Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-191

Proposal Title: Agrivoltaics to Improve the Environment and Farm Resiliency

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 model and evaluate alternative solar system designs that will maximize energy production as well as provide maximal benefits to cattle and farmers .

Funds Requested: $861,000

Proposed Project Completion: 2024-06-30

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 resilient strategies to integrate solar technology and livestock 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 10-year 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? i.e. What are you seeking funding to do? You will be asked to expand on this in Activities and 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 pollinator habitats, gardens, and cropping systems using the same land as a solar array. The proposed project will determine resilient strategies to integrate solar technology and livestock productions systems in the United States. Specifically, 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 fence for cattle during winter. We will also evaluate potential for solar arrays to produce electricity and serve as field windbreaks on lands that are marginal for livestock production. We will model and test novel use of tracking systems to optimize solar energy potential. The team will utilize a solar array in a pasture to evaluate its potential to shade and cool cows during summer and serve as a wind break during cold winter months 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.

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: Design solar systems for co-location of livestock and agriculture

Activity Budget: $503,000

Activity Description:
A 75 kW solar photovoltaic system or combination of systems will be installed in a pasture or field or along marginal land at the WCROC. 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 fence for cattle during winter. We will model and test novel use of tracking systems to optimize solar energy potential while improving livestock performance and welfare. The project team will model and evaluate alternative solar system designs that will maximize energy production as well as provide maximal benefits to cattle and farmers. Through this on-farm research and demonstration at WCROC, we will identify the major barriers and challenges for farmers to co-locate solar arrays in agricultural production settings. The project will involve testing new strategies and frameworks at the WCROC to assess results and make recommendations to farmers, and then work with farmers to replicate results on private farms.

Activity Milestones:

Description	Completion Date
Install energy meters and record energy consumption data	2022-06-30
Install 75 kW photovoltaic solar in pasture, field, and outdoor lot	2022-06-30
Model and test novel use of tracking systems to optimize solar energy potential	2023-06-30
Model clean energy alternatives with projected return-on-investment	2023-06-30

Activity 2: We will evaluate the potential of solar systems for agronomic conditions and cattle housed outdoors

Activity Budget: $328,000

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 feed production that will eventually be consumed by livestock. We will investigate, model, and research forages and crops for use as feed for livestock that can be grown under solar arrays. Modeling will determine land needed for solar arrays while allowing for continued crop and forage production and characterize the photosynthetic potential of crops grown under solar arrays. We will investigate various agronomic crops to include in a solar system. Spectral analysis, soil moisture, water usage, biomass productivity, and pollinator potential 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	Completion Date
Evaluate forages and crops for use as feed for livestock under solar panels	2022-06-30
Complete designs of clean energy systems for field testing at the WCROC	2022-06-30
Investigate various agronomic crops to include in a solar system	2023-06-30
Utilize the solar production system to evaluate long-term shade potential of cows	2023-06-30

Evaluate economic and ecological benefits of co-locating solar installations and agriculture	2023-06-30

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

Activity Budget: $30,000

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. Through this project we will develop a "Best Management Practices for Integrating Solar and Agriculture on Farms" and disseminate through a dedicated web portal and University Extension. This will provide information to farmers and the solar industry well beyond the period of the grant funding.

Activity Milestones:

Description	Completion Date
Conduct energy workshops and webinars and present results at conferences	2023-06-30
Host a tour and demonstration of the site during our Midwest Farm Energy Conference	2023-06-30
Submit semi-annual reports and a comprehensive final report	2024-06-30
Prepare Extension factsheets to inform stakeholders of the solar storage technologies	2024-06-30

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Researcher 3 - Technician - TBD	University of Minnesota WCROC	Data collection, system testing, data collection and management	Yes
PhD Graduate Research Assistant - TBD	University of Minnesota WCROC	Assist with all aspects of the project in data collection, monitoring and analysis.	Yes
Lee Johnston	University of Minnesota WCROC	Dr. Lee Johnston, U of MN Swine Scientist, will be co-investigator and manage the activities and outreach within his respected specialty. Dr. Johnston has previous experience with on-farm monitoring of energy use funded by LCCMR.	No
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 be funded?

