Environment and Natural Resources Trust Fund

2026 Request for Proposal

General Information

Proposal ID: 2026-527

Proposal Title: Biofuels for the Farm

Project Manager Information

Name: Aditya Bhan

Organization: U of MN - College of Science and Engineering

Office Telephone: (612) 626-3981

Email: abhan@umn.edu

Project Basic Information

Project Summary: The project addresses bioenergy research needs for heat, electricity, and liquid fuels by co-processing solid biomass and renewable biogas in small-scale reactors suitable for distributed chemical processing.

ENRTF Funds Requested: $291,000

Proposed Project Completion: June 30, 2029

LCCMR Funding Category: Small Projects (G)

Secondary Category: Energy (E)

Project Location

What is the best scale for describing where your work will take place?

Region(s): Metro

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

In the Future

Narrative

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

The conversion of solid, non-food biomass resources requires small-scale reactors that can handle variable feeds and overcome the recalcitrance of solid biomass. The nearly 50% oxygen content by weight of biomass requires the addition of hydrogen to produce fuels. Biogas or renewable natural gas produced by digesting manure (Minnesota ranks 8th of 50 states in its biogas production potential) lies at the opposite end of the chemical spectrum as biomass. Methane, the primary component of biogas, is chemically inert and its conversion involves the removal of hydrogen. While several processes have been proposed for biomass utilization, each has major drawbacks. Enzymatic conversion has been successfully applied but competes with food resources and results in dilute streams. Thermocatalytic processes for biofuels processing, the major approach for chemical transformations, have had very limited impact because challenges in working with solid biomass have appeared insurmountable. Another challenge in making biofuels is the need for small distributed production systems because transporting distributed biomass resources is cost prohibitive; this is unlike fossil fuel processing which favors large scale processing. The practical implementation of a bioenergy platform in a farm/agricultural setting requires novel technologies that address the scale and chemical characteristics of biomass derived feedstock.

What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.

We propose to leverage a novel plasma-reactor technology we have developed capable of handling pelletized or pulverized solids, processing up to 50-100 liters per minute of natural gas in one-inch reactor tubes, to co-process biomass and renewable biogas resources to make fuels and power. The technology is flexible in processing solid feedstock. However, depending on the biomass feedstock and the availability of biogas, the products may or may not be useful as liquid fuels, in which case we will use catalysts to tune product distributions to enhance hydrogen and synthesis gas production, which can be blended with natural gas or directly burned for clean power generation. The plasma-catalytic process is driven by electricity and does not require external heating. It offers flexibility for making electricity or fuel for bioenergy production systems necessitated by the variability in chemical composition of biomass feedstock and is capable of completely converting solid feedstocks and methane in seconds. The small-scale plasma-catalytic reactor to co-process solid biomass and natural gas that we propose to develop would enable flexible production of fuels or power depending on demand and feedstock characteristics and would provide renewable and reliant sources of energy for agriculture in Minnesota.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

- Demonstration of small-scale, electricity-driven, plasma-catalytic reactors that process solid biomass feedstock.
- Coprocessing of solid, non-food biomass resources with biogas to make precursors for fuel or electricity.
- Coprocessing of solid, non-food biomass resources with biogas to directly produce molecules suitable as fuels.

Activities and Milestones

Activity 1: Solid biomass processing in benchtop nonthermal plasma reactor

Activity Budget: $104,000

Activity Description:
The PIs have developed a benchtop microwave reactor in which the addition of solid carbon to natural gas streams enhances hydrogen production in decomposition reactions of natural gas. A patent application has been filed for this novel reactor configuration which can handle about 1 gram of solid per minute and 50-100 liters of natural gas. We will use this reactor to process solid cellulosic and lignocellulosic biomass with inert gas or hydrogen gas flow to determine the effect of feedstock composition on the rate of biomass consumption and whether a catalyst must be added to ensure stable biomass pyrolysis. Optical probes will allow temperature and flow characteristics in the reactor to be determined and capillary sampling with gas chromatography and Raman scattering analysis will allow product composition to be measured. Importantly, these capabilities exist in the setup developed by the PIs. We will intentionally change feed and flow conditions in time-dependent operation to mimic variability and transients in feedstock and demand. The tasks listed above will allow us to demonstrate operation of a nonthermal plasma reactor with biomass feedstock.

