Environment and Natural Resources Trust Fund

2024 Request for Proposal

General Information

Proposal ID: 2024-238

Proposal Title: Waste-Derived Synthetic Fuels for Sustainable Resource Recovery

Project Manager Information

Name: Sayan Biswas

Organization: U of MN - College of Science and Engineering

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Project Basic Information

Project Summary: Through University and Community partnerships, develop an affordable, eco-friendly synthetic fuel derived from waste streams with high combustion efficiency, low pollutant emissions, and competitive pricing compared to traditional fuels.

Funds Requested: $420,000

Proposed Project Completion: June 30, 2026

LCCMR Funding Category: Air Quality, Climate Change, and Renewable Energy (E)

Project Location

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

Statewide

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

Statewide

When will the work impact occur?

During the Project and In the Future

Narrative

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

Plastics and organic waste streams generated by human activities produce greenhouse gas and other hazardous emissions during every stage of their life cycle, which poses a significant threat to our climate, ecosystem, health, and food safety. In 2020, the US generated nearly 300 million tons (MT) of municipal solid waste (an average of 5 pounds per person per day), of which 50% was sent to landfills. The majority of the landfills constituted single-use/disposable plastics and organic waste, including food waste ~25%, plastic ~22%, paper ~12%, and wood ~8%. Plastics degrade slowly and contribute to microplastics and other pollutants in the soil, while other organics decompose and release methane and CO2, which are powerful greenhouse gasses. According to the Minnesota Pollution Control Agency, Minnesota produced nearly 3.6 MT of solid waste in 2021, of which only 20% was recycled, and the rest went into landfills. We propose to develop an affordable, eco-friendly synthetic fuel derived from waste streams with high combustion efficiency, low pollutant emissions, and competitive pricing compared to traditional fuels. UMN's mechanical, bioproducts, and biosystems engineering departments are partnering with Ramsey/Washington Recycling & Energy Center to establish pathways towards sustainable energy and carbon neutrality via community partnership.

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.

The energy content of the annual landfill of plastics and organic wastes that goes unused is equivalent to 30% of yearly US gasoline consumption. Our proposal aims to demonstrate novel strategies for converting plastics and organic waste into low-carbon fuels and conduct an extensive life-cycle and market analysis to evaluate the feasibility and benefits of using these fuels for sustainable and efficient energy production. UMN engineering brings an innovative, cost-effective, and environmentally sustainable process for converting waste into fuel, while the Ramsey/Washington R&E brings their industry knowledge, operational expertise, and infrastructure to scale the technology for commercial production. Our team will a) synthesize waste-derived fuels using plasma-assisted catalysis – a pioneering and promising route to produce ‘designer’ low-carbon synthetic fuels from solid wastes, with a high degree of waste-to-fuel conversion efficiency (~ 80% for single-use plastics), b) demonstrate the technical feasibility of using waste-derived fuels in commercial engines and industrial furnaces , and c) devise a commercial roadmap for marketing these waste-produced low-carbon fuels. Carlson School of Management will assist us in developing a comprehensive market analysis of the waste-fuel industry, help with the pricing strategy, and identify any economic challenges that could impede its widespread implementation.

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?

Treating waste as a resource benefits our environment and economy. In 2018, Minnesota spent nearly $200 million to dispose of 1.2 MT of recyclable material into landfills that could easily have been recycled for an estimated value of $285 million. When the economic advantages of recycling are clear, it becomes a desirable and widely embraced practice. This project lays the foundation for Minnesota to decrease its reliance on imported hydrocarbon fuels, and instead develop a sustainable means of harnessing energy from waste. Recycling waste reduces landfill use and methane emissions, improving air and soil quality and mitigating climate change.