The WCROC has a 10-year 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 measure energy consumption within the WCROC dairy and test clean thermal energy systems. 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 crop and livestock enterprises.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Generation, Storage, and Utilization of Solar Energy	M.L. 2017, Chp. 96, Sec. 2, Subd. 07c	$500,000
Utilization of Dairy Farm Wastewater for Sustainable Production	M.L. 2016, Chp. 186, Sec. 2, Subd. 07d	$475,000

Project Manager and Organization Qualifications

Project Manager Name: Bradley Heins

Job Title: Associate Professor

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

Dr. Heins is an Associate 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 $2.5 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 a $1.93 million dollar UDSA grant that will enhance organic dairy farm efficiency, productivity, and profitability. He is also principle investigator on an Environmental Natural Resources Trust Fund project that is evaluating energy consumption on Minnesota dairy farms that will make recommendation to farmers to reduce their

environmental footprint. Dr. Heins has also trained 10 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								
PhD Graduate Research Assistant		Data collection, monitoring and analysis			19.9%	3		$132,416
Researcher 3		Technician for data collection, system testing, data collection and management			31.8%	3		$183,327
Researcher 5		Engineering Technician to help with system design and placement and management			31.8%	0.6		$37,691
Undergraduate Student Internships		Clean Energy Technology for MN Farms			0%	3		$20,566
Farm Animal Attendant		Farm management to assist with labor of project, i.e. fencing, moving cattle			31.8%	0.3		$12,000
							Sub Total	**$386,000**
Contracts and Services								
AKF Engineering (or equivalent firm)	Professional or Technical Service Contract	Modeling, Pre-design, Design, Commissioning, and Control Optimization Engineering Professional Services				1		$15,000
General Contractor TBD	Professional or Technical Service Contract	Installation of solar systems				1		$25,000
Utility Engineering Study	Professional or Technical Service Contract	To evaluate the engineering designs of alternative and tracking solar systems for livestock and forages co-location.				1		$10,000
Forage Sample and Analysis	Professional or Technical Service Contract	Analysis of forage and crop quality for crops and forages growing under photovoltaic systems.				3		$15,000
WCROC Agronomy	Professional or Technical	Support for forage and crop testing with solar installation				3		$15,000

	Service Contract							
							Sub Total	**$80,000**
Equipment, Tools, and Supplies								
	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
	Tools and Supplies	Energy Meters	Meters for Dairy Facilities to Monitor Solar Installation					$10,000
	Tools and Supplies	Fencing Supplies	This will require purchasing fiberglass fence posts, insulators, poly wire and additional fence energizers.					$10,000
	Equipment	Tracking Systems	Supplies for Evaluating Tracking Systems for Solar installations					$75,000
							Sub Total	**$115,000**
Capital Expenditures								
		75 kW System	75 kW System and Foundation for Solar for Crops and Cows and Tracking System					$250,000
							Sub Total	**$250,000**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Conference Registration	Travel	Travel, Lodging and meals for WCROC project team at Minnesota Workshops					$5,000

	Miles/ Meals/ Lodging							
							Sub Total	**$5,000**
Travel Outside Minnesota								
	Conference Registration Miles/ Meals/ Lodging	Travel, Lodging and meals for WCROC project team at four regional workshops	Travel, Lodging and meals for WCROC project team at four regional workshops	X				$5,000
							Sub Total	**$5,000**
Printing and Publication								
	Printing	Extension Supplies and Printing	Printing for Extension Workshops, Field Days, and Printing					$10,000
	Publication	Peer Reviewed Publications	Publication of research in Open Access Journals					$10,000
							Sub Total	**$20,000**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$861,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Travel Outside Minnesota	Conference Registration Miles/Meals/Lodging	Travel, Lodging and meals for WCROC project team at four regional workshops	Travels funds are requested to graduate students to present research at National Dairy Science Meetings or other meetings out state. The meetings will allow others to be exposed to the research from the project at the WCROC.

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	$473,550
			State Sub Total	**$473,550**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**$473,550**

Attachments

Required Attachments

Visual Component

File: 171ea860-2ee.docx

Alternate Text for Visual Component

Our concept is to evaluate the applicability, implementation, and integration of solar systems for livestock and cropping production 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. Novel use of tracking systems will also be modeled and tested to optimize solar energy potential. We will investigate forages and crops for use as feed for livestock. Modeling will determine land needed for solar arrays while allowing for continued crop and forage production and characterize the photosynthetic potential of crops grown under solar arrays. This study is the first step to convert fossil-based energy used on farms, to clean and locally produced energy.

Optional Attachments

Support Letter or Other

Title	File
UMN Authorization of Proposal	877b08bb-1c3.pdf
Financial audit for UMN for Proposal	b8385822-72d.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Does your project have patent, royalties, or revenue potential?

No

Does your project include research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Agrivoltaics to Improve the Environment and Farm Resiliency

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