Forks, North Dakota, Energy & Environmental Research Center, February.

Nakles, D.V., Peck, W.D., Wildgust, N., Hamling, J.A., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2017, Geologic storage of carbon dioxide in the central plains of North America: 2017 American Institute of Chemical Engineers (AIChE) Annual Meeting, Minneapolis, Minnesota, October 29 – November 3, 2017.

Glazewski, K.A., Grove, M.M., Peck, W.D., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2015, Characterization of the PCOR Partnership region: Plains CO_2 Reduction (PCOR) Partnership value-added report for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2015-EERC-02-14, Grand Forks, North Dakota, Energy & Environmental Research Center, January.

Peck, W.D., Glazewski, K.A., Braunberger, J.R., Grove, M.M., Bailey, T.P., Bremer, J.M., Gorz, A.J., Sorensen, J.A., Gorecki, C.D., and Steadman, E.N., 2014, Broom Creek Formation outline: Plains CO_2 Reduction (PCOR) Partnership Phase III value-added report for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2014-EERC-09-09, Grand Forks, North Dakota, Energy & Environmental Research Center, August.

Peck, W.D., Liu, G., Klenner, R.C.L., Grove, M.M., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2014, Storage capacity and regional implications for large-scale storage in the basal Cambrian system: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 16 Deliverable D92 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2014-EERC-05-12, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

Synergistic Activities

- Leads CarbonSAFE Phase III characterization and permitting study.
- Led CarbonSAFE study investigating two locations in North Dakota to determine feasibility of storing 2 million tons of CO_2 at one location and 4 million tons of CO_2 at the second location.
- Led full-CO_2-chain techno-economic investigation in North Dakota linking lignite mining and electric generation to CO_2 EOR.
- Led regional characterization activities for the PCOR Partnership Program to determine CO_2 storage resource potential of viable saline reservoirs in the central part of North America.
- Led geologic modeling and simulation assessment of CO_2 storage resource of the 500,000-mi^2 basal saline aquifer system of the Williston and Alberta Basins.

KYLE A. GLAZEWSKI
Principal Analyst, Data/GIS Team Lead
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Education and Training

M.S., Geography, University of North Dakota, 2005.
B.S., Geography, University of North Dakota, 2003.
Software experience includes ESRI ArcView 3.2 and 3.3, ArcMap 8.x, ArcGIS 9.x, and ArcGIS 10.x; Spatial Analyst Extension for GIS; ERDAS Imagine; HYSPLIT (Hybrid Single-Particle Lagrangian Integrated Trajectory) atmospheric dispersion model; AnnAGNPS (Annual Agricultural Non-Point Source Pollution) watershed model; Soil and Water Assessment Tool (SWAT); and Microsoft Office Suite.

Research and Professional Experience

2008–Present: Principal Analyst, Data/GIS Team Lead, Energy & Environmental Research Center (EERC), University of North Dakota (UND), Grand Forks, ND. Mr. Glazewski oversees data analysis and geographic information system (GIS) activities in oil and gas research. Mr. Glazewski's work primarily supports carbon capture, utilization, and storage (CCUS) project activities including storage facility permit development, monitoring programs, and site characterization. He is involved in a variety of oil and gas activities including produced water management and wellbore integrity evaluations.

2005–2008: Watershed Coordinator, Grand Forks County Soil Conservation District, Grand Forks, ND. Mr. Glazewski's responsibilities involved administering and managing all aspects of two U.S. Environmental Protection Agency 319 water quality projects, including field data collection, watershed modeling with GIS template, data organization and analysis, final assessment report preparation, project implementation proposal writing, assisting with total maximum daily load (TMDL) development, assisting with water quality assessment project planning, budget management and planning, public outreach, and assisting landowners with conservation planning to improve water quality as well as working with other agencies on water quality projects.

2005: Associate Geographic Technician, Special Projects Team, NAVTEQ, Fargo, ND. Mr. Glazewski's responsibilities included updating a global mapping database, completing quality checks on map data, helping develop steps for a new network updating process using ArcMap 8.3 software, providing feedback to simply the process.

2003–2005: Graduate Teaching Assistant, Department of Geography, UND, Grand Forks, ND. Mr. Glazewski's responsibilities included teaching Introduction to Physical Geography and Introduction to Climatology labs and assisting department professors as needed.

2002–2003: GIS Technician, Upper Midwest Aerospace Consortium, Grand Forks, ND. Mr. Glazewski worked on a western North Dakota wetlands project and a study of greenhouse gases in agricultural fields in eastern North Dakota and western Minnesota, including creating ArcGIS maps and land use maps and collecting and organizing field data.

Relevant Publications

Laumb, J.D., Glazewski, K.A., Hamling, J.A., Azenkeng, A., and Watson, T.L., 2016, Wellbore corrosion and failure assessment for CO_2 EOR and storage—two case studies in the Weyburn Field: International Journal of Greenhouse Gas Control, v. 54, p. 479–489.
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Department of Energy National Energy Technology Laboratory and the PCOR Partnership Initiative, Grand Forks, North Dakota, Energy & Environmental Research Center, 109 p.

Peck, W.A., Glazewski, K.A., Klenner, R.C.L., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2014, A workflow to determine CO_2 storage potential in deep saline formations: Energy Procedia, v. 63, p. 5231–5238.

Glazewski, K.A., Martin, C.L., Salazar, A.Y., Beddoe, C.J., Nyberg, C.M., Taunton, M.A., Regorrah, J.G., Kurz, M.D., Connors, K.C., Vritis, J.L., Heebink, L.V., Schmidt, D.D., Hamling, J.A., Kurz, B.A., Sorensen, J.A., Zhang, X., and Dalkhaa, C. 2022, Subtask 3.2 – Produced water management through geologic homogenization, conditioning, and reuse: Final topical report (February 1, 2020 – January 31, 2022) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FE0024233, EERC Publication 2022-EERC-01-10, Grand Forks, North Dakota, Energy & Environmental Research Center, January.

Crocker, C.R., Leroux, K.M., Massmann, N.M., Crossland, J.L., Manthei, M.M.; Glazewski, K.A., Daly, D.J., and Hamling, J.A., 2020, Public outreach package for carbon capture and storage in North Dakota: Task 5 Deliverable D3 for North Dakota Industrial Commission Contract No. R-038-047, Grand Forks, North Dakota, Energy & Environmental Research Center, February.

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Glazewski, K.A., Aulich, T.R., Wildgust, N., Nakles, D.V., Hamling, J.A., Burnison, S.A., Livers, A.J., Salako, O., Sorensen, J.A., Ayash, S.C., Pekot, L.J., Bosshart, N.W., Gorz, A.J., Peck, W.D., and Gorecki, C.D., 2017, Best practices manual (BPM) for site characterization: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 4 Deliverable D35 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2017-EERC-06-08, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

Leroux, K.M., Klapperich, R.J., Azzolina, N.A., Jensen, M.D., Kalenze, N.S., Bosshart, N.W., Torres Rivero, J.A., Jacobson, L.L., Ayash, S.C., Nakles, D.V., Jiang, T., Oster, B.S., Feole, I.K., Fiala, N.J., Schlasner, S.M., Wilson IV, W.I., Doll, T.E., Hamling, J.A., Gorecki, C.D., Pekot, L.J., Peck, W.D., Harju, J.A., Burnison, S.A., Stevens, B.G., Smith, S.A., Butler, S.K., Glazewski, K.A., Piggott, B., and Vance, A.E., 2017, Integrated carbon capture and storage for North Dakota ethanol production: Final report (November 1, 2016 – May 31, 2017) for North Dakota Industrial Commission and Red Trail Energy, Grand Forks, North Dakota, Energy & Environmental Research Center, May.

Burton-Kelly, M.E., Peck, W.D., Glazewski, K.A., and Doll, T.E., 2014, Evaluation of near-term (5-year) potential for carbon dioxide enhanced oil recovery in conventional oil fields in North Dakota: Final report for Kadrmas, Lee & Jackson, EERC Publication 2014-EERC-07-07, Grand Forks, North Dakota, Energy & Environmental Research Center, July.

Glazewski, K.A., Hamling, J.A., Peck, W.D., Doll, T.E., Laumb, J.D., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2014, A regional wellbore evaluation of the basal Cambrian system: Energy Procedia, v. 63, p. 5715–5723.

Synergistic Activities

- Evaluates regional- and field-scale wellbore integrity utilizing GIS and available wellbore data.
- Evaluating CCUS build-out scenarios through PCOR Partnership activities.
- Task 4 lead (regional infrastructure) for the current PCOR Partnership Initiative.
- Utilizing GIS in carbon capture and storage-related activities.