Activities and Milestones

Activity 1: Synthesizing waste-derived fuels with improved yield and quality

Activity Budget: $100,000

Activity Description:
In this activity, our team will produce high-quality fuels from single-use plastics and organic solid wastes. In order to keep the cost low, the number of refinement steps must be limited. Two major tasks will be completed under Activity 1: (a) gain a clear understanding of the waste-to-fuel catalysis processes and find a balance between yield and quality, and (b) develop durable and robust catalysts with superior longevity and effectiveness. The key processing parameters and conditions to be investigated and optimized are pyrolysis/catalysis temperature, residence time, and catalysts. These planned activities are expected to generate information that will help us understand the relationships between processing variables and fuel quality and performance in engine testing. We will be partnering with Ramsey/Washington Recycling & Energy Center, who will provide us with an array of wastes, including a) waste plastic mixture, b) mixed solid waste materials, c) food waste, and d) refuse-derived fuel (RDF).

Activity Milestones:

Description	Approximate Completion Date
Improve and optimize yield and quality of waste fuel production	December 31, 2024
Complete testing different catalyst for longevity and performance	March 31, 2025
Perform physical and chemical property evaluation of waste fuels	April 30, 2025
Activity 1 summary report	May 31, 2025

Activity 2: Demonstrate the waste-derived fuels performance in commercial engines and furnaces

Activity Budget: $200,000

Activity Description:
In this activity, the quality and performance will be assessed for waste fuels synthesized in Activity 1. The density, viscosity, and fluid flow characteristics of waste fuels will be measured using rheometers in the Polymer Characterization Laboratory located in Chemical Engineering and Materials Science. Our novel counterflow atomizer uses high-pressure gasses to aerate viscous waste fuels to produce a fine mist. This would enable a uniform and clean burning of these waste fuels under any engine conditions. We will test the atomization behavior of the waste fuel sprays for a wide range of conditions in engines and furnaces. We will employ two different innovative ignition modules, a) plasma and b) corona ignition strategies, to improve the combustion performance and emission characteristics of the waste fuels. Both plasma and corona ignition outperform conventional spark ignition systems. The oxidation pathways of the fuel can be altered to minimize pollutant production. In the past, plasma ignition produced negligible NOx and unburned hydrocarbons. The outcome of Activity 2 will be to identify the promising waste-derived fuels that can work for a variety of engines and furnaces.

Activity Milestones:

Description	Approximate Completion Date
Measure rheological properties (density, viscosity, surface tension, etc.) of the waste fuels	June 30, 2025
Design modifications and testing of novel injector and ignition system custom for waste-derived fuels	October 31, 2025
Test and evaluate fuel's performance and emissions	December 31, 2025
Activity 2 summary report	December 31, 2025

Activity 3: Devise a commercial roadmap to ensure wide adoption of waste-derived fuels

Activity Budget: $50,000

Activity Description:
In this activity, a comprehensive market analysis will be conducted in partnership with the Carlson School of Management to identify the current and future demand for waste fuel in the energy market, as well as the competitive landscape and regulatory framework. A branding and marketing strategy will be developed to highlight the environmental and economic benefits of waste fuel production, followed by a pilot project to demonstrate effectiveness and viability. A scale-up roadmap for production and distribution will be developed, with a focus on sustainability, innovation, and stakeholder engagement. Throughout the process, it will be essential to maintain a strong focus on sustainability, innovation, and stakeholder engagement, in order to create a truly transformative and impactful waste fuel plant.

Activity Milestones:

Description	Approximate Completion Date
Activity 3 summary report	May 31, 2025
Research the market and competition	March 31, 2026
Determine the cost of production, life-cycle analysis	April 30, 2026
Finalize agreements with community partners and county officials	May 31, 2026

Activity 4: Develop strategic alliance and community partnership

Activity Budget: $50,000

Activity Description:
In this activity, we will develop a blueprint for a production-scale waste-to-fuel production facility. As part of our strategic alliance, we will perform the following steps. A) Conduct a feasibility study: This involves assessing the availability of waste materials, the potential demand for the produced fuel, and the financial viability of the project. B) Establish a partnership agreement: This should outline the roles and responsibilities of each partner, the ownership structure, and the intellectual property rights. C) Secure additional funding: Obtain financing from investors, banks, or government grants to cover the costs of the facility's construction and operation. D) Develop a pilot program: Start with a small-scale pilot program to test the feasibility of the project and fine-tune the production process. E) Build the production facility: Once the pilot program is successful, utilizing the external funds, a larger production facility will be built with the necessary equipment and staff. F) Obtain necessary permits and certifications: Work with regulatory agencies to obtain the necessary permits and certifications for the facility to operate. G) Establish a customer base: Build relationships with potential customers, such as energy companies or transportation providers, to purchase the produced fuel.

