INDUSTRIAL COMMISSION OF NORTH DAKOTA

RENEWABLE ENERGY PROGRAM

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

Renewable Energy Council

June 22, 2023, 1:00 pm (CT)

Room 103, Bismarck Event Center, 315 South 5th Street, Bismarck, ND 58504[1]

Click here to join the meeting

+1 701-328-0950,,374427315#

I. 1:00 p.m. Call to Order – *Josh Teigen*

1. Welcome & Opening Comments – *Josh Teigen/Rich Garman/ Reice Haase*
2. **Consideration of December 8, 2022 Meeting Minutes** – *Josh Teigen*
3. Renewable Energy Program Legislative Update – *Reice Haase*
    a. 2023-2025 Appropriation
    b. House Bill 1014: Digitization and Grant Management Software
    c. House Bill 1014: Carbon Capture Education
4. Project Management and Financial Report – *Reice Haase*

II. 1:30 p.m. **Consideration of Grant Round 51 Requests** – *Rich Garman*

1. R-051-A – **Integrated Renewable Combined Heat and Power for Ethanol;** Submitted by EERC; Total Project Costs: $2,250,000; Amount Requested: $450,000
    a. Technical Reviewer Results and Applicant's Response
    b. Technical Advisor Recommendations
    c. Applicant Presentation

2. R-051-B – **Clean Hydrogen from High-Volume Waste Materials and Biomass**; Submitted by EERC; Total Project Costs: $2,500,000; Amount Requested: $500,000
    a. Technical Reviewer Results and Applicant's Response
    b. Technical Advisor Recommendations
    c. Applicant Presentation

3. R-051-C – **DEFC Research and Development**; Submitted by 4H2, Inc.; Total Project Costs: $693,832; Amount Requested: $346,915
    a. Technical Reviewer Results and Applicant's Response
    b. Technical Advisor Recommendations
    c. Applicant Presentation

4. R-051-D – **Carbon Convert;** Submitted by Marlo Anderson, LLC; Total Project Costs: $4,500,000; Amount Requested: $500,000
    a. Technical Reviewer Results and Applicant's Response
    b. Technical Advisor Recommendations
    c. Applicant Presentation

[1] The North Dakota Indian Affairs Commission is hosting the Renewable Energy Council meeting during a breakout session of their Strengthening Government to Government Conference. Registration and attendance are free and open to the public.

III. 3:30 p.m. **Break**

IV. 3:45 p.m. **Discussion/Completion of Ballot**

1. Discussion and Completion of Ballot

V. 4:15 p.m. **Administrative Business**

1. Discussion for Proposed Round 52 Deadline – October 2, 2023
2. Proposed dates for next REC Meeting – November 13th, 14th, or 20th, 2023

VI. 4:45 p.m. Other Business

VII. 5:00 p.m. Adjourn

Minutes of the

RENEWABLE ENERGY COUNCIL (REC)

Thursday, December 8, 2022

1:00 pm (CT)

TEAMS Meeting Via Conference/Video Call

ONSITE Location: WSI Boardroom, 1600 E. Century Ave., Ste. 1, Bismarck

Members Present	Staff Present	Guests Present
Josh Teigen	Reice Haase, NDIC	Dr. Srivats Srinivasachar
Gerald Bachmeier	Karen Tyler, NDIC	Yun Ji
Al Christianson	Brenna Jessen, NDIC	Junior Nasah
Terry Goerger	Rich Garman, Commerce Dept.	Johannes van der Watt
Tony Grindberg	Joleen Leier, Commerce Dept.	Daniel Laudal
Rodney Holth		Dongmei Wang
		Mat Hirst
		Steve Kemp
		Mark Watson
		William Gosnold

WELCOME & OPENING COMMENTS

Rich Garman called the Renewable Energy Council (REC) meeting to order at 1:03 pm and stated Chairman Teigen will join later. Garman welcomed the members and guests in the conference room and on the TEAM video/audio platform. Reice Haase, Deputy Executive Director of the Industrial Commission introduced himself in his new role.

APPROVAL OF MINUTES

The minutes from the March 30, 2022 meeting were presented to the board. Bachmeier noted that he provided the "second motion" for approval of the September 22, 2021 minutes. **With that change noted, it was moved by Goerger and seconded by Bachmeier to approve the March 30, 2022 meeting minutes. The motion carried unanimously.**

PRESENTATION OF FINANCIAL STATEMENT

Reice Haase presented the financial report that had been posted on the Industrial Commission/Renewable Energy website. As of September 30, 2022, the uncommitted funds for the current biennium are $2,942,853.45. **It was moved by Goerger and seconded by Bachmeier to approve the financials as presented. The motion carried unanimously.**

REPORT ON GRANT ROUND 50 APPLICATIONS

Six applications were received, six were sent to Technical Reviewers for peer review. All six applications received scoring that supported funding and will be reviewed today for the Council's consideration. Total amount being considered for Round 50 is $2,232,159. Rich Garman, of the Commerce Department, presented the Grant Round Requests.

CONSIDERATION OF SPECIAL GRANT ROUND 50 REQUESTS

R-050-A – Novel process for Biocoal Production with CO2 Mineralization to Achieve Negative Carbon Emissions

Principal Investigator: Dr. Srivats Srinivasachar

Project Duration: 180 months

Requesting: $174,830

Total Project Cost: $349,825

Reviewers' Ratings

- Fund – 189/250
- Fund – 205/250
- Fund – 223/250
- Average Weighted Score – 205.67/250

Dr. Srivats Srinivasachar presented on the project.

R-050-B - Flexible Direct Air Capture System – Flex-DAC
Principal Investigator: Junior Nasah
Project Duration: 2 years
Requesting: $499,452
Total Project Costs: $1,670,138

Reviewers' Ratings

- Fund – 188/250
- Fund – 184/250
- Fund – 197/250
- Average Weighted Score – 189.67/250

Junior Nasah presented on the project.

Nasah confirmed they do have a federal grant.

R-050-C - Enhanced Sweep Efficiency for Geothermal Renewable Energy Using Bio-Polymer Supplement
Principal Investigator: Dongmei Wang
Project Duration: 2 years
Requesting: $468,877
Total Project Costs: $942,877

Reviewers' Ratings

- Fund – 220/250
- Fund – 192/250
- Fund – 205/250
- Average Weighted Score – 205.67/250

Garman stated the lower scores in the reviewers' ratings appear to pertain to the budget that should be addressed in the presentation.

Dongmei Wang presented on project.

There was a question regarding the charge of $418,000. Wang clarified this is for three software licenses (one license per machine) to utilize the software for two years.

R-050-D – Production of Hydrogen and Valuable Carbons from Methane-Sources
Principal Investigator: Johannes van der Watt
Project Duration: 1 year
Requesting: $180,000
Total Project Costs: $360,000

Reviewers' Ratings
- Funding May be Considered – 136/250
- Fund – 198/250
- Fund – 209/250
- Average Weighted Score – 181/250

Johannes van der Watt presented on the project.

There was a question regarding the carbon capture process. Van der Watt explained the process and how the optimization tools could bridge a gap by utilizing the new technology.

There was a question about how this research different than what the other companies out there are doing? This technology is the best to store the hydrogen, we don't produce carbon dioxide. This technology also brings together the optimization tool.

R-050-E – Unlocking Lithium Extraction in Produced Water
Principal Investigator: Mat Hirst
Project Duration: 6 months
Requesting: $500,000
Total Project Costs: $1,000,000

Reviewers' Ratings
- Fund – 200/250
- Fund – 205/250
- Fund – 184/250
- Average Weighted Score – 196.33/250

Mat Hirst presented on the project.

There was a question to confirm if they have capital if they receive grant funds. Hirsch confirmed they do have capital.

R-050-F – Modular Biomass Gasification for Co-Production of Hydrogen and Power
Principal Investigator: Junior Nasah
Project Duration: 2 years
Requesting: $500,000
Total Project Costs: $2,120,000

Reviewers' Ratings

- Fund – 179/250
- Fund – 197/250
- Fund – 186/250
- Average Weighted Score –187.33/250

Junior Nasah presented on the project.

The number of man hours needed was questioned. Nasah explained they will have approximately 4.5 full-time employees and 3 full-time graduate students.

There was a question asking if they have contacted anyone else for funding. Nasah responded "No".

CONSIDERATION OF CONFIDENTIAL INFORMATION

Reice Haase explained the next portion of the agenda would be the Executive Session to consider confidential information. The purpose of this Executive Session would be to discuss the confidential information in your packets and ask questions of the applicant in private. If the board has questions, we will need to go hold Executive Session separately for each application.

The board members indicated they did not have any questions for the applicants.

DISCUSSION/COMPLETION OF BALLOTS

R-050-A – Novel process for Biocoal Production with CO2 Mineralization to Achieve Negative Carbon Emissions
Project Duration: 180 months
Requesting: $174,830
Total Project Cost: $349,825
Conflict of Interest: None
Fund: 4 Do Not Fund: 1 Abstain: 0

R-050-B – Flexible Direct Air Capture System – Flex-DAC
Project Duration: 2 years
Requesting: $499,452
Total Project Costs: $1,670,138
Conflict of Interest: None
Fund: 1 Do Not Fund: 4 Abstain: 0

R-050-C – Enhanced Sweep Efficiency for Geothermal Renewable Energy Using Bio-Polymer Supplement
Principal Investigator: Dongmei Wang
Project Duration: 2 years
Requesting: $468,877
Total Project Costs: $942,877
Conflict of Interest: None
Fund: 4 Do Not Fund: 1 Abstain: 0

R-050-D – Production of Hydrogen and Valuable Carbons from Methane-Sources
Project Duration: 1 year
Requesting: $180,000
Total Project Costs: $360,000
Conflict of Interest: None
Fund: 3 Do Not Fund: 2 Abstain: 0

R-050-E – Unlocking Lithium Extraction in Produced Water
Project Duration: 6 months
Requesting: $500,000
Total Project Costs: $1,000,000
Conflict of Interest: None
Fund: 5 Do Not Fund: 0 Abstain: 0

R-050-F – Modular Biomass Gasification for Co-Production of Hydrogen and Power
Project Duration: 2 years
Requesting: $500,000
Total Project Costs: $2,120,000
Conflict of Interest: None
Fund: 5 Do Not Fund: 0 Abstain: 0

ADMINISTRATIVE BUSINESS

Reice Haase presented the project management update. The program has 13 active projects and have awarded $4.3 million. There is $3.5 Million outstanding committed dollars and have paid $0.8 Million to date. The projects submit reports to us that includes receipts. We review and information to ensure compliance with the rules prior to issuing payment to the projects.

Haase gave an update on the following completed projects:

- Fargo Smart Energy Ramp – start date was 12/1/2018. This is an installed rooftop solar, smart meter, AI battery charging and was installed at Roberts Commons Parking garage in Fargo. REC provided $305,000 of $610,000 project.
- Low-Pressure Electrolytic Ammonia – start date was 6/15/18. This is electrolytic ammonia production at ambient pressure; EERC-NDSU developed membrane. This is successful synthesis of ammonia within a temperature range of 200-300 degrees Celsius. They found they could produce ammonia at $700/ton versus Tampa Spot price of $1,400/ton. REC provided $437,000 of $3,164,010 project.
- Feed Study for Creosote Treated Railroad Ties – start date was 2/1/22. They evaluate creosote railroad ties as alternative fuel source. They found there is competition for used ties which could limit supply. Use of other preservatives could damage the boilers. Cost to modify boilers is up to $52 million. REC provided $66,500 of $133,000 project.

There was discussion regarding the next grant round. Proposed Round 51 deadline is May 1, 2023 (after legislative session). The next Renewable Energy Council meeting will be June 22 or 23, 2023. It was noted that June 22 is preferred.

Minutes of the

RENEWABLE ENERGY COUNCIL (REC)

Thursday, December 8, 2022

1:00 pm (CT)

TEAMS Meeting Via Conference/Video Call

ONSITE Location: WSI Boardroom, 1600 E. Century Ave., Ste. 1, Bismarck

ADJOURNMENT

Motion made by Holth and seconded by Christianson to adjourn the meeting. Garman adjourned the meeting at 3:55 pm.

INDUSTRIAL COMMISSION OF NORTH DAKOTA

Doug Burgum
Governor

Drew H. Wrigley
Attorney General

Doug Goehring
Agriculture Commissioner

Memorandum

TO: Renewable Energy Council

FR: Reice Haase

DT: June 22nd, 2023

RE: Report on 68th Legislative Session

The 68th Legislative Session concluded on April 30th, 2023. Highlights relevant to the Renewable Energy Program are summarized as follows:

- Appropriation remained unchanged at $3 million for 2023-2025 biennium
- 2 new FTEs for the Office of the Industrial Commission
    - 1 Grant Administrator
    - 1 Administrative Support
- $1.25 million for grant management software and records digitization, up to $250,000 of which is transferred from the Renewable Energy Development Fund
    - Online portal for applicants, collection of application fees
    - Real-time project dashboard
    - Real-time financial reporting
- New meeting management software
    - Digital meeting packets
    - Simplified file-sharing

- Carbon Capture Education:

HB 1014 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.

House Bill 1014 included the above provisions and was signed by the Governor on May 5th. It becomes effective July 1, 2023.

RENEWABLE ENERGY PROGRAM PROJECT MANAGEMENT AND FINANCIAL REPORT

Reice Haase, Deputy Executive Director, NDIC

June 22, 2022

NORTH Dakota
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ACTIVE PROJECTS

17
Active Projects

$1.7 Million
Paid To Date

$6.6 Million
Awarded Dollars

$4.8 Million
Outstanding Committed Dollars

$1.1 Million
Cash Available for Commitment in Renewable Energy Fund

Renewable Energy Program Active Projects

Contract #	Project Name	Company	Total Project Cost	Original Commitment	Spent to Date	Balance
R-025-035	Pilot Scale Facility for Biocomposite Development for Industrial and Consumer Products	c2renew	$ 1,250,000.00	$ 500,000.00	$ 330,443.74	$ 169,556.26
R-027-036	Gateway to Science Ethanol Exhibit	North Dakota Ethanol Council	$ 110,000.00	$ 50,000.00	$ 35,000.00	$ 15,000.00
R-027-037	Landfill Gas to Compressed Natural Gas Fast-Fill Fueling Station	City of Fargo	$ 1,000,000.00	$ 500,000.00	$ 15,000.00	$ 485,000.00
R-042-052	Living Stone Lodge-Phase III	MHA Nation-South Segment	$ 917,812.00	$ 398,850.00	$ 237,038.55	$ 161,811.45
R-045-054	Spiritwood Greenhouse CO2 Supply	Glass Investment Projects Inc	$ 2,684,713.00	$ 500,000.00	$ -	$ 500,000.00
R-045-055	Autonomous Operations within the North Dakota Renewable Energy Sector	Evolve Analytics LLC	$ 2,271,645.00	$ 500,000.00	$ 450,000.00	$ 50,000.00
R-046-056	Electrostatic Lubrication Filtration of Wind Turbine Oil Reservoirs	UND Institute for Energy Studies	$ 584,614.00	$ 286,234.00	$ 147,553.03	$ 138,680.97
R-046-057	Geothermal Development Consortium	UND College of Engineering & Mines	$ 873,895.00	$ 432,895.00	$ 128,452.70	$ 304,442.30
R-047-058	Seismic Survey to Advance Potential for CO2 Storge in Eastern ND	Midwest AgEnergy Group	$ 649,280.00	$ 324,640.00	$ 238,163.16	$ 86,476.84
R-048-060	Renewable Hydrogen Microgrid	BWR Innovations LLC	$ 665,909.00	$ 332,159.00	$ 184,356.07	$ 147,802.93
R-048-061	Grand Forks Green Ag-Park	Quintessence Partners LLC	$ 4,290,000.00	$ 500,000.00	$ -	$ 500,000.00
R-049-062	MSCTM High Protein Project	GP Turnkey Tharaldson, LLC	$ 80,322,468.00	$ 500,000.00	$ -	$ 500,000.00
R-050-064	Novel Process for Biocoal Production with CO2 Mineralization to Achieve Negative Carbon Emissions	Envergex LLC	$ 349,825.00	$ 174,830.00	$ -	$ 174,830.00
R-050-065	Enhanced Sweep Efficiency for Geothermal Renewable Energy Using Bio-Polymer Supplement	University of North Dakota (UND)	$ 942,877.00	$ 468,877.00	$ -	$ 468,877.00
R-050-066	Production of Hydrogen and Valuable Carbons from Methane-Sources	University of North Dakota (UND)	$ 360,000.00	$ 180,000.00	$ -	$ 180,000.00
R-050-067	Unlocking Lithium Extraction in Produced Water	Triple 8, LLC Dba Wellspring Hydro	$ 1,000,000.00	$ 500,000.00	$ -	$ 500,000.00
R-050-068	Modular Biomass Gasification for Co-Production of Hydrogen and Power	University of North Dakota (UND)	$ 2,120,000.00	$ 500,000.00	$ -	$ 500,000.00
			$ 100,393,038.00	**$ 6,648,485.00**	**$ 1,766,007.25**	**$ 4,882,477.75**

Renewable Energy Development Fund
Financial Statement
2021-2023 Biennium
June 22, 2023 Renewable Energy Council Meeting

	Cash Balance
July 1, 2021 Balance	4,928,500.06
Revenues from Resources Trust Fund through April 30, 2023	$3,000,000.00
Interest & Other Revenues through April 30, 2023	$14,262.67
Refund/returned cash	$16,036.63
Administrative Expenditures through April 30, 2023	($68,486.16)
Grant Expenditures through April 30, 2023	($1,808,861.57)
Cash Balance as of April 30, 2023	6,081,451.63
Outstanding Administrative Commitments	($71,513.84)
Outstanding Project Commitments as of April 30, 2023	($4,882,477.75)
Uncommitted Cash as of April 30, 2023	**1,127,460.04**

Renewable Energy Development Fund
Continuing Appropriation Authority
2021-2023 Biennium Projections

July 1, 2021 Balance of Uncommitted Dollars	$1,994,675.97
Transfer from Resources Trust Fund for 2021-2023 Biennium	$3,000,000.00
Interest Income (Estimated)	$10,000.00
Income from Project Applications (Estimated)	$1,800.00
Returned commitments	$991.05
	$5,007,467.02
Administrative Commitments (Estimated)	($140,000.00)
Commitments 2021-2023	($3,743,256.00)
	$1,124,211.02

There were no changes made to the Renewable Energy Fund during the 2021 legislative session. Following the 2017 Legislative Session N.D.C.C. Section 57-51.1-07. Allocation of moneys in Oil Extraction Tax Development Fund states the following:

Three percent of the amount credited to the Resources Trust Fund must be transferred no less than quarterly into the Renewable Energy Development Fund, not to exceed three million dollars per biennium.

Renewable Energy Development Fund (54-63-04, N.D.C.C.) – Continuing appropriation. The Renewable Energy Development Fund is a special fund in the state treasury. All funds in the Renewable Energy Development Fund are appropriated to the Industrial Commission on a continuing basis for the purpose of carrying out and effectuating this chapter. Interest earned by the Fund must be credited to the Fund.

Renewable Energy Development Program
Grant Round 51 Applications (June 2023)

Grant #	Application Title	Applicant	Principal Investigator	Funding Requested	Total Project Costs	Category	Confidentiality Requested	Duration	Funding Info
R-051-A	Integrated Renewable Combined Heat and Power for Ethanol	EERC	Joshua R. Strege	$450,000	$2,250,000	Biofuel	No	18 Months	Match provided by DOE and Red Trail Energy
R-051-B	Clean Hydrogen from High-Volume Waste Materials and Biomass	EERC	Dr. Michael L. Swanson	$500,000	$2,500,000	Hydrogen	No	21 Months	Match provided by DOE and Simonpietri Enterprises
R-051-C	DEFC Research and Development	4H2, Inc.	Dr. Yang Yang	$346,915	$693,832	Biofuel	No	24 Months	Match provided by 4H2
R-051-D	Carbon Convert	Marlo Anderson LLC	Steve Bakken	$500,000	$4,500,000	CCUS	No	12 Months	Applicant providing $600,000 of match, source of other project sponsor match is unclear
	Total being considered			**$1,796,915**	**$9,943,832**				

EERC
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018 • Grand Forks, ND 58202-9018 • P. 701.777.5000 • F. 701.777.5181
www.undeerc.org

February 1, 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. 2023-0100 Entitled "Integrated Renewable Combined Heat and Power for Ethanol"

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.

Enclosed please find an original and one copy of the subject proposal along with the application fee. Please note that the enclosed check for $200 covers this application (EERC Proposal No. 2023-0100) as well as the application being submitted under EERC Proposal No. 2023-0089.

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.

If you have any questions, please contact me by telephone at (701) 777-5080 or by email at jstrege@undeerc.org.

Sincerely,

DocuSigned by:
80B7CE5336464B9...
Joshua R. Strege
Assistant Director for Energy Systems

Approved by:
DocuSigned by:
29499751F2B84D7...
Charles D. Gorecki, CEO
Energy & Environmental Research Center

JRS/rlo
Enclosures

c: Karen Tyler, North Dakota Industrial Commission

Renewable Energy Program

North Dakota Industrial Commission

Application

Project Title: Integrated Renewable Combined Heat and Power for Ethanol

Applicant: Energy & Environmental Research Center (EERC), University of North Dakota; EERC Proposal No. 2023-0100

Principal Investigator: Joshua R. Strege

Date of Application: February 1, 2023

Amount of Request: $450,000

Total Amount of Proposed Project: $2,250,000

Duration of Project: 18 months

Expected Start: June 1, 2023

Point of Contact (POC): Joshua R. Strege

POC Telephone: (701) 777-5080

POC Email: jstrege@undeerc.org

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

Lead Organization: EERC

Cost Share Partner: U.S. Department of Energy Office of Fossil Energy and Carbon Management

TABLE OF CONTENTS

ABSTRACT

The Energy & Environmental Research Center (EERC) proposes to develop a detailed study of how gasification-based combined heat and power (CHP) using corn stover as fuel with CO_2 capture could benefit the state's ethanol industry. CO_2 capture from fermentation is already providing financial benefit through Section 45Q tax credits for stored CO_2 and has potential for California Low Carbon Fuel Standard (LCFS) credit sales. Making the ethanol process even less carbon-intensive by replacing natural gas with renewable syngas and adding additional CO_2 capture is expected to provide additional economic benefits. To complete this study, the EERC will characterize regional corn stover for its suitability and availability as gasifier feedstock; will conduct several weeks of stover gasification under different conditions to examine the impact on CO_2 capture solvent; will develop techno-economic models of a gasification CHP integrated into an ethanol plant; and will conduct life cycle analyses of the process to estimate potential for LCFS credits. **Objective:** The goal of the proposed project is to determine the technical and economic feasibility of implementing small-scale commercial CHP using corn stover at an operational ethanol facility. **Expected Results:** By the end of the project, the EERC

expects to have a thorough working knowledge of the specific challenges and solutions to using corn stover to provide heat and power using gasification with CO_2 capture. These data will be used to develop an engineering design for a well-integrated CHP system at an ethanol plant. In turn, this engineering design will allow the EERC to estimate the economic feasibility of using renewable heat and power with CO_2 capture at a North Dakota ethanol facility, including how the reduced carbon intensity can provide additional LCFS credits and payments for CO_2 sequestration. **Duration:** 18 months, with an anticipated start date of June 1, 2023. **Total Project Cost:** $2,250,000, with $450,000 from the North Dakota Industrial Commission Renewable Energy Program and $1.8 MM from federal funding. **Participants:** EERC, U.S. Department of Energy, and Red Trail Energy.

PROJECT DESCRIPTION

Introduction: Several recent factors have driven a strong push to decarbonize ethanol facilities in North Dakota. First, the California Low Carbon Fuel Standard (LCFS) allows fuel producers with a lower carbon intensity (CI) score than conventional petroleum fuel to earn CO_2 credits for fuel sold in California (replacing petroleum), with credits averaging about $130 per tonne of CO_2 in 2022 (Californica Air Resources Board, LCFS Data Dashboard, 2023). Second, the recent Bipartisan Infrastructure Law increased the value of sequestered CO_2 from $50 to $85/tonne and converted the payout mechanism from tax credits to direct pay for the first 5 years of operation. Third, the successful capture and storage of naturally fermented CO_2 from Red Trail Energy has proven the feasibility and potential for CO_2 capture from ethanol plants in North Dakota.

While the Red Trail Energy project has successfully demonstrated commercial CO_2 capture from the plant's fermenters, CO_2 is generated from multiple locations in ethanol plants, and additional capture is possible. However, whereas the fermenter CO_2 is relatively pure and needs only to be dried and compressed, CO_2 emissions from other units (such as boilers and driers) are dilute and require additional separation. Moreover, while the CO_2 from the fermenter is derived from corn and is largely renewable, other CO_2 sources are normally derived from natural gas or other fossil fuels. New approaches to provide steam, drying, and CO_2 capture are required to further reduce the CI score of North Dakota's ethanol facilities.

One option to provide a renewable natural gas replacement is biomass gasification. Ethanol plants are naturally located close to farmers growing corn, and past experience at the Energy & Environmental Research Center (EERC) has shown that corn stover can be readily gasified using technology such as a fluidized-bed gasifier (Stanislowski, 2022). Syngas generated in the gasification process can be fed to a microturbine or reciprocating engine to generate electrical power, and the waste heat from the process can be used to generate steam or to provide drying. With proper engineering design, this overall combined heat and power (CHP) process can be integrated into the ethanol plant for maximum efficiency. For processes that require significant electrical power, such as CO_2 compression, CHP using gasification can be more attractive than using combustion because of the potential for high power-to-heat ratios (DOE, 2017). Another advantage of gasification over combustion is that CO_2 can be captured using less energy-intensive processes. In combustion, CO_2 from the flue gas is usually captured using amine-based solvents. These amine-based solvents must be heated to high temperatures to recover the CO_2, then cooled again for capture. With pressurized gasification units, physical solvents can be used to absorb the CO_2 at pressure, and the CO_2 can then be recovered by reducing pressure and gently heating the physical solvent. Typical commercial physical solvent are blends of dimethyl ethers of polyethylene glycol, or DEPG.

