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:
2949951F2884D7...
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

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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

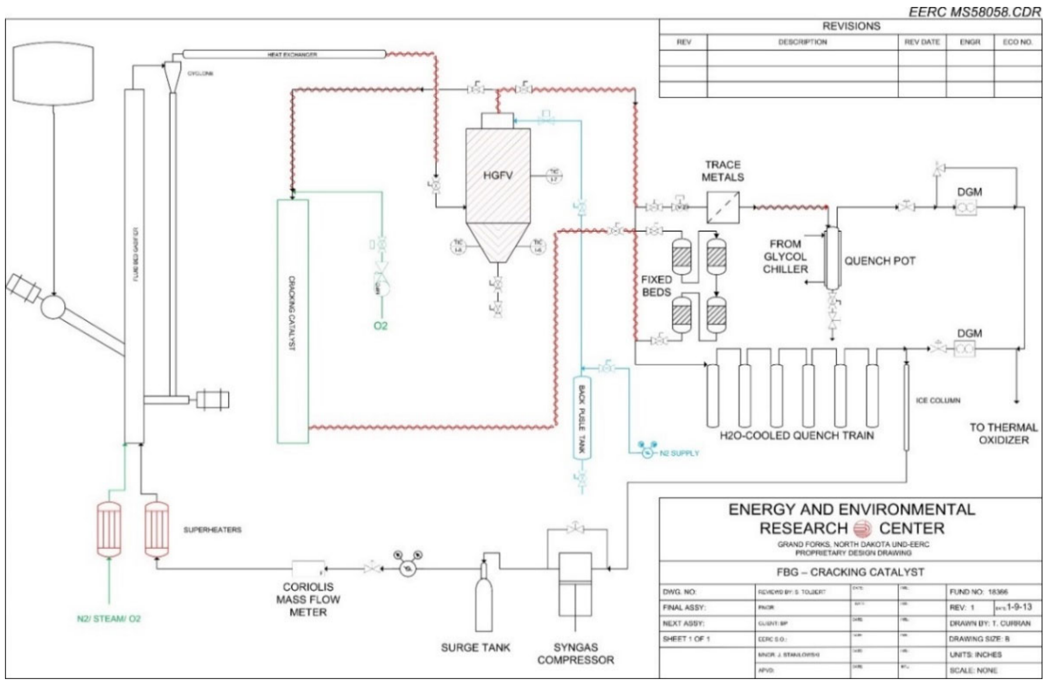

Figure 1. Projected process layout of the 10-lb/hr HPFBG.

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.

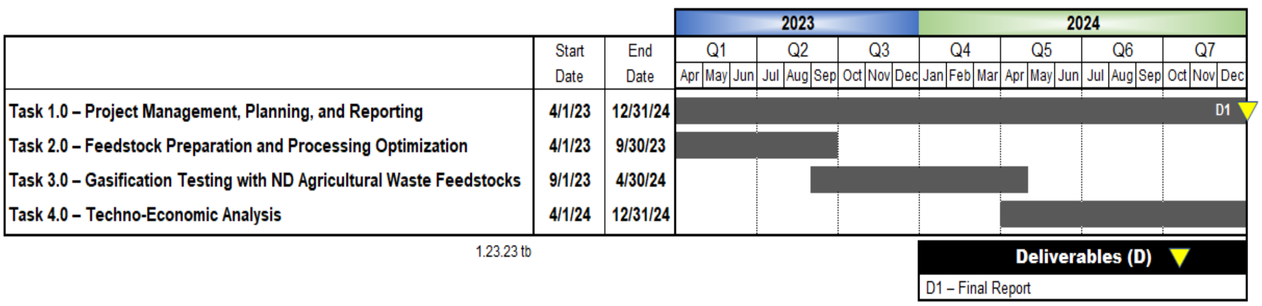

Figure 2. Project schedule.

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

Simonpietri Enterprises

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.