Environment and Natural Resources Trust Fund

M.L. 2021 Draft Work Plan

General Information

ID Number: 2021-191

Staff Lead: Michael Varien

Date this document submitted to LCCMR: March 18, 2021

Project Title: Agrivoltaics To Improve The Environment And Farm Resiliency

Project Budget: $646,000

Project Manager Information

Name: Bradley Heins

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Project Reporting

Date Work Plan Approved by LCCMR:

Reporting Schedule: December 1 / June 1 of each year.

Project Completion: June 30, 2024

Final Report Due Date: August 14, 2024

Legal Information

Legal Citation:

Appropriation Language:

Appropriation End Date: June 30, 2024

Narrative

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 .

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.

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

Activities and Milestones

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

Activity Budget: $391,000

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. A pre-design analysis will describe novel use of tracking systems to optimize solar energy potential while improving livestock performance and welfare. 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.

Activity Milestones:

Description	Completion Date
Install energy meters and record energy consumption data	June 30, 2022
Install 75 kW photovoltaic solar in pasture and field	June 30, 2022
Model and test novel use of tracking systems to optimize solar energy potential	June 30, 2023

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

Activity Budget: $242,000

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 and research forages and crops for use as feed for livestock (12 species) 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, and biomass 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	Completion Date
Evaluate forages and crops for use as feed for livestock under solar panels	June 30, 2022
Complete designs of clean energy systems for field testing at the WCROC	June 30, 2022
Investigate various agronomic crops to include in a solar system	June 30, 2023
Utilize the solar production system to evaluate long-term shade potential of cows	June 30, 2023
Evaluate economic and ecological benefits of co-locating solar installations and agriculture	June 30, 2023

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

Activity Budget: $13,000

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	June 30, 2023
Host a tour and demonstration of the site during our Midwest Farm Energy Conference	June 30, 2023
Submit semi-annual reports and a comprehensive final report	June 30, 2024

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

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.
The most effective way to educate and motivate livestock producers to adopt new technologies is to demonstrate improved profitability with the incorporation of solar energy into Minnesota dairy farms. The results from Activity 1 ,2, and 3 will be used to demonstrate the potential of the Solar PV system for Minnesota farms. The research and outreach center will be used as the demonstration site to showcase the opportunities for solar energy for farms, as well as generate new opportunities for the 5,000+ Minnesota dairy producers to utilize a solar energy to reduce the environmental footprint of their farm. These activities are well within the capabilities of the WRCOC and the University of Minnesota. The Environment and Natural Resources Trust Fund will be acknowledged with the trust fund logo on all presentations at conferences and workshops. In any printed material or electronic media we will utilize the logo and will acknowledge the ENTRF per the Acknowledgment Guidelines posted 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 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
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

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			31.8%	0.3		$5,000
Undergraduate Student Internships		Clean Energy Technology for MN Farms			0%	0.5		$12,000
Researcher 5		Engineering Technician to help with system design and placement and management			31.8%	0.4		$20,000
Researcher 3		Technician for data collection, system testing, data collection and management			31.8%	2		$108,000
PhD Graduate Research Assistant		Data collection, monitoring and analysis			19.9%	2.5		$125,000
							Sub Total	**$270,000**
Contracts and Services								
AKF Engineering (or equivalent firm)	Professional or Technical Service Contract	Modeling, Pre-design, Design, Commissioning, and Control Optimization Engineering Professional Services				0.2		$5,000
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.				0.2		$5,000
General Contractor TBD	Professional or Technical Service Contract	Installation of solar systems				0.2		$15,000
Forage Sample and Analysis	Professional or Technical Service Contract	Analysis of forage and crop quality for crops and forages growing under photovoltaic systems.				0.6		$12,000
WCROC Agronomy	Internal services or	Support for forage and crop testing with solar installation. This is for WCROC agronomy for services that include planting forages and crops, and				0.3		$7,000

	fees (uncommon)	harvesting of plants and crops, as well as some seeds. This is internal to the U of MN WCROC.						
							Sub Total	**$44,000**
Equipment, Tools, and Supplies								
	Equipment	Tracking Systems	Supplies for Evaluating Tracking 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.					$4,000
	Tools and Supplies	Energy Meters	Meters for Dairy Facilities to Monitor Solar Installation					$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.					$10,000
							Sub Total	**$69,000**
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 These expenses will be to participate	X				$5,000

	Miles/ Meals/ Lodging		in formal presentation of project findings at workshops and seminars within Minnesota.					
							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					$5,000
	Publication	Peer Reviewed Publications	Publication of research in Open Access Journals					$3,000
							Sub Total	**$8,000**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$646,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
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	$355,300
			State Sub Total	**$355,300**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**$355,300**

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 ...

Optional Attachments

Support Letter or Other

Title	File
UMN Authorization of Proposal	877b08bb-1c3.pdf
Financial audit for UMN for Proposal	b8385822-72d.pdf
Solar Plans	2607834d-178.pdf
Research Addendum - Brad Heins	bd8324ce-dc2.docx

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

We have reduced the budget and reduced scope of the project. The main main objectives of the project are still in place, we have removed some of the detailed information that we were planning on doing to reduce the scope because of the budget reduction. Thank you for the comments on the budget and narrative. Also, thank you for helping with the research addendum. We have updated the workplan based on suggestions and have uploaded the documents in the attachment section. We have also changed the budget and clarified as suggested.

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 agree travel expenses must 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 agree to the UMN Policy.

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

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

Agrivoltaics to Improve the Environment and Farm Resiliency

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.