APPENDIX C

BUDGET NOTES

BUDGET NOTES

ENERGY & ENVIRONMENTAL RESEARCH CENTER (EERC)

BACKGROUND

The EERC is an independently organized multidisciplinary research center within the University of North Dakota (UND). The EERC is funded through federal and nonfederal grants, contracts, and other agreements. Although the EERC is not affiliated with any one academic department, university faculty may participate in a project, depending on the scope of work and expertise required to perform the project.

INTELLECTUAL PROPERTY

The applicable federal intellectual property (IP) regulations will govern any resulting research agreement(s). In the event that IP with the potential to generate revenue to which the EERC is entitled is developed under this project, such IP, including rights, title, interest, and obligations, may be transferred to the EERC Foundation, a separate legal entity.

BUDGET INFORMATION

The proposed work will be done on a cost-reimbursable basis. The distribution of costs between budget categories (labor, travel, supplies, equipment, etc.) and among funding sources of the same scope of work is for planning purposes only. The project manager may incur and allocate allowable project costs among the funding sources for this scope of work in accordance with Office of Management and Budget (OMB) Uniform Guidance 2 CFR 200.

Escalation of labor and EERC recharge center rates are incorporated into the budget when a project's duration extends beyond the university's current fiscal year (July 1 – June 30). Escalation is calculated by prorating an average annual increase over the anticipated life of the project.

The cost of this project is based on a specific start date indicated at the top of the EERC budget. Any delay in the start of this project may result in a budget increase. Budget category descriptions presented below are for informational purposes; some categories may not appear in the budget.

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. The labor category rate is the average rate of a personnel group with similar job descriptions. Salary costs incurred are based on direct hourly effort on the project. Faculty who work on this project may be paid an amount over the normal base salary, creating an overload which is subject to limitation in accordance with university policy. As noted in the UND EERC Cost Accounting Standards Board Disclosure Statement, administrative salary and support costs that can be specifically identified to the project are direct-charged and not charged as facilities and administrative (F&A) costs. Costs for general support services such as contracts and IP, accounting, human resources, procurement, and clerical support of these functions are charged as F&A costs.

Fringe Benefits: Fringe benefits consist of two components that are budgeted as a percentage of direct labor. The first component is a fixed percentage approved annually by the UND cognizant audit agency, the Department of Health and Human Services. This portion of the rate covers vacation, holiday, and sick leave (VSL) and is applied to direct labor for permanent staff eligible for VSL benefits. Only the actual approved rate will be charged to the project. The second component is estimated on the basis of historical data and is charged as actual expenses for items such as health, life, and unemployment insurance; social security; worker's compensation; and UND retirement contributions.

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, and UND travel policies, which can be found at http://und.edu/finance-operations (Policies & Procedures, A–Z Policy Index, Travel). Daily meal rates are based on U.S. General Services Administration (GSA) rates unless further limited by UND travel policies; 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, and reference materials. General purpose office supplies (pencils, pens, paper clips, staples, Post-it notes, etc.) are included in the F&A cost.

Subcontractor – TBD Graphic Design: Graphic design support for handouts, outreach, website, and public engagement. Cost based on historical cost from previous work.

Subcontractor – TBD Workshop Partner: For an industry expert to lead a workshop for stakeholders. Cost based on historical cost from previous work.

Professional Fees: Not applicable.

Communications: Telephone, cell phone, and fax line charges are included in the F&A 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.

Printing and Duplicating: Page rates are established annually by the university's duplicating center. Printing and duplicating costs are allocated to the appropriate funding source. Estimated costs are based on prior experience with similar projects.

Food: Food for hosting listening sessions, focus groups, and engagement trips with community stakeholders. EERC employees in attendance will not receive per diem reimbursement for meals that are paid by project funds. The estimated cost is based on the number and location of previous meetings.

Rent and Leases – Venue: Venue rental for listening sessions, focus groups, and engagement trips with community stakeholders. 18 rentals at $300.

Honorarium: Nominal compensation for stakeholders to participate in listening sessions and focus groups. Based on 12 sessions with 8 people at $50 per.

Operating Fees: Operating fees generally include EERC recharge centers, outside laboratories, and freight.

EERC recharge center rates are established annually and approved by the university.

Document production services recharge fees are based on an hourly rate for production of such items as report figures, posters, and/or images for presentations, maps, schematics, website design, brochures, and photographs. The estimated cost is based on prior experience with similar projects.

Engineering services recharge fees cover specific expenses related to retaining qualified and certified design and engineering personnel. The rate includes training to enhance skill sets and maintain certifications using Webinars and workshops. The rate also includes specialized safety training and related physicals. The estimated cost is based on the number of hours budgeted for this group of individuals.

Geoscience services recharge fees are discipline fees for costs associated with training, certifications, continuing education, and maintaining required software and databases. The estimated cost is based on the number of hours budgeted for this group of individuals.

Facilities and Administrative Cost: The F&A rate proposed herein is approved by the U.S. Department of Health and Human Services and is applied to modified total direct costs (MTDC). MTDC is defined as total direct costs less individual capital expenditures, such as equipment or software costing $5000 or more with a useful life of greater than 1 year, as well as subawards in excess of the first $25,000 for each award.

APPENDIX D

EERC PROJECTS FUNDED BY THE NORTH DAKOTA INDUSTRIAL COMMISSION IN THE LAST 5 YEARS

EERC PROJECTS FUNDED BY THE NORTH DAKOTA INDUSTRIAL COMMISSION IN THE LAST 5 YEARS

Project Name	Start Date	End Date	Total Contracted
Bakken Production Optimization Program 2.0	11/01/16	05/31/20	$6,000,000.00
Initial Engineering, Testing, and Design of a Commercial-Scale CO_2 Capture System	09/01/17	12/31/19	$3,200,000.00
FERR 1.3 – Integrated Carbon Capture and Storage for North Dakota Ethanol Production	11/01/17	07/31/18	$345,000.00
iPIPE: The intelligent Pipeline Integrity Program	04/01/18	12/31/23	$2,600,000.00
Economic Extraction and Recovery of REES and Production of Clean Value-Added Products from Low-Rank Coal Fly Ash	06/16/18	02/15/20	$30,000.00
Low-Pressure Electrolytic Ammonia Production	06/16/18	06/30/22	$437,000.00
FERR 1.3 – Integrated Carbon Capture and Storage for North Dakota Ethanol Production	12/01/18	05/31/20	$500,000.00
State Energy Research Center	07/01/19	06/30/27	$20,000,000.00
Underground Storage of Produced Natural Gas – Conceptual Evaluation and Pilot Project(s)	06/01/19	06/30/23	$3,500,000.00
Assessment of Bakken and Three Forks Natural Gas Compositions	11/01/19	06/19/20	$300,650.00
Improving EOR Performance Through Data Analytics and Next-Generation Controllable Completions	01/27/20	09/30/24	$500,000.00
Wastewater Recycling Using a Hygroscopic Cooling System	01/31/20	09/30/22	$100,000.00
PCOR Partnership Initiative to Accelerate CCUS Deployment	02/01/20	09/30/24	$2,000,000.00
PCOR Partnership Initiative to Accelerate CCUS Deployment	02/01/20	09/30/24	$2,000,000.00
FERR 3.2 – Produced Water Management Through Geologic Homogenization, Conditioning, and Reuse	02/01/20	01/31/22	$300,000.00
Bakken Production Optimization Program 3.0	05/01/20	04/30/23	$6,000,000.00
EERC Technical Support for RTE CCS Activities – November 1, 2019	06/01/20	11/30/21	$500,000.00
Flue Gas Characterization and Testing	07/01/20	11/30/21	$3,741,450.00
Laboratory-Scale Coal-Derived Graphene Process	09/01/20	04/30/23	$162,500.00
Hydrogen Energy Development for North Dakota	07/01/21	06/30/23	$500,000.00
Ammonia-Based Energy Storage Technology	04/01/21	03/31/23	$101,390.00
Field Study to Determine the Feasibility of Developing Salt Caverns for Hydrocarbon Storage in Western North Dakota	07/01/21	06/30/23	$11,900,000.00
Williston Basin CORE-CM Initiative	02/01/22	05/31/23	$750,000.00
Front-End Engineering and Design for CO_2 Capture at Coal Creek Station	02/01/22	08/31/23	$7,000,000.00
Unitized Legacy Oil Fields: Prototypes for Revitalizing Conventional Oil Fields in North Dakota	07/01/21	06/30/24	$3,000,000.00
iPIPE 2.0: The intelligent Pipeline Integrity Program	01/01/22	12/31/23	$400,000.00
Advanced Processing of Coal and Waste Coal to Produce Graphite for Fast-Charging Lithium-Ion Battery	02/01/22	01/31/25	$500,000.00
Liberty H_2 Hub Front-End Engineering and Design	11/01/22	10/31/24	$10,000,000.00