Activity Milestones:

Description	Approximate Completion Date
Solid biomass processing with quantification of products	December 31, 2026
Demonstration of intermittent and transient operation in plasma reactor	June 30, 2027

Activity 2: Coprocessing biomass and biogas to make synthesis gas in plasma catalytic reactors

Activity Budget: $100,000

Activity Description:
Synthesis gas, a mixture of hydrogen and carbon monoxide, can be used directly for power generation and can also be used to make fuels like methanol (CO + 2H2 = CH3OH) using off-the-shelf catalysts. We will target synthesis gas production in coprocessing solid lignocellulosic biomass with biogas derived from anaerobic digestion of manure or food waste on the farm. Ideal reactor operation would produce synthesis gas with tunable ratio of hydrogen to carbon monoxide using a catalyst. The process would be optimized as necessary to meet the hydrogen demands of converting biomass using biogas and to operate stably in varying feeds of biomass and biogas. Such a process has not been attempted before but critical aspects of this operation in processing solids with natural gas streams in a nonthermal plasma catalytic reactor have been demonstrated by the PIs. We propose to optimize fast conversion of biomass feedstock with biogas in a one-pot plasma-catalytic reactor with a target throughput of 1 kg/hour biomass and 100 cubic feet/hour (~3000 liters/hour) of biogas.

Activity Milestones:

Description	Approximate Completion Date
Stable operation of biomass and biogas cofeeds in plasma reactor	December 31, 2027
Optimization of plasma reactor to make synthesis gas of targeted composition at high conversion	June 30, 2028

Activity 3: Fuels production from tandem processing of biomass and biogas in plasma catalytic reactor

Activity Budget: $87,000

Activity Description:

Low volatility and high energy density are primary characteristics of liquid fuels. Biogas is volatile and lacks carbon-carbon bonds typical in fuels while oxygen-containing biomass feedstock lacks the energy density and invariably oxygen-removal forms carbon chains that are too short for making fuels. Coprocessing biomass feedstock with biogas over catalysts can however directly result in a partially deoxygenated synthetic fuel. No such catalytic technologies exist because processing solid biomass in temperature-driven catalytic processes has been intractable. We propose to explore whether electron-driven processes in the plasma reactor which enable continuous processing of solids can, in tandem operation with catalysts, allow us to directly make organic species suitable as fuels. We will target organic species with carbon numbers ranging from 4-15, typical of gasoline and diesel fuels, with hydrogen-to-oxygen ratio >6 required for making high-energy density fuels. We will use catalysts reported by PI Bhan in prior research supported by the US DOE Early Career Award capable of both biomass and natural gas conversion. The proposed one-pot technology to make fuel-range organic species using biomass and biogas would represent a step-change technology for renewable energy use in agriculture.

Activity Milestones:

Description	Approximate Completion Date
Catalytic operation with nonthermal plasma reactor to co-process biomass and biogas	December 31, 2028
Optimization of catalytic plasma reactor to make fuels	June 30, 2029

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Peter Bruggeman	University of Minnesota Twin Cities	co-PI	Yes

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this work be funded?

Biofuels production has support from the US Department of Energy (DOE), the US Environmental Protection Agency (EPA), the US Department of Agriculture (USDA), and the US National Science Foundation (NSF). Biofuels represent a domestic clean energy source and enhance American Energy Security. In the past, PI Bhan has been awarded more than $1.5 million in grants by the NSF and DOE on research related to thermocatalytic conversion of biomass-derived feedstock. Initial support through LCCMR will position us to attract future funding while furthering development of this new reactor technology for stable processing of solid feedstocks developed at UMN.

