Environment and Natural Resources Trust Fund

2026 Request for Proposal

General Information

Proposal ID: 2026-476

Proposal Title: Sustainable Aviation Fuels from Renewables through Microwave-Assisted Conversion

Project Manager Information

Name: Paul Chen

Organization: U of MN - College of Food, Agricultural and Natural Resource Sciences

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Project Basic Information

Project Summary: This project aims to develop and demonstrate a catalytic microwave-assisted low-temperature pyrolysis system that converts renewable oils and fats into sustainable aviation fuels, thereby reducing reliance on fossil fuels.

ENRTF Funds Requested: $895,000

Proposed Project Completion: June 30, 2029

LCCMR Funding Category: 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.

In response to the pressing climate crisis, the government has set an ambitious target of achieving a net-zero emissions economy by 2050. The aviation sector, responsible for approximately 2–3% of global carbon emissions, is in urgent need of cleaner fuel alternatives to replace, in part or entirely, fossil-based aviation fuels. Sustainable aviation fuels (SAF), derived from diverse sources such as used cooking oil, municipal waste, and renewable feedstocks, have the potential to reduce the lifecycle carbon emissions of air travel by more than 80%. This positions SAF as a critical lever for the aviation industry to achieve net-zero emission. Notably, Minnesota is uniquely positioned to lead this transition, given its abundant renewable feedstocks and state-level tax incentives designed to support SAF production and blending. Yet, current SAF production relies largely on ethanol and vegetable oils, and conventional conversion methods depend on costly hydrogen and high-pressure processes, undermining their economic competitiveness. To overcome these barriers, it is imperative to develop an innovative, cost-effective conversion process that transforms waste renewables into high-quality SAF. Our proposal introduces a catalytic microwave-assisted hydrodeoxygenation process that addresses these challenges, promising to deliver a more sustainable, energy-efficient alternative while bolstering Minnesota's leadership in renewable energy innovation.

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.

Minnesota and our nation must boost the production of SAF to meet our ambitious climate goals. Minnesota aviation industry urgently requires innovative techniques to convert renewable resources, like used cooking oils, animal fats, soybean oil, and corn oil into SAF. Minnesota annually produced 2.23 billion lbs of soybean oil and 426 million lbs of corn oil. National trends show significant volumes of animal fats and used cooking oils, further increasing SAF potential. This project aims to develop an advanced catalytic microwave-assisted hydrodeoxygenation process and system to efficiently convert oils and fats into SAF, using polyolefinic plastics as a hydrogen donor. By eliminating costly hydrogen sources and high-pressure requirements, and leveraging the staggering annual production of waste plastics (400 million tonnes), this renewables-to-SAF technology represents a competitive alternative to fossil-based. The initial phase will assess the feasibility of converting various waste oils and fats into SAF through the proposed technology. This will involve designing a bench-scale catalytic microwave-assisted hydrodeoxygenation system, synthesizing tailored catalyst materials, and optimizing reaction parameters. The results will guide the development of a pilot-scale system for testing and demonstration. Subsequent techno-economic analysis and life cycle assessments will expedite the transition to commercial scale, maximizing carbon reduction potential.

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?

This project aims to provide scientific insights through exploratory research, focusing on two key aspects: 1) elucidating the process of converting waste oils and fats into SAF through catalytic microwave-assisted hydrodeoxygenation without external hydrogen; and 2) understanding the influence of catalyst structure, temperature, and other variables on SAF production. Additionally, we will work towards developing a cost-effective and practical pilot-scale system to showcase the feasibility of scaling up the process. Our collective efforts are poised to support Minnesota's commitment to protecting and enhancing natural resources, fosters sustainable industrial practices, and paves the way for a cleaner, net-zero future in aviation.

Activities and Milestones

Activity 1: Laboratory Investigation of Converting Waste Oils and Fats into SAF

Activity Budget: $200,000

Activity Description:
Building on our extensive experience in catalytic microwave-assisted pyrolysis, we will design and construct an advanced hydrodeoxygenation system tailored for converting renewable oils and fats into SAF. This system aims to efficiently process various feedstocks, including waste cooking oils, animal fats, and vegetable oils, at auto pressures, and moderate temperatures (350-450 ºC) with reaction times of 20-60 min. Our preliminary hydrodeoxygenation tests using waste vegetable oil have yielded promising results, producing an aviation fuel blend with negligible oxygenates, approximately 80% C8-C18 alkanes, and around 20% mono-aromatics. Polyolefinic plastics will serve as a hydrogen donor, facilitating hydrogenation and deoxygenation reactions. To enhance catalytic efficiency and selectivity, we will incorporate tailored catalysts such as metal oxides, zeolites, and metal-organic frameworks (MOF). Comprehensive product characterization will be conducted using GC-MS for liquid products, micro-GC/MS for gas products, and TG analysis, FTIR, and NMR for solid products. Key process parameters, including microwave absorbent loading, reaction conditions (temperature, time, catalyst, and plastic loading), and catalyst regeneration protocol will be optimized to maximize hydrocarbon yield and quality. This phase will also assess catalyst activity and stability to ensure long-term performance.