INDUSTRIAL COMMISSION OF NORTH DAKOTA
RENEWABLE ENERGY PROGRAM

TECHNICAL REVIEWERS' RATING SUMMARY

R-052-C
USE OF BIOENGINEERING TO ENHANCE THE AGRONOMIC POTENTIAL OF CAMELINA FOR USE AS A SOURCE FOR BIOFUEL FEESTOCK AND MEAL FOR LIVESTOCK

Principal Investigator: Eric J. Murphy
Request for $500,000 Total Project Costs $1,151,250

TECHNICAL REVIEWERS' RATING SUMMARY
R-052-C
USE OF BIOENGINEERING TO ENHANCE THE AGRONOMIC POTENTIAL OF CAMELINA FOR USE AS A SOURCE FOR BIOFUEL FEESTOCK AND MEAL FOR LIVESTOCK
Principal Investigator: Eric J. Murphy
Request for $500,000 Total Project Costs $1,151,250

		Technical Reviewer			
		1C	2C	3C	
Rating Category	Weighting Factor	Rating			Average Weighted Score
1. Objectives	9	3	4	3	30.00
2. Achievability	9	4	3	4	33.00
3. Methodology	7	3	4	3	23.33
4. Contribution	7	4	5	2	25.67
5. Awareness	5	3	3	3	15.00
6. Background	5	2	4	3	15.00
7. Project Management	2	2	3	3	5.33
8. Equipment Purchase	2	4	5	5	9.33
9. Facilities	2	3	5	4	8.00
10. Budget	2	3	5	3	7.33
Average Weighted Score		161	197	158	**172.00**
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)

Project objectives are very clear, each three well described in the narrative. Likewise, justification of the importance of each is strong with the ultimate goals of making camelina an additional crop of choice for ND farmers and offsetting the burden on soybean to meet biofuel feedstock needs. The crop rotation opportunity for farmers and decoupling from traditional commodity market driven pricing structure is of high potential value. Interesting is the note of the potential for pharmaceutical applications in the future, offering a new market facet to the region. Missing in the narrative was a discussion of how this work, if successful, might lead to the expansion of CamBioGene in Grand Forks, ND. Of interest is to understand its planned growth, opportunity for job creation, total current and future FTE's, etc. – these were not addressed and will potentially limit ND value.

Reviewer 2C (Rating 4)

The project meets the goals of developing renewable resources in ND by allowing additional land to be used for growing energy crops. Diversification away from row crops will be viewed favorably by end product users. Additionally, specialty (pharma grade) separation operations if processing the seeds in state.

Reviewer 3C (Rating 3)

The proposal indicates that the ultimate goal of the proposer's overall project is to enhance the agronomic potential of camelina, and the camelina is then potentially used as an oil source for biofuel production and as a feed source for livestock industry. However, the specific objectives of this project are to expand field-trials of two existing lines of camelina cultivars, and to modify another cultivar through laboratory experiments for improved seed quality. In other words, the proposed work is mainly agronomic with the indirect potential for the industrial development of renewable energy. Thus, its goal is clear but weakly in line with the REC funding missions of promoting the growth of North Dakota's renewable energy industries through research, development, marketing, and education.

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 4)

The team proposes as 3-year project with a total budget (NDIC and matching from participants) of $1.15M. This is adequate for the proposed objectives and is likely to lead to a successful project. Not having direct expertise in biofuels and crop research such as that proposed here on camelina, it is difficult to judge the likelihood of success in the team realizing its three main objectives. From the limited narrative, it seems reasonable that the planned work will drive higher lauric/myristic acid in camelina and increase herbicide tolerance in the crop. Likewise, I suspect the third objective to increase seed size and number per plan will succeed, though none of the objectives have quantitative listed targets to measure success.

Reviewer 2C (Rating 3)

The timeline appears to be adequate. The budget for oil and protein testing as well as proposed travel is optimistic, however, there appears to be sufficient flexibility for success.

Reviewer 3C (Rating 4)
This project is based on the findings and preliminary experimental results of an international researcher who is an expert in the field. The approach suggested in the proposal follows that in the traditional plant sciences. The project time of three years may be a bit tight but is reasonable. The project budget of $1.15M is also reasonable, although not all proposed funds have been secured at this moment.

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 3)
Within the limited space of the narrative, the team does appear to have a sound methodology planned. While specific tasks are not well defined, the overall approach is adequate and logical. The three objectives of the project are well described, and the associated three projects are directly aligned with the targeted outcomes.

Reviewer 2C (Rating 4)
The methodologies for propagation, gene enhancement, and testing are clear and proven. There is a stated goal of herbicidal resistance, but no stated goal to the oil or protein yield on a per pound, bushel, or acre basis (discussion on seed yield per plant only).

Reviewer 3C (Rating 3)
The techniques proposed in the proposal are claimed as well established by the project personnel including the technology provider who pioneered the transformation of camelina. Details are provided on previous/existing research projects; however, the implementation details of this project are lacking. In addition, some of the project activities will be conducted outside of the US, on which the proposal does not provide a good management plan regarding the transferability of the research results back to North Dakota.

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 4)
If camelina is to become a more significant crop option in ND, the objectives of the proposed program will be important. Increasing the lauric/myristic acid in camelina will enhance its value as a feedstock for biofuels (Objective 1). Increasing the tolerance to class-2 herbicides, particularly residuals in soil, offers resilience that ND farmers need and promotes crop cycling interests (Objective 2). Lastly, improving seed size and yield offer increased margin (Objective 3). The technical aspects of the project that aim to realize these objectives are of high value and would offer valuable scientific/technical contributions for ND.

Reviewer 2C (Rating 5)
This project, if successful, will give ND another vector into sustainable energy production. As camelina is not a food crop, it is treated favorably by various regulatory agencies. As for the NDIC/REP goals, this project fits well with fostering development of biomaterials and advanced biofuels.

Reviewer 3C (Rating 2)
The bioengineering approach to enhance the agronomic potential of camelina might be a great contribution to the fields of agronomy and plant science. However, justification is lacking on its scientific and/or technical contribution to specifically address the funding mission (namely, promoting

the growth of North Dakota's renewable energy industries through research, development, marketing, and education) of the North Dakota Industrial Commission/ Renewable Energy Council.

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 3)

Technical discussion in the proposed project provides indication that the PI (Murphy) is aware of current research in the field and has technical competency. PI is aware of the interplay and competition between biofuel feedstock and food grade oils. However, no formal references to specific literature were included in the narrative, nor were any prior publications referenced from any of the technical team (their bios listing any prior work were also not included).

Reviewer 2C (Rating 3)

From a plant science perspective and potential pharmaceutical uses, the PI is very aware of current research. However, in the fuels space, the PI is not up-to-date on the current state of renewable fuels and processing methods. That being said, the Lauric and Myristic fatty acids are much closer to the chain length required to produce renewable jet fuel than Oleic and Linoleic fatty acids. From a renewable energy product standpoint, the yield of jet fuel from this camelina would be significant.

Reviewer 3C (Rating 3)

The proposal documents the qualification of the proposer's company, which is a "fully operational plant science company". No discussions are provided on the principal investigator's awareness of current research activity and published literature. Per the context of the proposal, it is assumed that principal investigator has adequate awareness of current research activity and published literature.

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 2)

While content in the proposal suggests that the team has adequate expertise, the lack of any bio information for the PI (Murphy) is a major oversight. The narrative includes descriptions of the 3 major projects within the program, suggesting that the team has some prior work, but it is very vague and lacks any formal reference to disseminated work. In the very least, the PI should have included a description of his background, expertise in both the relevant field and also in managing projects. With a major portion of the project planned to be done in Helsinki, it is not clear (outside of budget) how much involvement and activities will occur in ND. A more direct discussion of expertise and experience of the PI and the two experimentalists (Kuvshinov and Kuvshinova) would have been valuable.

Reviewer 2C (Rating 4)

Mr. Murphy and his team appear to have the appropriate background and experience to complete the research and communicate the results.

Reviewer 3C (Rating 3)

The proposal does not provide discussions on the background of the investigators as related to the proposed work. Thus, the preparation of the investigators for this project is unable to be assessed adequately.

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 2)

The narrative includes a rather simple timetable for the three project objectives. The timetable is relatively simplistic and lacks milestones for key subtasks. What is not clear is if there are thresholds that indicate success and suitability for commercialization. For example, what lauric and myristic levels are targeted and/or required to consider objective 1 tasks successful? Similarly, what level of herbicide tollerance is considered a success for objective 2 tasks? As written, the project appears that it is simply a best effort approach to improvements that have no specific quantitative objective other than to be better. While this may be to some extent acceptable, the team should at least state how this aligns with commercial viability and a successful program. I will note that evaluation points are somewhat discussed for Objective 3, however are somewhat lacking for Objectives 1 and 2. Lastly, it is not clear how the team will report on progress without some specific deliverables. "Data analysis" is listed throughout the timetable but there is no mention of what this will lead to that will be reported on in the multiple interim reports during the project.