Project Manager and Organization Qualifications

Project Manager Name: Aditya Bhan

Job Title: Distinguished McKnight University Professor

Provide description of the project manager's qualifications to manage the proposed project.

Aditya Bhan is a Distinguished McKnight University Professor in the Chemical Engineering and Materials Science Department at the University of Minnesota Twin Cities (UMN). Following B.Tech. and Ph.D. degrees in chemical engineering from IIT Kanpur (2000) and Purdue University (2005), and post-doctoral research at the University of California Berkeley, he joined UMN in 2007. He leads a research group that focuses on developing innovative catalytic processes for energy conversion and petrochemical synthesis. His group at the University of Minnesota has been recognized with the Paul H. Emmett Award in Fundamental Catalysis from the North American Catalysis Society (2023), the Young Researcher Award from the Acid-Base Catalysis Society (2017), the Ipatieff Prize from the American Chemical Society (2016), and the Richard A. Glenn Award from the Energy & Fuels Division of the American Chemical Society (2016). He was awarded both the Department of Energy Early Career Award (2012) and the National Science Foundation Career Award (2011). He serves as Editor for Journal of Catalysis, is Past-Chair of the American Chemical Society Catalysis Science & Technology Division and has served on the Board of Directors of the International Symposium of Chemical Reaction Engineering and for the Chemical Reaction Engineering Division of the American Institute of Chemical Engineers.

Organization: U of MN - College of Science and Engineering

Organization Description:

The College of Science and Engineering at UMN houses 12 departments and a multitude of research centers and posted $162.9 million in research expenditure in FY2024. The University of Minnesota has spun out more than 260 startups since the formation of the Venture Center within UMN Technology Commercialization in 2006 and is the largest single source of startups in Minnesota, placing UMN within the top 3 of public universities in the US. The Characterization Facility (UMN Charfac) housed in the College of Science and Engineering provides state-of-the-art materials characterization facilities for UMN researchers that is maintained and upgraded by experts.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Principal Investigator		Prof. Bhan will lead the research effort			26.8%	0.18		$30,482
co-Principal Investigator		Prof. Bruggeman will lead the the plasma technology effort			26.8%	0.18		$29,622
Graduate Research Assistant		One student working in the Chemical Engineering and Materials Science Department on developing a plasma reactor for processing solids			37%	1.5		$177,319
							Sub Total	**$237,423**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Equipment	Solid feeder system	Solid fluidization and flow equipment to feed biomass in the plasma reactor system					$5,000
	Tools and Supplies	Materials and Supplies	Funds in the amount of ~$12,000 are requested annually to defray the costs of purchasing supplies including gases and chemicals, glassware, fabrication, and adaptation of reactors					$36,577
							Sub Total	**$41,577**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**

Travel In Minnesota								
							Sub Total	**-**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
		Scientific services - machining and materials characterization	Funds in the amount of ~$4,000 are requested annually to support scientific services which includes equipment use in the UMN Characterization Facility and UMN Machine Shops.					$12,000
							Sub Total	**$12,000**
							Grand Total	**$291,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**-**

Total Project Cost: $291,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: d6b31e38-8a0.pdf

Alternate Text for Visual Component

A reactor technology to convert non-food biomass resources to fuels is shown. The reactor technology is capable of directly processing solid biomass and removes oxygen from biomass feedstock using biogas produced from anaerobic digestion of manure and food waste....

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
UMN RIO letter - Bhan LCCMR 2025	a4459562-7aa.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

N/A

Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?

No

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

N/A

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

N/A

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

No

Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?

No

Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care, treatment, education, training, instruction, or recreation to children")?

No

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:

Victoria Troxler, Principal Grants and Contracts Officer, Team 3
Office of Sponsored Projects Administration
University of Minnesota
Phone: 612-624-9567
Email: vtroxler@umn.edu

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

N/A