Although there is significant potential for gasification-based CHP to benefit ethanol plants, an integrated CHP system has yet to be proven. Under an initial project funded through the State Energy Research Center (SERC), the EERC is currently completing a preliminary high-level study into the feasibility of different CHP options for ethanol plants. The proposed work will build on this initial SERC effort to better identify the challenges and solutions to gasifying corn stover to provide renewable CHP for an ethanol facility.

Objectives: The goal of the proposed project is to determine the technical and economic feasibility of implementing small-scale commercial CHP using corn stover feedstock at an operational industrial facility to validate a reduced-CI ethanol fuel applicable for low-carbon fuel programs. Specific objectives include the following:

- Complete a resource characterization study to determine the availability and suitability of corn stover for gasification-based CHP at an ethanol facility.
- Develop the data necessary to conduct a techno-economic analysis through pilot-scale testing.
- Evaluate the economic feasibility of CHP deployment, including techno-economic estimates of installation and operating costs, as well as identify potential revenue, such as carbon credits and carbon markets.
- Conduct life cycle assessments (LCAs) of gasification-based CHP to estimate CI score and possible benefit for LCFS credits.

80% cost share for the project will be provided by the U.S. Department of Energy (DOE) – Office of Energy and Carbon Management (FECM), with the remaining 20% share requested through NDIC's Renewable Energy Program.

Methodology: The project will be organized into four tasks. The task structure is identical to that in the matching proposal being submitted to 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 quarterlies and the final report. Results will be provided in project meetings to NDIC and will be shared at one or more technical conferences.

Task 2 – Biomass Characterization – Initial work under a SERC-funded study has identified some of the challenges that corn stover could present for a gasification-based CHP facility. Under Task 2, the EERC will procure corn stover from a regional source. The stover will be dried and processed as needed to be suitable for feeding into a gasifier. Any unique challenges with feedstock processing will be noted, and these data will be used to guide the engineering design efforts around fuel handling. In addition, the stover will be characterized for its fuel properties using proximate/ultimate analysis and for its ash composition using x-ray fluorescence (XRF). The XRF in particular will help to inform the team on optimal gasifier operation. Biomass can contain high levels of alkali material, which lowers the melting temperature of ash and can lead to sticky agglomerations that plug up gasifiers, leading to shutdowns and excessive maintenance. Additives such as kaolin are known to help reduce the tendency of alkali to cause agglomerations, but fuel additives present additional operational cost. XRF analysis is important to help predict ash melting temperatures and to determine optimum dosing of kaolin or other additives. Additionally, ash melting behavior will be directly tested using slag viscosity measurements.

In parallel with fuel characterization, the EERC also proposes to assess the regional availability and storage options for corn stover. The amount of stover that can be taken off the field will be dependent on regional soil conditions, which vary from the eastern to the western portion of the state. Moreover, while ethanol plants operate year-round, stover is only generated during harvest and must be stored if it is to be used as fuel for a CHP system. The EERC will study regional options for harvest and storage, including drying needs and the impacts of long-term field storage on stover's quality as a gasifier fuel.

Task 3 – Gasification – The EERC will use existing pilot-scale facilities to study gasifier and carbon capture performance when using 100% corn stover as a fuel. Corn stover that was dried and processed under Task 2 will be fed to a pressurized fluidized-bed gasifier to generate syngas. Based on studies completed under Task 2, kaolin or other additives may be blended with the stover to reduce the potential for agglomeration. The syngas will be cleaned to remove particulates and any traces of sulfur, shifted to convert most of the carbon monoxide to CO_2, and then passed through the EERC's carbon capture system. A commercially available solvent based on a mixture of dimethyl ethers of polyethylene glycol (DEPG) will be used to remove >90% of the CO_2.

The EERC will study both oxygen-blown and air-blown gasification of corn stover. In large-scale commercial gasifiers, fuel is gasified using purified oxygen mixed with steam to provide maximum efficiency. In smaller gasifiers, the cost of air separation to provide oxygen becomes prohibitive, and most small units are air-fired. National Energy Technology Laboratory (NETL) is actively researching new technologies to reduce the cost of small-scale air separation specifically to encourage more efficient small-scale gasification and has reported several recent successes (Dou, 2022; Singh, 2022). Because small-scale oxygen-blown gasification could become more attractive in the near future, it is worth comparing gasifier performance with both air and oxygen to study expected performance for CHP. In both cases, the CO_2 capture solvent will be exposed to syngas for periods of up to 200 hours. These tests will determine the impact of biomass-derived impurities on carbon capture performance and how these might differ when using oxygen versus air. Previous carbon capture testing at the EERC with coal and biomass blends (Stanislowski, 2022) showed that there were no major showstoppers observed when utilizing biomass as a feedstock, but longer-duration testing would enable the team to evaluate long-term impacts and, ultimately, the economics of the system.

Syngas will be sampled at various locations using Fourier transform infrared (FTIR) spectrometry and Dräger tubes to measure concentrations of organic tar components entering and leaving the carbon capture unit. This information will help to determine whether different components are accumulating in the CO_2 capture solvent, are passing through with the syngas, or are ending up in the CO_2 stream and might need to be removed before the CO_2 can be compressed and transported. Solvent samples will be taken throughout each week of testing and analyzed using gas chromatography coupled to mass spectrometry (GC–MS). The EERC has used GC–MS in the past to qualitatively monitor the buildup of tar components in CO_2 capture solvent. Based on past experience, the EERC will better develop this analytical method to help quantify the amount of tar accumulating in the solvent. This method development will provide a useful technique for future studies of the long-term impacts of different fuels on CO_2 capture solvent.

Task 4 – Integration Studies and Techno-Economic Analysis – Task 4 will develop a design for a fully integrated CHP system at an ethanol plant. The study will estimate the high-level technical and economic feasibility of such a system and will provide an LCA of a proposed CHP system design.

The overall design will be based on findings from Tasks 2 and 3 regarding fuel processing, gasifier performance, CO_2 capture performance, long-term impacts of biomass tar on CO_2 solvent and potential mitigation strategies, and needs at the ethanol plant. It is expected that the design will be sized to provide all electrical power needed for CO_2 compression, both from the CO_2 capture unit and also from the ethanol plant's fermenter. Initial designs from the EERC's SERC study predict that a CHP facility of this size will require only a portion of the stover available from corn harvest, though this will depend on findings from Task 2 regarding how much stover can be taken off the field in different areas of the state.

Although a very high-level technical model was developed under the SERC study, this model did not account for actual gasifier performance, for feedstock handling, or for how the heat and power generated at a CHP plant would actually be integrated into an ethanol facility. Under Task 4, the EERC will use plant information provided by Red Trail Energy to design an integrated CHP system. It is anticipated that such a system would include some syngas offtake for direct firing, a gas turbine or reciprocating engine for generating power from the bulk of the syngas, a heat recovery steam generator for generating steam from the hot engine exhaust, and steam offtake at different temperatures and pressures depending on the specific needs of different unit operations.

Once the technical design is completed, it will be used to conduct an LCA in accordance with NETL guidelines. An additional LCA assessment will be conducted using the California Greenhouse Gas, Regulated Emissions, and Energy Use in Transportation (CA-GREET) model, helping to provide insight into how a gasification-based renewable CHP system with CO_2 capture might provide eligibility for LCFS credits to an ethanol facility.

Anticipated Results: The final product will be a techno-economic analysis and feasibility-level review of this integrated renewable CHP project with a road map for potential implementation.

Facilities: The EERC's pressurized fluidized-bed gasifier (Figure 1) has been successfully operated on dozens of fuels for over more than 15 years of operation, and the CO_2 capture system has been operated for thousands of hours on a wide variety of syngas compositions. The gasifier and capture system were previously operated for short durations on 100% biomass feeds and on blends of up to 50% corn stover with coal. As such, the EERC is very confident in the capabilities of this system to gasify corn stover and to capture CO_2. Previous work has already identified the major concerns to CO_2 capture solvent performance that were observed over shorter durations, so the team is fully prepared on what data to gather and on what forms of degradation to expect during longer-term operation.

Resources: Red Trail Energy will provide information on its ethanol plant and the specific requirements for CO_2 capture from its fermenter (see letter of support in Appendix A). This information will be used to design the integrated CHP system to optimize how each stream can be best used in an existing ethanol facility using CO_2 capture.

Techniques to Be Used, Their Availability and Capability: The Aspen software package proposed for Activity 4 is an industry-standard tool used to model complex reactor systems. This software includes built-in modules to accurately model CO_2 capture performance. The EERC has used Aspen to conduct numerous techno-economic assessments of CO_2 capture performance with more than 15 years of experience and is well-versed in the approaches to accurately size, model, and cost major process

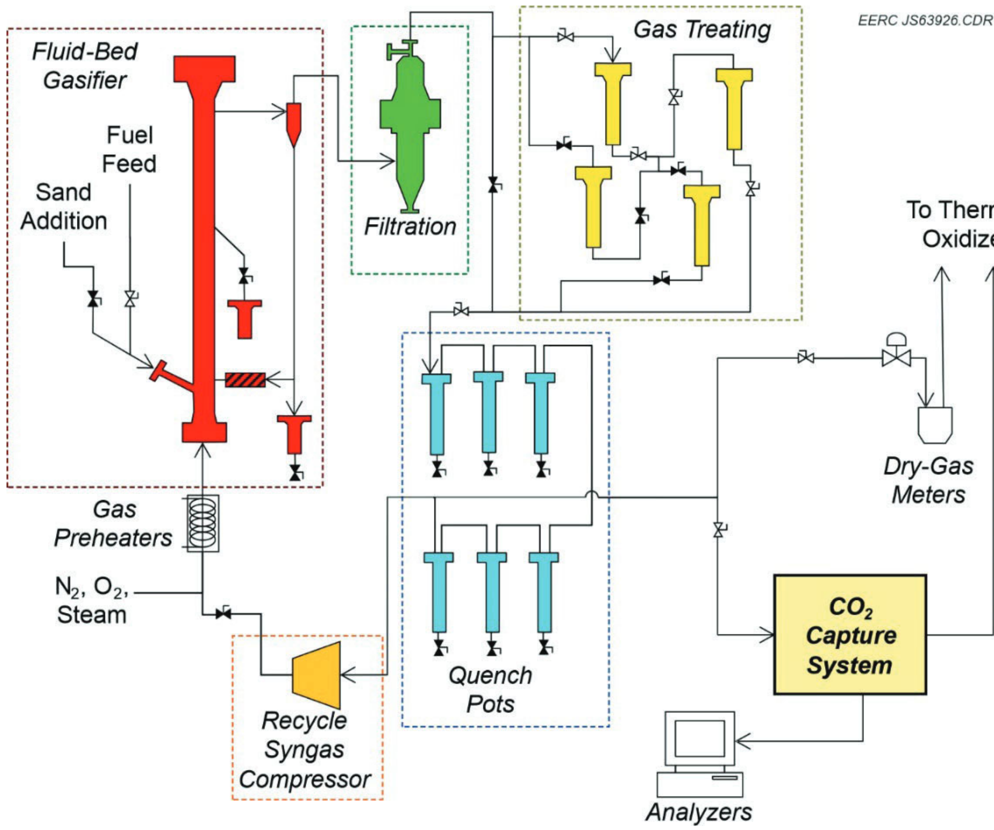

Figure 1. Projected process layout of the 10-lb/hr HPFBG.

equipment. For the full techno-economic assessment, the EERC will rely on standard approaches used in DOE baseline studies on CO_2 capture to estimate the full cost of capture.

The approach used for the LCA is a standard methodology adopted by NETL, and additional simulations used to assess carbon intensity for LCFS credits will use the CA-GREET model. The EERC team has significant experience using these models to conduct LCAs of CO_2 capture processes at Red Trail Energy and other facilities.

Environmental and Economic Impacts while Project Is Underway: The gasifier system has a well-demonstrated capability to capture particulate matter, residual sulfur, produced water, and tar compounds. All process water, solid waste, and air emissions will be treated and handled in accordance with local, state, and federal regulations and will be in compliance with the University's current permit to operate with the state. In terms of economic impacts, the project will directly leverage $1,800,000 in additional federal dollars and is expected to lead to future work with the state's ethanol industry.

Ultimate Technological and Economic Impacts: This project will provide a roadmap for implementing gasification-based renewable CHP at a North Dakota ethanol facility. The report will also help to define how the state's ethanol industry can monetize additional LCFS credits and other incentives for CO_2 capture and storage.

Why the Project Is Needed: Several factors are converging to create a unique opportunity for North Dakota ethanol producers to benefit from reducing their carbon intensity: the increase in Section 45Q tax credits to $85/tonne of CO_2; the LCFS credits available for renewable fuels; in-depth of knowledge in CO_2 storage opportunities within the state; and the success of the initial CO_2 capture effort at Red Trail Energy's ethanol facility. Adding a renewable CHP facility to an ethanol plant would further reduce the greenhouse gas (GHG) emissions associated with ethanol production, qualifying fuels for higher LCFS credits and providing direct pay benefits for CO_2 sequestration under Section 45Q of the U.S. Tax Code. Choosing gasification as the base process for CHP would provide more power output to drive CO_2 compression than would a combustion-based CHP facility, and for an oxygen-blown gasification process, using precombustion CO_2 capture would require less energy than using postcombustion CO_2 capture. However, to date, no publicly available data are known to be available on the long-term impacts of biomass impurities on precombustion CO_2 capture solvents. Actual gasification testing is necessary to determine the real-world feasibility of a gasifier-based renewable CHP technology at ethanol plants. The optimum approach to fully integrating a CHP facility into an ethanol plant will depend on the outcomes of gasifier testing, and a detailed techno-economic assessment is warranted to better understand the costs and complexity of installing such a system.

STANDARDS OF SUCCESS

The project will be considered successful if it can provide a profitable design to integrate renewable CHP with carbon capture into existing ethanol facilities in North Dakota. A further standard of success is to provide sufficient gasifier operating data to guide and validate the CHP facility design. If these standards are met, the final product can be used by the ethanol industry as the basis for detailed engineering that would lead to construction and implementation, ultimately leading to increased profitability for the state's ethanol industry.

BACKGROUND/QUALIFICIATIONS

The project will be led by Mr. Joshua Strege, who will also lead the techno-economic modeling under Task 4. Mr. Strege is the EERC's leading technical expert in Aspen software and has been responsible for techno-economic analyses of various renewable projects, including the initial SERC study on integrating CHP into ethanol facilities. He will be assisted on Task 4 by Mr. Chris Beddoe, who will lead the LCA efforts. Mr. Beddoe has used NETL's models as well as CA-GREET for LCA studies at the EERC, including work done in support of Red Trail Energy. Biomass processing and gasification work will be led by Dr. Michael Swanson, who has more than 30 years of experience in the design, fabrication, and operation of pilot-scale gasification equipment. Dr. Swanson led the design and construction of the EERC's fluidized-bed gasifier and has overseen operation of this equipment on every project since it was first installed. Full resumes for all key personnel are provided in Appendix B.

MANAGEMENT

The EERC maintains an in-house technical support team to monitor progress related to project deliverables, schedule, and spending. The project manager will hold regular meetings with the project team and will be assisted by a designated research manager to track progress and communicate with project partners.

TIMETABLE

This project is proposed to be performed over an 18-month period, with an anticipated start date of June 1, 2023. Quarterly progress reports will be submitted within 30 days after the end of each calendar quarter.

	Start Date	End Date
Task 1.0 – Project Management and Reporting	**6/1/23**	**11/30/24**
Task 2.0 – Biomass Characterization	**6/1/23**	**2/29/24**
Task 3.0 – Gasification	**9/1/23**	**5/31/24**
Task 4.0 – Integration Studies and Techno-Economic Analysis	**1/1/24**	**8/31/24**

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Deliverables (D)

D1 – Final Report

BUDGET

The total estimated cost for the proposed work is $2,250,000, as shown in Table 2. The EERC requests $450,000 from the Renewable Energy Program to be matched with $1,800,000 from the U.S. Department of Energy Office of Fossil Energy and Carbon Management. A letter of support is provided in Appendix A. Budget notes can be found in Appendix C.

If less funding is available than requested, then depending on the amount, the EERC would most likely propose to reduce the amount of gasifier testing. This would affect results on the long-term impacts of biomass firing on CO_2 capture solvent but would retain enough funding to complete the techno-economic study and LCA.

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. It is expected that some of confidential data may be provided by Red Trail Energy to develop the technical and LCA models. Project reports will

Table 1. Budget Breakdown

Project Associated Expense	NDIC Share (Cash)	DOE Share (Cash)	Total Project
Labor	$285,421	$834,308	$1,119,729
Travel	$0	$7,895	$7,895
Supplies	$0	$6,400	$6,400
Communications	$0	$81	$81
Printing & Duplicating	$0	$170	$170
Freight - Corn Stover	$0	$5,000	$5,000
Laboratory Fees & Services			
EERC Natural Materials Analytical Research Lab	$0	$1,716	$1,716
EERC Combustion Test Service	$0	$18,749	$18,749
EERC Particulate Analysis Lab	$0	$35,154	$35,154
EERC Process Chemistry & Development Lab	$0	$5,107	$5,107
EERC Fuel Preparation Service	$0	$7,258	$7,258
EERC Continuous Fluidized-Bed Reactor Service	$0	$156,492	$156,492
EERC Document Production Service	$0	$18,300	$18,300
EERC Shop & Operations	$7,592	$30,088	$37,680
EERC Technical Software Fee	$0	$55,944	$55,944
EERC Engineering Services Fee	$5,000	$9,391	$14,391
Total Direct Costs	$298,013	$1,192,053	$1,490,066
Facilities & Administration	$151,987	$607,947	$759,934
Total Project Costs	**$450,000**	**$1,800,000**	**$2,250,000**

summarize model results such that meaningful data can be extracted without compromising the underlying confidential design information provided by Red Trail Energy.

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.

REFERENCES

All references cited are in Appendix E.

APPENDIX A

LETTERS OF SUPPORT

January 26, 2023

Mr. Joshua Strege
Assistant Director for Energy Systems
University of North Dakota
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Subject: EERC Proposal No. 2023-0100, "Integrated Renewable Combined Heat and Power for Ethanol"

Dear Mr. Strege:

This letter is in response to the Energy & Environmental Research Center (EERC) request for participation in the subject project as proposed to the North Dakota Industrial Commission Renewable Energy Program.

The proposed effort aims to study the technical and logistical issues related to using crop residues such as corn stover as a renewable fuel for combined heat and power (CHP) systems at an ethanol facility and how such a CHP system could be used to provide power for CO_2 capture. Red Trail Energy is pleased to offer support for this effort by providing the EERC with operational and design data from our ethanol plant in Richardton, North Dakota. This data will be used to develop and validate process models of how such a CHP system could be best integrated with the ethanol plant to optimize efficiency.

Should you have any questions, please do not hesitate to contact me at kent@redtrailenergy.com Again, we express our support of the proposed project and look forward to working with the EERC on this project.

Sincerely,

Kent Glasser
Plant Manager
Red Trail Energy

EERC
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018 • Grand Forks, ND 58202-9018 • P. 701.777.5000 • F. 701.777.5181
www.undeerc.org

January 30, 2023

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

Dear Mr. Haase:

Subject: Cost Share for EERC Proposal No 2023-0100, Entitled "Integrated Renewable Combined Heat and Power for Ethanol"

The Energy & Environmental Research Center (EERC) is conducting complementary research and development efforts under a multimillion-dollar 10-year Cooperative Agreement with the U.S. Department of Energy (DOE) entitled "Joint Program on Research and Development for Fossil Energy-Related Resources." Through this joint program, nonfederal entities can team with the EERC and DOE on projects that address the goals and objectives of DOE's Office of Energy and Carbon Management.

The proposed project to the North Dakota Industrial Commission (NDIC) Renewable Energy Program is a viable candidate for funding under the EERC–DOE National Energy Technology Laboratory Program. Therefore, the EERC intends to secure $1,800,000 of cash cost share for the proposed project through its Cooperative Agreement with DOE, providing that NDIC commits $450,000 of cash cost share.

Proposals submitted to DOE by EERC under this program receive expeditious consideration, and the success rate is traditionally very high. However, there is no guarantee of approval.

As a cosponsor of the project, DOE would require access to all data generated and a royalty-free right to practice. However, certain project details can often be held confidential for some period of time.

Initiation of the proposed work is contingent upon the execution of a mutually negotiated agreement between the EERC and each of the project sponsors.

If you have any questions, please contact me by phone at (701) 777-5157 or by email at jharju@undeerc.org.

Sincerely,

DocuSigned by:
John Harju
34253F4468294EF...
John A. Harju
Vice President for Strategic Partnerships

JAH/rlo

c: Karen Tyler, North Dakota Industrial Commission

APPENDIX B

RESUMES OF KEY PERSONNEL

JOSHUA R. STREGE
Assistant Director for Energy Systems
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
701.777.5080 (phone), 701.777.5181 (fax), jstrege@undeerc.org

Principal Areas of Expertise

Mr. Strege's principal areas of interest and expertise include biomass and fossil fuel conversion for energy production, with an emphasis on CO_2 capture and storage in power generation and in industrial applications. He is certified in Aspen Plus and Aspen HYSYS and is proficient in process modeling and techno-economic assessments. He also has significant experience in the design, fabrication, and operation of bench- and pilot-scale equipment for combustion, gasification, synthetic and renewable fuel production, and CO_2 capture.

Education and Training

M.S., Chemical Engineering, University of North Dakota, 2005. Thesis: High-Temperature Corrosion of Potential Heat Exchange Alloys under Simulated Coal Combustion Conditions.

B.S., Chemical Engineering, University of North Dakota, 2005.

Training includes project management training through PM College, Six-Sigma Green Belt, and Design Flow Technology (DFT).

Software skills include Microsoft Office suite (Excel, MS Project, Word, and Access) and advanced VBA macro programming and SQL server integration; CAD design and engineering drawing creation (PTC Creo Parametric).

Certifications include Aspen Plus- and Aspen HYSYS-certified.

Research and Professional Experience

May 2021–Present: Assistant Director for Energy Systems, EERC, UND. Mr. Strege leads a multidisciplinary team of engineers and scientists in evaluating and demonstrating energy processes from the initial modeling phase through physical testing at the bench, pilot, and demonstration scales. Specific areas of interest include CO_2 capture and transport, process modeling and techno-economic analysis, gasification and combustion technology development and demonstration, and other energy conversion technologies. Current research activities are focused on low-carbon-intensity power cycles for fossil fuel- and biomass-fired systems.

October 2019–April 2021: Principal Process Engineer, Energy Systems Development, EERC, UND. Mr. Strege led the process engineering team in process modeling and techno-economic analysis efforts across applied research projects encompassing CO_2 capture and transport, advanced power cycle technology development, and other energy conversion technologies.

2013–September 2019: Project Manager and Senior Engineer, Cirrus Aircraft. Mr. Strege's responsibilities as Project Manager included building an 80-member team to develop and manufacture composite products for small aircraft under contract with an outside client. As Senior Engineer, he led a team of engineers and technicians responsible for reducing waste, implementing root cause and corrective actions on product defects and downstream issues, and developing and implementing software solutions for improved tracking and accountability across all departments.

2005–2013: Research Engineer, EERC, UND. Mr. Strege participated in and managed several multiyear, multiclient projects aimed at researching and developing alternative energy and fuel sources. Specific projects included hydrotreating of waste vegetable oils for conversion to drop-in-compatible JP-8 jet fuel, assessing the feasibility of modern warm-gas cleanup technologies for liquid fuel synthesis via the Fischer–Tropsch process, and design and testing of cold-gas cleanup reactors for syngas. He also participated in pilot-scale studies comparing the postcombustion CO_2 capture efficiency of a variety of proprietary and conventional amine-based solvents.

2000–2005: Student Research Assistant, EERC, UND. Mr. Strege's responsibilities included design and development of instrument control software. In addition, he studied corrosion rates and mechanisms of high-temperature alloys as part of his master's research.

Publications
Mr. Strege has authored and coauthored numerous professional publications.

DR. MICHAEL L. SWANSON
Distinguished Engineer, Fuels Conversion
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
701.777.5239 (phone), 701.777.5181 (fax), mswanson@undeerc.org

Principal Areas of Expertise

Dr. Swanson's principal areas of interest and expertise include integrated gasification combined cycle (IGCC), pressurized fluidized-bed combustion (PFBC), hot-gas cleanup, coal reactivity in low-rank coal (LRC) combustion, supercritical solvent extraction (SFE), and liquefaction of LRCs.

Education and Training

Ph.D., Energy Engineering, University of North Dakota, 2000. Dissertation: Modeling of Ash Properties in Advanced Coal-Based Power Systems.
M.B.A., University of North Dakota, 1991.
M.S., Chemical Engineering, University of North Dakota, 1982.
B.S., Chemical Engineering, University of North Dakota, 1981.

Research and Professional Experience

2022–Present: Distinguished Engineer, Fuels Conversion, EERC, UND.

2004–Present: Adjunct Professor, Chemical Engineering, UND.

1999–2022: Principal Engineer, Fuels Conversion, EERC, UND. Dr. Swanson is currently involved in the demonstration of advanced power systems such as IGCC and PFBC focused on hot-gas cleanup issues.

1997–1999: Research Manager, EERC, UND. Dr. Swanson managed research projects involving the demonstration of advanced power systems such as IGCC and PFBC focused on hot-gas cleanup issues.

1990–1997: Research Engineer, EERC, UND. Dr. Swanson was involved with the demonstration of advanced power systems such as IGCC and PFBC focused on hot-gas cleanup issues.