Reviewer 2C (Rating 3)

A multi-year timeline is provided for the project objectives. The objectives are broken down into specific tasks with beginning and end dates. A Gantt chart would have been helpful. The financial budget is justified and then broken down into line items with lump sums. A spend schedule would be helpful.

Reviewer 3C (Rating 3)

The proposal provides a timetable that outlines the milestones of the project progress. One of the key participants locates overseas and will participate in the project activities remotely. Other project personnel plan to travel overseas periodically for in-person meetings. However, the discussion on the management plan is brief.

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 4)

$140k is budgeted for equipment, provided from the applicant's share at no cost to NDIC. The budget justification provides a specific list of equipment (growth chamber, laminar flow hood, PCR machine, etc.) that appear to be appropriate.

Reviewer 2C (Rating 5)

The specified equipment is necessary and required for the research project.

Reviewer 3C (Rating 5)

No purchase of equipment is requested in this proposal.

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 3)
CamBioGene has a growth room in Helsinki, but it does not currently have the ability to carry out the proposed work, necessitating a capital investment for the necessary equipment (included in budget). Noted is that there is no such resource available in the Grand Forks region, so work appears to be planned to continue in Helsinki rather than in ND. Future plans are to build up a lab in ND, but resources for this are not secured nor tied in any form to the proposed program.

Reviewer 2C (Rating 5)
No facilities are to be purchased only rented

Reviewer 3C (Rating 4)
The facilities are notably good from the international technology provider and the collaborators in North Dakota, who have been conducting research and extension activities for years in the field of 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 1C (Rating 3)
Just over 50% of the total budget is sourced from the participants, with $500k requested from NDIC and a total of ~$650k coming from the applicants. Equipment is included in the budget but is covered from applicant funding at no cost to NDIC. This meets the minimum requirements of the program and aligns with that of similar submissions of average budget value.

Reviewer 2C (Rating 5)
Developing a resistant camelina variety for energy production and potential bio-similar pharmaceuticals provides significant return potential for ND.

Reviewer 3C (Rating 3)
The proposed work and expected technical outcome have an average value for the budget requested due to the inadequate justifications for its technical/scientific contribution to and/or economic significance for the further development and commercialization. The funding commitment from other sources is approximately $651k. The request from this REC program is $500k which is about 43% of the overall budget.

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
Overall, the justification for the work and listed project objectives are very clear. The technical approach is sound and worthy of effort, though specifics on the tasks of the project are limited. Of concern was the lack of clarity on the project team qualifications since no bio paragraphs were provided. Also confusing is the level of work being done in Helsinki since it is does not appear that a formal transition plan to establishing strong and sustained activities in ND is an intended outcome of the project, limiting ND benefit. Concerning is that most, if not all, of the technical work is to be

conducted there rather than in ND. Not clear is how much will be done in ND and the level of effort at NDSU outside of involvement in the field trials. Letters of support would have been valuable.

Reviewer 2C
Recommend to Fund

From an energy perspective, the oil makeup is of particular interest. The shorter fatty acids will improve renewable jet yield significantly. Long term, this does take away the food or fuel argument as camelina can be grown on more marginal land. PI needs to confirm partners participation with a minimum of a letter of intent.

Reviewer 3C
This is a good agronomic project. The technology is tested, and the project plan is good, and the project outcome has a high potential to benefit North Dakota's agricultural sector. Its significance in contributing to North Dakota's clean energy industry and sustainable environment, however, is not adequately justified.

Although this project plans to demonstrate the improved cultivars of camelina for better productivity so camelina oil could be used for biofuel production, there are still stages between the outcome from this project and the development of technologies for Northa Dakota's bioenergy industry.

It is recommended that this proposal be funded by the REC program if funds are available.

Renewable Energy Program

North Dakota Industrial Commission

Application

Project Title: Use of Bioengineering to Enhance the Agronomic Potential of Camelina for Use as a Source for Biofuel Feedstock and Meal for Livestock

Applicant: CamBioGene

Principal Investigator: Eric J. Murphy

Date of Application: 2 October 2023

Amount of Request: $500,000

Total Amount of Proposed Project: $1,151,250

Duration of Project: 3 years

Point of Contact (POC): Eric J. Murphy

POC Telephone: 701-213-1510

POC Email: eric.murphy@cambiogene.com

POC Address: 3902 15th Ave. S. Grand Forks, ND 58201

APPLICATION CHECKLIST

Use this checklist as a tool to ensure that you have all of the components of the application package. Please note, this checklist is for your use only and does not need to be included in the package.

X☐	Application
X☐	Transmittal Letter
☐	$100 Application Fee SENT VIA MAIL
X☐	Tax Liability Statement
☐	Letters of Support (If Applicable)
☐	Other Appendices (If Applicable)

When the package is completed, send an electronic version to the Industrial Commission at ndicgrants@nd.gov. Send payment to:

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

For more information on the application process please visit:
https://www.ndic.nd.gov/renewable-energy-program/rep-applicant-council-information

Questions can be addressed by calling 701-328-3722.

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Transmittal Letter

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

2 October 2023

Dear Sirs:

Please find herein our application for a Renewable Energy Program grant from the North Dakota Industrial Commission. We are requesting $500,000 with an anticipated match of $543,250 and additional in-kind match of $108,000, for a total budget of $1,151,250.

CamBioGene is leveraging over 20+ years of experience in plant sciences and is a new startup company in Grand Forks, ND. We have no tax liability owed to the State of North Dakota. This is an exciting project to bring a sustainable source of oil seed feedstock to our biorefineries in the State of North Dakota. This would put North Dakota in a leadership position as we address the food vs fuel debate around use of soybean oil as a feedstock for fuels.

I look forward to your consideration of our proposal.

Sincerely,

Eric J. Murphy

CEO, CamBioGene

ABSTRACT

Objective:
There are three objectives to this project:
1). Expand existing high lauric/myristic acid camelina for field trials and commercialization.
2). Expand existing lines of camelina with mutated acetolactate synthase (ALS) that imparts class-2 herbicide tolerance for field trials and commercialization.
3). Transform camelina with purple acidic phosphatase-2 (PAP2) to increase seed size, seed number per plant, and net oil content and move transformed plants into field trials.

Expected Results:
For Objectives 1 and 2, we expect to expand 4-5 existing plants lines for the high lauric/myristic acid camelina and 4-5 existing lines for mutated ALS containing camelina in growth room located in Helsinki, then transferring the seed stock to the U.S. for field trials. As we routinely expand seed stocks, this expansion is not anticipated to be a problem. Application for field trials will be done through APHIS and EPA as necessitated by federal regulations. It would be ideal, based upon approval by federal regulatory agencies, to perform field trials at several field trial locations that are managed by North Dakota State University (NDSU). Based upon field trials data, applications for approval of commercial launch in the U.S. will be initiated.

For Objective 3, there is existing data suggesting that enhancing the expression of PAP2 in camelina will increase agronomic performance. Based upon our 20+ years of experience in transforming camelina, we do not anticipate a problem transforming camelina with PAP2. This process will take 1.5 to 2 years to establish fourth generation plants. We don't anticipate any problems with transformation or lethality of overexpression of PAP2 in the plant. Upon satisfying the requirements of U.S. regulatory agencies, we will move into field trials to commence in spring of 2026.

Duration:
Duration of this project is 3 years, with an anticipated start in late 4Q23 to early 1Q24.

Total Project Cost:
$1,151,250

Participants:
CamBioGene is based in Grand Forks, ND and Agragen, OY in Helsinki, Finland. Ongoing negotiations are in the final stages to transfer ownership of Agragen, OY to CamBioGene and the exclusive licensing of Agragen, LLC's existing intellectual property to CamBioGene. The founder and CEO of CamBioGene, Eric J. Murphy, currently serves as Chairman of the Board for Agragen, OY and Senior Vice-President of Research and Development of Agragen, OY and Agragen, LLC.

Additional participants are anticipated to be NDSU for field trials.

PROJECT DESCRIPTION

Objectives:

There are three objectives to this project:

1). Expand existing high lauric/myristic acid camelina for field trials and commercialization.

2). Expand existing lines of camelina with mutated acetolactate synthase (ALS) that imparts class-2 herbicide tolerance for field trials and commercialization.

3). Transform camelina with purple acidic phosphatase-2 (PAP2) to increase seed size, seed number per plant, and net oil content and move transformed plants into field trials.

