Environment and Natural Resources Trust Fund

2025 Request for Proposal

General Information

Proposal ID: 2025-078

Proposal Title: Agrivoltaics 2.0 Building a Resilient E-Farm

Project Manager Information

Name: Bradley Heins

Organization: U of MN - WCROC

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Project Basic Information

Project Summary: The project team at the WCROC will evaluateemerging solar system designs that will maximize energy production as well as provide maximal benefits to farmers.

ENRTF Funds Requested: $678,000

Proposed Project Completion: June 30, 2028

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.

Livestock production is based on capturing energy from the sun through photosynthesis by crops that are fed to livestock. Solar power is based on capturing energy from the sun by photovoltaic conversion to electricity. The proposed project will determine emerging strategies to integrate solar technology and livestock and vegetable production systems in the United States. Through past investments and institutional experience in renewable energy and dairy production research, the University of Minnesota West Central Research and Outreach Center (WCROC) has a globally unique opportunity to lead a new green revolution - a revolution that greens energy currently consumed within agricultural industries. The WCROC has a strategic plan to reduce fossil energy consumption and the carbon footprint within dairy production systems. This collaborative project will build on renewable energy and solar technology activities of the project investigators. This proposal will leverage current efforts by further integrating solar technology and livestock production strategies for agricultural producers.

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.

Agrivoltaics (co-location of solar and agriculture) is a relatively new idea in which agricultural systems are combined with use of solar systems to maximize land use. Some potential concurrent land uses include vegetable production and cropping systems using the same land as a solar array. The proposed project will determine emerging strategies to integrate solar technology, vegetable and livestock productions systems in the United States. Specifically, this project will provide new designs that will develop and demonstrate innovative designs for a combination solar shade for livestock during the summer. We will also evaluate potential for solar arrays to serve as field windbreaks on land. We will model and test novel use of bifacial solar systems to optimize solar energy potential. The team will utilize a portable solar array in a pasture to evaluate its potential to shade and cool cows during summer to protect cattle housed outdoors all with the objective of improving welfare of cattle. The project will involve testing these new strategies to assess results and make recommendations to farmers. The project will also evaluate the use of vegetable crops for use in solar production systems as a method of dual-land use.

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?

The team will leverage current research by testing agrivoltaic systems and provide consumers with an evaluation of solar technologies. By providing information on solar technologies to the public, we will help improve the image of solar technologies to protect and preserve the state's natural resources that will enable Minnesota to meet greenhouse gas emissions and other current and future environmental regulatory requirements. Furthermore, demonstrating concurrent use of land for solar and livestock production, farmers and consumers will not view solar production as a competitor with food production for use of limited land.

Activities and Milestones

Activity 1: Bifacial solar systems for co-location of livestock and agriculture

Activity Budget: $375,000

Activity Description:
A Bifacial solar photovoltaic system will be designed that will be located in the pasture at the WCROC. The solar system will also include battery storage for charging of equipment and for power usage for irrigation and cow cooling methods. The system would allow for battery storage to be powered from solar panels for the use of irrigation of pastures, cow cooling, and water pumping for farms. The system will allow longer term studies during the winter and summer and allow for more diverse solar technologies that will allow for cow cooling in the summer and for windbreaks during the winter. This project will provide new frameworks that will develop and model innovative structural designs for a combination solar shade for pastured livestock during the summer and windbreaks/ snow fences for cattle during winter. A pre-design analysis will describe novel use of bifacial systems to optimize solar energy potential.

Activity Milestones:

Description	Approximate Completion Date
Test bifacial solar systems to optimize solar energy potential	December 31, 2026
Install energy meters and record energy consumption data	December 31, 2026
Install photovoltaic solar in pasture and field	December 31, 2026

Activity 2: Evaluate the potential of solar systems for vegetable farming and cattle housed outdoors

Activity Budget: $275,000

Activity Description:
Solar arrays in pasture or on farmland represents an area to integrate energy production with feed production for livestock, as well as ecological restoration and the sustained conservation of valuable farmland. Our project will address plant growth potential under the same solar panels for vegetable production that will eventually be consumed by people. We will investigate and research vegetable crops (12 species) that can be grown under solar arrays. Modeling will determine land needed for solar arrays while allowing for continued vegetable production and characterize the photosynthetic potential of vegetables grown under solar arrays. We will investigate various vegetable crops to include in a solar system. Spectral analysis, soil moisture, water usage, and productivity will be determined for the solar system designs that will be evaluated. The direct and indirect effects of solar systems on micro-climatic factors and plant-soil interactions will also be modeled and tested. The team will utilize a solar array in a pasture to evaluate its potential to shade and cool cows thus improving their welfare and serve as a wind break during cold winter months to protect cattle housed outdoors.