1986–1990: Research Engineer, EERC, UND. Dr. Swanson supervised a contract with the U.S. Department of Energy (DOE) to investigate the utilization of coal–water fuels in gas turbines, where he designed, constructed, and operated research projects that evaluated the higher reactivity of low rank coals in short-residence-time gas turbines and diesel engines.

1983–1986: Research Engineer, EERC, UND. Dr. Swanson designed, constructed, and operated SFE and coal liquefaction apparatus; characterized the resulting organic liquids and carbonaceous chars; and prepared reports.
1982–1983: Associated Western Universities Postgraduate Fellowship, DOE Grand Forks Energy Technology Center, Grand Forks, North Dakota. Dr. Swanson designed and constructed an SFE apparatus.

Publications

Dr. Swanson has authored or coauthored numerous professional publications.

CHRISTOPHER J. BEDDOE
Senior Research System Engineer
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
701.777.5216 (phone), 701.777.5181 (fax), cbeddoe@undeerc.org

Principal Areas of Expertise
Mr. Beddoe's principal areas of interest and expertise include measurement system analysis and design, development of control systems, fabrication, computer programming, and automation, life cycle analysis and air dispersion modeling.

Education and Training
B.S., Mechanical Engineering, University of North Dakota, 2007.
Proficient in the use of 2-D and 3-D AutoCad; Pro-Engineer; Solid Works; ANSYS; MATLAB; C++; Java and G-code for CNC operations; Microsoft Office Suite; MS Macros; Visual Basic; and various communications protocols.

Research and Professional Experience
2021–Present: Senior Research System Engineer, EERC, UND. Mr. Beddoe supports testing, engineering design, fabrication, management, and support of EERC laboratory, pilot, and field systems related to the production, combustion, and gasification of fuels, preparing research proposals, interpreting data, writing reports and papers, presenting project results to clients, and presenting papers at national and international conferences.

2018–2021: Senior Research Engineer and Manager, Applied Geology Laboratory (AGL), EERC, UND. Mr. Beddoe's responsibilities include working in collaboration with subject matter experts, principal investigators, and EERC leadership to prepare proposals and develop and pursue new business opportunities; management of the Applied Geology Laboratory; close coordination of research efforts with personnel and laboratories to ensure successful project completion on-time, on-budget, and within clients expectations; ensuring proper operation of laboratory systems and that laboratory data and results are of excellent quality and integrated with the theoretical, modeling, and field components of EERC research efforts; ensuring laboratory safety and updating/maintaining laboratory testing and safety procedures; developing and expanding research efforts and laboratory capabilities, particularly in the areas of CO_2 enhanced oil recovery (EOR), CO_2 storage, unconventional hydrocarbon recovery, natural resource management, critical resource characterization and recovery, geologic and synthetic materials characterization, and environmental aspects of energy management; and mentoring staff and colleagues and promoting professional development, education, and training opportunities.

2011–2018: Research Engineer, EERC, UND. Mr. Beddoe's responsibilities included development of precision measurement and control systems for material testing in the AGL, modifying existing equipment, designing and building new parts and equipment, developing new standard operating procedures (SOPs) and training/supervising technical staff, testing and calibrating transducers and measurement system, and analyzing and interpreting raw data.

2007–2009: Manufacturing Process Engineer, Hutchinson Technology Inc. Mr. Beddoe was responsible for developing and qualifying new precision measurement and manufacturing equipment and processes, supervising technical staff, reviewing and signing off on proposed changes to measurement systems, coordinating equipment for repairs, interfacing between managers, designers and machinists developing new equipment, and led projects organizing efforts for as many as 12 people.

2006: Engineered Surfaces Center, Grand Forks, North Dakota. Mr. Beddoe worked in a small team responsible for the design, modeling, and fabrication of a vibration isolation table, began design of a rolling contact fatigue test machine, and worked as a laboratory assistant for metallurgical testing.

Publications
Mr. Beddoe has coauthored several professional publications.

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 is 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 which 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 which 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.

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.

Freight – Corn Stover: Estimated cost for receiving the feedstock based on historical costs.

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.

Laboratory and analytical recharge fees are charged on a per-sample, hourly, or daily rate. Additionally, laboratory analyses may be performed outside the university when necessary. The estimated cost is based on the test protocol required for the scope of work.

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, Web site design, brochures, and photographs. The estimated cost is based on prior experience with similar projects.

Shop and operations recharge fees cover specific expenses related to the pilot plant and the required expertise of individuals who perform related activities. Fees may be incurred in the pilot plant, at remote locations, or in EERC laboratories whenever these particular skills are required. The rate includes such items as specialized safety training, personal safety items, fall protection harnesses and respirators, CPR certification, annual physicals, protective clothing/eyewear, research by-product disposal, equipment repairs, equipment safety inspections, and labor to direct these activities. The estimated cost is based on the number of hours budgeted for this group of individuals.

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.

Technical software fees are for the use of ASPEN modeling software.

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

APPENDIX E

REFERENCES CITED

REFERENCES CITED

California Air Resources Board. LCFS Data Dashboard. https://ww2.arb.ca.gov/resources/documents/lcfs-data-dashboard, accessed January 2023.

Stanislowski, J.J.; Kay, J.P.; Musich, M.A.; Strege, J.R.; Stanislowski, N.E.; Carriere, N.D.; Oleksik, J.S. *Biomass Cofiring with Precombustion Carbon Capture Baseline Testing at UND EERC*; Final Report for U.S. Department of Energy National Energy Technology Laboratory Contract No. P010227025; EERC Publication 2022-EERC-06-05; Energy & Environmental Research Center: Grand Forks, ND, June 2022.

Overview of CHP Technologies. DOE/EE-1692, November 2017.

Dou, J.; Krzystowczyk, E.; Li, F. *Radically Engineered Modular Air Separation System with Tailored Oxygen Sorbents.* Final Report for U.S. Department of Energy. April 2022.

Singh, R. *High Selectivity and Throughput Carbon Molecular Sieve Hollow Fiber Membrane-Based Modular Air Separation Unit for Producing High Purity* O_2*.* Project Review Meeting for U.S. Department of Energy National Energy Technology Laboratory. May 2, 2022.

INDUSTRIAL COMMISSION OF NORTH DAKOTA
RENEWABLE ENERGY PROGRAM

TECHNICAL REVIEWERS' RATING SUMMARY

R-051-A
INTEGRATED RENEWABLE COMBINED HEAT AND POWER FOR ETHANOL

Principal Investigator: Joshua R. Strege

Request for $450,000; Total Project Costs $2,250,000

TECHNICAL REVIEWERS' RATING SUMMARY
R-051-A
INTEGRATED RENEWABLE COMBINED HEAT AND POWER FOR ETHANOL
Principal Investigator: Joshua R. Strege
Request for $450,000; Total Project Costs $2,250,000

Rating Category	Weighting Factor	Technical Reviewer 1A	2A	3A	Average Weighted Score
		Rating			
1. Objectives	9	5	5	4	42.00
2. Achievability	9	4	5	5	42.00
3. Methodology	7	5	4	4	30.33
4. Contribution	7	4	2	5	25.67
5. Awareness	5	4	4	4	20.00
6. Background	5	5	5	4	23.33
7. Project Management	2	4	4	3	7.33
8. Equipment Purchase	2	5	5	5	10.00
9. Facilities	2	5	4	5	9.33
10. Budget	2	5	3	4	8.00
Average Weighted Score		227	209	218	**218.00**
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 1A (Rating 5)

The project goal is to determine the economic feasibility of small-scale commercial CHP using corn stover feedstock at industrial sites. Objects are clearly stated in the project description. The success criterion for the effort is noted as delivery of a profitable design to integrate renewable energy CHP with carbon capture into ethanol facilities. This is of interest and value to ND and is consistent with NDIC REC goals.

Reviewer 2A (Rating 5)
The stated objectives through 4 tasks are clearly articulated.

Reviewer 3A (Rating 4)
The applicant has a clear goal that aligns with the NDIC/REC goals. This project can be used at other ag processing facilities as the technology fully matures with the ability to capture carbon without amine scrubbers. Important to note here that the applicant anticipates that federal or state subsidies may be necessary for the techno-economic model to be financially acceptable. In referencing the LCFS for CARB, the applicant needs to understand that while using the stover for a fuel feedstock is a positive, the land use from additional fertilizer and shipping must also be addressed.

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 project is to be carried out over an 18-month period with a total budget of $2.25M ($450k from NDIC). The planned budget should be more than sufficient to carry out the proposed project activities. It is difficult t gauge if 18 months is sufficient for the project. It is certainly feasible given that the only deliverable is a final report. One would generally suspect that the primary funding from DOE through the cooperative agreement will be subject to more defined deliverables, though this is not detailed.

Reviewer 2A (Rating 5)
The objectives are achievable within the timeframe and budget, contingent upon DOE funding.

Reviewer 3A (Rating 5)
The objectives the applicant has set forth are achievable given the previous work performed by the investigators and available equipment.

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 project contains 4 listed tasks: (1) Project management and reporting, (2) Biomass characterization, (3) Gasification, and (4) Integrated CHP design and economic feasibility. Each of these is a logical and necessary step that is important to realize the project goals. Of note is that plant data is to be provided by Red Trail Energy (letter of support provided) from its Richardton ethanol plant, offering high value to the CHP design effort in the last task.

Reviewer 2A (Rating 4)
Given the past success of the EERC, the methodology is well proven.

Reviewer 3A (Rating 4)
The EERC set forth a clear and achievable methodology/thought process for completing the research objectives. With the heavy references to LCFS & CARB, discussion of stover life cycle is important, i.e. farm to wheel.

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)
There are numerous strong economic drivers in ND that warrant such research. A viable CHP process that uses gasification rather than combustion would be of high value to ethanol plans and aligns very well with NDCI goals. Project success is noted as identifying a profitable design for integrating renewable energy CHP with carbon capture into ethanol facilities. The project tasks offer key technical value in assessing this concept and directly align with NDIC REC goals. One small note is that no workforce/job benefits from the project appear to be discussed.

Reviewer 2A (Rating 2)
If successful, a pilot implementation at Red Trail could be achieved with additional funding. Statewide success beyond pilot is questionable given challenges noted below.

Reviewer 3A (Rating 5)
The use of a crop residue as a fuel feedstock would significantly improve the competitiveness of ND produced ethanol. This value would exceed the initial investment of the renewable energy program. The resource optimization and value added with LCFS credit production achieve this goal.

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 4)
Although very few references were cited, the PI appears versed in current research and literature in the subject matter. This is further evidenced by the CVs of the team provided in the narrative.

Reviewer 2A (Rating 4)
Very thorough and impressive application.

Reviewer 3A (Rating 4)
The EERC team lead by Mr. Strege has extensive experience with gasifiers and syngas production along with material characterization. The team did not reference significant reports on stover feedstock quantity or quality and supply other than back of the envelope statements. This is listed in as being part of the investigation however.

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 5)
The team has a demonstrated expertise in the subject area and is positioned well to carry out the proposed work. The PI (Mr. Strege) has conducted prior similar technical and economic analyses in other renewable energy projects. Likewise, Dr. Swanson has significant biomass processing and gasification expertise. Overall, the team appears to be very experienced and well-positioned for the proposed project. Additionally, the team indicates it has many years (~ 15 years) experience with the Aspen software to be used in Task 4 of the project. It would have been helpful to have been provided a list of some example publications authored by the team in their respective CVs rather than a basic statement that they have publications. Doing so would better validate their expertise.

Reviewer 2A (Rating 5)
The PI is an active contributor to research in this particular field.

Reviewer 3A (Rating 4)
See section 5, above.

7. The project management plan, including a well-defined milestone chart, schedule, financial plan, and plan for communications among the investigators and subcontractors, if any, is: 1 – very inadequate; 2 – inadequate; 3 – adequate; 4 – very good; or 5 – exceptionally good.

Reviewer 1A (Rating 4)
Specific tasks (total of 4) are logical and generally clear. A Gantt chart is provided in the narrative, though it is very limited in detail with just the 4 top-level tasks noted. Table I provides the budget breakdown for the project in typical expense categories. The majority of the total budget is directed towards personnel, with nearly all of the NDIC budget requested supporting salary. As this is largely a feasibility study using existing equipment, this seems appropriate.

Reviewer 2A (Rating 4)
The milestone and schedule information is provided and presented well in easy to interpret charts and tables.

Reviewer 3A (Rating 3)
The financial plan/budget is sufficiently detailed. However, the individual task sub-details such as feedstock procurement and testing plan development should be sited or discussed with expected start and completion dates.

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)
There does not appear to be any equipment proposed for purchase under the project.

Reviewer 2A (Rating 5)
No equipment purchase is budgeted.

Reviewer 3A (Rating 5)
No equipment listed to be purchased.

9. The facilities and equipment available and to be purchased for the proposed research are: 1 – very inadequate; 2 – inadequate; 3 – adequate; 4 – notably good; or 5 – exceptionally good.

Reviewer 1A (Rating 5)
The team appears to have access to all necessary facilities and equipment required for the proposed project.

Reviewer 2A (Rating 4)
Established resources (staff, equipment and experience) at EERC.

Reviewer 3A (Rating 5)
The EERC has the facilities and equipment of conduct this investigation.

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 5)
The total project budget is $2.25M over 18 months, with $450k requested from the NDIC. The cost share is to be sourced from DOE through the existing cooperative agreement. This constitutes 80% cost share from external sources beyond the NDIC request, and far exceeds the 50% minimum.

Reviewer 2A (Rating 3)
The overall state-wide impact of this particular work may be of limited value to one or two small scall applications given the known challenges of corn stover feedstock and temporary nature of federal incentives.

Reviewer 3A (Rating 4)
The value proposition here is to use a crop residue as a fuel feedstock. This resource optimization for ingratiated CHP with CO2 capture and apply it to industrial scale economics creates value for both the farmer, producer, and entities that wish to reduce their carbon intensity.

Section C. Overall Comments and Recommendations:

Please comment in a general way about the merits and flaws of the proposed project and make a recommendation whether or not to fund.

Reviewer 1A
Overall, a topically suitable project for ND. The team appears to be well-positioned for the effort.

Reviewer 2A
Various studies already exist regarding the challenging characteristics and economic viability of corn stover. Corn stover is highly valued as a nutrient soil amendment by North Dakota farmers, and the short seasonal harvest window and subsequent storage challenges are well documented for any large-scale operation.

I am concerned that the economic viability is overly dependent upon ephemeral nature of S45Q tax credits and low carbon fuel standard credits, which will severely limit the long-term window of opportunity for expansion beyond Red Trail and greater state wide benefit.

The application is exceptionally well done with significant supporting material (resumes, budget notes, references, etc.).

Excellent leverage with potential DOE funding, in-kind only support from Red Trail.

Recommendation: FUND

Reviewer 3A
Determining the economics for gasifier CO2 capture with CHP can be applied not only to ethanol production facilities, but many ag processing industries. As industries become more transparent on

CO_2, additional methods of emission reduction will be required. Be very careful of the land use penalty for CARB's Greet model, as you may need to determine increased fertilizer costs associated with removing stover from the field.

Funding is Recommended.

EERC

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

February 1, 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. 2023-0089 Entitled "Clean Hydrogen from High-Volume Waste Materials and Biomass"

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.

Enclosed please find an original and one copy of the subject proposal, along with the application fee. Please note that the enclosed check for $200 covers this application (EERC Proposal No. 2023-0089) as well as the application being submitted under EERC Proposal No. 2023-0100.

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 make the requested grant.

If you have any questions, please contact me by telephone at (701) 777-5239 or by email at mswanson@undeerc.org.

Sincerely,

DocuSigned by:
Michael Swanson
804E8DF42610465...
Michael L Swanson
Distinguished Engineer, Fuels Conversion

Approved by:

DocuSigned by:
[signature]
284991351F2884D1...
Charles D. Gorecki, CEO
Energy & Environmental Research Center

MLS/bjr

Enclosures

c: Karen Tyler, North Dakota Industrial Commission

UND UNIVERSITY OF NORTH DAKOTA

Renewable Energy Program

North Dakota Industrial Commission

Application

Project Title: Clean Hydrogen from High-Volume Waste Materials and Biomass

Applicant: Energy & Environmental Research Center (EERC), University of North Dakota
EERC Proposal No 2023-0089

Principal Investigator: Dr. Michael L. Swanson

Date of Application: February 1, 2023

Amount of Request: $500,000

Total Amount of Proposed Project: $2,500,000

Duration of Project: 21 months

Expected Start: April 1, 2023

Point of Contact (POC): Dr. Michael L. Swanson

POC Telephone: (701) 777-5239

POC Email: mswanson@undeerc.org

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

Lead Organization: EERC

Cost Share Partner: U.S. Department of Energy
Simonpietri Enterprises, LLC

TABLE OF CONTENTS

ABSTRACT

The Energy & Environmental Research Center (EERC) proposes to conduct research around gasifying biomass materials to make hydrogen in support of the development of a hydrogen hub facility located in the state of North Dakota. This biomass/agricultural residue/waste stream would be selected based on availability of selected biomass feedstocks in the state of North Dakota. Potential biomass streams would include agricultural residues such as sunflower/soybean hulls, wheat straw, or recovered lignin from ethanol production and potential energy crops such as switchgrass. A modular-scale oxygen-blown fluid-bed gasifier would be the conversion system of choice; however, tar production from biomass materials is known to be problematic so the emphasis of this project will be the demonstration of enhanced conversion of the tars in the syngas stream through the utilization of tar-cracking catalyst or a high-temperature second stage to thermally crack the tars. **Objective:** Maximizing hydrogen production and purification from these selected biomass feedstocks will be the major emphasis, along with demonstrating CO_2 capture for a potential net-carbon-negative hydrogen production process to potentially feed a North Dakota hydrogen hub. **Expected Results:** The anticipated outcomes of the proposed research are the development of a robust hydrogen production pathway utilizing North

Dakota-centric biomass feedstocks that will minimize tar production while producing a potential carbon-negative high-hydrogen-purity supply for a commercial North Dakota hydrogen hub. By focusing on moderate-scale modular systems, feedstock collection and transportation issues for low-density residual biomass feedstocks can be optimized. **Duration:** 21 months. **Total Project Cost:** $2,500,000.

Participants: EERC, U.S. Department of Energy, and Simonpietri Enterprises, LLC.

PROJECT DESCRIPTION

Objectives: The Energy & Environmental Research Center (EERC), in partnership with the U.S. Department of Energy (DOE) and Simonpietri Enterprises, LLC (Simonpietri) (see letter of commitment in Appendix A), will produce price-competitive clean hydrogen via thermochemical conversion of high-volume waste and biomass streams with a limited utilization potential. This research will build on previous bench-scale gasification trials as well as a previous engineering model, simulation, and cost feasibility study for modular-scale plants at the 15- and 50-MWe scale. This modular scale is the most appropriate for more widely dispersed agricultural residues that are likely to be a large fraction of any North Dakota-derived biomass stream. Previous research showed the technical and commercial feasibility of gasifying some North Dakota-centric biomass into a useful syngas suitable for making high-purity hydrogen (1, 2). When combined with carbon capture and storage, the process has the potential to produce hydrogen with a net-carbon-negative footprint. This type of project could provide hydrogen to a potential hydrogen hub project being proposed for the state of North Dakota or a modular-scale ammonia production facility. By focusing on residues close to agricultural processing plants, the residue aggregation, gasification, gas cleanup, and entry into a fuel distribution or power generation system can be in a much tighter radius and even collocated, thereby reducing the feedstock collection and transportation costs. The techno-economic analysis (TEA) will be structured around a notional modular-scalable "base case study" plant sited in North Dakota where there is access to a potential hydrogen hub market within close proximity to an existing residue aggregation node. The economic improvements in this approach are to reduce capital and operating cost as compared to the current state of the art by combining commercially ready gasification and gas cleanup system technology with novel technology specifically configured to convert feedstock into clean hydrogen while achieving a hydrogen production cost of \$1/kg H_2. The focus will be on more modular-scale (15 to 50 MWe) processing to keep the overall capital costs lower while utilizing a plentiful agricultural residue value feedstock.

Methodology: For this research, an oxygen-blown fluid-bed gasifier with the most appropriate shift catalyst will be used to evaluate both warm- and cold-gas cleanup technologies including tar cracking at a small integrated scale (<15-lb/hr laboratory scale) to develop data on agricultural residue gasification. This project will investigate key operating variables, including gasifier operating temperature, hot-gas filtration temperature, bed additives, and other downstream syngas cleanup techniques, including the use of tar-cracking catalyst, fixed sorbent beds, water scrubbing, Selexol™ solvent-based acid gas scrubbing and, possibly, even low-temperature activated carbon beds. For a previous feasibility engineering study at the reduced scale of 500 dtpd, the capital cost estimate came in at <\$150 million, well below the \$300 million–\$330 million "green field" capital cost estimate for the larger 1000-dtpd plant discussed in a published report (3, 4). The conclusions of this previous TEA conducted by Simonpietri Enterprises, LLC were that no-cost or negative-cost feedstocks significantly improve the project financial viability and that capital cost is the largest technical challenge and the largest cost driver impacting the project economics; the second largest cost driver was the elimination of waste disposal costs. Capital expenditures (CAPEX) were projected to be 50% of other competing technologies because of throughput reductions and process integration. The biggest risk was identified as being a first-of-a-kind (FOAK) process with relatively unknown feedstocks with little industry standardization. Life cycle analysis (LCA) calculations also showed that 97+% pure hydrogen produced for refinery hydrotreating had a 97% reduction in the grams of carbon emitted/MJ of hydrogen energy as compared to fossil natural gas reformer. The proposed work scope comprises four tasks as follows.

Task 1.0 – Project Management, Planning, and Reporting – The Recipient will perform project management activities to include project planning and control, subcontractor control, financial management, data management, management of supplies and/or equipment, risk management, and reporting as required to successfully achieve the overall objectives of the project.

Task 2.0 – Feedstock Preparation and Processing Optimization – Agricultural residue material will be collected, characterized, and prepared for use as a feedstock in Task 3.0. Ongoing characterization and optimization will be performed to convert the agricultural residue into a form that can be reliably fed into gasifiers.

Task 3.0 – Gasification Testing with North Dakota Agricultural Waste Feedstocks – An oxygen-blown fluidized-bed gasifier will be used for converting nonhomogeneous agricultural residue waste feedstock into syngas while dealing with inorganic contaminants, including high alkali ash. By utilizing numerous syngas cleanup hardware collocated with the fluid-bed gasifier, numerous syngas cleanup possibilities can be integrated for rapid screening of control options. For this single 6-day integrated gasification and tar-cracking test campaign, existing hardware will be modified to perform as a tar-cracking system. Laboratory-scale gasification and gas cleanup system components will be set up, including tar-cracking reactors, shift catalyst beds, and potential trace metal sorbent beds, plus a PEGDME (polyethylene glycol dimethyl ether) Selexol-type solvent-based acid gas cleanup system. The first part of the campaign will establish a baseline for the amount of tar production for one North Dakota biomass feedstock. This baseline will be followed by two separate tar-reforming/cracking tests in which an oxygen-blown high-temperature burner and then a fixed-bed tar-cracking catalyst bed will be tested. The second half of the campaign will perform the same set of tests utilizing a second selected North Dakota biomass feedstock. Parameters to be evaluated include shift catalyst type and operating temperature, tar-cracking catalyst type and operating temperature, fixed-bed sorbent type, and Selexol operating temperature. Numerous solid-, liquid-, and gas-phase samples and analyses will be collected and performed to determine the most effective control strategies. For each test campaign, near-continuous analysis of all gas-phase constituents will be conducted with an array of laser gas analyzers (LGAs) (based on Raman spectroscopy), online gas chromatographs (GCs), and heated-cell Fourier transform infrared (FTIR) analysis. After each test campaign, ash samples will be sent for elemental analysis.

4.0 – Techno-Economic Analysis – Scaleup of the performance data to a 15- to 50-MWe-scale hydrogen production plant will be engineered to conduct a TEA to determine the hydrogen production costs as a function of engineering and commercial parameters as well as cost estimates for construction, operation, and financing. The TEA will be done iteratively to test and refine key assumptions and to include data gathered from the gasification trials. A spreadsheet model will be developed for a 15- to 50-MWe hydrogen production plant. The TEA will be revised from the one being updated with the current DOE-funded project. The TEA will include engineering parameters, cost estimates for construction and operation, and commercial parameters as inputs. The outputs will include financial, and investor return of a 20-year business at full commercial scale, total capital costs, annual operating costs, minimum selling price, sensitivity analysis, and technology readiness/risk analysis of process blocks. A baseline block flow diagram (BFD) for an integrated gasification system taking raw residual waste fresh all the way to finished hydrogen will be upgraded to a process flow diagram (PFD) after receiving information from each of the other tasks. A process engineering model will be updated with the information and experimental data generated from Tasks 2.0 through 4.0. Vendors will be engaged for information sharing and technical review to identify throughput, inputs and outputs, and capital and operating cost assumptions.

Anticipated Results: This project has conceptualized a novel pathway to reduce the cost of clean hydrogen. This pathway combines some simple commercial off-the-shelf adaptations and proprietary innovations to thermochemically convert organic agricultural waste residues into a commercially viable hydrogen fuel. This project will test processing of actual waste residues into gasification feedstock;

gasify the residue in an oxygen-blown fluid-bed gasifier; and evaluate integrated gasification and syngas cleanup technologies with an emphasis on syngas tar reduction to control syngas pollutants, handle the higher amount of ash and macrocontamination, and yield a syngas clean enough to prevent poisoning of shift catalyst, contamination of the final hydrogen product, or its emission to the environment. This project will also perform several critical analyses using modeling tools to inform the design for a base-case commercial-scale residue gasification plant: TEA, LCA, chemical and process engineering, particle and fluid dynamics estimation, and air emission estimation. The target level of performance for this research is to identify integrated gasification and gas cleanup system components and operating condition combinations to yield 99 mol% hydrogen at the delivered cost target of $1/kg in a manner that can be sited and permitted. Data from the proposed project including gasification conversion, tar production with tar cracking, catalyst poisoning, and gas cleanup trials will inform a techno-economic model to yield an estimate of the hydrogen production costs. This modular system will be scaled to between 15- and 50-MWe equivalent.