Methodology:

Use our existing, patented transformation techniques to transform *Camelina sativa* (camelina) using agrobacterium to insert a construct containing the target gene into the genome of camelina. Stable transformants, as confirmed by expression of the target gene, are grown and the seeds harvested. These seeds are planted to generate the T2 generation of plants, and this process is repeated to ensure that no negative impacts of the transformation occur in successive generations and that the transformation is stable. Stable plant lines are then prepared for seed expansion and analysis as required by federal compliance agencies for field trials.

Field trails will be conducted in collaboration with NDSU. Initial trials will be small plots, 10 x 10 m, and then expanded to larger plots in the second year. Plant performance and phenotype will be assessed with an emphasis on target gene expression, yield, seed oil lipid composition and content, and protein amino acid composition and content. Upon the completion of two years of field trials, varieties will be selected to move into application for commercial release with APHIS and EPA as needed.

For camelina containing mutated ALS, application of class-2 herbicides will be used to determine dose-dependent tolerance to imidazolinone and to chlorsulfuron. Although the major objective of class-2 herbicide tolerant camelina is to prevent crop failure due to residual class-2 herbicides in the soil, it is possible that future use of class-2 herbicides to control weeds in fields will be advantageous.

Anticipated Results:

We anticipate that the phenotype for each camelina will be maintained during the field trials. Hence, both the ALS and high lauric/myristic acid camelinas will continue to produce the biochemical phenotype displayed in the growth room during field trials.

Because there is one paper in the literature demonstrating the positive attributes of overexpressing PAP2 in camelina, we anticipate seeing the same results in our hands. Hence, we anticipate generating a camelina with greater seed size and seed yield and successful generation of this camelina in the laboratory will result in plant varieties for field trials.

Facilities:

CamBioGene has a growth room in our Helsinki location and will expand our laboratory space for transformation of camelina. This will require a capital investment by CamBioGene for the necessary

equipment to carry out these transformations. The equipment previously held by Agragen, OY was sold in a financial reorganization and much of the equipment was antiquated and required replacement. Since that time, Agragen, OY has been using the growth room to expand seed stocks and to conduct camelina breeding.

Unfortunately, at this time there are no laboratory resources in the greater Grand Forks regions suitable for a plant sciences laboratory. As such, the plan is to continue operations in Helsinki for 2-3 years, when we anticipate was can raise sufficient capital for building a laboratory facility or laboratories are made available in a partnership with the University of North Dakota.

Resources:
Our major resource is the intellectual infrastructure that exists in Helsinki. Both Dr. Kuvshinov and Svetlana Kuvshinov pioneered the techniques for transforming camelina. Dr. Kuvshinov also pioneered the techniques used to effectively breed camelina. We have assembled a low cost approach to expand camelina in an inexpensive, controlled environment, essential for this project.

NDSU has worked with camelina at several of its Research Extension Centers. The REC at Williston, Hettinger, Dickinson, and Carrington will be considered for the field trials and a key consideration is ability to comply with APHIS requirements.

Financial resources for CamBioGene include an investor from the Cincinnati area investing $250,000 and an expected match of $250,000 from the federal COVID economic development funds in angel matching program at the North Dakota Development Fund, North Dakota Department of Commerce.

Techniques to Be Used, Their Availability and Capability:
The techniques used are well established by CamBioGene personnel who pioneered the transformation of camelina. As such, the intellectual infrastructure is readily deployable and has full capability to complete seed expansion and transformation as required in Objectives 1-3.

NDSU has worked with camelina in the past at multiple REC. As such, there is little doubt that they have the infrastructure in place to complete the field trials. However, engaging NDSU for seed trials will more than likely commence in late fall of this year as we determine seed stock expansion in Finland. If sufficient seed stock expansion has not occurred, we may use greenhouse expanded seed stock and initiate field trials in spring of 2025.

Environmental and Economic Impacts while Project is Underway:
There are no anticipated environmental impacts for this project. The transformed camelinas will be assessed for suitability to be released for commercial use by APHIS and other relevant federal agencies. Hence, that is the environmental impact assessment.

Economic impacts are perceived to be positive, giving North Dakota producers greater cropping choices, especially producers in the more arid regions of the state.

Ultimate Technological and Economic Impacts:
The ultimate technological impact is to produce varieties of camelina that have enhanced class-2 herbicide tolerance, that have enhanced seed yield and seed size, which reduces seed loss during harvesting, and that have a fatty acid profile that enhances the quality of the feedstock for traditional biofuel production as well as for production of non-oxygenated biofuels.

Commercialization of these bioengineered camelinas provides an additional cropping choice for North Dakota farmers, especially those producers in the more arid regions of North Dakota. Using a closed loop cropping system, producers uncouple the production from the traditional commodity pricing system. As the long-term goal of CamBioGene is focused on plant made pharmaceuticals, successful producers will have an opportunity to participate in growing camelina used in production of biotherapeutic proteins, which has a very high potential for enhanced payments to producers.

Why the Project is Needed:
The food to fuel debate is important one in selection of an oil to be used as a feedstock for biofuel production. Unfortunately, soybean oil comprises a tremendous amount of feedstock used in biofuel production, removing this a widely used oil from our food supply. As such, it is important to consider if this oil should be used to make fuel or whether alternative feedstocks from alternative crop oil feedstocks should be considered. Camelina fulfills this need as it is a non-food oil.

Additional advantages for camelina are that it grows on less productive land than soybeans, requires less inputs than canola, and its moisture requirements are low. This makes it an ideal crop for western North Dakota farmers and serves as an alternative to wheat. In fact, experience in Montana demonstrates that in a two-crop rotation, wheat yields following camelina are greater, presumably due to greater residual soil moisture, an added advantage for North Dakota producers.

In addition, camelina performs poorly for traditional biodiesel due to the high degree of fatty acid unsaturation in its oil and a higher gel point. By adding medium chain saturated fatty acids and reducing the unsaturation of the oil, the iodine number (degree of unsaturation) should be reduced, and the gel point will also be reduced, making it a much better oil feedstock for traditional biofuel. Hence, the rational for transforming camelina to synthesize high lauric and myristic acid (12:0 and14:0, respectively) is to reduce the degree of unsaturation while also changing the physical chemical properties of the oil, thereby reducing the gel point.

In our experience, significant crop failures for camelina have occurred due to residual class-2 herbicide levels in fields. While the emergence of these crops was outstanding, the seedlings quickly died. Forensic agronomy indicated that in fields experiencing this failure, there were high levels of residual class-2 herbicides accumulated in the soil. This coupled with the high susceptibility of camelina to these herbicides resulted in crop failure. We have engineered the active site of ALS to increase herbicide tolerance.

Hence, camelia provides a higher value cropping solution for the more arid regions of North Dakota that removes the traditional dependency on commodity pricing due to a closed loop farming system where CamBioGene, or a future partner, provides seed and purchases the crop for downstream processing into oil for biofuel production and meal for livestock feed.

STANDARDS OF SUCCESS

Measurable Deliverables

Objective 1 and 2: Seed expansion 4Q23 through 4Q24 with field trials starting with spring planting in 2025. APHIS application for field trials and for transferring of seed into U.S. from Finland will commence in 3Q24. Field trials in spring 2025 and data analysis following harvest assessing both physical and biochemical phenotype. Field trials repeated in spring 2026 and assessment of physical and biochemical phenotype. If data is sufficient, in collaboration with APHIS and other federal regulatory entities, submit an application for commercial use.

Objective 3: Transformation of two varieties of camelina with class-2 herbicide tolerance with a construct containing purple acidic phosphatase-2 (PAP2). Determine successfully transformed plants and plant T1 generation seeds. Assess seed size and seed yield of T1 plants, selecting plants to move forward T2 generation and repeat assessment and selection for T3-T5 generations. Expand T5 plants and begin application for transferring seed to the U.S. and field trials. This will occur 4Q23-4Q25. Field trials are anticipated in spring 2026.

Value to North Dakota

A transformed camelina for use by producers to enhance field performance and production of camelina for biofuel feedstock provides options to add another suitable crop for use as a rotation crop in the more arid locations in North Dakota. Further, the initial success of CamBioGene will help raise capital for projects in the pharmaceutical space, with much higher returns for our most successful producers. Our long-term vision is to use camelina to product AGR-131, which is an etanercept (Enbrel) biosimilar in a drug family that currently has about a $45B market cap. Using our patented protein expression system, we anticipate being able to substantially lower the cost for this drug commonly used to treat rheumatoid arthritis and psoriatic arthritis. This represents a strong potential reduction in drug costs to insurers and to the State visa vie Medicaid. Additional pharmaceuticals are in the pipeline.