Activity Milestones:

Description	Approximate Completion Date
Feedstock collection	August 31, 2026
Develop and improve a catalytic microwave-assisted conversion system	December 31, 2026
Develop and synthesize catalysts tailored for the process	March 31, 2027
Conduct experiments on catalytic microwave-assisted hydrodeoxygenation and optimize the process	December 31, 2027

Activity 2: Designing and Constructing a Pilot-Scale Demonstration System for Catalytic Microwave-Assisted Hydrodeoxygenation

Activity Budget: $500,000

Activity Description:
Following the bench-scale development and optimization in Activity 1, this phase focuses on designing, constructing, testing, and demonstrating a pilot-scale catalytic microwave-assisted hydrodeoxygenation system. Addressing key technical challenges associated with pilot-scale system, including temperature uniformity, microwave field distribution, and continuous operation, will be a primary focus. Multiphysics simulations will guide the optimization of critical design elements, such as microwave cavity geometry, power distribution, and material flow, to achieve consistent performance at larger throughputs.
The pilot-scale system will enable continuous conversion under real-world conditions, maintaining the high efficiency observed in lab-scale trials. Key operational parameters—such as temperature control, catalyst loading, and reaction time—will be fine-tuned to maximize hydrocarbon yield and quality. Comprehensive data on mass and energy balances, product yield, energy consumption, and emissions of pollutants and greenhouse gases will be collected to evaluate system performance and environmental impact. These findings will provide critical insights for subsequent techno-economic analysis and life cycle assessment in the next phase.

Activity Milestones:

Description	Approximate Completion Date
Design and construction of a pilot-scale catalytic microwave-assisted hydrodeoxygenation system	August 31, 2028
Pilot system test, improvement and demonstration	December 31, 2028

Activity 3: Conducting Techno-Economic Analysis and Life Cycle Assessment for the Proposed Technology

Activity Budget: $195,000

Activity Description:
In this activity, we will conduct a comprehensive techno-economic analysis (TEA) and life cycle assessment (LCA) to evaluate the economic feasibility and environmental impact of the proposed catalytic microwave-assisted hydrodeoxygenation technology. Using data from the pilot-scale system, we will design end-to-end conversion process and build the simulations to generate mass and energy balances and information about energy consumption and operational costs for a techno-economic analysis. For the LCA, pollutants and greenhouse gas emissions, including CO, CO2 and CH4, C1-C4 hydrocarbons, will be quantified during pilot system operation. In addition, the potential impact of organic gases and aerosols emitted by the system on air quality will be evaluated with continuous monitoring and point measurements. The LCA will also evaluate the system's carbon footprint, resource efficiency, and overall environmental performance across its lifecycle, from feedstock sourcing to fuel production. This systematic analysis will benchmark both economic and environmental performance, guiding necessary adjustments for commercial viability.

Activity Milestones:

Description	Approximate Completion Date
Generate information for a techno-economic analysis	March 31, 2029
Monitor pollutants and greenhouse gas emissions for life cycle assessment	March 31, 2029
Final Report on this project with outreach materials	June 30, 2029

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Roger Ruan	University of Minnesota	Co-PI	No

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?

This project aims to develop a practical, cost-effective, pilot-scale catalytic microwave-assisted hydrodeoxygenation system for SAF production. Success could significantly impact SAF commercialization. Strategic partnerships with aviation, renewable energy, and manufacturing sectors will help address engineering challenges and secure investment. Funding will be pursued from DOE, USDA, and private partners. Collaboration with airlines and industry stakeholders will facilitate adoption. Outreach efforts will promote SAF benefits, with long-term funding from government grants, public-private partnerships, and potential revenue from initial production. This strategy positions Minnesota as a leader in SAF, supporting climate goals while ensuring economic viability and scalability.

