Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-093

Proposal Title: From Minnesota Agricultural Waste to Sustainable Aviation Fuel

Project Manager Information

Name: Xiaowen Chen

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

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Project Basic Information

Project Summary: This project focuses on developing novel technologies converting Minnesota based agriculture waste into cost competitive sustainable aviation fuels. While advancing technologies, the project will access the environmental benefits for Minnesota.

ENRTF Funds Requested: $300,000

Proposed Project Completion: December 31, 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?
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.

Minnesota produces approximately 1.4 billion bushels of corn annually from about 8.9 million planted acres, supporting roughly 24,000 corn farmers statewide. This level of production can generate up to 18 million tonnes of sustainably harvestable corn stover annually without increasing soil erosion risk. If utilized for sustainable aviation fuel (SAF) production, it could produce approximately 0.6–0.7 billion gallons of SAF annually. At a market price of about $8/gallon (at 2025), this represents a $5–7 billion annual market opportunity for Minnesota's agricultural and bioenergy sectors. Using corn stover for SAF provides environmental benefits for farmers beyond economic returns. Partial stover removal improves residue management, leading to warmer, drier soils in spring and better planting conditions. This practice can also enhance nitrogen use efficiency and potentially reduce nitrous oxide emissions.

One promising pathway for converting corn stover into SAF involves hydrolyzing biomass carbohydrates into sugars, converting those sugars into lipids via fermentation, and upgrading the lipids through the HEFA-SAF process (which is already commercialized for crop-oil based SAF). However, efficient and scalable conversion of corn stover into lipids remains a key barrier to commercialization. This project is designed to address this critical limitation.

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.

In this project, we aim to unlock the full value of corn stover by converting it into SAF. Building on our successful Department of Energy - funded research, we will develop an efficient, low-impact process that transforms corn stover into renewable lipids compatible with the already commercialized HEFA-SAF pathway.

Our approach integrates chemical, mechanical, and biological steps into a streamlined process that converts plant material into clean sugars with significantly lower energy, water, and chemical use than conventional technologies. By operating at milder conditions, the process avoids harmful byproducts that often limit performance and increase environmental pollution. A key innovation is the use of glycerol based solvent that boosts sugar yields. Glycerol is a by-product from lipid conversion to produce biodiesel or SAF, thereby closing the chemical loop.

These sugars will be fermented using specialized yeast to produce energy-dense lipids, which will be recovered through an environmentally friendly, green-solvent extraction process and upgraded to sustainable aviation fuel. We will evaluate the compatibility of these lipids with Minnesota soybean oil–derived feedstocks for SAF upgrading.

Finally, we will conduct techno-economic and life-cycle analyses to demonstrate a cost-competitive, scalable pathway that creates new revenue for Minnesota farmers while achieving statewide sustainability.

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?

Reliance on fossil fuels has increased atmospheric CO_2 concentrations from approximately 300 ppm in 1920 to over 420 ppm in 2025, driving a rise in global average temperatures of nearly 2 °C. Climate change is already affecting Minnesota through more frequent extreme weather events and ecological disruption. According to the Minnesota Pollution Control Agency, lakes across the state have lost 10–14 days of ice cover over the past 50 years, negatively impacting fish health, ecosystems, outdoor recreation, and local economies. This project directly addresses these challenges by displacing fossil-derived jet fuel with SAF produced from agricultural residues.