Public and Private Sector Use

The public sector is not the primary beneficiary of this project beyond what is highlighted above. Private sector use will be planting seed for producers and crushing options for our emerging oil seed crushing facilities. Oil will be used by our state's biorefineries, and the meal can be used in state for livestock feed. A letter of no objection has been issued by the FDA for use of camelina meal in poultry and cattle rations.

Commercial Use of Deliverables

Commercial use is camelina oil as a feedstock in the production of biofuels and camelina meal for use as a livestock ration. The plants expressing PAP2 we anticipate will have enhanced seed yield and bigger seed size, which will increase harvest yield.

Enhance Research, Development, and Marketing for North Dakota's Renewable Energy Resources

Funding of this application will help establish a plant sciences company in North Dakota. Providing funding helps move two projects through commercialization and initiate a project that will enhance key agronomic properties of camelina. It is critical to diversify the economy of North Dakota and adding a plant biosciences company links two elements we do well agriculture and downstream processing including biofuel production. But unlike many efforts in agriculture our long-term goal is to have all facets of CamBioGene located in Grand Forks, North Dakota. By leading the way in the use of camelina-derived oil for biofuels, we uncouple biofuel production from using food grade oils, leading the way on the fuel vs food debate.

Satisfying Mission of Grant Program

This project promotes a sustainable feedstock for traditional biodiesel and feed stock for deoxygenated biofuel production. One important element is a feedstock must compete with petroleum-based oil in the absence of subsidies, and camelina does that because of its low cost of production, whereas soybean oil is much less competitive in the $70-85 per barrel price range. That ensures sustainability as a renewable energy feedstock and long-term market stability. This project is focused on improving a crop that can be introduced in North Dakota, providing producers with a cropping option that uncouples them from the traditional commodity market driven pricing structure associated with other crops. This adds wealth for landowners and our agriculture producers, aiding in maintaining a robust rural economy.

But most importantly, as noted previously, it is critically important to have at-scale feedstocks to feed biofuel needs without using human food grade oils. Soybean oil is traditionally used, but in the long-term this oil should be targeted for human consumption. This project will position North Dakota to be a leader in alternative seed oil-derived feedstocks, a positive position in the food vs fuel debate.

BACKGROUND/QUALIFICIATIONS

CamBioGene is a new plant biotechnology company based in Grand Forks, ND that is leveraging over twenty (20) years of expertise working with Camelina sativa (camelina). It has exclusively licensed an extensive, world-leading intellectual property (IP) portfolio giving it freedom to operate (FTO) as a fully operational plant science company. Using this technology and existing intellectual infrastructure in Helsinki, FI, CamBioGene will have the capability to significantly improve key traits in camelina using proven techniques for genetic engineering. This project is designed to take two existing projects to field trials in collaboration with North Dakota State University Research Extension Centers' APHIS qualified field trial locations.

The first project is a high lauric/myristic acid camelina that putatively overcomes suitability problems for using camelina oil as a feedstock for traditional biofuels, e.g. biodiesel. Camelina has been used extensively in the past as a biojet feedstock. It was successfully used by KLM in a daily flight from Amsterdam to Frankfurt using 100% camelina derived biojet in a continuous manner as well as by the U.S. Navy to fly an F-18 fighter jet on 100% camelina oil derived biojet. However, when used in traditional biodiesel, camelina underperforms other seed oils, in part due to its high iodine number (high degree of unsaturation in the fatty acid chains) and due to a relatively high gel point, often just above standards. By increasing the medium chain saturated fatty acids coupled with a reduction in the total amount of unsaturation, the goal is to produce a camelina oil that could be used to make traditional biodiesel as well as deoxygenated fuels, including biojet.

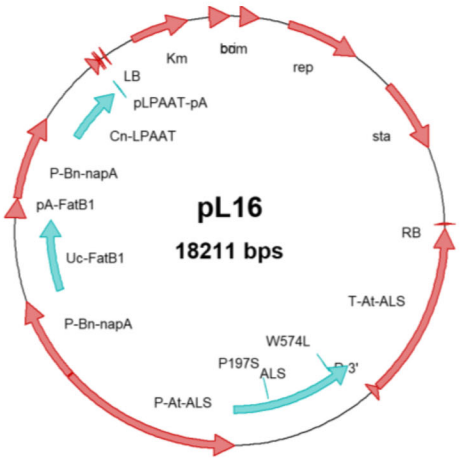
The second project is a class-2 herbicide tolerant camelina that overcomes the normal sensitivity of camelina to residual class-2 herbicides in the soil. This plant is bioengineered to replicate successful mutations in the active site of acetolactate synthase that impart tolerance to class-2 herbicides in weeds. By using a combinatorial approach, we elucidated which amino acids in the active site had to be modified to gain tolerance to chlorsulfuron and imidazolinone.

Projects 1 and 2 are ready for seed expansion, final analysis for an application for field trials, and then field trials. This is essential for commercialization.

The third project is designed to overexpress purple acidic phosphatase-2 (PAP-2) in camelina to increase yield and seed size, both of which impact yield off the field. Work presented in the literature indicates that both traits are increased by PAP-2 expression in camelina. Seed size is an important consideration as seed is lost during harvesting and just a small increase in camelina seed size is advantageous for greater off field yield. Thus, increasing seed yield per plant as well as yield during harvest would add to the profitability of camelina.

PROJECT 1.

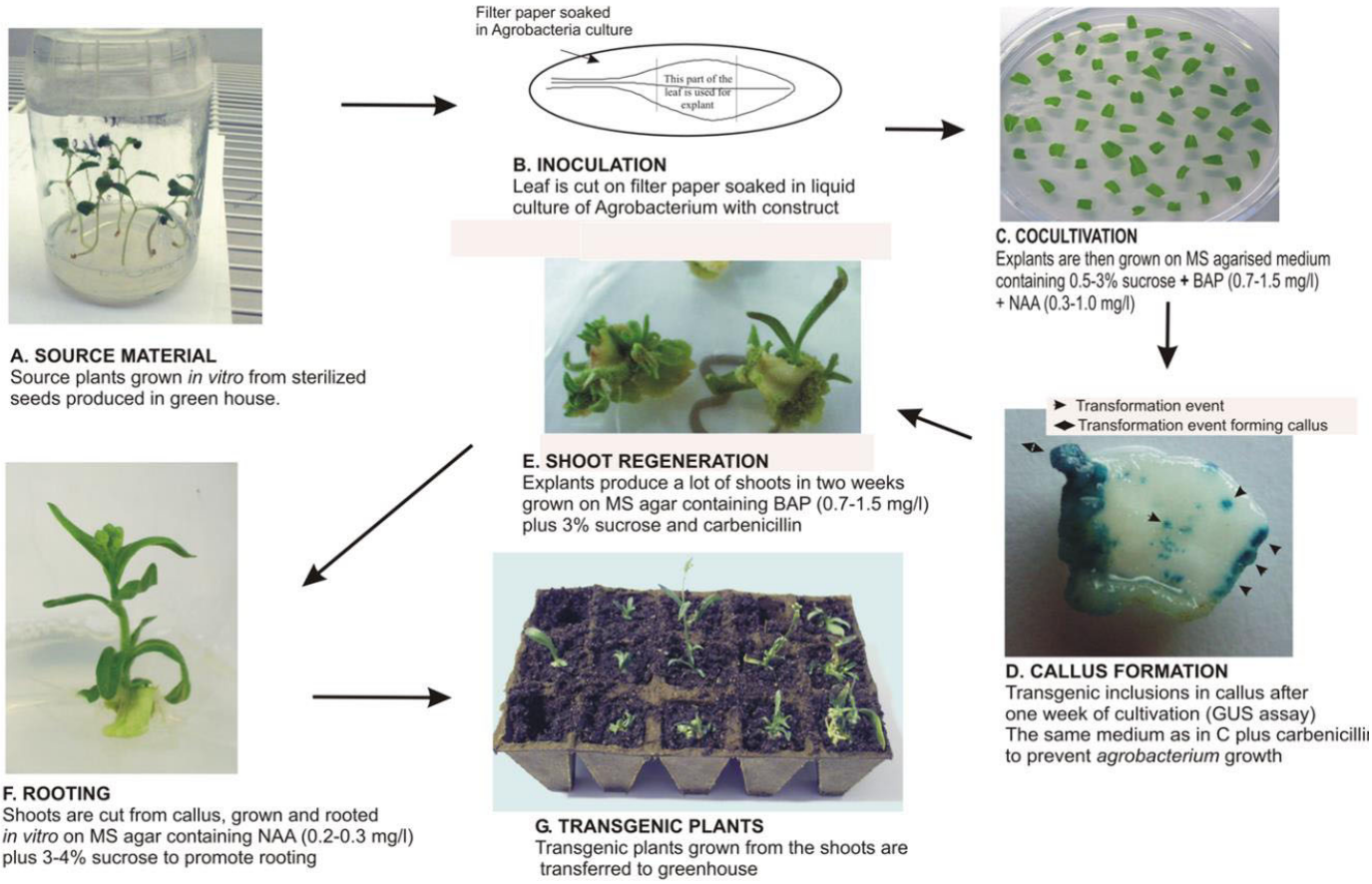
Figure 1. Construct for transforming camelina.