Facilities and Resources: The EERC has conducted several test programs on biomass at both the bench and pilot scale on its various gasification platforms. These platforms include bubbling fluid-bed, circulating fluid-bed, moving fixed-bed, and entrained-flow systems. The EERC has built feedstock systems capable of reliably feeding 100% biomass feedstock to these systems. The EERC is committed to providing the infrastructure required for this project; specifically, a fluidized-bed gasifier and syngas cleanup equipment have been designated as equipment that will be used in support of this research program. The EERC also is committed to providing the engineering and operations personnel time necessary for the completion of this research project within the proposed project period. The EERC will ensure that Principal Investigator Dr. Michael Swanson has adequate time committed to the project to ensure its timely completion. The relevant gasifier for this effort is the EERC's high-pressure fluid-bed gasifier (HPFBG) located in the EERC's National Center for Hydrogen Technology® (NCHT®). The HPFBG is capable of operating at up to 1000 psig and includes a pressurized fuel feed system that can be periodically reloaded during operation for long-term continuous operation. Fuel feed is nominally 8 to 15 lb/hr of solids, which is of sufficient scale to obtain high-fidelity material balance data. Oxidant is provided as preheated oxygen and steam. Dry product syngas can be recycled through a compressor to replace nitrogen in purge lines and pressure taps, which greatly reduces nitrogen dilution and provides a syngas more representative of what would be generated in a full-scale system. Unconverted solids exiting the expanded freeboard section of the gasifier are captured by a cyclone and returned to the bottom of the gasifier via an auger at the bottom of a standpipe. Syngas then passes through the hot-gas filter vessel, where a metallic candle filter removes the extremely fine particulate that was not captured by the cyclone. The hot, wet syngas can then be routed through several fixed beds for contaminant removal and the water–gas shift reaction before passing to a train of water-cooled quench pots where the condensable liquids are removed in several stages.

Techniques to Be Used, Their Availability and Capability: The dry, pressurized gas can then be further processed in the gas-sweetening absorption system using cold solvents such as Selexol to capture CO_2 and sulfur, or it may pass directly to a pressure control valve and then to a dry gas meter before being combusted in a thermal oxidizer. Gas is sampled from various locations throughout the system, and its composition is continuously monitored by online LGAs, an FTIR with an online heated-flow cell, and GCs. The HPFBG, illustrated in Figure 1, has been run on a wide variety of coals and woody biomass types from around the world and has a proven track record for successful gasification in an environment closely simulating full-scale fluidized-bed gasification. The EERC already possesses all of the major equipment needed to complete the testing.

Environmental and Economic Impacts while Project Is Underway: This project will conduct one 6-day test campaign with two separate feedstocks at approximately a 10-lb/hr scale with clean agricultural residue feedstocks. With the advanced syngas cleanup capabilities associated with this testing

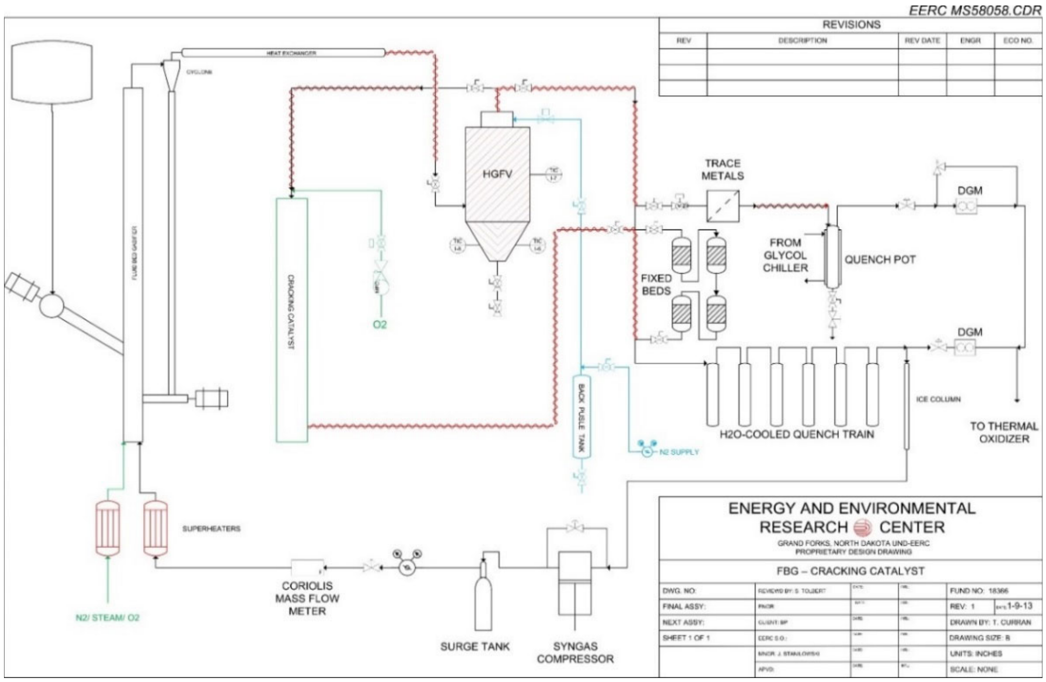

Figure 1. Projected process layout of the 10-lb/hr HPFBG.

hardware, the environmental impact will be minimal, with less than 4 lb of sulfur and approximately 1000 lb of CO_2 being emitted over the course of the project. All process water (circa 300 gallons) is treated before being discharged to the City of Grand Forks publicly owned treatment works.

Ultimate Technological and Economic Impacts: Innovating and deploying local, right-sized gasification plants that use complex and variable feedstocks will not only increase the supply and geographical availability of hydrogen to meet U.S. net-zero carbon targets and reduce the need for trucking and pipelines to carry hydrogen, but it will also create jobs and economic growth in nearby communities. This project will achieve several goals including 1) social goals of reducing the effects of heavy industrial activities sited within minority neighborhoods while retaining/creating higher-quality jobs that embody cultural values of protecting the land and conserving resources, 2) environmental goals of displacing life cycle greenhouse gas emissions from fossil fuels, and 3) municipal goals to increase value-added waste recycling and generate low-carbon hydrogen.

Why the Project Is Needed: Advances in hydrogen technologies capable of improving performance, reliability, and flexibility of existing and novel methods to produce/transport/store/use hydrogen will enable North Dakota to greatly reduce its carbon footprint associated with energy use, supporting Burgum Administration goals for North Dakota to become carbon-neutral by 2030. Traditional large-scale hydrogen production approaches will face challenges in the U.S. marketplace to realize a net-zero carbon future. Technologies that use carbonaceous feedstock routes to hydrogen need technological advancements to improve their greenhouse gas (GHG) emission performance. Hydrogen production from more distributed but renewable agricultural residues/solid wastes and waste plastics have the potential for additional environmental and public safety benefits by diverting residue/wastes from landfills and land application, thus potentially relieving a burden faced by local communities and promoting environmental justice. Judicious use of biomass with incorporation of carbon capture and storage technologies is essential to enable net-zero life cycle GHG emissions. The leveraging of gasification approaches offers opportunities to advance environmental justice because gasification technology can convert varied residue waste feedstock materials into clean energy with superior environmental performance, including the attainment of net-zero GHG emissions. The societal push toward net-zero carbon power sources in the United States encourages the continued development of hydrogen turbines and solid oxide fuel cells by DOE, in addition to other hydrogen and fuel cell technologies pursued by other DOE offices. Developing more efficient and reduced-cost pathways supports DOE's Hydrogen Shot Initiative, which seeks to reduce the cost of clean hydrogen to $1 per 1 kilogram in 1 decade. With involvement of multiple concerned DOE offices, technologies for advanced hydrogen production methods identified here will be improved and matured to make progress toward the ambitious Hydrogen Shot goals. To realize the widespread contribution of clean hydrogen to a carbon-neutral economy, significant improvements must be made to ensure that storage and transportation of hydrogen are both safe and economically viable.

STANDARDS OF SUCCESS

This project will demonstrate the production of low-carbon renewable hydrogen from North Dakota-centric biomass feedstocks and determine the economic potential for modular-scale hydrogen production facilitates. These facilities have the potential to supply high-purity hydrogen to a potential hydrogen hub for the production of low-carbon products such as ammonia or even renewable diesel fuel, thereby creating new jobs for short-term construction and installation and for long-term implementation, operation, and maintenance of hydrogen production installations. Determining the TEA and LCA of a hydrogen production facility as a function of feedstock type will determine the feasibility of this concept for a North Dakota-based application.

BACKGROUND/QUALIFICATIONS

PI Dr. Michael Swanson has over 30 years of experience in the area of gasification at the EERC. Dr. Swanson has extensive experience in managing bench- and pilot-scale gasification and syngas cleanup projects. Mr. Tyler Newman, EERC Senior Engineer, will serve as the project engineer. Ms. Joelle Simonpietri, owner of Simonpietri Enterprises, LLC, will oversee the techno-economic and modeling work for this project. She brings a 15-year background in running large-scale technology experiments for the U.S. Department of Defense as well as private industry. Appendix B contains resumes of all key personnel.

MANAGEMENT

PI Dr. Swanson will recommend and execute project test plans utilizing the fluidized-bed gasifier and ash collection activities and the trace metal analytical verification in support of project goals and objectives. Dr. Swanson will be responsible for all technical reporting of EERC results to the project team to meet NDIC and other sponsor requirements. Ms. Simonpietri will oversee techno-economics and modeling work for this project. She previously led a team that evaluated the TEA and LCA implications of selected local West Coast waste resources and will be improving upon their models as part of the matching cost-share DOE-funded program (5). As part of this project, data and gasification performance results from the selected North Dakota biomass feedstocks will be incorporated into the TEA/LCA models to refine this information for a North Dakota-located plant producing renewable hydrogen for a hydrogen hub from North Dakota biomass feedstocks. Internal review meetings will also be conducted regularly to ensure that all project activities are completed in a timely manner according to the project schedule. Progress reports and a final report at project completion will be prepared.

TIMETABLE

The proposed scope of work will be performed over a 21-month period (Figure 2). Initiation of the proposed work is contingent upon the execution of a mutually negotiated agreement with each project sponsor. Progress reports will be submitted 30 days following the end of each calendar quarter.

	Start Date	End Date
Task 1.0 – Project Management, Planning, and Reporting	**4/1/23**	**12/31/24**
Task 2.0 – Feedstock Preparation and Processing Optimization	**4/1/23**	**9/30/23**
Task 3.0 – Gasification Testing with ND Agricultural Waste Feedstocks	**9/1/23**	**4/30/24**
Task 4.0 – Techno-Economic Analysis	**4/1/24**	**12/31/24**

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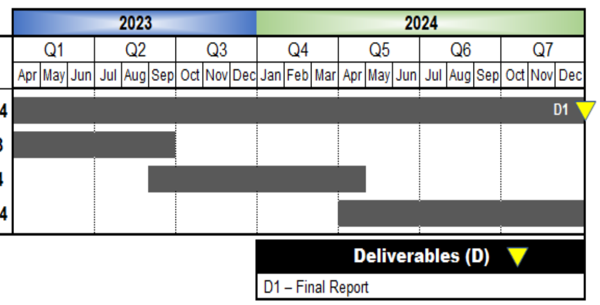

Figure 2. Project schedule.

BUDGET

The total estimated cost for the proposed project is $2,500,000, as shown in Table 1. The EERC requests $500,000 from the Renewable Energy Program (REP). Matching cash funds of $1,600,000 are being provided by DOE, while Simonpietri Enterprises, LLC and its partners are providing $400,000 in in-kind cost share. A letter of commitment is provided in Appendix A. Budget notes can be found in Appendix C. If less REP funding is available, adjustments to scope will need to be considered.

TAX LIABILITY/CONFIDENTIAL INFORMATION

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. No confidential information is included in this proposal.

Table 1. Budget Breakdown

Project Associated Expense	NDIC Share (Cash)	DOE Share (Cash)	Commercial Share (In-Kind)	Total Project
Labor	$144,847	$417,899	$0	$562,746
Travel	$1,381	$1,252	$0	$2,633
Supplies	$21,750	$76,500	$0	$98,250
Subcontractor - Simonpietri	$50,000	$550,000	$0	$600,000
Communications	$30	$700	$0	$730
Printing & Duplicating	$113	$577	$0	$690
Utilities - Hazardous Waste	$0	$3,000	$0	$3,000
Laboratory Fees & Services				
EERC Natural Materials Analytical Research Lab	$13,212	$5,361	$0	$18,573
EERC Analytical Research Lab	$1,280	$27,459	$0	$28,739
EERC Combustion Test Service	$4,732	$10,497	$0	$15,229
EERC Particulate Analysis Lab	$7,098	$20,283	$0	$27,381
EERC Fuel Preparation Service	$3,256	$0	$0	$3,256
EERC Continuous Fluidized-Bed Reactor Service	$72,173	$58,320	$0	$130,493
EERC Document Production Services	$3,593	$11,664	$0	$15,257
EERC Shop & Operations	$14,461	$34,146	$0	$48,607
EERC Engineering Services Fee	$1,643	$4,262	$0	$5,905
EERC Freight	$0	$15,000	$0	$15,000
Total Direct Costs	$339,569	$1,236,920	$0	$1,576,489
Facilities & Administration	$160,431	$363,080	$0	$523,511
Total Cash Requested	**$500,000**	**$1,600,000**	**$0**	**$2,100,000**
In-Kind Cost Share				
Simonpietri	$0	$0	$400,000	$400,000
Total In-kind Cost Share	**$0**	**$0**	**$400,000**	**$400,000**
Total Project Costs	**$500,000**	**$1,600,000**	**$400,000**	**$2,500,000**

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 Table 2.

REFERENCES

All references cited are listed in Appendix E.

Table 2. 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

APPENDIX A

LETTER OF COMMITMENT

Dr. Michael Swanson
Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 28202-9018

30 Jan 2023

Dear Dr. Swanson:

Simonpietri Enterprises LLC (SEL) is committed to partnering with the Energy & Environmental Research Center (EERC) in the proposed project 2023-0089 "Clean Hydrogen from High-Volume Waste Materials and Biomass" submitted to the North Dakota Industrial Commission Renewable Energy Program (REP), in response to the REP's open request for renewable energy project that involve research and development of renewable energy technologies that have strong growth potential in North Dakota.

Our organization is a U.S. small business focused on innovating in environmental performance and resilience at the intersection between the transportation, energy, and waste industries. We are developing a patent-pending process to divert underutilized waste streams and biomass, including contaminated waste destined for landfills, and convert it into green hydrogen, in modular community-scale plants and in a manner cost-competitive with fossil hydrogen production. We identified the need for this process through work with our industrial clients over the past 15 years, which include fuel, energy, waste, logistics, and bioeconomy companies in the U.S., Canada, and Australia. Another former client is the State of Hawaii, for whom we co-authored the Hawaii Hydrogen Plan.

We have enjoyed a productive, multi-year research relationship with the EERC, to help us prove our innovations to make pipeline-quality clean hydrogen from underutilized high-volume waste streams. This collaboration includes a successful 100-hour continuous waste gasification trial converting real-world waste to industrial hydrogen, performed at your High Pressure Fluidized Bed Gasifier laboratory in June 2022 for our Small Business Innovation Research project for the U.S. Department of Agriculture, followed by this upcoming Hydrogen from High-Volume Wastes research (High-VolWaste2H2) awarded by the U.S. Department of Energy.

Should this REP project be awarded, Simonpietri is committed to provide the technoeconomic analysis and systems engineering necessary to model and simulate a commercial plant to perform this waste-to-hydrogen process. Our proposed work scope calls for $50,000 to conduct an iteration of the systems engineering and TEA modeling for the DOE High-VolWaste2H2 study that is the cost share for this proposed project, focused specifically on locally sourced waste streams and feedstocks from North Dakota. In case of questions, our point of contact is Mr. Aaron Ellis, our technoeconomic analyst, who can be reached at aaron@simonpietri.com, phone 808-392-7365.

Sincerely,

Marie-Joelle Simonpietri
President

APPENDIX B

RESUMES OF KEY PERSONNEL

DR. MICHAEL L. SWANSON
Distinguished Engineer, Fuels Conversion
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
701.777.5239 (phone), 701.777.5181 (fax), mswanson@undeerc.org

Principal Areas of Expertise
Dr. Swanson's principal areas of interest and expertise include integrated gasification combined cycle (IGCC), pressurized fluidized-bed combustion (PFBC), hot-gas cleanup, coal reactivity in low-rank coal (LRC) combustion, supercritical solvent extraction (SFE), and liquefaction of LRCs.

Education and Training
Ph.D., Energy Engineering, University of North Dakota, 2000. Dissertation: Modeling of Ash Properties in Advanced Coal-Based Power Systems.
M.B.A., University of North Dakota, 1991.
M.S., Chemical Engineering, University of North Dakota, 1982.
B.S., Chemical Engineering, University of North Dakota, 1981.

Research and Professional Experience
2022–Present: Distinguished Engineer, Fuels Conversion, EERC, UND.
2004–Present: Adjunct Professor, Chemical Engineering, UND.
1999–2022: Principal Engineer, Fuels Conversion, EERC, UND. Dr. Swanson is currently involved in the demonstration of advanced power systems such as IGCC and PFBC focused on hot-gas cleanup issues.
1997–1999: Research Manager, EERC, UND. Dr. Swanson managed research projects involving the demonstration of advanced power systems such as IGCC and PFBC focused on hot-gas cleanup issues.
1990–1997: Research Engineer, EERC, UND. Dr. Swanson was involved with the demonstration of advanced power systems such as IGCC and PFBC focused on hot-gas cleanup issues.
1986–1990: Research Engineer, EERC, UND. Dr. Swanson supervised a contract with the U.S. Department of Energy (DOE) to investigate the utilization of coal–water fuels in gas turbines, where he designed, constructed, and operated research projects that evaluated the higher reactivity of low rank coals in short-residence-time gas turbines and diesel engines.
1983–1986: Research Engineer, EERC, UND. Dr. Swanson designed, constructed, and operated SFE and coal liquefaction apparatus; characterized the resulting organic liquids and carbonaceous chars; and prepared reports.
1982–1983: Associated Western Universities Postgraduate Fellowship, DOE Grand Forks Energy Technology Center, Grand Forks, North Dakota. Dr. Swanson designed and constructed an SFE apparatus.

Publications
Dr. Swanson has authored or coauthored numerous professional publications.

MARIE-JOELLE "JOELLE" SIMONPIETRI

Education and Training

M.B.A., Tuck School of Business, Dartmouth College, 2005.
B.S., Neurobiology, Duke University, 1994.

Research and Professional Experience

- 25 years of management experience in innovation, competitive strategy, and technology
- Advanced renewable fuel supply chain and manufacturing subject matter expert
- Skill at forming multistakeholder teams to address complex problems
- Corporate management work experience at Fortune 200 firm
- Department of Defense subject matter expert for renewable aviation fuel specifications and manufacturing, waste gasification, contingency basing, logistics planning, and energy planning
- U.S. Navy veteran, attained rank of Captain and Commanding Officer

2017–Present and 2007–2009: Simonpietri Enterprises LLC, Honolulu, Hawaii.
Clean technology development and investment strategy for renewable fuels and heavy industry

- Founder and developer of the Aloha Carbon technology and process to manufacture hydrogen, renewable fuels, and low-greenhouse gas building materials from organic urban wastes.
- Technoeconomic consultant for petroleum refining, renewable fuel production, waste management, electricity production, microalgae nutraceutical and energy production, and energy and logistics info technology and services firms.
- Led internal Innovation Team and renewable fuel integration planning for Par Hawaii Inc., a client with over 150,000 barrels per day in petroleum refining and distribution operations, for over 2 years.
- Helped clients develop and execute sustainability strategy, renewable energy procurement initiatives, clean technology investment and technology evaluation, and capability gap assessments
- Assisted client teams to develop over $100 million in first-of-kind renewable fuels and energy technology commercial plants, demonstration facilities, and pilot facilities.
- Special Venture Capital Partner for a Honolulu-based venture capital fund. Led investment syndication and performed due diligence and mentoring of renewable energy companies.

2009–2016: Program Manager, Energy and Contingency Basing, Innovation and Experimentation Division, Headquarters, U.S. Indo-Pacific Command (IPACOM), Camp Smith, Hawaii.
On Science and Technology Intergovernmental Personnel Act detail from University of Hawaii

- Program Manager and Contracting Officer's Technical Representative (COTR) for $40 million in research, development, test, and evaluation (RDT&E) campaigns in renewable fuels, waste to energy, fuel supply and logistics optimization, and contingency base waste/water/energy supply.
- Technical subject matter expert on renewable aviation and marine fuel procurement and supply chain development, transportation, and logistics planning energy improvements; remote/austere contingency base energy efficiency improvements; and deployable waste gasification.
- Supervised over 30 civil service and technical support contract personnel.

2004–2007: Waste Management Inc. (NYSE Ticker: WM; a Fortune 200 firm), Houston, Texas.
Special Project Manager for $250 million corporate venture fund and industrial waste reduction services.

- Reported directly to Vice President, Upstream Group and Vice President, Organic Growth corporate venture capital group. "Plankowner" for new $250 million venture fund.
- Waste-to-Energy and Biofuels investment lead nationwide.
- Industrial waste recycling and management special projects for U.S. and Canadian industrial firms: oil refiners, auto assembly plants, foundries, pharmaceutical firms.
- Organized teams to develop and write corporate strategy for renewable energy market entry and disaster management and response for Hurricane Katrina & H1N1 Influenza response.

1994–2003: Senior Counter-Terrorism Analyst/Foreign Liaison Officer/Lieutenant Commander, U.S. Navy and U.S. Embassy Singapore, Singapore and Pearl Harbor, Hawaii.

- Promoted to PACOM commander's briefing team; one of four analysts selected from pool of 300.
- Recalled to duty after Sep 11th attacks to help start and train counter-terrorism team for PACOM.
- Hand-picked to represent PACOM command to the Singapore Armed Forces for a 4-month counter- terrorism coordination project at the U.S. Embassy in Singapore.

Relevant Publications: Publications are in business press and industry fora.

Synergistic Activities

- Commercial Aviation Alternative Fuel Initiative (www.caafi.org) lead for Hawaii regional focal
- Federal Aviation Administration Sustainability Center of Excellence (www.ascent.aero) industry advisory committee member
- U.S. Department of Energy – State of Hawaii joint Hawaii Clean Energy Initiative – Advisory Board, U.S. Pacific Command action officer
- Hawaii Energy Policy Forum, Member 2007–Present
- Hawaii Bioeconomy Trade Organization (www.hawaiibioeconomy.org), Chair of the Board, 2018–Present

TYLER K. NEWMAN
Senior Research Engineer
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
701.777.5079 (phone), 701.777.5181 (fax), tnewman@undeerc.org

Principal Areas of Expertise

Mr. Newman's principal areas of interest and expertise include design, fabrication, and operation of bench- and pilot-scale equipment for biomass and fossil fuel conversion for energy production, with an emphasis on CO_2 capture and storage in power generation and in industrial applications.

Education and Training

M.Eng., Mechanical Engineering, University of North Dakota, 2021.
B.S., Mechanical Engineering, University of North Dakota, 2015.

Research and Professional Experience

October 2022–Present: Senior Research Engineer, EERC, UND. Mr. Newman's work focuses on advancing new technologies and practical solutions to critical energy and environmental challenges, in support of the EERC mission and strategic plan. This includes planning, supervision, and execution to design, fabricate, and operate lab and/or pilot-scale process systems. Following operation, he analyzes and reports results from the experiments. He prepares research proposals, interprets data, writes reports and papers, and presents project results to clients.

November 2017–2022: Research Engineer, EERC, UND. Mr. Newman's work focuses on process engineering and design related to conversion of coal/biomass to fuels, chemicals, and energy and pre/postcombustion carbon capture, including creating engineering drawings and process modeling/simulations, hands-on fabrication, and oversight and operation of equipment and processes related to energy conversion. He assists with preparing research proposals, interpreting data, and writing reports and papers.

June 2015–October 2017: Mechanical Engineer, Odra, LLC, Grand Forks, North Dakota. Mr. Newman served as head of research and development, technical service manager, and service parts specialist. Specific activities included:

- Continuously improving product for safety and reliability.
- Designing new factory layout to expedite workflow by 50%.
- Writing work instructions, maintaining equal work for each stage of production.
- Designing test hardware and process to reduce electrical subassembly time by 80%.
- Reducing the cost of a hydraulic system for international markets by 50%.
- Quality control and product warranty.

September 2013 – May 2015: Research Assistant (part-time), EERC, UND. Mr. Newman's responsibilities included:

- Creating piping and instrumentation diagrams for high-temperature, high-pressure equipment.
- Preparing shop drawings for fabrication of experimental equipment.
- Organizing and maintaining archive of confidential engineering documentation.
- Conducting facility maintenance tasks for safe identification of instrumentation.
- Assisting with creation of training and safety material.

Publications

Has coauthored several professional publications.

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 is 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.

Equipment: If equipment (value of $5000 or more) is budgeted, it is discussed in the text of the proposal and/or identified more specifically in the accompanying budget detail.

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.

Subcontract – Simonpietri Enterprises: Simonpietri will be overseeing the techno-economic and modeling work. Its cost is based on a verbal quote.

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: Expenditures for project partner meetings where the primary purpose is dissemination of technical information may include the cost of food. 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 project partner meetings.

Professional Development: Fees are for memberships in technical areas directly related to work on this project. Technical journals and newsletters received as a result of a membership are used throughout the development and execution of the project by the research team.

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.

Laboratory and analytical recharge fees are charged on a per sample, hourly, or daily rate. Additionally, laboratory analyses may be performed outside of the university when necessary. The estimated cost is based on the test protocol required for the scope of work.