Activities and Milestones

Activity 1: Enabling Efficient Sugar Production from Corn Stover

Activity Budget: $50,000

Activity Description:
In this activity, we will develop a hybrid, atmospheric pressure, mild-temperature chemical and mechanical pretreatment (CMP) process to significantly enhance corn stover digestibility, enabling efficient enzymatic hydrolysis of cellulose and hemicellulose into clean fermentable sugars. The process employs a glycerol-based solvent system with a homogeneous catalyst to selectively extract xylan and lignin from biomass. Importantly, the glycerol is sourced as a byproduct from lipid upgrading to SAF, thereby closing the loop within the SAF production pathway. Glycerol and glycerol derived solvents can effectively modify lignin through the formation of new ether linkages, increasing lignin hydrophilicity. The lignin dissolved in glycerol forms a valuable lignin-derived bio-oil with potential for upgrading into renewable fuels. A systematic matrix of glycerol-based solvent–catalyst combinations will be designed and optimized using response surface methodology. Furthermore, mechanical refining will be incorporated to increase surface area and further improve carbohydrate accessibility. The performance target is to achieve greater than 90% total sugar yields with enzyme loadings below 15 mg per gram of cellulose, while lowering the cost of sugar production. Beyond improving sugar yields, we will generate new knowledge on glycerol–lignin chemistry and biomass morphological changes using advanced analytical tools, including NMR, FTIR, and SEM.

Activity Milestones:

Description	Approximate Completion Date
Identify corn stover source from Minnesota Corn Farm and complete characterization of the biomass	October 31, 2027
Optimize glycerol based pretreatment of the biomass to achieve > 90% sugar yields	March 31, 2028
Understand the chemical modification of lignin by glycerol grafting	October 31, 2028
Publish at least 1 papers on peer reviewed journals	June 30, 2029

Activity 2: Enabling Efficient Lipid Production and Extraction

Activity Budget: $100,000

Activity Description:
In this activity, we will optimize microbial lipid production using biomass-derived hydrolysates generated in Activity 1. Building on prior success, we will implement an advanced fed-batch fermentation strategy that decouples cell growth from lipid accumulation. Approximately two-thirds of the total sugars will be supplied upfront with organic nitrogen to promote rapid biomass formation, followed by a final one-third sugar feed without nitrogen to induce lipid biosynthesis under nitrogen-limited conditions. Hydrolysates produced from optimized pretreatments will be systematically evaluated for compatibility with this strategy, with feeding profiles and nitrogen-to-carbon ratios adjusted based on hydrolysate composition. Key bioreactor parameters, including oxygen transfer rates, will be optimized using modified Rushton impellers to support high-density fermentation while minimizing energy demand. The overall goal is to establish a robust, scalable fermentation protocol that maximizes lipid titers and productivity using real biomass-derived streams. Following fermentation, we will develop an efficient lipid recovery process from oleaginous yeast biomass. Cells will be harvested by centrifugation and subjected to dilute acid to disrupt cell walls and enhance lipid accessibility. The resulting slurry will undergo solid–liquid separation, after which the recovered solids will be extracted using a hexane-based solvent system. The extracted lipids will be recovered by further distillation.

Activity Milestones:

Description	Approximate Completion Date
Demonstrate lipid production via bench-scale fed-batch fermentation, achieving >90% lipid yield	December 31, 2028
Demonstrate lipid extraction from oleaginous yeast, achieving > 95% lipid recovery yield.	July 31, 2029
Publish at least 1 paper that is associated with activity 2	December 31, 2029

Activity 3: Enabling SAF production from Corn Stover Derived Lipid

Activity Budget: $100,000

Activity Description:

The dominant commercial pathway for SAF production is the Hydrogenated Esters and Fatty Acids (HEFA) process, also referred to as hydrogenated vegetable oils. This activity will focus on upgrading biomass-derived lipids using a two-stage catalytic HEFA process. Lipid feedstocks will first undergo pretreatment to remove impurities that can deactivate catalysts. In the first hydroprocessing step (HT1), catalytic hydrodeoxygenation and double-bond saturation will be carried out to convert oxygenated lipids into a normal paraffin mixture. This step will produce a high-cetane (>100) n-paraffin stream with a cloud point above 20 °C, using conventional CoMo- or NiMo-based alumina catalysts. In the second hydroprocessing step (HT2), the n-paraffins will be selectively converted to iso-paraffins through hydroisomerization, with controlled cracking to produce naphtha and light hydrocarbon gases. Pt-based zeolite catalysts will be employed to tailor product distribution and cold-flow properties. The final SAF cloud point will be tuned by balancing isomerization severity and cracking, enabling optimization of fuel performance and coproduct yields.