Activity Milestones:

Description	Approximate Completion Date
Investigate various vegetable crops to include in a solar system	September 30, 2026
Complete designs of clean energy systems for field testing at the WCROC	September 30, 2026
Utilize the solar production system to evaluate long-term shade potential of cows	June 30, 2027
Evaluate economic and ecological benefits of co-locating solar installations and agriculture	June 30, 2027

Activity 3: Educate consumers, industry representatives, farmers and the general public about solar energy technologies.

Activity Budget: $28,000

Activity Description:

The most effective way to educate farmers and consumers to adopt new technologies is to demonstrate improved solar systems. The results from all activities will be used to demonstrate the potential of the co-location of the agrivoltaic system. The knowledge and information generated will be disseminated to agricultural producers, energy professionals, students, government officials, and other stakeholders through Extension websites, social media, and field days hosted at the WCROC. The WCROC also hosts a Midwest Farm Energy Conference every 2 years in Morris, Minnesota where strategic information is presented to farmers and industry representatives. This will provide information to farmers and the solar industry well beyond the period of the grant funding.

Activity Milestones:

Description	Approximate Completion Date
Submit semi-annual reports and a comprehensive final report	June 30, 2027
Conduct energy workshops and webinars and present results at conferences	June 30, 2027
Host a tour and demonstration of the site during our Midwest Farm Energy Conference	June 30, 2027

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Researcher 5 - Technician - TBD	University of Minnesota WCROC	Data collection, system testing, data collection and management	Yes
Rechearer 3 Graduate Research Assistant - TBD	University of Minnesota WCROC	Assist with all aspects of the project in data collection, monitoring and analysis.	Yes
Eric Buchanan	University of Minnesota WCROC	Eric Buchanan, WCROC Renewable Energy Scientist, will be assist in the design, installation, testing, and control strategies of the solar technologies. He will also assist with the outreach and dissemination of results.	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?

The WCROC has a strategic plan to reduce fossil energy consumption and the carbon footprint within dairy production systems. This collaborative project will build on renewable energy and solar technology activities of the project investigators. Previous funding has been received through the ENRTF fund to evaluate solar shading and grazing systems. This current project will build on past agrivoltaics work at the WCROC. This proposed project will facilitate and demonstrate the need for co-location of solar photovoltaic and agriculture. Additional long-term funding will be sought to conduct research with alternatives to fossil energy within all agricultural systems.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Utilization of Dairy Farm Wastewater for Sustainable Production	M.L. 2016, Chp. 186, Sec. 2, Subd. 07d	$475,000
Generation, Storage, and Utilization of Solar Energy	M.L. 2017, Chp. 96, Sec. 2, Subd. 07c	$500,000
Agrivoltaics To Improve The Environment And Farm Resiliency	M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 07c	$646,000

Project Manager and Organization Qualifications

Project Manager Name: Bradley Heins

Job Title: Professor

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

Dr. Heins is a Professor of Dairy Management at the University of Minnesota West Central Research and Outreach Center – Morris. He has overseen the development of the dairy program at Morris and has participated as Principal Investigator on over $25 million of research projects including grazing and pasture management, profitability of organic dairies, livestock efficiency, and renewable energy systems for dairy farms. Specifically, Dr. Heins has overseen the development of the University of Minnesota's organic dairy production system and is the Principle Investigator for numerous USDA grants that enhance dairy farm efficiency, productivity, and profitability. He has been principle investigator on three Environmental Natural Resources Trust Fund projects that have evaluated agrivoltaics and energy consumption on Minnesota dairy farms that made recommendations to farmers to reduce their environmental footprint. Dr. Heins has also trained 18 graduate students in the areas of dairy cattle management and livestock farm

efficiency. He has been an invited speaker for numerous national and international conferences and workshops on the topic of dairy cattle management. Dr. Heins serves on the Minnesota Organic Advisory Task Force. In addition to Dr. Heins, the project team include faculty with over fifty years of experience in livestock production and bioengineering research and outreach.