Activity Milestones:

Description	Approximate Completion Date
Completed feasibility and market study	April 30, 2026
Developed a pilot program with a sizeable fuel production output	June 30, 2026
Found a critical number of community partner, a customer base in established	June 30, 2026

Activity 5: Reporting, IP and patent filing, results dissemination, and journal paper writing

Activity Budget: $20,000

Activity Description:

This phase of the project will focus on patent filing and IP licensing, the final data analysis and report writing. In addition to meeting the deliverable requirements of the LCCMR Fund, the project team will prepare manuscripts for submission to peer-reviewed journals and will communicate the results of the project with the energy companies and waste management entities. Our final goal is to find a cost-effective, low-carbon waste fuel that will power the off-road transportation and energy sector of Minnesota for decades to come.

Activity Milestones:

Description	Approximate Completion Date
File IP and patents before any public disclose of research results	March 31, 2025
Finished writing the first draft of the journal/conference article	March 31, 2025
Activity 3 summary report	April 30, 2025
Final project report	June 30, 2025

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Vinod Srinivasan	Mechanical Engineering, University of Minnesota	Dr. Vinod Srinivasan is an assistant professor of Mechanical Engineering, is an expert in two-phase flow and heat transfer, focusing on liquid atomization, boiling, and evaporation; his research serves as the link that enables the transfer of viscous fuels to engine conditions.	Yes
Roger Ruan	Bioproducts and Biosystems Engineering, University of Minnesota	Dr. Roger Ruan is a professor of BBE, is a recognized world leader in the waste fuel catalytic process. He has an extensive publication record demonstrating improvement in fuel production while reducing processing steps allowing for a wide range of feedstocks ranging from municipal solid waste to biomass/agricultural waste.	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?

Project results will be communicated with the energy and waste management industry and other stakeholders via conferences, reports, patents, and direct communication. The impact of this project will influence strategic planning activities of waste management and clean energy stakeholders as they develop the next generation of environment-friendly technologies. The US Department of Energy and the Minnesota Pollution Control Agency are committed to reducing the environmental impacts of landfill wastes and fund research aimed at this goal. Future proposals for funding will be submitted to these sources, as well as by establishing partnerships with private energy and waste management.

Project Manager and Organization Qualifications

Project Manager Name: Sayan Biswas

Job Title: Assistant Professor

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

Prof. Sayan Biswas, Benjamin Mayhugh Assistant Professor of Mechanical Engineering, is an expert in clean energy, combustion, synthetic fuels, and novel laser-based sensing and diagnostics, will lead this project. PI Biswas is currently working with several industry partners to develop next-gen sustainable aviation fuels (SAF). PI Biswas has extensive experience developing optical sensors for energy applications and waste-fuel characterization. His research has received support from the Department of Energy (DOE), Advanced Projects Research Agency-Energy (ARPA-E), Office of Naval Research (ONR), National Science Foundation (NSF), and several clean energy companies. He manages an annual research portfolio of $2.1M. Before joining the University of Minnesota in 2020, Dr. Biswas spent 3+ years at the Sandia National Laboratories and 5+ years at Purdue University, working on clean energy and developing advanced light/laser sensing systems. To date, PI Biswas has published 20+ journal articles, 40+ conference articles, 1 single-authored book, 6 book chapters, and holds 1 US patent. PI Biswas leads a highly diverse research group consisting of 6 PhD, 3 MS, and 8 UG students. His lab actively participates in educating the community about our energy future and in K-12 outreach activities, inspiring the next generation of scientists and engineers, and providing an open and equitable learning atmosphere for women, minorities, and indigenous students. Prof. Biswas serves on several technical and advisory committees, volunteering for his professional societies and local Minnesota-based organizations.