Activity Milestones:

Description	Approximate Completion Date
Demonstrate bench-scale hydrotreating of corn stover derived lipid and soybean oil blendstocks	June 30, 2029
Evaluate fuel properties for SAF blendstock to confirm suitability as SAF	December 31, 2029

Activity 4: Enabling Comprehensive Evaluation of Economic Viability and Environmental Benefits

Activity Budget: $50,000

Activity Description:

In this task, we will conduct experimental data-driven Techno-economic Analysis using Aspen Plus simulations and cost analysis models. These evaluations will assess the financial viability, scalability, and environmental impact of the integrated process. Our target is to demonstrate minimum SAF selling price to be less than $5/gallon. Sensitivity analysis will be conducted to identify the most influential parameters affecting capital, operational, and overall performance. Key variables include sugar yields, lipid yields, biomass costs, and lignin utilization efficiency. These analyses will inform us where future R&D can have the greatest impact for the successful commercialization of the technology. The overall outcome from this objective is to establish a robust foundation for the future scale-up and integration of biomass-derived SAF production.

In conjunction with TEA, a life cycle assessment (LCA) will be performed to evaluate the potential environmental benefits of the proposed fuel process. We will evaluate the impacts of life cycle greenhouse gas (GHG) emissions of both products with a functional unit of a MJ of fuel produced, and with system boundaries of well-to-wake (WTW) and well-to-gate (WTG); potential GHG reductions relative to the petroleum counterparts will be also estimated.

Activity Milestones:

Description	Approximate Completion Date
Establish preliminary TEA and LCA model frameworks	December 31, 2027

Report Mid-term TEA and LCA results and improve models based on experiment findings	December 31, 2028
Report Final TEA and LCA results and show benefits associated with Minnesota economy and environment	December 31, 2029
Publish at least 1 paper summarizing the whole project	December 31, 2029

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Nancy Dowe	National Laboratory of the Rockies	Consulting	No
Julia Silvis	Minnesota SAF hub	Consulting	No

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.
This research will help ensure that Minnesota farmers and industries benefit from the growth of renewable energy and sustainable aviation fuel. By developing SAF technologies that use Minnesota's most abundant agricultural residues, the project will create new revenue opportunities for farmers, support higher-value jobs, and strengthen the state's bioeconomy. At the same time, this work will provide environmental benefits by reducing waste and lowering greenhouse gas emissions in Minnesota and beyond. Project results will be shared with key stakeholders, including farmers, agricultural cooperatives, fuel producers, airline partners, Minneapolis–Saint Paul International Airport, and relevant state agencies, to support adoption and real-world impact.
The results will also be published in peer-reviewed journals and presented at national and international conferences to ensure scientific rigor and broad dissemination. In addition, the project team will actively pursue technology transfer by sharing process data, performance metrics, and techno-economic insights with industry partners, technology developers, and commercialization organizations. Where appropriate, results will be used to support patent filings, licensing opportunities, and scale-up activities in collaboration with the University of Minnesota's technology commercialization office and industry partners of this project. These efforts will help position Minnesota as a national leader in the development of sustainable aviation fuels.

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 implemented through partnerships with the Minnesota SAF Hub, the U.S. Department of Energy, the National Laboratory of the Rockies (formerly National Renewable Energy Laboratory), World Energy and SAFFiRE Renewables to advance pilot- and demonstration-scale SAF production in Minnesota. Process data, techno-economic analysis, and life-cycle results will guide scale-up, feedstock integration, and deployment strategies. Following project completion, additional development and commercialization activities will be supported through federal funding programs (DOE, USDA) and industry cost-sharing.

Project Manager and Organization Qualifications

Project Manager Name: Xiaowen Chen

Job Title: Assistant Professor

Provide description of the project manager's qualifications to manage the proposed project.
Dr. Xiaowen Chen will serve as the Project Investigator, overseeing all research and coordination activities. Dr. Chen currently is an Assistant Professor at the University of Minnesota and previously worked as a senior engineer at the National Renewable Energy Laboratory (NREL). He has more than 20 years of experience in biomass preprocessing,

extraction, pretreatment, deconstruction, and conversion. Notably, he is the inventor of a patented deacetylation and mechanical refining (DMR) process for converting corn stover to ethanol (U.S. Patent 12,129,342), which has been exclusively licensed to SAFFiRE Renewables, formerly a Southwest Airlines venture-backed company and now part of Conestoga Energy. Conestoga is currently constructing a 10-ton-per-day ethanol pilot facility in Liberal, Kansas. Dr. Chen has secured over $10 million in competitive research funding to advance biofuel and biomaterials research. He has extensive experience leading and managing large, multidisciplinary research projects, from fundamental research through pilot-scale demonstration.