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, Web site design, brochures, and photographs. The estimated cost is based on prior experience with similar projects.

Shop and operations recharge fees cover specific expenses related to the pilot plant and the required expertise of individuals who perform related activities. Fees may be incurred in the pilot plant, at remote locations, or in EERC laboratories whenever these particular skills are required. The rate includes such items as specialized safety training, personal safety items, fall protection harnesses and respirators, CPR certification, annual physicals, protective clothing/eyewear, research by-product disposal, equipment repairs, equipment safety inspections, and labor to direct these activities. The estimated cost is based on the number of hours budgeted for this group of individuals.

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.

Software solutions services recharge fees are for development of customized Web sites and interfaces, software applications development, data and financial management systems for comprehensive reporting and predictive analysis tools, and custom integration with existing systems. The estimated cost is based on prior experience with similar projects.

Field safety fees cover safety training and certifications, providing necessary PPE, and annual physicals. The estimated cost is based on the number of days individuals are budgeted to work in the field.

Freight expenditures generally occur for outgoing items and field sample shipments.

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.

Cost Share: Cash cost share is being provided by DOE in the amount of $1,600,000, and Simonpietri is providing $400,000 of in-kind cost share.

APPENDIX D

REFERENCES CITED

REFERENCES CITED

1 Stanislowski, J.J.; Kay, J.P.; Musich, M.A.; Strege, J.R.; Stanislowski, N.E.; Carriere, N.D.; Oleksik, J.S. *Biomass Cofiring with Precombustion Carbon Capture Baseline Testing at UND EERC*; Final Report for U.S. Department of Energy National Energy Technology Laboratory Contract No. P010227025; EERC Publication 2022-EERC-06-05; Energy & Environmental Research Center: Grand Forks, ND, June 2022.

2 Stanislowski, J.J.; Tolbert, S.G.; Beddoe, C.J.; Musich, M.A.; Henderson, A.K.; Carriere, N.D. *Biomass Cofiring with Precombustion Carbon Capture Baseline Testing at UND EERC;* Final Report for Leidos Task Release 11; EERC Publication 2021-EERC-12-07; Energy & Environmental Research Center: Grand Forks, ND, Dec 2021.

3 Kramer, A. *Low-Carbon Renewable Natural Gas (RNG) from Wood Wastes*; Gas Technology Institute, Feb 2019; 86 p.

4 Simonpietri, M.J. *Sequestering Arsenic from Effluents in Construction and Demolition Wood Recycling (SAFE C&D Wood Recycling) – Final Report*; Small Business Innovation Research (SBIR) Phase I Award No. 68HERC21C0025; Simonpietri Enterprises LLC; Aug 31, 2021.

5 Simonpietri, M.J. *Reducing Cost of Cellulosic Jet Fuel Made from Woody Biomass*; FY20 Phase I SBIR Final Technical Report, Grant ID: USDA-NIFA-SBIR-006790 GRANT 12960001 Topic No. 8, 15 April 2021.

INDUSTRIAL COMMISSION OF NORTH DAKOTA
RENEWABLE ENERGY PROGRAM

TECHNICAL REVIEWERS' RATING SUMMARY

R-051-B
CLEAN HYDROGEN FROM HIGH-VOLUME WASTE MATERIALS AND BIOMASS

Principal Investigator: Dr. Michael L. Swanson

Request for $500,000; Total Project Costs $2,500,000

TECHNICAL REVIEWERS' RATING SUMMARY
R-051-B
CLEAN HYDROGEN FROM HIGH-VOLUME WASTE MATERIALS AND BIOMASS
Principal Investigator: Dr. Michael L. Swanson
Request for $500,000; Total Project Costs $2,500,000

Rating Category	Weighting Factor	Technical Reviewer 1B	Technical Reviewer 2B	Technical Reviewer 3B	Average Weighted Score
		Rating			
1. Objectives	9	4	4	5	39.00
2. Achievability	9	4	3	4	33.00
3. Methodology	7	5	4	5	32.67
4. Contribution	7	5	3	5	30.33
5. Awareness	5	2	4	3	15.00
6. Background	5	4	4	5	21.67
7. Project Management	2	4	4	2	6.67
8. Equipment Purchase	2	5	4	5	9.33
9. Facilities	2	5	4	5	9.33
10. Budget	2	5	4	3	8.00
Average Weighted Score		210	184	221	**205.00**
Maximum Weighted Score					250.00

1. **The objectives or goals of the proposed project with respect to clarity and consistency with North Dakota Industrial Commission/Renewable Energy Council goals are: 1 – very unclear; 2 – unclear; 3 – clear; 4 – very clear; or 5 – exceptionally clear.**

Reviewer 1B (Rating 4)

Though the potential, rural economic potential is not quantified, it can be speculated that the outlined project fits exceptionally well with the NDIC's specified goals.

Reviewer 2B (Rating 4)
The project plans to verify the use of North Dakota waste and biomass to make hydrogen for production of ammonia or renewable diesel while capturing and thereby reducing the State's carbon footprint. All predicted to produce hydrogen and a cheaper overall cost versus conventional means.

Reviewer 3B (Rating 5)
The project will identify techniques/equipment to control the formation of tar and to produce a quality hydrogen project. It also has a goal of identifying needs to meet a $1/kg price for the product.

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)
The EERC is well equipped to achieve the specified timeline and the budget and requested funding is reasonable.

Reviewer 2B (Rating 3)
A 21 month schedule has been proposed at total cost of $2,500,000. $500k is being asked for from the ND Renewables Program; the partners propose $400,000 support and the DOE will support the project with $1.6M. The amount of gasification experience at the EERC and modeling experience of the Simonpietri partner should result in timely completion.

Reviewer 3B (Rating 4)
There seems to be ample time in the project schedule to conduct the testing. The bar chart schedule is not detailed enough to thoroughly understand the testing schedule; one must trust the demonstrated experience of the project team to pull it off.

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 5)
The attached flow diagram along with the thorough explanation of the processes indicates that the methodology of this project is well founded.

Reviewer 2B (Rating 4)
Planning and project management by EERC, biomass preparation, gasification of two separate ND biomasses, and techno-economic evaluation to prove reduced CAPEX for this method. Baseline tar production on the first feedstock and then continued testing on a second feedstock. Utilization of a 15#/hr lab-scale O_2 blown gasifier with shift, tar-cracking, Selexol, etc.

Reviewer 3B (Rating 5)
The proposal clearly describes the major issues associated with the project. It also clearly identifies the process components and operations which incorporates known processes while investigating methods of tar cracking.

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 5)
This process could be readily constructed in the rural areas of North Dakota, providing life into the small communities adjacent to the sources of the biomass production.

Reviewer 2B (Rating 3)
Supplying pure hydrogen for the ND h2 hub for ammonia and renewable diesel while reducing the ND carbon footprint is indeed significant.

Reviewer 3B (Rating 5)
Although there is only a little original work contemplated, the process application of agricultural biomass is unique and is directly in line with the NDIC/REC goals of advancing agriculture and energy production in North Dakota. The integration of the tar cracking advances the state of the art of gasification technology overall. This would certainly be worthy of a paper at the Gasification Technology conference.

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 2)
I have not kept abreast of the development of hydrogen production.

Reviewer 2B (Rating 4)
Mr. Swanson's 30 years of gasification experience and the staff at EERC's operational gasification experience is well documented. A project list was supplied that equals many millions of dollars for the DOE and others.

Reviewer 3B (Rating 3)
The investigator has pointed out the successful use of much of the equipment involved in other EERC projects. There is only limited reference to 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 1B (Rating 4)
As a chemical engineer, I have an understanding of the processes involved in this proposal along with the costs associated with conducting the work.

Reviewer 2B (Rating 4)
Simonpietri Enterprises previous 15 year TEA experience for the DOE and others is also significant (previous DOE engineering study work).

Reviewer 3B (Rating 5)
Dr. Swanson's work related to this project appears to be significant. He also has implied experience through his extensive work for EERC. Ms. Simonpietri's background shows her to be experienced in related activities and likely a quick learner.

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 areas of concern are well addressed in the proposal.

Reviewer 2B (Rating 4)
The proposal includes all the elements mentioned in item 7. Dr. Swanson's tasks include an item for communication with the other partners, DOE, and NDIC.

Reviewer 3B (Rating 2)
There is nothing in the proposal that is adequate with respect to the management plan: the milestone chart is limited to three actual lines; There is nothing that would allow one to evaluate the progress of the testing. There are no defined meetings or reports mentioned other than a final report, no communication plan. The financial plan is somewhat better, but lacks any real level of detail showing the expenditure of funds. An expected expenditure schedule should be included.

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)
Equipment to be utilized is provided by the EERC.

Reviewer 2B (Rating 4)
About $100,000 was identified in the budget for travel and supplies however no major equipment was mentioned to be added.

Reviewer 3B (Rating 5)
There is a discussion of the use of existing equipment. It is commendable that EERC can use existing facilities. As no new equipment is to be purchased, no further comment is necessary.

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 5)
The EERC is exceptionally well equipped both in facilities and equipment available for use.

Reviewer 2B (Rating 4)
The budget spreadsheet shows, in detail, where the money is to be used and where the contributions are proposed. EERC, as previously mentioned, has the equipment and experience to accomplish the testing.

Reviewer 3B (Rating 5)
The success of past projects by EERC demonstrates the applicability of the existing equipment and facilities.

I question if the adequacy of the gasifier feed stock hopper has been evaluated; it was likely sized for coal, and almost any bio-mass feedstock will be much less dense.

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 5)
The value of the projected outlined work could provide a substantial impact on many communities in North Dakota and so this part would be ranked as a 5. The financial commitment from Simonpietri (as in-kind) is not well defined or explained. It is set at a value of $400,000 without any sort of justification for this assessment. Perhaps a breakdown on how this commitment value was derived should be in order before any grant for the project is approved.

Reviewer 2B (Rating 4)
Utilization of North Dakota biomass for the Hydrogen Hub which in turn can be used in the production of ammonia or renewable diesel is significant. Proving this can be accomplished utilizing the vast amount of North Dakota biomass in a tighter agricultural radius is advantageous to North Dakota as well the reduction of the carbon footprint. This should also lead to additional higher paying jobs.

Reviewer 3B (Rating 3)
The overall value of the project, if successfully executed as described, appears to be huge compared to the cost of the research. I suppose DOE could be considered a sponsor of the project thereby showing $2M of a $2.5M being self-funded. The real internal funding though is limited to Simonpietri's contribution.

It is disappointing that the investigators have not been able or did not try to solicit even modest financial participation from the Agricultural Community which would be a direct benefactor of the project.

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
The only flaw I could find is, as cited in item 10, the in-kind commitment from a private industry is without any clarification as to how this value was determined. The merits of the proposal echo each and every goal & purpose written in the NDIC's mission statement.

So, with a bit of clarification on how the in-kind value is determined, I would strongly recommend the funding of this project.

Reviewer 2B
The proposed project should be funded for reasons previously mentioned in #10 above and because it presents a unique opportunity to leverage federal DOE funding to answer a very specific question…Can marriage of technology with ND biomass produce pure hydrogen for less cost than conventional production methology because of the tighter agri-biomass radius?
Also, can the addition of small amounts of ND lignite improve overall hydrogen production efficiency/tar cracking?

Reviewer 3B
I recommend the project be funded.

The project recognizes and takes on one of the critical issues in bio-mass gasification –formation and destruction of tar. It also seeks to identify technologies to control the quality of the hydrogen gas.

The TEA should include the labor qualifications and quantities to operate and maintain the plant. It should also identify potential sources of sufficient feedstock to supply a commercial plant.

Letter of Transmittal

May 23, 2023

Reice Haase

Executive Director

North Dakota Industrial Commission

State Capitol-14th Floor

600 East Boulevard Ave Dept 405

Bismarck, ND 58505-0840

Dear Mr. Haase,

On behalf of 4H2, Inc. we are submitting our grant application for the May 26th, 2023, grant round of the ND Industrial Commission Renewable Energy Program. We have sent via USPS the $100 Application fee separately from the electronic submission of the grant.

Our submission includes the grant application, patent rights reservation, tax liability statement, and an appendix containing Letters of Support from agriculture-related associations and economic development entities.

4H2, Inc. is requesting $346,915.00 over a 2-year research period, matched equally with private funding from within 4H2, Inc. for a total research and development proposal of $693,832.00.

4H2, Inc. is a North Dakota corporation operating in the renewable, clean energy industry. We greatly appreciate the opportunity to apply to the Renewable Energy Program. Please feel free to contact me at any time with any questions regarding this submission.

Sincerely,

Jason LaPlante

Jason LaPlante

CEO - 4H2, Inc.

1610 Mill Road

Grand Forks, ND 58201

Renewable Energy Program

North Dakota Industrial Commission

Application

Project Title: DEFC Research and Development

Applicant: 4H2, Inc.

Principal Investigator: Dr. Yang Yang

Date of Application: May 22, 2023

Amount of Request: $346,915

Total Amount of Proposed Project: $693,832

Duration of Project: 2023 - 2025

Point of Contact (POC): Brian LaPlante

POC Telephone: (218) 280-0945

POC Email: brian.laplante@4h2inc.net

POC Address: 1610 Mill Road, Grand Forks, ND 58201

TABLE OF CONTENTS

Please use this table to fill in the correct corresponding page number.

ABSTRACT

Objective:

4H2, Inc is engaging in a “Sponsored Research Project” with the University of Central Florida for the development of a high-energy density, direct ethanol fuel cell (DEFC). The goal is to develop a catalyst that is low in rare earth metals yet can achieve the same energy density as current state hydrogen fuel cell technology (1 watt per centimeter-squared). 4H2, Inc., (herein referred to as 4H2) will own the patent rights to this technology upon completion of the research work. Dr. Yang Yang and his team of researchers at the University of Central Florida (UCF) will be conducting the research and development effort of this novel catalyst.

In achieving the research goals of this project, the high energy output catalyst allows for 4H2 to create DEFC systems which are scalable in power output based upon its application. 4H2 believes that with the advent of high-energy density DEFC, this technology can assist the corn ethanol industry in surviving the negative market impact from recent California Air Resources Board (CARB) and related government regulations. These regulations will drive the phasing out of internal combustion engines and therefore the demand for ethanol fuel currently used to blend with gasoline.

DEFC technology allows for the direct creation of electricity from ethanol as a fuel source for the fuel cell without any additional steps. DEFC stationary, portable, and mobile electricity generation competes favorably against hydrogen fuel cell systems, utilizing the existing production and distribution infrastructure system of ethanol, whereas hydrogen fuel cell technology does not have significant production or distribution infrastructure to date.

Expected Results: Upon completion of the 2-year research project, the “Deliverables” from the UCF research team are:

1.) Novel, patentable, low rare or noble earth metal catalyst with a power density of 0.8 – 1.0 W per CM^2.
2.) DEFC prototype stack based upon the novel catalyst for 4H2 for the purposes of testing, feasibility, and design of a commercially viable DEFC system.
3.) 4H2 and UCF will file for patent of this novel catalyst, which 4H2 will own.

Duration: Research commences in 2023 and will continue for a period of two years, culminating in 2025 with the completion of the above-stated deliverables to 4H2.

Total Project Cost: The UCF project budget is $693, 832.

Participants: Dr. Yang Yang as Primary Investigator and his team of UCF graduate students will undertake the direct research on behalf of 4H2 who is sponsoring the research.

PROJECT DESCRIPTION

Objectives: The objective of this project is to develop a novel technology based on direct-ethanol (EtOH) fuel cells (DEFC) with a power density of 0.8-1.0 W cm^{-2} in both single cell and stack, which will be ideal as the power source in various commercial and defense applications.

Methodology: We will develop a high-throughput synthesis method to produce palladium (Pd)-based alloys, which will be employed as the catalysts for the DEFC.

Anticipated Results: The DEFC will deliver a power density of 0.8-1.0 W per cm^2 in both single cell and stack, which is competitive to hydrogen fuel cells but can be operated in a much safer and more convenient normal atmospheric pressure condition without the need for a high-pressure condition as is needed in hydrogen fuel cell.

Facilities: The University of Central Florida (UCF) research Laboratory has the necessary research facilities, including three hoods, three sinks, and sufficient counter space for postdocs and students to be working on simultaneously. More detailed information can be found from: http://www.yangyanglab.com/facilities.html

Resources: Material characterization equipment is available at the UCF shared facilities. The Advanced Materials Processing and Analysis Center (AMPAC) has two user facilities centers, Advanced Microfabrication Facility (AMF) and Materials Characterization Facility (MCF), that provide sufficient shared instrument facilities to pave the way to project success. The following equipment and facilities can be accessible: Cryo Small Single Sputtering, CHA E-Beam Evaporation, Physical Electronics 5400 ESCA (XPS), PANalytical Empyrean Thin Film X-ray Diffraction (XRD), Hitachi S3500N Scanning Electron Microscope (SEM), FEI Tecnai F30 Transmission electron microscope (TEM), Renishaw RM 1000B Micro-Raman Spectrometer, inductively coupled plasma mass spectrometry (ICP-MS, Agilent Technologies, Palo Alto, CA) model 7500s, Perkin Elmer Spectrum 100 attenuated total reflection (ATR) Fourier Transform Infra-red Spectroscopy (FT-IR) Spectrometer, N_2 adsorption/desorption analyzer (NOVA 2000e, Quantachrome Instrument) for specific surface area measurement, PAR model M273 potentiostat/galvanostatic (Princeton Applied Research) for electrical conductivity measurement. A cleanroom facility is also available for nanodevice fabrication.

Techniques to Be Used, Their Availability and Capability: Thermal annealing technique will be used to synthesize the desired materials for DEFC, which has been well explored in the research lab at UCF.

Environmental and Economic Impacts while Project is Underway:

Current means of utilizing ethanol as an energy source is primarily via blending with gasoline for use in passenger vehicles. As has been determined, this contributes to the generation of climate threatening GHG's and the generation of harmful levels of nitrous oxides (NOx) emissions. Recent CARB and EPA regulations imposed on the internal combustion engine market calls for the phasing out of these internal combustion engines within the next several years. This will severely impact the current market for corn-derived ethanol resulting in a substantial loss of market revenue to corn producers and the ethanol production industry. This loss of revenue will have an extensive negative ripple-effect impact on the agriculture industry as a whole.

Further, with the current production of ethanol produced with the intention of blending with gasoline as a fuel oxygenation additive, this requires ethanol to be distilled to an anhydrous state. The energy required to remove all water from the ethanol requires significant energy input which in turn drives up the cost to reach this state. Because natural gas is used to fuel the distillation process, this adds to the CO_2 generated during production. Comparatively, it is desirable for ethanol used for fueling DEFC's to retain a certain amount of water, thereby reducing cost and CO_2 generation. As a result, the amount of fuel produced by existing ethanol plants could be increased by as much as 30% with no additional cost.

Ultimate Technological and Economic Impacts:

DEFC technology can utilize ethanol directly without blending with gasoline and without using thermal combustion. Rather, electro-chemical conversion of ethanol directly to electricity under ambient temperature and pressure is how DEFC operates. An important benefit of the DEFC technology that 4H2 will manufacture is that CO_2 found in ethanol will be molecularly converted to a non-gaseous carbon product, thereby not entering the atmosphere. Essentially, ethanol as a fuel becomes CO_2 negative within the DEFC we are developing.

The impact of the DEFC technology is that it provides a market pathway for ethanol to remain as a strategic commodity for North Dakota for the near and foreseeable future. 4H2 also seeks to set up manufacturing of the DEFC product line in the state of ND due to its business-friendly policies and proximity to the raw materials needed to produce DEFC's.

Why the Project is Needed:

Maintaining the current market for corn-derived ethanol is critical for maintaining the health of the agricultural industry and all those employed downstream and upstream of the corn producers. Furthermore, corn ethanol is a sustainable fuel that contributes to the United States' energy independence. DEFC technology creates a path forward for ethanol in a "post-internal combustion" era. DEFC technology increases the potential applications of ethanol beyond what is able to be achieved today. Finally, by converting ethanol fuel into electricity by chemical process, it can help lead to the zero-carbon production of energy per the goals of federal regulations.

STANDARDS OF SUCCESS

Standards of Success should include: The measurable deliverables of the project that will determine whether it is a success; The value to North Dakota; An explanation of what parts of the public and private sector will likely make use of the project's results, and when and in what way; The potential that commercial use will be made of the project's results; How the project will enhance the education, research, development and marketing of North Dakota's renewable energy resources; How it will preserve existing jobs and create new ones; How it will otherwise satisfy the purposes established in the mission of the Program.

The measurable deliverables of the project:

- Report on DEFC prototype single cell - 12 months after Effective Date
- Report on DEFC prototype stack – 24 months after Effective Date
- Novel catalyst which will be patented and owned by 4H2

The value to North Dakota:

The DEFC research sponsored by 4H2 provides for the continuation of and growth of the value of corn-derived ethanol production in the state of North Dakota and the preservation of the jobs and commerce related to this industry. Further, with the support of North Dakota, 4H2 is looking to establish a DEFC manufacturing presence in the state, creating new job opportunities for its residents. Finally, in communications with the administration of North Dakota State University, 4H2 seeks to collaborate with the University in developing a biofuels research and development program starting with the manufacturing process development for DEFC production.

An explanation of what parts of the public and private sector will likely make use of the project's results, and when and in what way:

As stated above, the direct benefit for the private sector of the research is the preservation and growth of the state's corn growers, ethanol producers and the supply chains associated with both. An important public sector benefit is the continuation of state revenues related to these industries. Equally important is the utilization of the DEFC technology by the private and public sector. Stationary, portable, and mobile electricity generation via DEFC allows for a new approach to electricity generation for farms, homes, businesses, vehicles, and off-road vehicles and equipment. Power generation to complement the power grid via micro-grids and distributed energy resources (DER's) is critical today.

How the project will enhance the education, research, development and marketing of North Dakota's renewable energy resources:

By bringing a biofuels focus to North Dakota State University, this will enhance the University's standing in this extensive field of research and development. We have had discussions with and intend to partner with the ND Department of Ag Extension to demonstrate the feasibility of multiple applications of electrified ag production equipment as the future trend in the industry. Furthermore, by collaborating with the Agronomy department at NDSU, 4H2 wishes to explore the development of additional ethanol product feedstock plant varieties. The ability of DEFC to play a critical role in complimenting existing electricity generation (especially intermittent sources such as wind and solar) by producing electricity on demand when insufficient electricity exists will impact renewable energy vitality in North Dakota. Finally, promoting ethanol as a verified carbon neutral (or negative) fuel will aid in the transition of North Dakota as a leader in fossil fuels production to a sustainable clean energy production state of the future.

How it will preserve existing jobs and create new ones:

By supporting the ND ethanol industry in its transition from ethanol as a pure additive for blending with gasoline as a fuel for ICE-powered vehicles, which is facing its demise via recent fossil fuel free regulatory mandates, this research will lay the foundation for a more robust future for the ethanol industry and all who are employed in it and its supply chain. Growing this industry brings with it the opportunity for employment growth, as will the manufacturing of the DEFC's themselves in the state of ND.

How it will otherwise satisfy the purposes established in the mission of the Program:

An important aspect of the Renewable Energy Development program is to identify technologies "presently not used in North Dakota". DEFC technology does not commercially exist on the market today. 4H2 will endeavor to make DEFC commercially viable after this research is completed and intends to set up manufacturing within North Dakota. DEFC research serves to promote the growth of North Dakota's standing as a renewable energy industries leader through direct research and development. Furthermore, by collaborating with NDSU and the ND Department of Ag Extension, we will be enabling the education of a new and future generations of technical careers in this industry.

BACKGROUND/QUALIFICATIONS

Please provide a summary of prior work related to the project conducted by the applicant and other participants as well as by other organizations. ***This should also include summary of the experience and qualifications pertinent to the project of the applicant, principal investigator, and other participants in the project.***

Dr. Yang Yang, an associate professor at UCF, has devoted research and published more than 130 peer-reviewed articles related to the programmable and controlled synthesis of innovative materials for many applications across different fields of renewable energy, including energy conversion and storage, green catalysis, artificial photosynthesis, and reactor design for various energy devices such as fuel cells, flow batteries, and (water and CO_2) electrolyzers. In particular, Dr. Yang's expertise in exploring innovative techniques and approaches for the development of fuel cells catalysts will be the solid basis for the project's success.

This new research intends to build on the science used to develop the catalyst which is now under patent pending and for which 4H2 has secured the option for exclusive rights. This previous catalyst technology shows that the DEFC can generate 0.7 W per CM^2 and therefore is a solid basis on which to improve to the desired output of 1.0 W per CM^2 while reducing the amount of rare earth materials in the catalyst formulation.

Jason LaPlante, co-founder of 4H2 Inc., obtained his B.S. degree in Agricultural Engineering from North Dakota State University in 1986 and has been leading product development efforts for several major corporations since then. He currently serves as Vice President of Product and Technology for TBEI, Inc., a manufacturer of light to heavy duty dump trucks and semi trailers. While serving as VP at TBEI, Jason is also involved in running 4H2, Inc.

Brian LaPlante, co-founder of 4H2, Inc., obtained his B.S. degree in Business Administration from North Dakota State University in 1990. He has since led a career in research and development in a number of industries, including machinery and food production. He co-authored published studies jointly with the University of Minnesota in the field of cereal grain genetics and fermentation. He was the co-founder of the Hydrogen Economy Collaborative launched in 2020, now administered by the Great Plains Initiative in Minneapolis, MN. Brian initiated the founding of 4H2 in order to pursue the research and development of direct ethanol fuel cells based on his knowledge of the science and a need for this technology as detailed elsewhere in this application.

MANAGEMENT

*A description of **how** the applicant will manage and oversee the project to ensure it is being carried out on schedule and in a manner that best ensures its objectives will be met, **and a description of the evaluation points to be used** during the course of the project.*

Jason LaPlante and Brian LaPlante have extensive experience in project management and research management. The following project management approach will be implemented, along with the utilization of a Project Management software system for precise implementation, tracking, and cataloging of data.

