Environment and Natural Resources Trust Fund

M.L. 2025 Approved Work Plan

General Information

ID Number: 2025-078

Staff Lead: Lisa Bigaouette

Date this document submitted to LCCMR: June 6, 2025

Project Title: Agrivoltaics 2.0 Building a Resilient E-Farm

Project Budget: $535,000

Project Manager Information

Name: Bradley Heins

Organization: U of MN - WCROC

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Project Reporting

Date Work Plan Approved by LCCMR: June 24, 2025

Reporting Schedule: March 1 / September 1 of each year.

Project Completion: June 30, 2028

Final Report Due Date: August 14, 2028

Legal Information

Legal Citation: M.L. 2025, First Special Session, Chp. 1, Art. 2, Sec. 2, Subd. 07b

Appropriation Language: $535,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota for the West Central Research and Outreach Center at Morris to evaluate emerging solar system designs and solar technology integration with vegetable and livestock production systems to maximize energy production and benefits to farmers.

Appropriation End Date: June 30, 2028

Narrative

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

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.

Project Location

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

Region(s): Central

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

Activities and Milestones

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

Activity Budget: $275,000

Activity Description:
A Bifacial solar photovoltaic system will be designed that will be located in the pasture at the WCROC. 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	June 30, 2026
Install energy meters and record energy consumption data	June 30, 2026
Install photovoltaic solar in pasture and field	June 30, 2026

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

Activity Budget: $245,000

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 and fruit production that will eventually be consumed by people. We will investigate and research vegetable crops (4 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. 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
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
Investigate various vegetable crops to include in a solar system	September 30, 2027

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

Activity Budget: $15,000

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

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.
To effectively educate and motivate livestock producers to adopt new technologies, demonstrating the profitability of incorporating solar energy into Minnesota dairy farms is crucial. The outcomes from Activities 1, 2, and 3 will serve as evidence of the potential benefits of Solar PV systems for Minnesota farms. The research and outreach center will act as a demonstration site, showcasing the opportunities solar energy presents for farms, while also creating new possibilities for over 5,000 Minnesota dairy producers to reduce their environmental footprint. These initiatives are well within the capabilities of WRCOC and the University of Minnesota. The Environment and Natural Resources Trust Fund will be acknowledged by displaying the trust fund logo on all presentations at conferences and workshops. Additionally, all printed and electronic materials will feature the logo and comply with the Acknowledgment Guidelines provided on the LCCMR website.

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

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%	0.1		$5,000
Researcher 5		Engineering Technician to help with system design and placement and management			32%	0.4		$20,000
Researcher 3		Technician for data collection, system testing, data collection and management			32%	2		$124,000
Undergraduate Student Interns		The student interns will collect data and evaluate vegetable crops for agrivoltaics systems.			0%	0.6		$20,000
							Sub Total	**$169,000**
Contracts and Services								
Utility Engineering Study	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	Service Contract	Installation of solar and Agrivoltaic component system				0.2		$20,000
Vegetable Sample and Analysis	Service Contract	Analysis of nutritional quality for vegetables growing under photovoltaic systems.				0.6		$10,000
							Sub Total	**$35,000**
Equipment, Tools, and Supplies								
	Tools and Supplies	Solar Systems	Supplies for Evaluating Bifacial Systems for Solar installations. Vertical bifacial panels collect light from both sides, but energy production can still vary a lot during the day. Alternative tracking systems could be installed to rotate the panels east to west, which will optimize exposure to sunlight as it moves. Trackers can be aligned or adjusted to Provide strategic shade					$25,000

			during the hottest part of the day, improving cattle comfort and welfare and move panels upright during milder parts of the day, reducing shade if grass growth is a priority. These are for tracking systems and panels and wiring to include for the panels for 5 at $5,000.					
	Tools and Supplies	Fencing Supplies and Cattle Chute Supplies	This will require purchasing fiberglass fence posts, insulators, poly wire and additional fence energizers.					$25,000
	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. No single unit will cost more than $5,000.					$20,000
							Sub Total	**$70,000**
Capital Expenditures								
		Bifacial Solar System with Battery	Solar System and Chute and Foundation for Solar for Vegetable Crops and Cows	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					$3,000
	Publication	Peer Reviewed Publications	Publication of research in Open Access Journals					$3,000
							Sub Total	**$6,000**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$535,000**

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. Without this would could not do the research.
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	$294,250
			State Sub Total	**$294,250**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**$294,250**

Total Project Cost: $829,250

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
2025-078 Research Addendum revised_Final	efef8be9-11f.docx

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

I have updated the work plan based on the research addendum and have make changes in the activities and milestones to reflect the changes. I have updated the budget to include justification of expenses, removed the tracking system because it should have been removed because of the budget reduction, and we have updated the budget to indicate supplies that no unit will be more than $5,000. We have also provide justification for capital expenses, as well as acknowledging everything in Services under the Budget.

Question 10: I have revised the project location that indicates that Most of the work with take place in Central Minnesota at the West Central Research and Outreach Center. However, initially I included it as statewide, because I have a statewide Extension position and will be presenting the information to many farmers and industry professionals all over Minnesota. However, I do understand the relevance of the question and have indicated that most of the work will be regional in Central Minnesota.

Question 33: I have updated the dates in the Activity and Milestones section that reflect the dates that are in the research addendum.

Question 36:
I have changed the description to Supplies and have added additional description.
Vertical bifacial panels collect light from both sides, but energy production can still vary a lot during the day. Alternative tracking systems could be installed to rotate the panels east to west, which will optimize exposure to sunlight as it moves.
Trackers can be aligned or adjusted to Provide strategic shade during the hottest part of the day, improving cattle comfort and welfare and move panels upright during milder parts of the day, reducing shade if grass growth is a priority.

Solar Systems in Budget Line (June 6, 2025)
I have added some description in the budget for the tracking systems that are 5,000 each

Additional Acknowledgements and Conditions:

The following are acknowledgements and conditions beyond those already included in the above workplan:

Do you understand and acknowledge the ENRTF repayment requirements if the use of capital equipment changes?

Yes

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?

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 project:

Rob Nigg, Eric Buchanan, 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

Yes, I understand