The construct used to transform camelina to produce lauric (12:0) and myristic (14:0) acid is shown in **Figure 1**. This construct contains the genes from *Umbellularia californica* (California bay) thioesterase (Uc-FatB1) under control of *Brassica napus* NapA-promoter and *U.c.* thioesterase terminator. *Cocos nucifera* lysophosphatidic acid acyltransferase (Cn-LPAT) under control of *Brassica napus* NapA-promoter and Cn-LPAT terminator is also included. This construct also contains the gene for ALS with the P197S and W574L mutations to impart optimal tolerance to class-2 herbicides and provide a non-antibiotic selection marker. This construct is placed in agrobacterium that is then used to infect camelina leaflets and inserts this construct randomly into the camelina genome. The process is demonstrated in **Figure 2** below, where sterile leaflets are grown, the leaflets harvested and inoculated with agrobacterium containing the construct in Figure 1. These leaflets are cultivated on medium and callus formation occurs and these calluses are

removed and put on medium to induce shoot generation. Successful shoots are transferred to rooting medium and following root development, put into soil to grow T0 plants. These plants produce less seeds than normal camelina. Plant tissue is assessed for mRNA levels of constructs and plants with the highest expression level have their seeds planted (T1 plants) and those seeds harvested. This process is then repeated for successive generations and transformation stability is assessed.

Figure 2. Transformation Protocol for Camelina



Camelina normally does not synthesize a fatty acid with a chain length shorter than 16:0 carbons (**Table 1.**). Thus, to produce a shorter chain fatty acid, we transformed camelina to express the thioesterase from the California bay plant. This cleaves the fatty acids from fatty acid synthetase when the chain length is 12 and 14 carbons, thus producing 12:0 and 14:0. Using the lysophosphatidic acid acyl transferase from coconut, the incorporation of these fatty acids into the plant oil in the seed is facilitated. Currently have plants in the T7+ generation and the level of 12:0 and 14:0 is slightly less than

in Table 1, but still very commercially viable. A similar strategy was employed to make a canola with high lauric acid by Calgene and grown in the Park River, ND region a few years ago.

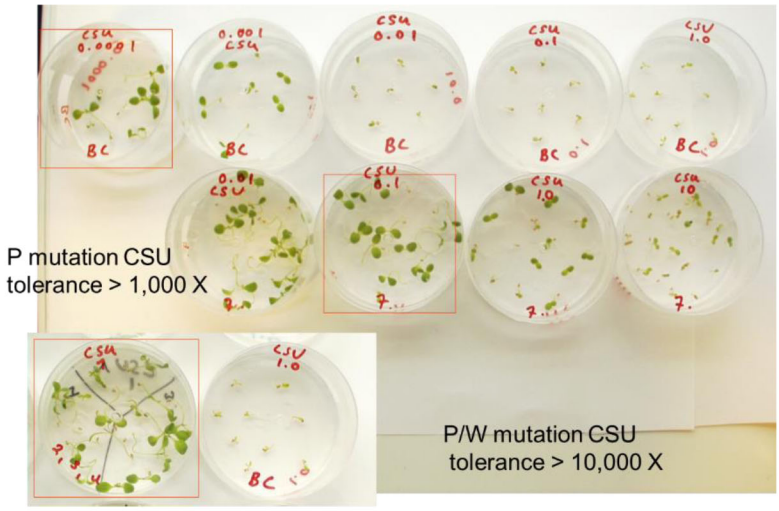
Table 1. Fatty acid composition of camelina producing 12:0 and 14:0

Fatty acid	1	2	4	5	6	7	8	9	10	Control	Vector
Lauric 12:0	3.4	6.4	23.1	19.8	0.2	14.5	13.5	10.7	4.4	0.0	0.0
Myristic 14:0	0.7	1.1	4.2	3.8	0.1	2.5	3.0	2.4	0.8	0.0	0.0
Palmitic 16:0	6.0	6.0	7.0	4.3	4.8	6.2	5.6	5.6	5.6	5.8	6.3
Stearic 18:0	3.4	2.8	2.1	2.3	2.9	2.8	2.5	2.5	3.2	4.0	4.4
Oleic 18:1n-9	14.8	14.0	9.9	8.8	16.9	10.9	10.6	11.1	11.8	17.2	14.7
Linoleic 18:2n-6	16.4	17.1	11.7	12.4	17.3	16.6	13.8	14.3	13.8	16.1	14.6
Linoleic 18:3n-3	31.7	29.7	28.9	30.8	32.3	27.2	30.3	33.5	36.8	31.5	34.1
Arachidic 20:0	1.9	2.0	1.8	2.0	1.9	2.5	2.3	2.2	2.7	2.0	2.4
Eicosenoic 20:1n-9	12.6	12.9	8.1	8.7	13.8	10.2	9.7	9.4	12.4	13.6	12.8
Eicosadienoic 20:2n-6	1.8	1.6	0.9	1.1	1.7	1.3	2.1	1.5	1.6	2.4	1.8
Eicosatrienoic 20:3n-3	1.4	1.2	0.8	1.0	1.4	0.9	1.2	1.3	1.6	1.5	1.7
Behenic 22:0	0.7	0.6	0.4	0.5	0.5	0.4	0.7	0.5	0.5	0.6	0.9
Erucic 22:1n-9	3.5	3.4	2.7	3.0	3.2	3.2	3.5	3.5	3.0	3.1	4.3
Lignoseric 24:0	0.4	0.3	0.3	0.3	0.6	0.5	0.2	0.3	0.3	0.3	0.3
Nervonic 24:1n-9	1.1	0.9	0.7	0.8	1.1	0.9	1.0	1.2	1.1	1.3	0.9
Camelina parent line	BC	BC	BC	BC	BC	BC	BC	BC	BC	BC	BC*

As highlighted in red are lauric (12:0) and myristic (14:0) levels in transformed line of the Blaine Creek varietal, which is a good performing camelina in fields. Note that there is normally no 12:0 or 14:0 in camelina. There is a reduction in 18:0 (stearic acid) and in 18:1 (oleic acid), although the essential fatty acids remain at a level similar to seeds from control and vector control plants. There is a modest reduction in 18:2, which when combined with the reduction in 18:1, would depress the iodine number. Similar changes in the fatty acids is maintained in successive generations (proprietary date, not presented).

Hence, we have plants that are stably transformed to produce 12:0 and 14:0. The seed stock of the best lines are being expanded for field trials as proposed in this application.

PROJECT 2.



A similar construct was made to transform camelina to express acetolactate synthase with up to three of the following mutations: A122T, P197S, and W574L. We found that while single P197S mutation increased tolerance 1,000-fold, but a combination of the P197S and W574L mutation provided the greatest increase in tolerance to chlorsulfuron >10,000-fold.

Figure 3. Enhanced tolerance to chlorsulfuron by P197S mutation and stacked P197S and W574L

Table 2. Single and combined mutations of ALS active sit on metsulfuron, chlorsulfuron, and imi tolerance in transformed camelina.

	IMI	MSU	CSU
C.microcarpa wt	< 0.001	< 0.001	<< 0.001
C.microcarpa W-mutation	> 0.1 100 X	> 0.1 10 -100 X	0.001- 0.01 100 X
Camelina wt (Blaine Creek)	0.01	0.0001	0.0001
Camelina W -mutation		0.0001	0.01 10 -100 X
Camelina P/W -mutation	10 1000 X	1 10 000 X	1 10 000 X
Camelina P/W -mutation/ *C.microcarpa* W-mutation	10 X	100 X	100 X

In **Table 2.**,increased tolerance of mutated camelina was assessed and compared wildtype camelina and to wildtype camelina macrocarpa and to mutated camelina macrocarpa (W574L). The red values represent the of herbicide where tolerance is lost. The W574L mutation demonstrated less tolerance to metsulfuron than chlorsulfuron but had no effect on imi tolerance. Combining the W574L mutation with the P197S mutation resulted in a 1,000-fold increase in tolerance to imi and a 10,000-fold increase in tolerance to mutsulfuron and chlorsulfuron. Additional stacked mutations did not add any additional tolerance to these class-2 herbicides. Hence, we moved forward with the plants with the combined W574L and P197S mutations.

These seed stocks for the best transformants is being expanded and will be used in field trials as indicated in Objective 2.