Organization: U of MN - College of Science and Engineering

Organization Description:

The University of Minnesota, Twin Cities is a public land-grant research university in the Twin Cities of Minneapolis and

Saint Paul, Minnesota, and one of the most comprehensive research universities in the nation. The University leadership acknowledges that the University of Minnesota Twin Cities is built within the traditional homelands of the Dakota people. It is the flagship institution of the University of Minnesota System and is organized into 19 colleges, schools, and other major academic units. The University advances Minnesota state and US society through new ideas, technologies, treatments, and cures, and continues to create and transfer technology to companies for the development of new products and services that benefit the public good and foster economic growth. The University's College of Science and Engineering received $141.9 million in research funding in FY2015. The University of Minnesota College of Science and Engineering (CSE) ranks #4 in the country for the best bachelor's degree in engineering. In other rankings, CSE majors traditionally rank among the top 20.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Sayan Biswas		Principal Investigator			26.9%	0.06		$7,987
Vinod Srinivasan		Co-Principal Investigator			26.9%	0.06		$8,138
Roger Ruan		Co-Principal Investigator			26.9%	0.06		$10,752
Research Assistant _BBB		Graduate Student			44.8%	1		$105,528
Research Assistant_ME		Graduate Student			44.8%	1.5		$170,870
							Sub Total	**$303,275**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Tools and Supplies	Fuel, wiring supplies, spray injector, plasma igniter, plumbing parts, chemicals, etc.	Detailed test campaign to optimize waste fuels, their spray characteristics and combustion performance					$49,225
							Sub Total	**$49,225**
Capital Expenditures								
		Pressure and temperature sensor, fuel quality measurement, and waste-to-fuel efficacy estimation	Measure waste fuel properties, efficacy, spray performance, and combustion behavior	X				$45,000
		Fuel viscosity and volatility measurement instrument	Waste-derived fuel's characteristics are very important for this project					$7,500
							Sub Total	**$52,500**
Acquisitions and Stewardship								

							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Two people to one domestic conference per year	Present the work in a domestic conference, knowledge dissemination and attract potential customers/end-users					$5,000
							Sub Total	**$5,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
		Scientific Services	Characterization of fuels in UMN CharFac facility and polymer lab					$10,000
							Sub Total	**$10,000**
							Grand Total	**$420,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Capital Expenditures		Pressure and temperature sensor, fuel quality measurement, and waste-to-fuel efficacy estimation	XXX **Additional Explanation :** These sensors will serve 2-year research period for this LCCMR project. In the future, the sensors will be utilized to test more waste fuels as the project seeks partnerships with local industries or startups.

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
In-Kind	unrecovered F&A calculated at 55% MTDC	Support of ME facilities where research will be conducted.	Secured	$155,542
			Non State Sub Total	**$155,542**
			Funds Total	**$155,542**

Attachments

Required Attachments

Visual Component

File: 97d322b9-3e4.pdf

Alternate Text for Visual Component

The visual illustrates the challenges with landfill wastes, the missing profit, and jobs. Our solution is to develop an affordable, eco-friendly synthetic fuel derived from waste streams with high combustion efficiency, low pollutant emissions, and competitive pricing compared to traditional fuels....

Optional Attachments

Support Letter, Photos, Media, Other

Title	File
UMN Sponsored Projects Administration Authorization	6558422f-efb.pdf
Washington-Ramsey R&E Support Letter	827e5377-043.pdf
Resynergi - Waste Fuel Startup Company	eedd646c-d94.pdf
Resynergi Startup Story	5865aea9-d89.pdf
UMN Waste Fuel Research	012a50a8-9b8.pdf
PI Biswas Plasma Award - Impact Innovation Award 2022	2c4379ae-b97.pdf
Microwave-Assisted Plasma Catalysis of Waste Fuels	2f656485-e96.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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

Yes

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

Yes

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

No

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Does your project include the design, construction, or renovation of a building, trail, campground, or other capital asset costing $10,000 or more?

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?

No