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

Organization Description:
In the College of Food, Agricultural and Natural Resources Sciences (CFANS) at the University of Minnesota, we look at the bigger picture. When we envision a better tomorrow, it includes disease-resistant crops, products that protect our health, lakes free from invasive species, and so much more. We use science to find answers to Minnesota and the world's grand challenges and solve tomorrow's problems. Almost 93 percent of students who earn CFANS undergraduate degrees find jobs in their career field or enter graduate school within six months of graduation.
The Department of Bioproducts and Biosystems Engineering, in CFANS, discovers and teaches solutions for the sustainable use of renewable resources and the enhancement of the environment. We discover innovative solutions to address challenges in the sustainable production and consumption of food, feed, fiber, materials, and chemicals by integrating engineering, science, technology, and management into all degree programs.
We have a public impact through community engagement and extension efforts. We develop and deliver high quality, regionally and nationally-recognized research-based programs to meet current and emerging needs of industry and communities. We also have a long-standing tradition of close partnerships with alumni, industry professionals, organizations, government agencies, donors, and community members.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
1 Assistant Professor - 9-month appointment, requesting summary salary		Professor Chen will serve as the project manager. He will oversee project execution by mentoring student researchers, coordinating research activities, and ensuring that experiments and analyses align with project objectives. He will guide the technical direction, manage project logistics and timelines, and facilitate communication among partners. He will also prepare reports to LCCMR and identify opportunities to translate research outcomes toward practical applications and commercialization.			36.6%	0.33		$40,980
1 graduate student		The graduate student will conduct the core research activities, including experimental work, data collection, and analysis. The student will maintain laboratory records, participate in project meetings to report progress, and assist with laboratory operations. The graduate student will also prepare manuscripts for peer-reviewed publications and contribute to conference presentations and project reports.			54%	3		$188,326
postdoc researcher		The postdoc researcher will work with PD to design experiment, write reports and publish paper. He will also work with the graduate on biomass pretreatment, characterization, and conversion			26.1%	0.15		$34,693
							Sub Total	**$263,999**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Equipment	Floor Standing Incubator (1)-$4000, Benchtop fermenter (1) $15,000, MSE PRO 50L Shaking Incubator with Universal Spring Tray (1) $4000	The equipment will include incubators for high-solids enzymatic hydrolysis a bench-scale fermenter for lipid					$23,000

			production, and shaker tables for microbial cultivation.					
	Tools and Supplies	pipets, gloves, chemicals, other lab supplies	essential for conducting experiment					$10,001
							Sub Total	**$33,001**
Capital Equipment								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Conference Registration Miles/ Meals/ Lodging	1 conference, 2 people, any extra for other below	present at state conference, workshops, outreach centers and etc.					$1,000
							Sub Total	**$1,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	cost for publication	publish the results on peer review journal, and most journal request a publication fee					$2,000
							Sub Total	**$2,000**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$300,000**

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: $300,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: e6035a9c-a69.pdf

Alternate Text for Visual Component

This is the flowchart of project activities illustrating the DMR process that converts corn stover into sustainable aviation fuel. The project is supported by the National Renewable Energy Laboratory (now operating as the National Laboratory of the Rockies), SAFFiRE Renewables (formerly the Southwest Airlines venture and now part of Conestoga),...

Supplemental Attachments

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

Title	File
Letter of Approval to Submit	a783b204-33b.pdf
Support letter from SAFFiRe Renewable	1f58879b-2de.pdf
Support letter from Minnesota SAF hub	eba491ce-ed7.pdf
Support letter from NLR (previously NREL)	2466cc3c-660.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

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