- **Management and Oversight of the Sponsored research by 4H2, Inc.**
  - 4H2, Inc. is the sponsor of the research project with Dr. Yang and the UCF team. As such we will manage and oversee the funding of the research as well as “milestone” and “deliverables” set forth in our “Master Agreement” and “Task Orders” of the project.
  - Dr. Yang will complete monthly reports for work completed and hours of work undertaken for invoicing by the UCF. 4H2 will pay the invoices on a monthly basis.
  - 4H2, Inc. will remain in weekly, monthly, and quarterly “Status Meetings” for project progress and to address any specific questions or needs of the UCF team.
  - Quarterly and Semi-annual performance and outcome reports from Dr. Yang will be delivered to 4H2 to ensure progress of the project is on time as per the Task Order timeline.
  - 4H2 will remain in quarterly contact with the Director of Intellectual Property at UCF for discussions regarding patent application as the project meets specific goals and the stated deliverables are undergoing performance testing.
- **Ensuring the project remains on schedule and objectives are met.**
  - 4H2 will maintain very tight schedules for weekly, monthly, and quarterly meetings with Dr. Yang to monitor progress and to discuss any needs the research team has that may impact milestones stated within the project task order.
  - 4H2 will establish a weekly and monthly “Roadblocks Protocol” which will be a designated discussion in our meetings in the attempt of anticipating any research roadblocks either in outcomes, materials used in research, equipment malfunctions, staffing situations, etc. and how alternate solutions can be made ready for such potentials.
- **Evaluation points within the project.**
  - Specific evaluation points are tied directly to the Project Task Order with Milestones and Deliverables stated. These milestones and deliverables are:
  - Milestone 1.1: Catalyst with a power density of 0.7-0.8 W cm^{-2} in DEFC
  - Milestone 1.2: Scale up of DEFC prototype cell from 10 cm^2/cell to 50 cm^2/cell
  - Deliverable 1: DEFC prototype single cell (3-4 W/Cell)
  - Milestone 2.1: The catalyst with a power density of 0.8-1.0 W cm^{-2} in DEFC
  - Milestone 2.2: DEFC prototype cell (50 cm^2/cell)
  - Milestone 2.3: DEFC prototype cells in a stack (50 cm^2/cell)
  - Deliverable 2: DEFC prototype stack (20-100 W/stack)

TIMETABLE

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

<u>Master Schedule for DEFC Project (2-Year timeline)</u>

Project Begin Date (proposed): August 1, 2023

Project Completion Date (proposed): July 31, 2025

<u>**Task 1:**</u> Composition selection of Pd-based Catalysts (August 2023-July 2024)

Milestone 1.1: Catalyst with a power density of 0.7-0.8 W cm^{-2} in DEFC (to be completed by July of 2024).

Milestone 1.2: Scale up DEFC prototype cell from 10 cm^2/cell to 50 cm^2/cell (to be completed by July of 2024).

Deliverable 1: DEFC prototype single cell, 3 to 4 W/ cell (to be completed by July of 2024).

Quarterly reporting due dates: (Due to 4H2, Inc.)

October 31, 2023

January 31, 2024

April 30, 2024

July 31, 2024

Semi-annual reporting due dates: (Due to the ND Industrial Commission-REP)

January 31, 2024

July 31, 2024

<u>**Task 2:**</u> Supporting materials selection to immobilize Pd-based catalysts (August 2024-July 2025).

Milestone 2.1: The catalyst with a power density of 0.8 W cm^{-2} in DEFC (to be completed by January 31, 2025).

Milestone 2.2: DEFC prototype cell, 50 cm^2/cell (to be completed by July of 2025).

Milestone 2.3: DEFC prototype cells in a stack, 50 cm^2/cell (to be completed by July of 2025).

Deliverable 2: DEFC prototype stack, 20-100 W/stack (to be completed by July of 2025).

Quarterly reporting due dates: (Due to 4H2, Inc.)

October 31, 2024

January 31, 2025

April 30, 2025

July 31, 2025

Semi-annual reporting due dates: (Due to the ND Industrial Commission-REP)

January 31, 2025

July 31, 2025

BUDGET

*Please use the table below to provide an **itemized list** of the project's capital costs; direct operating costs, including salaries; and indirect costs; and an explanation of which of these costs will be supported by the grant and in what amount. The budget should identify all other committed and prospective funding sources and the amount of funding from each source. **Please feel free to add columns and rows as needed.** Higher priority will be given to those projects have matching private industry investment equal to at least 50% or more of total cost.*

Project Associated Expense	NDIC's Share	Applicant's Share (Cash)	Applicant's Share (In-Kind)	Other Project Sponsor's Share
Key Personnel	$ 13,023	$13,024		
Other Personnel	$152,250	$152,250		
Fringe Benefits	$ 28,397	$ 28,398		
Direct Costs	$ 2,000	$ 2,000		
Other Direct Costs	$ 39,096	$ 39,096		
Indirect Costs	$112,149	$112,149		
Total	$346,915	$346,917		

Below is the budget prepared by UCF to cover the expenses for the research project as defined in their proposal. The funds indicated below have been entered into the table above.

Cumulative Budget				
		Funds Requested		
Budget Cost Category	RATE	Year 1	Year 2	Total Project
A. Direct Labor - Key Personnel				
Dr. Yang Yang	1	$ 12,831	$ 13,216	
Subtotal Salary		$ 12,831	$ 13,216	$ 26,047
Direct Labor - Other Personnel				
Post Doctoral Associate	2	$ 100,000	$ 103,000	
Graduate Student	2	$ 50,000	$ 51,500	
Undergraduate Student				
Subtotal OPS		$ 150,000	$ 154,500	$ 304,500
B. Fringe Benefits				
Faculty	31%	$ 3,978	$ 4,097	
Post Doc	23%	$ 23,000	$ 23,690	
Students	2%	$ 1,000	$ 1,030	
Subtotal Fringe		$ 27,978	$ 28,817	$ 56,795
Total Labor Costs (A+B)		**$ 190,809**	**$ 196,533**	**$ 387,342**
C. Direct Costs - Equipment		$ -	$ -	$ -
D. Direct Costs - Travel				
Domestic Travel		$ 2,000	$ 2,000	
Total Travel Costs		**$ 2,000**	**$ 2,000**	**$ 4,000**
F. Other Direct Costs				
Materials & Supplies		$ 10,000	$ 10,000	
OCO or Facility Rental		$ 10,000	$ 10,000	
Tuition	2	$ 18,630	$ 19,562	
Total Other Direct Costs		**$ 38,630**	**$ 39,562**	**$ 78,192**
G. Total Direct Costs (A+B+C+D+E+F)		**$ 231,439**	**$ 238,095**	**$ 469,534**
Modified Total Direct Costs		$ 212,809	$ 218,533	$ 431,342
H. Indirect Costs	**52%**	$ 110,661	$ 113,637	$ 224,298
I. Total Direct and Indirect Costs (G+H)		**$ 342,100**	**$ 351,732**	**$ 693,832**
				$ 693,832

Please use the space below to justify project associated expenses, and discuss if less funding is available than that requested, whether the project's objectives will be unattainable or delayed.

The project expenses indicated above are the direct and indirect costs associated with performing the research at the University of Central Florida. If the funding of $346,915 is not available from the NDIC, then other sources of funding will need to be sought out and obtained, which will delay the start of the research project. In turn, this will delay the economic benefits for ND as a result of this research.

CONFIDENTIAL INFORMATION

Any information in the application that is entitled to confidentiality and which the applicant wants to be kept confidential should be placed in an appendix to allow for administrative ease in protecting the information from public disclosure while allowing public access to the rest of the application. The appendix must be clearly labeled as confidential and must include the following information: (a.) a general description of the nature of the information sought to be protected, (b.) an explanation of why the information derives independent economic value, actual or potential, from not being generally known to other persons, (c.) an explanation of why the information is not readily ascertainable by proper means by other persons, (d.) a general description of any person or entity that may obtain economic value from disclosure or use of the information, and how the person or entity may obtain this value, and (e.) a description of the efforts used to maintain the secrecy of the information.

*If there is no confidential information, please note that below. If you plan to request confidentiality for **reports** if the proposal is successful, this section must still be completed.*

There is no confidential information in this application.

PATENTS/RIGHTS TO TECHNICAL DATA

Any patents or rights that the applicant wishes to reserve must be identified in the application. If this does not apply to your proposal, please note that below.

4H2, Inc holds the exclusive rights to the following patent filed by the University of Central Florida:

High-Entropy Alloy for High-Performance Direct Ethanol Fuel Cells (63/388,085)

STATE PROGRAMS AND INCENTIVES

Any programs or incentives from the State that the applicant has participated in within the last five years should be listed below, along with the timeframe and value.

None to date

Appendix: Tax Liability Statement

Tax Liability Statement

Applicant:

4H2, Inc.

Application Title:

DEFC Research and Development

Program:

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

Certification:

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

[signature] JASON LAPLANTE

Signature

CEO - 4H2, Inc.

Title

May 22, 2023

Date

Appendix: Letters of Support

North Dakota Ethanol Council:

North Dakota Ethanol Council

Sept. 9, 2022

To whom it may concern:

On behalf of the North Dakota Ethanol Council (NDEC), representing the state's six ethanol plants, we are submitting this letter of support for research on direct ethanol fuel cell technology. It is our understanding 4H2 Inc. is one of the companies exploring this opportunity.

While we have limited details on the technology proposed by 4H2 Inc., North Dakota's ethanol industry generally supports the exploration of the direct ethanol fuel cell technology given its many benefits to the ethanol industry, along with consumers. These include, but aren't limited to, a decreased carbon footprint and an additional market for ethanol increasing the sustainability of the industry through diversification of marketing options.

We would welcome the opportunity to learn more about the technology and the opportunities it would create for the state's ethanol industry.

Sincerely,

Jeff Zueger
Chairman

Deana Wiese
Executive Director

1605 E. Capitol Avenue
PO Box 1091 • Bismarck, ND 58502
Phone: 701.355.4458 • Fax: 701.223.4645

Minnesota Agricultural Utilization Research Institute

May 12, 2023

North Dakota Renewable Energy Program
Director: Reice Haase
North Dakota Industrial Commission
State Capitol, 14th Floor, 600 E Boulevard Ave. Dept. 405
Bismarck, ND 58505-0840

RE: AURI Letter of Support for 4H2, Inc.'s North Dakota Renewable Energy Program application

North Dakota Renewable Energy Program Review Committee,

It is my pleasure to write this letter of support on behalf of the Agricultural Utilization Research Institute (AURI) for 4H2 Inc.'s proposal submitted to the North Dakota Renewable Energy Program. AURI is a non-profit corporation funded primarily by the State of Minnesota with a mission to foster long-term economic benefit for Minnesota through value-added agricultural products. AURI accomplishes this by developing new uses for agricultural products through science and technology, using a deliberate approach on multiple levels, including focused basic research, public information dissemination, building strategic collaborations among partners and by placing a strong emphasis on applications with near-term implementation plans.

The proposed project aims for direct ethanol fuel cell systems which will direct conversion of ethanol to electricity via fuel cell technology. Developing this technology may play a critical role in complimentary electricity generation. 4H2, Inc. believes the additional benefits of agriculturally sourced byproducts for the components of the DEFC systems are important factors.

AURI supports 4H2, Inc. as it partners to seek external funding to reach its research objectives.

Sincerely,

Jennifer L Wagner-Lahr

Jennifer Wagner-Lahr
Senior Director of Commercialization

Crookston
510 County Rd 71, Ste. 120
Crookston, MN 56716

Marshall
1501 State Street
Marshall, MN 56258

Waseca
PO Box 251
Waseca, MN 56093

Minnesota Corn Research & Promotion Council:

MinnesotaCorn
RESEARCH & PROMOTION COUNCIL

5/17/2023

500 E. Travelers Trail, Suite 600
Burnsville, MN 55337
952.233.0333
mncorn.org

Riece Haase
Executive Director
North Dakota Industrial Commission
State Capitol-14th Floor
600 East Boulevard Ave Dept 405
Bismarck, ND 58505-0840

Dear Ms. Haase,

I am writing this letter on behalf of the Minnesota Corn Research and Promotion Council (MCR&PC) to provide support for funding research on Direct Ethanol Fuel Cell technology. The mission of MCR&PC is to identify and promote opportunities for Minnesota's 24,000 corn farmers, while enhancing quality of life. As a part of this mission, the MCR&PC supports quality research and encourage novel ideas.

Corn plays a vital role in the supply chain for human, animal, and ethanol feedstocks. Minnesota is the 3rd largest corn producer in the U.S. and corn is the largest crop grown in Minnesota. Regarding ethanol, Minnesota is home to 19 ethanol plants producing over 1.4 billion gallons. Corn and ethanol are critically important to the state of Minnesota.

The MCR&PC is aware of technology being developed by 4H2, Inc. which could impact the future of ethanol. 4H2, Inc. is developing Direct Ethanol Fuel Cell systems which allows for the **DIRECT** conversion of ethanol to electricity via fuel cell technology. Ethanol is electro-chemically manipulated to release electrons for direct electricity creation, rather than ethanol being utilized as a thermal energy source via internal combustion engines. The process also has the potential to reduce or even eliminate CO_2 release to the atmosphere from the utilization of ethanol. This technology allows for stationary, portable, and mobile electricity generation. Microgrids, portable generators, and vehicle electrification are just a few of the applications of this DEFC technology.

MinnesotaCorn
RESEARCH & PROMOTION COUNCIL

Clean energy technologies are the focus of great attention and developing technologies for ethanol as a clean power source is essential for the future of ethanol. Therefore, MCR&PC supports the ongoing development of this technology and encourages the REP to support funding of 4H2, Inc. research and development.

Sincerely Yours,

Maciej Kazula, Ph.D.
Research Director
Minnesota Corn Research and Promotion Council

We are dedicated to identifying and promoting opportunities for corn growers while enhancing quality of life.

Southern Valley Economic Development Authority:

SOUTHERN VALLEY
SVEDA
ECONOMIC DEVELOPMENT AUTHORITY

Reice Haase

Executive Director

North Dakota Industrial Commission

State Capitol-14th Floor

600 East Boulevard Ave Dept 405

Bismarck, ND 58505-0840

Dear Reice Haase,

SVEDA is writing to express our strong support for 4H2, Inc. in their application for a grant from the Renewable Energy Program. As an economic development entity, we have had the pleasure of working closely with 4H2, Inc. and witnessing their dedication, innovation, and impact they will have on our region.

4H2, Inc. is dedicated to providing a better source of energy. Their commitment to renewable energy involving ethanol has set them apart as a true leader in the industry.

SVEDA believes that 4H2, Inc. would make excellent use of the grant funds from the Renewable Energy Program. The grant would enable them to develop high energy output catalysts for their direct ethanol fuel cell system. This would not only benefit their business, but also our region as a whole.

I strongly urge you to consider 4H2, Inc. for the grant from the Renewable Energy Program. They are a deserving and impactful business that has already achieved great things and has the potential to achieve even more with the support of this grant.

Thank you for your time and consideration.

Sincerely,

Southern Valley Economic Development Authority

Justin Neppl
Executive Director

Kory Kaste
Business Development

Crookston MN Housing & Economic Development Authority:

HOUSING & ECONOMIC DEVELOPMENT AUTHORITY CROOKSTON

May 18th, 2023

To whom it may concern:

On behalf of the Crookston Housing & Economic Development Authority we are submitting this letter as a letter of support for funding research on Direct Ethanol Fuel Cell (DEFC) technology.

Minnesota is in the top 5 largest producers of ethanol in the nation and houses 19 ethanol plants capable of producing over 28 million barrels of ethanol per year. Ethanol is produced from fermenting the sugar in the starches of grains which includes corn. There are more than 24,000 farmers who grow corn in Minnesota, making Minnesota the 3rd largest corn producer in the nation. Therefore, corn and ethanol are very important to the state of Minnesota and its economy.

Recent federal events, including Minnesota and California (California Air Resource Board), are creating potential risks and opportunities for the corn and ethanol industries. Creating a focus on developing Clean Energy technologies surrounding ethanol and using it as a clean power source is essential for ethanol's future.

Crookston Housing & Economic Development Authority is aware of the technology and initiatives being developed by 4H2, Inc. which could greatly impact the future of ethanol. 4H2, Inc. is developing Direct Ethanol Fuel Cell systems which allows for the direct conversion of ethanol to electricity via fuel cell technology. In this system, ethanol is electro-chemically manipulated to release electrons for direct electricity creation, rather than ethanol being applied as a thermal energy source through internal combustion engines.

This process also has the potential to reduce and possibly eliminate CO_2 release to the atmosphere as a product of utilizing ethanol. This technology allows for stationary, portable, and mobile electricity generation. Microgrids, portable generators, and vehicle electrification are just a few of the applications of this Direct Ethanol Fuel Cell technology.

The Crookston Housing & Economic Development Authority supports 4H2, Inc.'s ongoing development of Direct Ethanol Fuel Cell technology and encourages REP to support funding of their continued research and development.

Karie Kirschbaum

Executive Director

INDUSTRIAL COMMISSION OF NORTH DAKOTA
RENEWABLE ENERGY PROGRAM

TECHNICAL REVIEWERS' RATING SUMMARY

R-051-C
DEFC RESEARCH AND DEVELOPMENT

Principal Investigator: Dr. Yang Yang

Request for $346,915; Total Project Costs $693,832

TECHNICAL REVIEWERS' RATING SUMMARY
R-051-C
DEFC RESEARCH AND DEVELOPMENT
Principal Investigator: Dr. Yang Yang
Request for $346,915; Total Project Costs $693,832

Rating Category	Weighting Factor	Technical Reviewer 1C Rating	Technical Reviewer 2C Rating	Technical Reviewer 3C Rating	Average Weighted Score
1. Objectives	9	4	3	4	33.00
2. Achievability	9	3	2	4	27.00
3. Methodology	7	4	2	4	23.33
4. Contribution	7	2	3	5	23.33
5. Awareness	5	2	4	1	11.67
6. Background	5	5	4	1	16.67
7. Project Management	2	3	4	4	7.33
8. Equipment Purchase	2	5	5	5	10.00
9. Facilities	2	3	3	5	7.33
10. Budget	2	3	3	5	7.33
Average Weighted Score		168	150	183	**167.00**
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 4)

The stated (and somewhat modest) objectives are very clear in terms of power output (at watts/cm2, cell and stack) and milestone dates. Yang Lab has already achieved 0.57 watts/cm2 (fluorine doping of Pd-N-C).

Reviewer 2C (Rating 3)
Goals for EtOH fuel cell power density are stated and consistent with the goals of the NDIC/REC for enhancement of ND renewable resources. However, these goals are applicable to any ethanol production, not just ND's. No additional scale up plans if the project is successful are provided.

Reviewer 3C (Rating 4)
This proposal does outline a very good concept for North Dakota as it is attempting to preserve a renewable energy resource along with the jobs and stability associated with this industry as the US attempts to eliminate the domestic use of fossil fuels. This R&D project is utilizing new technologies for the development of fuel cells. In the end, if the internal combustion engine remains, they may increase the demand for ethanol produced in North Dakota.

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 3)
The modest objectives are likely achievable within the timeframe and budget.

Reviewer 2C (Rating 2)
While this project builds on previous work, including the principal investigators, this project may be able to achieve an increased power density as the stated goal. The additional and un-addressed factors such as carbon management (where does it go?) are glossed over.

Reviewer 3C (Rating 4)
The timetable is well defined and certainly appears to be achievable. The proposed budget appears to be of realistic value.

3. **The quality of the methodology displayed in the proposal is: 1 – well below average; 2 – below average; 3 – average; 4 – above average; or 5 – well above average.**

Reviewer 1C (Rating 4)
Given the past success of the Yang Lab at UCF, I believe the methodology is reasonably proven.

Reviewer 2C (Rating 2)
In addition to the above comments, longevity of the catalyst was not addressed, nor was the tolerance of contaminants/poisons. What are the systematic approaches you are going to take, ie size, edge factors, geometry, chemistry, EtOH concentration, etc. It's understood that there is proprietary information involved, but all that is listed is that the applicant will create the method.

Reviewer 3C (Rating 4)
The milestones for this two year research project are well define and the specified equipment available for use at the University of Central Florida is tremendous.

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 2)
If successful, and with continued funding for fuel cell development, this technology could prove significant for the ethanol industry over the long term, as transportation fuel blending markets wain.

Reviewer 2C (Rating 3)
If this technology becomes mainstream, then the contribution would be significant. The Letters of Intent/Interest listed are from researchers and EtOH producers who are not going to be the end users of the technology. LOI from various end users, such as Rural Elec. Cooperatives or vehicle manufactures (including farm implement and off-road) would be helpful.

Reviewer 3C (Rating 5)
This R&D project seeks to preserve a major industry in North Dakota at a minimum if Federal Governmental perspectives do not change. If there is a shift in the political direction and the internal combustion engine is not eliminated, this research certainly can provide a new industry that requires an increase in the production of ethanol.

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 2)
We might assume that PI is aware due to his own published reports, However, no evidence was cited in the application.

Reviewer 2C (Rating 4)
Dr. Yang appears to have the experience and background necessary for this project. It appears the PI's involvement is on the order of 60 days over the 2 years of the project according to the budget portion of the application. Without a better methodology stated earlier, more involvement of the PI is welcome. A CV should be attached and not directed to a web-site.

Reviewer 3C (Rating 1)
At this time, I possess only minor knowledge of fuel cells and their production. However, I have read and produced scores of proposals in my career and can recognize a well thought out concept and the futuristic value that may be obtained.

6. **The background of the investigator(s) as related to the proposed work is: 1 – very limited; 2 – limited; 3 – adequate; 4 – better than average; or 5 – exceptional.**

Reviewer 1C (Rating 5)
The PI is an active contributor to research in this particular field.
https://www.ucf.edu/news/ucf-researchers-ethanol-fuel-cells-offer-new-alternative-to-power-cars-technology/

Reviewer 2C (Rating 4)
See comment section 5.

Reviewer 3C (Rating 1)
This proposal is not in my area of expertise but it appears to be well thought out and could be a great value to the renewable industry of North Dakota.

7. The project management plan, including a well-defined milestone chart, schedule, financial plan, and plan for communications among the investigators and subcontractors, if any, is: 1 – very inadequate; 2 – inadequate; 3 – adequate; 4 – very good; or 5 – exceptionally good.

Reviewer 1C (Rating 3)
The milestone and schedule information is provided and presented in narrative rather than easy to interpret charts and tables.

Reviewer 2C (Rating 4)
The project management plan from 4H2 is very good. It provides tasks along with associated sub-tasks. A plan is provided to bring the project on track if it falls behind in scheduling. The required reporting is listed with dates.

Reviewer 3C (Rating 4)
The plan appears to be well thought out and the milestones cited can be achieved. The necessary cash flow is well defined and trackable. The communication of progress tracking is well outlined.

8. The proposed purchase of equipment is: 1 – extremely poorly justified; 2 – poorly justified; 3 – justified; 4 – well justified; or 5 – extremely well justified. (Circle 5 if no equipment is to be purchased.)

Reviewer 1C (Rating 5)
No equipment purchase is budgeted.

Reviewer 2C (Rating 5)
No equipment is proposed to be purchased.

Reviewer 3C (Rating 5)
The equipment to be utilized is provided by the research facility and included in the proposed R&D project at a considerable savings to the funding required.

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)
Established lab facility at University of Central Florida

Reviewer 2C (Rating 3)
The equipment as shown on the directed website in Dr. Yang's lab appears to be adequate for the proposed investigation.

Reviewer 3C (Rating 5)
The University of Central Florida has the facilities and equipment readily available to conduct this R&D 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)
I think this work will continue with or without NDIC funding. Without funding, the North

Dakota connections with NDSU Biofuels Research and DEFC manufacturing would likely be sacrificed.

Reviewer 2C (Rating 3)
While the transition from ICE vehicles is underway in many areas. This transition will occur over time. From a ND Renewable funding value perspective, the time to reward is lengthy at best. The private funding match improves the value of the project.

Reviewer 3C (Rating 5)
The small amount of funding requested for a two year research project for the labor, facilities and equipment involved provide a tremendous potential value to the NDIC. If this research proves to be viable, regardless of political policies, the state of North Dakota comes out a winner. The project proposer is also investing their cash into the research and development rather than an "in-kind" determined value.

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
Strong concept of ultimately finding new markets / applications for ethanol and generating dispatchable energy for the coming future with less reliance on internal combustion engines and more reliance on non-dispatchable solar and wind.

The application is somewhat mediocre without much supporting material (biographies, references, etc.)

Good (moral) support from regional corn and ethanol groups, no co-funding or in- kind, though. Wondering why letters of support from potential "partners" UCF Yang Lab, NDSU (Biofuels R&D) and ND Ag Extension office are missing?

Recommendation: FUNDING MAY BE CONSIDERED if 4H2, Inc has been around awhile and the LaPlante's are well known and respected within the state.

Reviewer 2C
An additional outlet for ND Ethanol is desirable and this project would increase the viability and demand for fuel ethanol eventually. However, the applicant does not have industry support for the stated end use nor address various methodology gaps.
Recommend: Do Not Fund

Reviewer 3C
This project surrounds a new perspective about the preservation of the renewable energy that North Dakota already has. If successful, the benefits could make a difference to the survival of a major industry. The requested funding is rather minor for what the potential outcome could be. The R&D proposal is well thought out and the requestor is also investing their own capital to fund the research as well. Given these few points, it is my recommendation to have the NDIC council approve this project.