PROJECT 3.

In this project, purple acidic phosphatase-2 (PAP2) will be overexpressed in camelina. PAP2 is involved in regulation of plant carbon metabolism and when camelina is transformed with PAP2, seed weight per 100 seeds is increased 2-fold, indicating a heavier seed and a bigger seed (Zhang et al, 2012). In addition, seed yield increased 1.6-fold in one trial and 2-fold in another trial, indicating that seed yield is significantly increased. The plants also grow taller and have more flowers, consistent with increased seed formation. These data are very promising and suggest that this is a good target to enhance yield of camelina via two mechanisms, more seed and a seed that is 2X heavier, making harvesting easier.

Camelina will be transformed with PAP2 using our transformation strategy. We anticipate it will take 1.5 years to achieve stable transformed lines and an additional 0.5 years to expand the seed stock.

In **Figure 4.** camelina expressing PAP2 is considerably taller than the null transformed control camelina, which is about the same size as the wildtype control. Note the presence of more flower buds on the PAP2 overexpressing camelina.

Figure 4. OE lines expressing PAP2 and null transformed controls and wildtype control.

MANAGEMENT

The CamBioGene team has over 17+ years of work experience with senior management located in Grand Forks and laboratory operations based in Helsinki. Helsinki laboratory operations have been led by Dr. Viktor Kuvshinov for over 10 years. While our previous efforts were for Agaragen, OY, we will continue under CamBioGene to finish what we started several years ago.

We have substantial experience navigating this distance to keep projects on time and productive. This is done via remote management using a combination of:

- Weekly calls with Dr. Kuvshinov
- Data transmission via email and simultaneous analysis is Grand Forks and Helsinki followed by a discussion
- Zoom calls as needed
- Quarterly visits for face-to-face meetings in Helsinki
- Adjusting strategy based upon data obtained
- This recognizes that science is plastic, and we must adjust as needed to overcome obstacles to progress

Evaluations points are based upon phenotype analysis of each plant, including biochemical analysis as needed. Best performing lines are continued, with poorer performing lines stored. For Objectives 1 and 2, this is planting seed, analysis of phenotype, and continuation of selected lines to expand seed.

For Objective 3, this involves several additional evaluation points. This includes evaluation of transformation success, which may necessitate evaluation of construct organization, e.g. the sequence of genes and the polarization, e.g. 5' to 3' versus 3' to 5' insertion into the construct. The second key evaluation point is to assess transgene mRNA levels to determine transgene expression. Because this is a random insertion into the camelina genome, at times the plant will silence an insertion that it biologically cannot tolerate. Clearly of the 1000's of transformation events, not all are successful. The third key evaluation point is selecting T0 plants that produce seeds for the T1 generation. The T1 generation is planted and then evaluated for target phenotype, which is repeated for successive generations through minimally T5 generation, at which point the phenotype is considered stable. Hence, a key evaluation point in Objective 3 is the performance of each generation in the growth room and a selection process in which only the best transformed lines are moved forward to the next generation.

Overall, the CamBioGene team has a long history working together and honed a management strategy that is highly effective despite the distance.

TIMETABLE

Objectives 1 and 2

Seed Expansion and phenotype analysis	4Q23 through 4Q24
Final phenotype analysis and APHIS application	3Q24 through 1Q25 INTERIM REPORT in 1Q25

Planning field trial #1	3Q24 through 1Q25
Field trial #1	2Q25 through 3Q25
Data analysis field trial #1	3Q25 through 4Q25 INTERIM REPORT in 4Q25
Planning field trial #2	1Q25
Field trial #2	2Q26 through 4Q26
Data analysis field trial #2	3Q25 through 4Q25
Seed expansion	2Q26 through 3Q26
FINAL REPORT	1Q26

Anticipated submission of application for approval of specific lines of ALS mutated camelina and high lauric/myristic acid camelina for commercialization to APHIS.

Objective 3

Construct design and synthesis	4Q23 through 1Q24
Transformation of camelina	1Q24 through 2Q24
Phenotype assessment and data analysis	2Q24
Plant T1 seeds	2Q24 through 3Q24 INTERIM REPORT in 3Q24
Phenotype assessment and data analysis	3Q24
Plant T2 seeds	3Q24 through 4Q24
Phenotype analysis and data analysis	4Q24
Plant 4 seeds	4Q24 through 1Q25
Phenotype analysis and data analysis	1Q25
Plant T4	1Q25 through 2Q25
Phenotype analysis and data analysis	2Q25
Plant T5	3Q25 through 4Q25 INTERIM REPORT in 4Q25
Application to APHIS for field trials	4Q25
Plan field trials	1Q26
Field trial #1	2Q26 through 3Q26
Data analysis field trial #1	3Q26
FINAL REPORT	4Q26

BUDGET

Project Associated Expense	NDIC's Share	Applicant's Share (Cash)	Applicant's Share (In-Kind)	Other Project Sponsor's Share
Salaries + Fringe	350,000	$300,250	$108,000	$
Equipment	$0	$140,000	$	$
Supplies	70,000	$5,000		
Field Trials	$0	$40,000		
Travel	$0	$48,000		$
Indirect	$80,000	$10,000		
Total	$500,000	$543,250	$108,000	

Salaries
Viktor Kuvshinov $80,000 Svetlana Kuvshinova $50,000 Fringe $35,000 Total/year $165,000 x 3 = $495,000 TBA scientist (MS or PhD) $75,000 for 1.5 years $155,250,
IN KIND Eric J. Murphy $36,000 x 3 = $108,000
CBG- $300,250 NDIC-$350,000 Total cash $650,250

Equipment
Growth chamber, laminar flow hood, PCR machine, spectrophotometer, freezer, misc glassware and plasticware CBG $140,000 NDIC $0 Total $140,000

Supplies
Soil and growth room supplies $10,000 x 2.5 yrs = $25,000, DNA construct services $10,000, transformation supplies $15,000, PCR, mRNA, Southerns, phenotype testing $13,000, Oil and protein testing $12,000, other misc supplies $15,000 CBG $5,000 NDIC $70,000 Total $75,000

Field Trials and Seed Expansion
NDSU estimated $40,000 CBG$40,000 NDIC $0 Total $40,000

Travel
12 trips to Helsinki x $4,000 =$48,000 CBG $48,000 NDIC $0 Total $48,000

Indirect
Rent including utilities $90,000 CBG- $10,000 NDIC $80,000 Total $90,000

It is anticipated that this is an integrated budget for all three Projects. However, if other this application is partially funded, then the scope of the work would have to be adjusted to the altered budget, including the match by CamBioGene (CBG)

CONFIDENTIAL INFORMATION

A person or entity may file a request with the Commission to have material(s) designated as confidential. By law, the request is confidential. The request for confidentiality should be strictly limited to information that meets the criteria to be identified as trade secrets or commercial, financial, or proprietary information. The Commission shall examine the request and determine whether the information meets the criteria. Until such time as the Commission meets and reviews the request for confidentiality, the portions of the application for which confidentiality is being requested shall be held, on a provisional basis, as confidential.

If the confidentiality request is denied, the Commission shall notify the requester and the requester may ask for the return of the information and the request within 10 days of the notice. If no return is sought, the information and request are public record.

*Note: Information wished to be considered as confidential should be placed in separate appendices along with the confidentiality request. The appendices must be clearly labeled as confidential. If you plan to request confidentiality for **reports** if the proposal is successful, a request must still be provided.*

To request confidentiality, please use the template available at https://www.ndic.nd.gov/renewable-energy-program/rep-applicant-council-information.

If you are not requesting confidentiality, please note that below.

No confidential information has been disclosed and all information contained herein has been previously publicly disclosed.

PATENTS/RIGHTS TO TECHNICAL DATA

Again, there is no disclosure herein of proprietary information. Intellectual property will be protected via plant variety protection mechanisms.

STATE PROGRAMS AND INCENTIVES

Bioscience Innovation Grant Request $960,000 Funding $80,000, which requires a $40,000 match.

RENEWABLE ENERGY COUNCIL

Ballot for November 6th, 2023

Grant Round 52 Applications

Name:

RECOMMEND FUNDING	DO *NOT* FUND	
		R-052-A – Smart Holistic Zero Waste Utilization Paradigm (SH0WUP); Submitted by UND; Total Project Costs: $3,780,360; **Amount Requested: $500,000** Contingencies: •
		R-052-B – Prairie Horizon Carbon Management Hub; Submitted by EERC; Total Project Costs: $3,225,000; **Amount Requested: $100,000** Contingencies: •
		R-052-C – Use of Bioengineering to Enhance the Agronomic Potential of Camelina; Submitted by CamBioGene; Total Project Costs: $1,151,250; **Amount Requested: $500,000** Contingencies: •