Organization: U of MN - WCROC

Organization Description:
The primary organization is the University of Minnesota with researchers from the WCROC and Animal Science departments. The WCROC, located near Morris, will serve as the primary project location. The WCROC is a 1,100-acre agricultural experiment station that focuses on applied research. The WCROC has several relevant program areas including dairy and renewable energy. The WCROC is ideally positioned to address critical dairy production and agricultural environmental issues. The faculty and staff have considerable experience in developing and effectively implementing applied research, outreach, and extension programs at the applied farm-level. The WCROC has nationally unique facilities and programs that compare conventional and organic crop and livestock production systems. The dairy program has the only side-by-side comparison of organic and conventional systems in the nation. In addition to agricultural production systems, the WCROC has a robust renewable energy program with farm-scale production systems. The renewable energy program features 110 kW of solar photovoltaic, solar thermal, wind energy, and algal production systems. A primary goal for the renewable energy program is to decrease fossil-fuel consumption in the agricultural sector. The project team strives to optimize energy efficiency, develop effective clean water strategies, and improve long-term profitability for producers.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Farm Animal Attendant		Farm management to assist with labor of project, i.e. fencing, moving cattle			32%	0.2		$10,000
Researcher 5		Engineering Technician to help with system design and placement and management			32%	0.4		$40,000
Researcher 3		Technician for data collection, system testing, data collection and management			32%	2		$175,000
Undergraduate Student Interns		The student interns will collect data and evaluate vegetable crops for agrivoltaics systems.			0%	0.6		$20,000
							Sub Total	**$245,000**
Contracts and Services								
Engineering firm	Professional or Technical Service Contract	Modeling, Pre-design, Design, Commissioning, and Control Optimization Engineering Professional Services				0.2		$10,000
Utility Engineering Study	Professional or Technical Service Contract	To evaluate the engineering designs of alternative and bifacial solar systems for livestock and vegetables co-location.				0.2		$5,000
Solar Development	Professional or Technical Service Contract	Installation of solar and Agrivoltaic component system				0.2		$20,000
Vegetable Sample and Analysis	Professional or Technical Service Contract	Analysis of nutritional quality for vegetables growing under photovoltaic systems.				0.6		$20,000
WCROC Horticulture	Internal services or fees (uncommon)	Support for crop testing with solar installation. This is for WCROC horticulture for services that include planting vegetable crops, and harvesting of plants and crops, as well as some seeds. This is internal to the U of MN WCROC.				0.3		$15,000
							Sub Total	**$70,000**

Equipment, Tools, and Supplies								
	Equipment	Tracking Systems	Supplies for Evaluating Bifacial Systems for Solar installations					$50,000
	Tools and Supplies	Fencing Supplies	This will require purchasing fiberglass fence posts, insulators, poly wire and additional fence energizers.					$20,000
	Tools and Supplies	Energy Meters	Meters for Dairy Facilities to Monitor Solar Installation and Agrivoltaic Voltage Systems					$5,000
	Tools and Supplies	Field, Lab, and Feed Supplies	All objectives will require supplies that include: plot markers, sample bags, laboratory reagents, assays, and other supplies. The sampling supplies include milk sample tubes, gloves, protective clothing and a freezer. Seeds for cropping system objectives will also be needed for studies.					$20,000
							Sub Total	**$95,000**
Capital Expenditures								
		Bifacial Solar System with Battery	Solar System and Foundation for Solar for Vegetable Crops and Cows and Tracking System	X				$250,000
							Sub Total	**$250,000**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Conference Registration Miles/ Meals/ Lodging	Travel	Travel, Lodging and meals for WCROC project team at Minnesota Workshops These expenses will be to participate in formal presentation of project findings at workshops and seminars within Minnesota.	X				$5,000

							Sub Total	**$5,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Printing	Extension Supplies and Printing	Printing for Extension Workshops, Field Days, and Printing					$8,000
	Publication	Peer Reviewed Publications	Publication of research in Open Access Journals					$5,000
							Sub Total	**$13,000**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$678,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Capital Expenditures		Bifacial Solar System with Battery	Captial Expenditure **Additional Explanation :** The system will be a permanent system at the WCROC and will be used throughout the life of the project and well beyond. We will continue to research novel solar systems with the project and will provide a demonstration site for educating farmers, legislators, and consumers about the benefits of solar technologies. The system would be used as leverage for other projects at the WCROC as well. The system would include battery storage for the bifacial systems.
Travel In Minnesota	Conference Registration Miles/Meals/Lodging	Travel	These expenses will be to participate in formal presentation of project findings at workshops and seminars within Minnesota. These will be for either the Project investigator or the graduate student to present on the project. We feel it is very important to attend in state conferences and workshops to disseminate the project findings throughout the project.

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
In-Kind	In-Kind services from the University of Minnesota	The foregone federally negotiated ICR funding constitutes the University of Minnesota's cost share to the project. Additionally, PI and Co-I unpaid effort. ICR is 55%	Pending	$372,900
			State Sub Total	**$372,900**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**$372,900**

Total Project Cost: $1,050,900

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 7532479a-fe6.docx

Alternate Text for Visual Component

Our concept is to evaluate the applicability, implementation, and integration of solar systems for livestock and vegetable systems. We will develop and model innovative structural designs for a combination of livestock windbreaks and shading as well as field windbreaks and use of solar on marginal lands for livestock production....

Supplemental Attachments

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

Title	File
UMN Approval Letter	b71f40f5-a01.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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?

Yes, Sponsored Projects Administration

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:

Rob Nigg, Eric Buchanan, University of Minnesota