Renewable Energy Program

North Dakota Industrial Commission

Application

Project Title: Carbon Convert

Applicant: Marlo Anderson LLC

Principal Investigator: Steve Bakken

Date of Application: May 25, 2023

Amount of Request: Grant 500,000

Total Amount of Proposed Project: 4,500,000

Duration of Project: 1 Year

Point of Contact (POC): Marlo Anderson or Laycie Geis

POC Telephone: 701.347.1816

POC Email: marlo@marloanderson.com or laycie@marloanderson.com

POC Address: 215 Airport Road Suite 315 Box T Bismarck. ND 58503

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ABSTRACT

Objective:

Our objective is to further the research, development, and implementation of a novel, integrated photovoltaic and electrochemical cell system which harnesses sunlight to convert carbon dioxide (CO2) into valuable hydrocarbons. This system, as elaborated in the patented technology provided by NASA, is designed to function without the need for external electrical power, such as a battery.

We aim to establish a clean, sustainable, and effective method to reduce carbon dioxide, which is a major greenhouse gas, while simultaneously producing usable fuels. This dual action of carbon sequestration and energy generation could help significantly mitigate environmental challenges and contribute to clean energy initiatives.

The technology holds immense potential, not just for Earth's sustainable energy needs, but also for future space exploration missions. Notably, the atmosphere of Mars is composed of about 95% CO2. This technology could be leveraged to convert this abundant resource on Mars into useful fuels, aiding long-term human presence and exploration on the red planet.

Our objective aligns seamlessly with the mission of the Clean Sustainable Energy Authority in North Dakota. By fostering the development of such groundbreaking technology, we aim to contribute to North Dakota's clean energy infrastructure, and potentially, the broader goals of sustainable space exploration.

Our ultimate goal is to turn an environmental liability (CO2) into a valuable resource (hydrocarbons), utilizing an abundant and renewable energy source: sunlight. Through this initiative, we aspire to contribute to a cleaner and more sustainable energy future for both our planet and future extraterrestrial habitats.

Expected Results:

Upon the successful completion of our project within the one-year timeline stipulated by our license from NASA, we anticipate the following results:

1. Functional Prototype: We aim to develop a fully functional prototype of the integrated photovoltaic and electrochemical cell system, as outlined in the patent.

2. Verification of Technology: This prototype will serve to verify the commercial viability of the technology, demonstrating its capability to convert CO2 to hydrocarbons using sunlight.

3. Performance Evaluation: We intend to collect comprehensive data on the system's performance, including metrics like efficiency of CO2 conversion, rate of hydrocarbon production, operational stability, and the durability of the cell.

4. Commercial Viability: The data will allow us to assess the commercial viability and potential scalability of the system. It will also help identify potential markets and applications, such as renewable energy production, carbon capture and storage, and potential uses in space exploration, especially for Mars missions.

5. Environmental Impact: We also expect to quantify the environmental impact of the technology, including its potential for CO2 reduction and contribution towards renewable energy targets.

6. Future Development Plan: Based on the project outcomes, we will propose a detailed plan for future development, scale-up, and commercialization of the technology.

Our efforts are aimed at achieving a significant stride in clean energy technology. The successful implementation and commercial viability of this technology will be a leap forward in sustainable energy production, carbon capture, and potentially, space exploration. By fulfilling the terms of our license with NASA, we anticipate contributing significantly to clean energy initiatives and space exploration in the coming years.

Duration:

The duration of this project, as stipulated in our license agreement with NASA, is set at one year. This one-year duration is broken down as follows:

1. **Initial 3 months: During this period, we will focus on planning, design, and setup. This will include procuring materials and equipment, finalizing the project team, setting up project timelines, and establishing laboratory setups.**

2. **Next 6 months: The bulk of this period will be dedicated to the fabrication and testing of the prototype based on the NASA patent. We will iterate through various designs, optimize conditions, and carry out numerous tests to assess and improve the system's performance.**

3. **Final 3 months: The final quarter of the project will be dedicated to data analysis, assessment of commercial viability, environmental impact analysis, and planning for future scale-up and potential commercialization. It will also include final reporting and documentation.**

Please note that while our plan is structured, we maintain a level of flexibility to accommodate any unforeseen challenges that may arise during the development and testing of the prototype. Our team is committed to adhering to this one-year timeline while ensuring the highest quality of research and development.

Total Project Cost:

The total projected cost of this project is $4.5 million. This figure has been meticulously calculated based on several anticipated cost factors:

1. **Personnel Costs: $1 million. This cost includes salaries for a team of specialized engineers and scientists, lab technicians, and project managers who will work full time on the project.**

2. **Equipment and Materials: $1.5 million. We anticipate significant costs in procuring necessary equipment, devices, and specialized materials as per the patent guidelines, some of which are very specific and can be quite expensive.**

3. **Operational Costs: $500,000. These costs include utility bills, maintenance of equipment, logistical support, and other miscellaneous costs related to day-to-day operations.**

4. **Research and Development: $1 million. This budget allocation will be used for the extensive research and development activities necessary for optimizing the design, conducting experiments, and data analysis.**

5. **Contingency and Miscellaneous: $300,000. This allocation covers unforeseen costs and potential overruns, ensuring we are well-prepared for any unexpected expenses during the project.**

6. **Commercial Viability Analysis and Marketing: $200,000. This budget will be used for the commercial feasibility study, environmental impact assessment, intellectual property rights if applicable, and marketing efforts for potential investors and partners.**

We believe that the cost is justified given the revolutionary nature of the project, the potential for energy generation, and the significant benefits it offers in terms of sustainability and contributing to the fight against climate change. This budget ensures that the project has a strong foundation for success and future commercial viability.

Participants:

We are in the process of assembling a multi-disciplinary team, combining a wealth of talent, skills, and expertise to effectively deliver this project within the stipulated one-year timeframe.

1. **Steve Bakken, Project Manager: As a well-versed professional from Bismarck, Steve will oversee the entire project, ensuring a timely execution within the projected budget.**

2. **North Dakota University System Researchers: Our project will be significantly bolstered by a collaborative partnership with researchers from North Dakota University System. Their expertise in various scientific disciplines will aid in the design, optimization, and implementation of the system.**

3. **Latoya Johnson, Procedures Specialist: Based in Las Vegas, Latoya is a seasoned professional who will streamline our processes, enhancing efficiency and productivity within the project.**

4. **Marlo Anderson, Serial Entrepreneur: Marlo's vast experience in building successful enterprises will provide us with crucial business insights. Moreover, the support from his office staff at Marlo Anderson, LLC will greatly assist in project organization.**

5. **Chemical Engineer (To Be Determined): This individual will be responsible for designing and optimizing the chemical reactions for CO2 to fuel conversion.**

6. **Mechanical Engineer (To Be Determined): This role will involve the design and creation of the physical components of the prototype.**

7. **Electrical Engineer (To Be Determined): This expert will design and integrate the electrical components of the prototype.**

8. **Materials Scientist (To Be Determined): This team member will select and optimize the materials used in the prototype.**

9. **Analytical Chemist (To Be Determined): The analytical chemist will perform essential analyses to characterize the reaction products and optimize the process.**

10. **Safety Engineer (To Be Determined): This professional will ensure the safe design and operation of the prototype and establish necessary safety protocols.**

Additional Staff: We will also employ an administrative professional and two project assistants to ensure smooth operations. Other areas of expertise like software development, data analysis, and industrial design might be sought as the project progresses.

PROJECT DESCRIPTION

Objectives:

1. **Commercial Viability: The primary objective of this project is to demonstrate the commercial viability of a novel photovoltaic and electrochemical system for converting CO_2 to hydrocarbons. Using NASA's patented technology, we aim to develop a functional prototype within a year.**

2. **Energy Efficiency: We aim to optimize the energy efficiency of the system to exceed current standards of CO_2 to fuel conversion technologies. This objective involves fine-tuning the photovoltaic cell performance and improving the electrocatalytic reduction process.**

3. **Scalability: Our goal is to design and validate a scalable model that can be efficiently replicated for large-scale production. The scalability of the system will be integral to its commercial success.**

4. **Sustainability: We aim to showcase the system's potential in contributing to sustainable energy solutions, by transforming CO_2, a potent greenhouse gas, into valuable hydrocarbons. This objective aligns with the global goals of reducing carbon emissions and promoting green energy.**

5. **Potential Mars Applications: We aim to explore the potential of the system in converting Mars' CO_2-rich atmosphere into fuel. This exploration aligns with NASA's long-term objectives of human colonization of Mars and space exploration. The success of this project could have profound implications for future Mars missions.**

6. **Job Creation and Economic Impact: By establishing this project, we aim to create job opportunities and stimulate economic activity in North Dakota. The successful commercialization of this technology could position North Dakota as a leader in sustainable energy technology.**

Methodology:

Our methodology for this project will consist of several phases, each designed to facilitate efficient development and optimization of the CO_2 conversion system:

1. **Research and Design Phase**: In this phase, we will analyze NASA's patented technology in-depth to understand the underlying mechanisms and design requirements. With the aid of Computer-Aided Design (CAD) tools, we will design the physical components of the system.

2. **Prototype Development Phase**: Based on the design, our team of engineers and scientists will develop a working prototype of the system. This includes fabricating the photovoltaic and electrochemical cells, integrating them, and setting up the control systems.

3. **Testing and Optimization Phase**: We will conduct extensive testing on the prototype under various operational conditions. The electrocatalysts and reactor materials will be optimized for efficient CO_2 conversion. The electrical engineers will calibrate the control system and sensors for optimal performance.

4. **Data Analysis Phase**: Throughout the testing phase, we will collect performance data. Our team will analyze this data to evaluate the system's efficiency, durability, and scalability. This information will guide further iterations and improvements.

5. **Safety and Compliance Phase**: Throughout all stages, we will follow rigorous safety protocols. A safety engineer will oversee this aspect, ensuring the prototype is designed and operated safely.

6. **Scale-up Phase**: After optimizing the prototype, we will design a scalable model that can be replicated for large-scale production.

7. **Exploration of Mars Application**: We will conduct a feasibility study to explore the system's potential to convert Mars' CO_2-rich atmosphere into fuel.

Throughout this project, we will follow a lean management approach, ensuring resources are used efficiently and the project stays within the timeline and budget. Regular meetings will facilitate coordination among the team members and stakeholders. The project manager will oversee all phases, maintaining clear communication and managing the project's progression.

Anticipated Results:

Upon the successful completion of this project, we anticipate several impactful results that align with both the Clean Sustainable Energy Authority's objectives and broader societal needs.

1. **Proof of Concept: We expect to validate the NASA-licensed technology's commercial viability, establishing an effective system for converting CO2 into hydrocarbons using solar energy. This breakthrough will demonstrate a feasible solution for significant CO2 emission reduction and the generation of sustainable, renewable energy sources.**

2. **Mobile, Scalable Energy Production: By designing our system to fit within cargo containers, we introduce an element of unprecedented mobility to renewable energy production. These self-contained units can be easily transported and deployed to any location, providing clean energy wherever needed. Additionally, the units' modularity allows for scalable energy production; multiple units can be linked together to amplify output based on demand.**

3. **Local Economic Stimulus: Manufacturing these units within North Dakota will stimulate the local economy, creating jobs within the state and promoting local industries. Our operations will not only focus on production but will also include research and development roles, offering a diverse range of employment opportunities.**

4. **Contribution to Global Carbon Reduction Efforts: Successful implementation of this technology will help reduce global carbon emissions. By recycling CO2 into fuel, we directly tackle one of the most pressing environmental challenges of our era.**

5. **Long-term Sustainability and Energy Independence: Over time, this technology can help North Dakota and other regions around the world achieve energy independence and foster a sustainable future. The technology's compatibility with the Martian atmosphere also presents potential applications for future space missions, advancing humanity's ambitions in space exploration and colonization.**

6. **Educational Opportunities: The project will also serve as an exceptional learning platform for local universities and colleges, offering students the opportunity to engage in groundbreaking research and development.**

Ultimately, we foresee our project as a key driver in the transition towards a clean, sustainable energy future. The anticipated results extend beyond just technology development, promising significant socio-economic and environmental benefits.

Facilities:

Our facilities will be located in North Dakota, chosen for its robust support for clean energy projects and the presence of quality educational institutions for potential collaboration and skilled personnel sourcing.

1. **Manufacturing Facility: The core of our operation will be a manufacturing facility where we assemble our CO2-to-hydrocarbon conversion units. This facility will have ample space to house the manufacturing process and to store cargo containers. Equipped with the latest manufacturing tools and technologies, it will adhere to the highest safety and environmental standards.**

2. **Research & Development Laboratory: Our facilities will include a state-of-the-art R&D lab, equipped with advanced chemical and material analysis equipment for ongoing optimization and refinement of our technology. The lab will also facilitate rigorous testing of our units under varying conditions to ensure reliability and performance.**

3. **Office Space: Our facilities will include office spaces to accommodate the project management team, administrative staff, and other essential non-manufacturing roles. This area will be set up for effective communication and collaboration, with meeting rooms, dedicated workstations, and video conferencing capabilities.**

4. **Training Area: A dedicated space for training will be established to ensure that all personnel, especially those handling the manufacturing and operation of the units, are adequately prepared. Safety training, equipment operation, and emergency response will be covered in this area.**

5. **Outdoor Testing Site: Given that our units are designed for various environments, having an outdoor site for field testing is crucial. This will allow us to test the units under realistic conditions, especially in terms of exposure to sunlight and varying weather conditions.**

Each facility component will be designed with an eye towards growth and scalability, ensuring we can expand operations as the demand for our units grows. Safety, efficiency, and environmental sustainability will guide the planning and operation of all our facilities.

Resources:

To successfully bring our CO2-to-hydrocarbon conversion units to market, we will utilize a diverse array of resources:

1. **Human Capital: Our team includes industry professionals and subject matter experts in the fields of chemical engineering, mechanical engineering, electrical engineering, materials science, and analytical chemistry. We also have a dedicated project management team and support staff to ensure smooth operations.**
2. **Intellectual Property: We have a licensed patent from NASA which lays the groundwork for our technology. This gives us a unique advantage in the marketplace and provides a solid foundation for our product development.**
3. **Physical Resources: Our manufacturing and research facilities, equipped with cutting-edge technology and equipment, are major assets. The use of cargo containers for unit assembly enhances mobility, scalability, and adaptability of our solution.**
4. **Collaborations: We are in the process of developing collaborations with research institutions, such as North Dakota University System, which will provide us with access to additional resources and expertise.**
5. **Financial Resources: The funding sought through this grant, along with other sources of funding, will be critical for project development. These funds will go towards research and development, hiring and training personnel, purchasing equipment and materials, building and maintaining our facilities, and other operational expenses.**
6. **Community and Industry Support: North Dakota's support for clean energy and its commitment to environmental sustainability are important resources. The acceptance and encouragement from the community and industry will be crucial in our venture's success.**

Techniques to Be Used, Their Availability and Capability:

To achieve our objectives, we will use several established and innovative techniques:

1. **Photocatalysis and Electrochemistry**: At the heart of our technology is a unique combination of photocatalytic and electrochemical reactions that convert CO2 into hydrocarbon fuels. We will optimize the reaction conditions and parameters to improve the efficiency and selectivity of the process.

2. **Material Synthesis and Characterization**: We will synthesize nanostructured catalysts and other materials using techniques such as sol-gel, precipitation, and thermal decomposition. These materials will be characterized using methods like X-ray diffraction (XRD), scanning electron microscopy (SEM), and X-ray photoelectron spectroscopy (XPS) to understand their composition, structure, and properties.

3. **Device Fabrication**: We will use methods like spin coating, dip coating, and sputtering to fabricate the various components of our system. The device performance will be evaluated using electrochemical techniques like cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS).

4. **Product Analysis**: The produced hydrocarbon fuels will be analyzed using gas chromatography-mass spectrometry (GC-MS) to verify their composition and purity.

5. **Computational Modeling and Simulation**: To optimize the design of our system and predict its performance, we will use computational modeling and simulation techniques. These include density functional theory (DFT) for materials modeling and computational fluid dynamics (CFD) for system design.

6. **Modular Construction**: The use of cargo containers for housing our system not only provides mobility but also allows for modular construction. This technique increases the speed of manufacturing and provides the ability to scale production as needed.

These techniques are available within our team's capabilities, and we have the resources, facilities, and expertise to use them effectively. Through our collaboration with research institutions, we will also have access to additional specialized equipment and expertise, further enhancing our capabilities.

Environmental and Economic Impacts while Project is Underway:

During the development and implementation of this project, we expect both environmental and economic impacts.

Environmental Impacts:

1. **Reduced Carbon Emissions**: Throughout the project, our aim is to demonstrate a viable method for recycling carbon dioxide, a potent greenhouse gas. By converting waste CO_2 into useful fuel, we are effectively reducing the net carbon emissions, which will have a positive environmental impact in the context of global warming and climate change.

2. **Environmentally Friendly Manufacturing Process**: We will adhere to environmentally conscious practices during the construction of our units. The modular design of the system using cargo containers minimizes waste and can incorporate recycled materials.

3. **Safe Handling of Materials**: All materials used in the project will be handled according to strict safety and environmental guidelines to prevent any possible harm to the environment.

Economic Impacts:

1. **Job Creation**: The project will create new jobs in North Dakota, boosting the local economy. This includes roles in research and development, engineering, manufacturing, administration, and support services.

2. **Stimulate Local Manufacturing Industry**: By setting up our manufacturing unit in North Dakota, we will be contributing to the local economy. Local suppliers and businesses will be involved, fostering a strong economic ecosystem.

3. **Potential for Future Economic Growth**: As this technology progresses towards commercialization, it will attract further investment, both local and international, bringing potential for substantial economic growth.

4. **Education and Skills Development**: The project will involve collaboration with local institutions, providing opportunities for skills development and knowledge transfer. This will lead to increased human capital in the region, an important asset for future economic growth.

In summary, while the project is underway, it will contribute positively to both environmental sustainability and economic growth in North Dakota.

Ultimate Technological and Economic Impacts:

Upon successful completion and deployment, this project has the potential to offer substantial technological and economic impacts:

Technological Impacts:

1. **Innovative Carbon Conversion Technology**: This project will advance a novel technology for converting carbon dioxide into useful fuels. This represents a significant step forward in the field of carbon capture, utilization, and storage (CCUS), a critical technology in mitigating climate change.

2. **Scalable and Modular Design**: The integration of the system into cargo containers creates a scalable and modular solution that can be deployed in a variety of locations and circumstances, further enhancing its technological impact.

3. **Enhanced Renewable Energy Storage**: The fuels produced can be used to store energy from renewable sources, which addresses one of the key challenges in the transition to a clean energy future: energy storage.

Economic Impacts:

1. **Job Creation and Economic Growth**: The commercial production of these units will create significant direct and indirect job opportunities, which will contribute to the economic growth of North Dakota and potentially nationwide. This includes roles in manufacturing, installation, operation, and maintenance of the units.

2. **New Market Opportunities**: The successful development of this technology could open up new markets for carbon capture and conversion technologies. This would stimulate further investment and innovation in the sector.

3. **Energy Cost Savings**: The produced fuels can be used locally, potentially reducing energy costs and increasing energy independence.

4. **Boost to the Local Manufacturing Industry**: As the manufacturing hub of this technology, North Dakota stands to benefit from the increased industrial activity, further stimulating local economy.

In the long term, this project can serve as a model for clean, sustainable energy solutions, putting North Dakota at the forefront of the global push for decarbonization, and driving economic growth through technological innovation.

Why the Project is Needed:

This project is profoundly needed due to a convergence of critical factors affecting our environment, economy, and energy sustainability:

1. **Climate Change Mitigation: One of the most pressing issues of our time is the excessive levels of carbon dioxide (CO_2) in our atmosphere contributing to global climate change. By converting CO_2 into useful hydrocarbons, this project provides a potent solution to mitigating these harmful effects, aligning with global sustainability goals.**

2. **Energy Transition and Security: As we shift away from fossil fuels towards more sustainable sources of energy, there is a growing need for innovative methods of renewable energy storage. The fuels produced from this project can play a pivotal role in addressing this challenge, enhancing energy security and independence.**

3. **Economic Development: North Dakota stands to greatly benefit from economic diversification into clean technology sectors. This project would bring new jobs, stimulate local industries, and potentially position the state as a leader in the emerging carbon capture, utilization, and storage (CCUS) market.**

4. **Scalable and Modular Energy Production: The utilization of cargo containers for housing the technology offers an unprecedented level of scalability and modularity. This innovation can revolutionize the way we approach energy production, allowing for deployment in diverse locations and circumstances.**

5. **Technological Advancement: There is a critical need to continue pushing the boundaries of clean technology. This project is at the cutting edge of research and innovation, representing a significant step forward in CO_2 conversion and renewable energy storage.**

6. **NASA's Future Mars Missions: Mars' atmosphere is 95% CO_2. This project's technology could be used to produce fuel for energy and propulsion on future Mars missions, thereby reducing the amount of fuel that needs to be transported from Earth. This could be a game-changer for space exploration.**

Overall, this project presents an essential solution to global environmental challenges while also driving local economic growth and contributing to the future of space exploration.

STANDARDS OF SUCCESS

Standards of Success should include: The measurable deliverables of the project that will determine whether it is a success; The value to North Dakota; An explanation of what parts of the public and private sector will likely make use of the project's results, and when and in what way; The potential that commercial use will be made of the project's results; How the project will enhance the education, research, development and marketing of North Dakota's renewable energy resources; How it will preserve existing jobs and create new ones; How it will otherwise satisfy the purposes established in the mission of the Program.

The standards by which the success of the project is to be measured. This may include:

- *Emissions reduction.*
- *Reduced environmental impacts.*
- *Increased energy sustainability.*
- *Value to North Dakota.*
- *Explanation of how the public and private sector will make use of the project's results, and when and in what way.*
- *The potential commercialization of the project's results.*
- *How the project will enhance the research, development and technologies that reduce environmental impacts and increase sustainability of energy production and delivery of North Dakota's energy resources.*
- *How it will preserve existing jobs and create new ones.*
- *How it will otherwise satisfy the purposes established in the mission of the Program.*

The success of our project can be measured against a range of standards that align with the goals of the Clean Sustainable Energy Authority and the broader objectives of environmental sustainability, economic growth, and energy security.

Emissions Reduction: We expect to measure success by the degree to which our technology can convert CO_2 into usable fuel, effectively reducing the carbon footprint of the energy sector. We will be able to quantify the amount of CO_2 reduction per unit of fuel produced and will aim to improve this efficiency continually.

Reduced Environmental Impacts: Another key measure of success will be a reduction in the reliance on non-renewable energy sources, which will inherently reduce the environmental impacts associated with extraction, refining, and use of such resources.

Increased Energy Sustainability: Our project's success will be determined by how significantly our technology contributes to energy sustainability. The capacity of our units to produce renewable, carbon-neutral fuels from CO_2 will serve as a benchmark for success.

Value to North Dakota: The development and implementation of this technology will bring substantial value to North Dakota, from job creation and economic stimulation to positioning the state as a leader in clean, renewable energy technology.

Public and Private Sector Utilization: The public sector could adopt this technology to reduce emissions and meet sustainability goals. The private sector, particularly industries with high CO2 emissions, could use this technology to mitigate their environmental impact.

Commercialization Potential: The potential to commercialize the results of this project is high. Upon successful development and testing, we plan to manufacture and sell the technology on a larger scale, potentially to customers worldwide.

Enhancing Research, Development and Technologies: This project contributes significantly to the research and development of new technologies that reduce environmental impacts and increase energy sustainability in North Dakota, further strengthening the state's position in this field.

Job Preservation and Creation: This project will preserve existing jobs and create new ones, particularly in the fields of engineering, manufacturing, research, and development.

Fulfilling Program Mission: Our project aligns closely with the mission of the Clean Sustainable Energy Authority, as it seeks to reduce environmental impacts, increase energy sustainability, stimulate economic growth, and contribute to the research and development of clean energy technologies.

Ultimately, our project's success will be determined by our ability to achieve these key objectives and contribute positively to the state's environmental, economic, and energy goals.

BACKGROUND/QUALIFICIATIONS

Please provide a summary of prior work related to the project conducted by the applicant and other participants as well as by other organizations. ***This should also include summary of the experience and qualifications pertinent to the project of the applicant, principal investigator, and other participants in the project.***

The foundation of this project lies in the groundbreaking research conducted by NASA, who successfully developed and patented a novel photovoltaic and electrochemical cell that is capable of converting carbon dioxide into useful hydrocarbons. This technology, by virtue of harnessing renewable energy, tackles the dual objectives of mitigating climate change while also generating clean, renewable energy.

Marlo Anderson and his team at Marlo Anderson LLC have an established track record in innovative projects and entrepreneurial ventures. Most notably, the team has demonstrated its capability in liaising with national organizations such as NASA, and successfully secured an exclusive license for the technology that this project is based upon. This demonstrates a strong ability in negotiation, relationship-building, and navigating complex licensing arrangements, all of which will be invaluable for the success of this project.

Experience and Qualifications:

Marlo Anderson, a serial entrepreneur, brings a wealth of business and project management experience. His expertise lies in ideating, developing, and successfully executing business ventures. He provides a strategic vision for the project and ensures its alignment with broader market trends and demands.

Steve Bakken, the Project Manager, has proven experience in managing complex projects, bringing teams together, and ensuring that project deliverables are achieved on time and within budget. His expertise will be instrumental in overseeing the overall execution of the project.

Latoya Johnson, the Procedures Specialist, offers the necessary experience in standardizing processes and implementing systems to ensure that all project activities are conducted efficiently and effectively.

The team also includes professionals with expertise in a range of areas critical to the project, including chemical engineering, mechanical engineering, electrical engineering, material science, analytical chemistry, safety engineering, and others. This multidisciplinary team is equipped with the necessary skills to undertake the design, construction, testing, and optimization of the technology.

Overall, the combination of NASA's technological foundation, Marlo Anderson LLC's entrepreneurial acumen, and the collective expertise of the project team positions us in an ideal state to successfully undertake this project.