Project Manager and Organization Qualifications

Project Manager Name: Paul Chen

Job Title: Research Professor and Program Director

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

Dr. Paul L. Chen is a Research Professor and Program Director at the Center for Biorefining, Department of Bioproducts and Biosystems Engineering, University of Minnesota. With over 28 years of experience in biomass conversion, waste valorization, sustainable fuels, and advanced thermochemical processes, he has pioneered catalytic microwave-assisted pyrolysis, hydrodeoxygenation, and biorefining technologies. His extensive research portfolio includes 260+ peer-reviewed journal articles, 15 book chapters, and two books, amassing over 26,800 citations (h-index: 85, i10-index: 237). His expertise in microwave-assisted waste-to-fuel conversion, catalyst development, and resource-efficient recycling has driven key innovations in renewable energy. Holding 18 U.S. patents, Dr. Chen has developed novel technologies in microwave-assisted biofuel production, catalyst design, and pollutant control. His breakthroughs in hydrodeoxygenation have significantly reduced reliance on costly hydrogen and high-pressure conditions for fuel upgrading, making sustainable aviation fuel and waste-to-energy solutions more economically viable.

Dr. Chen has secured over $45 million in research funding from agencies such as USDA, DOE, DOD, and NSF, leading multi-institutional and industry-collaborative projects. His leadership has enabled the scaling of renewable energy and waste mitigation technologies, including the development of pilot-scale microwave-assisted systems for biofuel production and electronic waste recycling. His expertise in techno-economic analysis and life-cycle assessment ensures that projects are scientifically rigorous, financially viable, and environmentally sustainable.

Beyond academia, Dr. Chen actively collaborates with industry to commercialize waste-to-energy and sustainable fuel technologies. He has played a key role in technology transfer, licensing agreements, and industry partnerships, ensuring real-world applications of his research. His service as an editor, peer reviewer, and committee member in multiple scientific organizations further solidifies his influence in shaping the future of renewable energy and waste conversion research.

Organization: U of MN - College of Food, Agricultural and Natural Resource Sciences

Organization Description:

The Center for Biorefining is a University of Minnesota research center affiliated with the College of Food, Agricultural

and Natural Sciences and helps coordinate the University efforts and resources to conduct exploratory fundamental and applied research and provide education on science and technology for environment protection and circular economy; stimulate collaboration among the University researchers, other public sector investigators, and private investigators involved in biobased production technology development; promote technology transfer to industries; and foster economic development in rural areas. The Center's research programs are founded by DOE, USDA, DOT, DOD, LCCMR, IREE, Xcel Energy, and other federal and state agencies, NGOs, and private companies. The Center is equipped with state of the arts analytical instruments, and processing facilities ranging from bench to pilot scale.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
PI - grant funds will add to <full time FTE		Direct all research and personnel			36.8%	0.3		$43,488
Co-PI - summer salary only		Oversee fabrication			36.8%	0.15		$45,341
post doctoral		conduct experiments and analysis			25.9%	3		$251,866
graduate student researcher		conduct experiments and analysis with post doc, education			83.6%	3		$179,501
							Sub Total	**$520,196**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Equipment	computer hardware	specifically for analytical requirements of instruments	X				$3,000
	Equipment	components	for lab system testing and development					$46,000
	Tools and Supplies	lab and miscellaneous supplies, including feedstock, catalysts, chemicals, consumable supplies for analytical instruments, gloves, masks	to conduct proposed research accurately and safely					$27,204
							Sub Total	**$76,204**
Capital Expenditures								
		components including microwave-assisted reactor vessel, insulation materials, magnetrons, control, motors, mixer, feeder, valves, etc.	for fabrication of a small pilot-scale demonstration system for catalytic microwave-assisted hydrodeoxygenation	X				$295,600
							Sub Total	**$295,600**

Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	tbd	Journeys undertaken for the collection and transportation of feedstock					$3,000
							Sub Total	**$3,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$895,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Equipment, Tools, and Supplies		computer hardware	necessary for proposed research: integral to overall equipment functioning
Capital Expenditures		components including microwave-assisted reactor vessel, insulation materials, magnetrons, control, motors, mixer, feeder, valves, etc.	necessary for proposed research **Additional Explanation :** The capital equipment will be integral to developing and demonstrating the catalytic microwave-assisted hydrodeoxygenation system for sustainable aviation fuel (SAF) production. Post-project, it will remain in use at the University of Minnesota for continued SAF research, process optimization, student training, and future grant-funded projects. This ensures long-term value, industry collaboration, and Minnesota's leadership in renewable energy innovation.

Non ENRTF Funds

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

Total Project Cost: $895,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 074edff6-8a6.pdf

Alternate Text for Visual Component

The schematic highlights our catalytic microwave-assisted hydrodeoxygenation process for converting renewable oils and fats into SAF. This innovative method, eliminating external hydrogen and high pressure, supports aviation decarbonization and enhances sustainability, positioning SAF as a viable alternative to fossil fuels....

Supplemental Attachments

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

Title	File
Letter of Authorization to Submit	bc6a34a6-8de.pdf
Audit	36fdd68b-a43.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?

Yes, I understand the UMN Policy on travel applies.

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

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?

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:

Wendy Moylan, Juer Liu, University of Minnesota

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