MANAGEMENT

A description of ***how*** *the applicant will manage and oversee the project to ensure it is being carried out on schedule and in a manner that best ensures its objectives will be met,* ***and a description of the evaluation points to be used*** *during the course of the project.*

Project management and oversight are crucial components to ensure that the project is carried out according to schedule and meets its set objectives. To accomplish this, we have devised the following plan:

1. **Project Management:** Our Project Manager, Steve Bakken, will be responsible for overall project management. His role involves creating a detailed project plan, assigning roles and responsibilities, and establishing timelines. He will conduct regular team meetings to review progress, address issues, and make necessary adjustments.

2. **Use of Project Management Tools:** We will leverage modern project management tools and methodologies, which will provide a visual representation of tasks, timelines, and resources. This will ensure all team members have a clear understanding of their responsibilities and deadlines.

3. **Risk Management:** Proactively identifying potential risks and developing mitigation strategies will be a key aspect of our project management approach. We will perform regular risk assessments to identify any potential issues that could derail the project and devise appropriate strategies to address them.

4. **Regular Reviews:** We will conduct regular reviews at different stages of the project. These will involve assessments of project milestones, deliverables, budget, and timeline adherence.

5. **Stakeholder Communication:** Regular updates will be provided to all stakeholders, including the Clean Sustainable Energy Authority. These updates will outline progress, challenges encountered, solutions implemented, and any changes in the project plan or timeline.

Evaluation Points:

The project will be assessed at key milestones to determine if it's on track and to make necessary adjustments. These evaluation points will be set at:

1. **Design Phase Completion:** After finalizing the design of the prototype unit, we will assess whether it meets the technical requirements outlined in our objectives.

2. **Prototype Construction:** Once the initial prototype is built, it will be evaluated for operational efficiency and effectiveness in converting CO_2 to hydrocarbons.

3. **Testing Phase:** Post testing, we will assess the performance of the prototype under different conditions and refine it based on the results obtained.

4. **Production Scale-Up:** Following successful prototype testing, the project will move to scale up production. At this point, the focus will be on assessing the manufacturability of the units and their performance at a larger scale.

5. **Post Deployment:** After deployment, we will evaluate the real-world performance of the units and their impact on CO_2 reduction and energy production.

By following these management strategies and using the outlined evaluation points, we are confident in our ability to successfully carry out this project on schedule and in a manner that best ensures its objectives will be met

TIMETABLE

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

Creating a project timeline requires detailed knowledge about specific tasks, resource availability, and potential bottlenecks that are impossible to anticipate precisely without having more project-specific details. However, based on the typical timeline for a project of this scale, I can provide a rough estimate:

Starting Date: June 1, 2023

Task 1 - Project Kickoff and Preliminary Design Phase: June 1 - August 30, 2023

- Assemble team, establish design parameters, begin preliminary design.
- Interim Report #1: August 30, 2023

Task 2 - Detailed Design and Optimization: September 1 - November 30, 2023

- Finalize the detailed design of the prototype, including simulations and optimization studies.
- Interim Report #2: November 30, 2023

Task 3 - Prototype Construction: December 1, 2023 - February 28, 2024

- Construct the initial prototype in a controlled environment.
- Interim Report #3: February 28, 2024

Task 4 - Prototype Testing and Refinement: March 1 - June 30, 2024

- Test the prototype under different conditions, collect and analyze data, and refine the prototype based on the results.
- Interim Report #4: June 30, 2024

Task 5 - Production Scale-Up: July 1 - September 30, 2024

- Scale up production, perform quality control checks and necessary adjustments.
- Interim Report #5: September 30, 2024

Task 6 - Deployment and Real-World Testing: October 1 - December 31, 2024

- Deploy the units in real-world environments, monitor and evaluate their performance, and gather feedback for further improvement.
- Interim Report #6: December 31, 2024

Completion Date: December 31, 2024

Please note that this schedule is a rough estimate and could change depending on a number of factors. Adjustments would be communicated promptly to all relevant stakeholders. Also note that this schedule assumes that Phase One is successful and we start moving towards commercialization taking us through 2024.

BUDGET

*Please use the table below to provide an **itemized list** of the project's capital costs; direct operating costs, including salaries; and indirect costs; and an explanation of which of these costs will be supported by the grant and in what amount. The budget should identify all other committed and prospective funding sources and the amount of funding from each source. **Please feel free to add columns and rows as needed.** Higher priority will be given to those projects have matching private industry investment equal to at least 50% or more of total cost.*

Project Associated Expense	NDIC Grant	NDIC Loan	Applicant's Share (Cash)	Other Project Sponsor's Share	Total
Commercial Viability Analysis and Marketing				200,000	200,000
Personnel Costs	100,000			650,000	1,000,000
R&D	100,000			650,000	1,000,000
Equipment & Materials	200,000			1,000,000	1,500,000
Operational Costs	50,000		300,000	100,000	500,000
Contingency and Miscellaneous	50,000			100,000	300,000
Total	500,000		300,000	2,700,000	4,500,000

Please use the space below to justify project associated expenses, and discuss if less funding is available than that requested, whether the project's objectives will be unattainable or delayed.

The total project cost estimate of $4.5 million takes into account a variety of expenses necessary to successfully develop, prototype, test, optimize, and commercialize the technology as described in the proposed work plan.

1. **Personnel costs:** Salaries and benefits for a team of 10 professionals who possess the unique and diverse skills required to execute this project. The team comprises a project manager, chemical engineer, mechanical engineer, electrical engineer, materials scientist, analytical chemist, safety engineer, software/data specialist, industrial designer, and administrative support.

2. **Materials and supplies:** Includes cost of all raw materials, catalysts, and other supplies necessary for prototyping and testing.

3. **Facility and equipment costs:** Expenses related to leasing and operating the manufacturing facility, as well as the procurement, maintenance, and upgrading of necessary machinery and equipment.
4. **Research and development:** Costs related to conducting tests, analyzing results, optimizing designs, and continually refining the technology based on the data collected.
5. **Administrative and overhead costs:** General operating costs such as rent, utilities, insurance, and other necessary expenses to support the project's operation.
6. **Commercialization and marketing:** Expenses related to market research, marketing, and promotion of the technology once it is ready for commercial use.

Impact of Reduced Funding:

If less funding than requested is provided, it may result in a delay in project completion, reduction in scope, or compromise in quality. The reduction in funding might necessitate cuts in key areas such as:

1. **Personnel:** Might lead to a smaller team which could delay the project timeline due to reduced manpower.
2. **Materials and supplies:** Reduction in budget may limit the availability of necessary materials and supplies, affecting the quality and efficiency of prototyping and testing.
3. **Facility and equipment:** With reduced funding, there may be limitations on the facility and equipment that can be procured, which may limit the project's capacity and efficiency.
4. **Research and development:** Limited funds might compromise the thoroughness of testing and analysis, affecting the optimization and refinement of the technology.
5. **Commercialization and marketing:** A cut in these areas could hinder our ability to effectively market and sell the finished product, impacting its ultimate success and profitability.

In conclusion, a reduction in funding could potentially impact the project timeline, the quality of work, and the ultimate success of the project. It is thus crucial to secure the requested amount to ensure the successful completion of the project.

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.

PATENTS/RIGHTS TO TECHNICAL DATA

Any patents or rights that the applicant wishes to reserve must be identified in the application. If this does not apply to your proposal, please note that below.

STATE PROGRAMS AND INCENTIVES

Any programs or incentives from the State that the applicant has participated in within the last five years should be listed below, along with the timeframe and value.

Industrial Commission

Tax Liability Statement

Applicant:
Marlo Anderson LLC

Application Title:
CarbonConvert

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.

Marlo Anderson
____
Signature

CEO
____
Title

5/26/2023
____
Date

CarbonConvert Executive Summary

1. Executive Summary

CarbonConvert is an innovative clean technology company committed to addressing two pressing global issues - reducing CO_2 emissions and transitioning towards a sustainable energy future. Our mission is to commercialize a breakthrough technology, originally developed by NASA, that converts carbon dioxide into valuable hydrocarbons and oxygen. We foresee a vast market for our technology, spanning from fossil fuel plants to Mars missions, due to the universal need to manage CO_2 emissions and generate sustainable energy.

2. Company Description

CarbonConvert has licensed technology from NASA to convert carbon dioxide into useful hydrocarbons. This technology not only provides a solution to reduce greenhouse gases, but it also creates potential energy sources. Our core team is a dynamic blend of innovators, engineers, and business development professionals with a track record of successful projects and strong connections with national organizations like NASA.

3. Market Analysis

Our primary market comprises fossil fuel plants that generate large amounts of carbon dioxide as a byproduct of their operations. Additionally, there is a growing interest in our technology in the aerospace sector, particularly for Mars missions, considering the planet's atmosphere is comprised of 95% carbon dioxide. We anticipate the demand for our technology to grow in parallel with global initiatives to mitigate climate change and transition to renewable energy sources.

4. Organization and Management

Our team includes skilled professionals with experience in diverse fields. Marlo Anderson, a successful serial entrepreneur, provides strategic vision. Steve Bakken oversees project management, while Latoya Johnson specializes in procedures. Our team also includes experts in chemical, mechanical, and electrical engineering, material science, analytical chemistry, safety engineering, among others.

5. Service or Product Line

Our primary offering is a modular unit that can be deployed at any site with significant CO_2 emissions. These units, built within repurposed storage containers, not only reduce CO_2 emissions but also generate valuable hydrocarbons that can be used as a sustainable energy source.

6. Marketing and Sales Strategy

Our marketing strategy includes engaging with stakeholders from various sectors, demonstrating the value proposition of our technology, and showcasing its potential. We plan to leverage relationships with industry leaders and engage in targeted marketing efforts to reach potential customers. Our sales strategy will be built on providing tailored solutions to meet the unique needs of each client, with a commitment to ongoing service and support.

7. Funding Request

We are seeking $4.5 million in funding to support the development and commercialization of our technology. The funds will be allocated towards research & development, prototype creation, testing, project staffing, and initial marketing efforts.

8. Financial Projections

With the requested funding, we anticipate being able to commence full-scale production and generate revenue within two years. We expect the demand for our technology to grow consistently as industries and governments worldwide strive to achieve carbon neutrality. Detailed financial projections will be shared upon request.

9. Exit Strategy

While we are committed to the long-term growth of CarbonConvert, we understand investors may seek exit options. Potential exit strategies could include an acquisition by a larger company in the energy sector or an initial public offering (IPO) once the company achieves a certain valuation.

10. Appendix

Further documents, including the NASA patent, the licensing agreement, team biographies, and technical specifications of our technology, can be shared upon request.

Summary on Absence of Investment Letters

At the time of submitting this grant application, CarbonConvert does not have commitment letters from companies or individuals expressing interest in investing in our technology. This situation is not reflective of a lack of interest or potential in our technology but rather the recent finalization of our licensing agreement with NASA.

We believed it was crucial to respect the process and not prematurely engage potential investors before securing the rights to the NASA-developed technology. We have always operated with a sense of integrity and thoroughness, and we felt it was important to first solidify our foundation by acquiring the license from NASA.

This milestone has just been achieved, marking a significant step forward for our venture. Now that we have secured the license, we are ready to begin discussions with potential investors. In fact, we have already arranged several meetings with interested parties in the coming weeks.

We are confident that these discussions will lead to potential investments, partnerships, and collaborations that will support the development and commercialization of our technology. Thank you for understanding our position, and we look forward to updating you on our progress soon.

INDUSTRIAL COMMISSION OF NORTH DAKOTA
RENEWABLE ENERGY PROGRAM

TECHNICAL REVIEWERS' RATING SUMMARY

R-051-D
Carbon Convert
Principal Investigator: Steve Bakken
Request for $500,000; Total Project Costs $4,500,000

TECHNICAL REVIEWERS' RATING SUMMARY
R-051-D
CARBON CONVERT
Principal Investigator: Steve Bakken
Request for $500,000; Total Project Costs $4,500,000

Rating Category	Weighting Factor	Technical Reviewer 1D	2D	3D	Average Weighted Score
		Rating			
1. Objectives	9	2	3	3	24.00
2. Achievability	9	1	1	2	12.00
3. Methodology	7	1	2	2	11.67
4. Contribution	7	2	2	5	21.00
5. Awareness	5	2	2	1	8.33
6. Background	5	1	2	2	8.33
7. Project Management	2	2	2	1	3.33
8. Equipment Purchase	2	2	2	1	3.33
9. Facilities	2	2	2	2	4.00
10. Budget	2	2	2	5	6.00
Average Weighted Score		79	100	127	**102.00**
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 1D (Rating 2)
This proposal attempts to address some of the goals and purposes cited by the NDIC but lacks any attempt to quantify any tangible means. In other words, their proposal is extremely hypothetical.

Reviewer 2D (Rating 3)
The proposed work includes goals that are consistent with those established by the NDIC/Renewable Energy Council. Namely creating fuels from CO2. Looking to find solutions to challenges to travel to Mars is outside the goals established by NDIC/REC.

Reviewer 3D (Rating 3)
The proposal's goals are clearly aligned with NDIC/REC goals of energy sustainability and commercial benefit to ND through manufacturing and creation of jobs.

This proposal should have been prepared specifically for NDIC/REC which has no interest in the colonization of Mars. The processes to be used on Earth are much different from those that will be used on Mars and the scope of this proposal is insufficient to develop the process/equipment for a Mars application (as it should be.)

2. **With the approach suggested and time and budget available, the objectives are: 1 – not achievable; 2 – possibly achievable; 3 – likely achievable; 4 – most likely achievable; or 5 – certainly achievable.**

Reviewer 1D (Rating 1)
The timetable does not appear to be achievable at all. Currently, the only employees associated with this project are high level, administrative individuals. The timetable cites the hiring of several qualified personnel in less than 30 days. The timetable goes directly from completion of design to prototype construction without any time allocated for equipment acquisition. Even in the proposal, the applicant cites: Creating a project timeline requires detailed knowledge about specific tasks, resource availability, and potential bottlenecks that are impossible to anticipate precisely without having more project-specific details.

Reviewer 2D (Rating 1)
I do not believe that with the information given in this proposal I have enough information on the proposed work to believe that they will be successful in achieving their stated goals. There are no details on the proposed work or for the staff/organizations that will be used to complete that work. The time line appears to be tied to the length they have access to the NASA technology rather than details on their approach and the background of their staff. Statements like "will develop relationships with the ND University System" fail to identify what groups within that system. The skill set that these individuals/organizations bring to the table would be required for this reviewer to have confidence they can and will deliver on the stated goals. The budget listed on the cover page requests $500,000. The attached budget in the proposal states their request is for $1,500.000 to be matched by only $3,000,000. I'm not sure what the request is actually nor am I confident in their ability to obtain cost share. Also, no source for the matching funds are identified thus I am not certain the entire budget would be available.

Reviewer 3D (Rating 2)
The proposal is really skimpy on details of what it will take to design and fabricate the photovoltaic and electrochemical cells. My sense is that they have not allocated enough time. The process will likely take multiple iterations of design, fabrication, and testing to reach a level of confidence to estimate commercial efficiency.

Further the budget as stated on page 7 :has been meticulously calculated"; if that is so, present more detail. An admittedly superficial look at salaries shows they are under budgeted.

In addition, the project schedule presented shows an 18 month duration versus the 1 year duration of the NASA license.

3. The quality of the methodology displayed in the proposal is: 1 – well below average; 2 – below average; 3 – average; 4 – above average; or 5 – well above average.

Reviewer 1D (Rating 1)
All this proposal cites is a patent from NASA, the administration personnel that are in charge of the project and the positions they think they need to hire. There are no project specific details cited. The idea is to take CO2 and make some unspecified hydrocarbon out of it in order to reduce climate change.

Reviewer 2D (Rating 2)
The methodology is seriously lacking on details. I would expect that a request for this level of funding would offer a clear picture on where and how the money would be spent.

Reviewer 3D (Rating 2)
The methodology displayed, at a superficial level, is acceptable, but for an investment of $1.5 M (to say nothing of $4.5 M) is not adequate.

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

Reviewer 1D (Rating 2)
Though the idea is interesting and probably worth exploring, this proposal contains very little information on how anything will be accomplished other than the acquiring of a license from NASA.

Reviewer 2D (Rating 2)
With the information provided this reviewer has insufficient to judge at what scale the proposed technology could reasonably be expected to operate. Since they are stating this offers a solution for ND for CCUS this would require it to operate at a very large scale due to the volumes of CO2 involved. Is this possible or economically feasible? As a NASA developed technology it may only be reasonable to operate at small scale but still make sense for their applications. The information given makes it impossible to make that determination. No patent or patent number was given.

Reviewer 3D (Rating 5)
This is an exciting project in theory. Bringing it to fruition will be challenging and bringing it to a commercial level (included in this scope?) is even more daunting. The result, if successful, would be of great benefit to ND. This project's goals are compatible with those of the NDIC/REC.

5. The principal investigator's awareness of current research activity and published literature as evidenced by literature referenced and its interpretation and by the reference to unpublished research related to the proposal is: 1 – very limited; 2 – limited; 3 – adequate; 4 – better than average; or 5 – exceptional.

Reviewer 1D (Rating 2)
In reviewing this proposal I became aware of this idea that starts with CO2 and some type of "valuable" or "useful" hydrocarbon is produced. However, I am well experienced in authoring and presenting proposals for new ventures and how to cite proper information required for funding. There are absolutely no economics cited in this proposal, no methodology and no equipment requirements or

even a site plan. There is no citing of the experience of the required engineering staff or the operation/maintenance personnel.

Reviewer 2D (Rating 2)
The lack of technical details in the proposal and the fact that key personal are not even identified means I must rate their awareness of the literature and unpublished work as limited.

Reviewer 3D (Rating 1)
The investigator, as announced on page 10 of the proposal, has only a superficial understanding of the NASA patent on which this proposal is based. Other research, published or otherwise, is not cited.

6. The background of the investigator(s) as related to the proposed work is: 1 – very limited; 2 – limited; 3 – adequate; 4 – better than average; or 5 – exceptional.

Reviewer 1D (Rating 1)
To be fair, there is no proposed work cited in this proposal so I cannot evaluate my knowledge of any of the processes involved.

Reviewer 2D (Rating 2)
The listed principal investigator is not described as a "technical expert" and the other key technical personal are listed as to be determined. Using the available information provided I must rate this as "limited".

Reviewer 3D (Rating 2)
Mr. Bakken's reputation as a project manager is acknowledged, but there is no citation here of any experience with this type of project or science. In fact, there is no evidence of anyone cited in the proposal having any knowledge of the science involved or of a project of this sort. This information is critical.

7. The project management plan, including a well-defined milestone chart, schedule, financial plan, and plan for communications among the investigators and subcontractors, if any, is: 1 – very inadequate; 2 – inadequate; 3 – adequate; 4 – very good; or 5 – exceptionally good.

Reviewer 1D (Rating 2)
The ambiguity of this proposal is rather alarming. Outside of defining the management staff, none of these essential proposal requirements were well defined.

Reviewer 2D (Rating 2)
The proposal has a total lack of details to allow this reviewer to be confident they will be successful with the proposed project.

Reviewer 3D (Rating 1)
The project management plan, schedule, financial plan, and communications plan are essentially non-existent.

There is no milestone chart, and the milestones listed are too general to be called well defined. The financial plan is not spelled out showing any guess of spend rate not even a generic S – curve. There is no communication plan outlined.

8. The proposed purchase of equipment is: 1 – extremely poorly justified; 2 – poorly justified; 3 – justified; 4 – well justified; or 5 – extremely well justified. (Circle 5 if no equipment is to be purchased.)

Reviewer 1D (Rating 2)
Equipment to be utilized only cited by the expense of equipment, nothing else.

Reviewer 2D (Rating 2)
The proposal only states that they will spend up to $1,500,000 on equipment**.** No details on what equipment will be purchase only that it will be driven by their analysis of the NASA patent.

Reviewer 3D (Rating 1)
Other than acknowledgement of the need for physical facilities, there is no purchase plan presented.

9. The facilities and equipment available and to be purchased for the proposed research are: 1 – very inadequate; 2 – inadequate; 3 – adequate; 4 – notably good; or 5 – exceptionally good.

Reviewer 1D (Rating 2)
The facility location/requirements or the required equipment were uncited.

Reviewer 2D (Rating 2)
Since there is no details on their facility or the partners that will be working as part of the team from the ND University System their existing facilities must be rated as inadequate. The same is true for the equipment purchases as they not provided any details on the equipment to be purchased.

Reviewer 3D (Rating 2)
There is not enough information presented to even guess at adequacy of the facilities and equipment to be used.

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

Reviewer 1D (Rating 2)
Due to the incompleteness of this proposal, this line item is rather difficult to evaluate. The cover sheet is requesting $500k and the expense table has factored in $1.5 million. The remaining funding is to be made by unknown and non-committed investors to be named later. It is cited that $300k will be provide by the applicant. The proposal cites that 10 professionals will be required for this project at a cost of $1 million and unspecified equipment will cost $1.5 million. The expense table also includes an additional $1 million for research and development but does not explain how this would be an additional cost as salaries and equipment have their own line item.

Reviewer 2D (Rating 2)
In earlier sections of the rating form I have identified a number of short comings due to a lack of details. The inconsistences in budgets noted, Lack of identified cost share, and not being able to identify key technical players on the team make it impossible to assign a higher value to the proposed work. I don't believe they will be successful in completing the project with the information provided.

Reviewer 3D (Rating 5)
The value of the outcome is high to very high if it can be accomplished within the proposal's budget and if the outcome is suitable for further development. This is not a government project to colonize Mars at any cost; this is to be a commercial project to further energy production and usage.

There are no other sources of financing except "other sponsors."

Section C. Overall Comments and Recommendations:

Please comment in a general way about the merits and flaws of the proposed project and make a recommendation whether or not to fund.

Reviewer 1D
The flaws of this proposal are all cited above. It would appear that the only reason to consider conducting this proposal in North Dakota is because governmental funding may be available. They truly have an interesting concept and it could be a very valuable industry in North Dakota. The problem is that there is no clarity of what will be manufactured, how it will be done, who will get it done or how it will be funded. Until these issues are addressed and clarified, I would not support funding this project. In my opinion, the proposal only asks for up-front financial support on a promise that they will build something once investors can be found and make something out of carbon dioxide. The proposal is premature.

Reviewer 2D
This reviewer would **not recommend** funding for this activity.

This proposal does not provide the technical information required for this reviewer to recommend ND make the requested investment. There are serious inconsistencies in the budget. No attempt to identify sources of cost share. Key technical players for the proposed team have not been identified. The equipment purchases are only identified by amount of budget. No information is given on the rights received to the NASA technology only that the agreement will last for one year. It's not clear if they move to commercialize something if they would have any "rights" to access the core technology on an ongoing bases. There are no page numbers listed on the table of contents. It appears to this reviewer that a rush was made to get something submitted and critical details are missing to this application.

Reviewer 3D
I do **NOT recommend** funding for this project. It does not meet the NDIC//REC standards for a proposal.

While the project is interesting, exciting, and possibly of great benefit, the proposers have not taken the time to prepare a proper proposal – perhaps by the next round of applications.

The proposal does not identify the source of CO_2. Is this to be a direct capture process or an industrial source? If an industrial source, where in the schedule is the system to be tested on the industry source instead of bottled CO_2?

The staffing plan is not developed and in some respects is overloaded. Mr. Anderson is presented as a project manager why is Mr. Bakken needed? Why is Latoya Johnson involved? Shouldn't the PM be able to streamline processes? Further, no one named in the project is shown to have any expertise in anything that will help this project. Mr. Bakken's reputation is known to the reviewer, but the proposal should outline the experience of everyone cited in the project.

The schedule is shown as 18 months but the NASA license is one year; what is the impact of this?

The financial plan is weak showing no detail, and no other sponsors are identified.

The references to use on Mars suggest the sponsor is more interested in developing something for NASA rather than for North Dakota.

RENEWABLE ENERGY COUNCIL

Ballot for June 22, 2023

Grant Round 51 Applications

Name:

RECOMMEND FUNDING	**DO *NOT* FUND**	
		R-051-A – Integrated Renewable Combined Heat and Power for Ethanol; Submitted by EERC; Total Project Costs: $2,250,000; **Amount Requested: $450,000** Contingencies: •
		R-051-B – Clean Hydrogen from High-Volume Waste Materials and Biomass; Submitted by EERC; Total Project Costs: $2,500,000; **Amount Requested: $500,000** Contingencies: •
		R-051-C – DEFC Research and Development; Submitted by 4H2, Inc. Total Project Costs: $693,832; **Amount Requested: $346,915** Contingencies: •
		R-051-D – Carbon Convert; Submitted by Marlo Anderson, LLC; Total Project Costs: $4,500,000; **Amount Requested: $500,000** Contingencies: •

NDIC Schedule: October 2023

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2 **Deadline for Lignite Research Grant Round 103 and Renewable Energy Grant Round 52**	3	4 Outdoor Heritage Fund Advisory Board Meeting 10:00-5:00	5	6	7
8	9	10	11	12	13 ND Housing Finance Advisory Board 10:00-Noon	14
15	16 **IOGCC Conference**	17 **IOGCC Conference**	18 **IOGCC Conference**	19 BND Advisory Board 1:00-4:00	20	21
22	23	24	25 DMR Hearings	26 DMR Hearings	27	28
29	30	31 NDIC Meeting 8:00-Noon				

NDIC Schedule: November 2023

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1 **Deadline for Oil and Gas Research Grant Round 59 and Clean Sustainable Grant Round 5?**	2	3	4
5	6	7 **National Carbon Capture Conference**	8 **National Carbon Capture Conference**	9 Lignite Research Council Meeting 1:30-4:30	10	11
12	13 **Possible REC Meeting?**	14 **Possible REC Meeting?**	15 DMR Hearings	16 DMR Hearings BND Advisory Board 10:00-Noon	17 ND Housing Finance Advisory Board 10:00-Noon	18
19	20 **Possible REC Meeting?**	21	22	23 Thanksgiving	24	25
26	27	28 NDIC Meeting 12:30-5:00	29	30		