Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-474

Proposal Title: FIELDS: Farms Integrating Energy, Land, and Dairy Sustainability

Project Manager Information

Name: Uwe Kortshagen

Organization: U of MN - College of Science and Engineering

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Project Basic Information

Project Summary: FIELDS evaluates innovative management practices on agricultural lands to provide long-term environmental benefits while ensuring economic viability for Minnesota farmers through integrating agrivoltaic energy production.

ENRTF Funds Requested: $1,408,000

Proposed Project Completion: June 30, 2030

LCCMR Funding Category: Land (F)

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's statutory goals for carbon-free electricity by 2040 necessitate the rapid development of several gigawatts of utility-scale solar energy, a land-intensive process that increasingly competes with our state's most valuable agricultural assets. This surge in demand for land-use creates mounting tensions between long-term agricultural productivity and rural economic stability against traditional solar development.

Rural communities grapple with the prospect of relinquishing prime agricultural land due to adverse effects such as reduced land availability for farming and diminished local revenues from agricultural operations. In the past, many projects have proceeded without addressing these multifaceted concerns, which has led to permanent loss or degradation of prime agricultural soils. This has prompted community backlash and even moratoria on future solar ventures in some Minnesota counties.

Failure to mitigate these issues risks compromising the sustained conservation of valuable farmland while impeding Minnesota's energy independence. Given the rapidly increasing needs of electrical power, now is the opportune time to reconcile these competing interests through strategic land-use optimization. This ensures developments that co-maximize energy production with tangible economic benefits for local communities while protecting and enhancing Minnesota's vital agricultural lands.

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.

The proposed FIELDS (Farms Integrating Energy, Land, and Dairy Sustainability) project aims to protect Minnesota's agricultural lands while enabling an energy future built for maximum sustainability and rural economic benefit. FIELDS will demonstrate the advantages of an innovative new practice—agrivoltaics, the integration of agricultural production with solar energy generation on the same land—as a tool for preserving and improving agricultural land.

Rather than forcing choices between food and power, agrivoltaic systems can synergistically enhance energy generation and agricultural yields. For Minnesota farmers, this represents a vital opportunity to diversify income and reduce economic risk. Furthermore, this approach provides a critical tool for agricultural resilience, as research indicates that the partial shading provided by agrivoltaics can improve soil water retention and protect crops, agricultural workers, and livestock from extreme heat stress.

FIELDS addresses the technical and economic compatibility of energy systems with Minnesota's primary agricultural drivers: specialty vegetables, large-scale row crops (corn, soybeans, and small grains), and dairy grazing. It will ensure that energy developments align with the needs and values of Minnesota's agricultural communities.

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?

- Scientific Assessment of Best Practices: Science-based guidance for vegetable growth, row-crop feed production, and dairy grazing specifically optimized for Minnesota's climate.
- Assessment of improved soil water retention and crop health.
- Enhancing Public Acceptance: Demonstrating the viability of integrated systems will reduce land competition and remove barriers to a sustainable energy future.
- Economic Opportunity Assessment: County-level modeling will quantify economic impacts of agrivoltaics, providing local decision-makers with science-based data on the statewide benefits of integrated land-use practices.
- Implementing Research Results: Curated website repository and stakeholder outreach will provide science-based strategies for solar developers and farmers to adopt agrivoltaic practices.

Activities and Milestones

Activity 1: Optimizing Land Use for High-Value Agrivoltaic Vegetable Production

Activity Budget: $447,936

Activity Description:
This activity, the first of three cornerstones of the FIELDS project's field research, will establish best practices for land-use optimization of utility-scale solar farms. In a collaboration with US Solar, a Minnesota-based developer, UMN Twin Cities (UMN-TC) researchers will demonstrate how integrating specialty vegetable production within utility-scale energy projects can ensure that prime Minnesota soil remains a productive, revenue-generating asset while diversifying farm income.

Research will be conducted at the Big Lake LLC 1 solar farm in collaboration with the National Laboratory of the Rockies (NLR). Utilizing scientific instruments, the team will measure the microclimatic benefits of agrivoltaic systems, including soil moisture retention and heat stress mitigation. These data are critical for building agricultural resilience in a warming climate, showing that partial shading can be a valuable asset for protecting crops such as lettuce, kale, tomatoes, and peppers from extreme weather volatility, while improving the long-term health of agricultural soils.

By quantifying biomass production and yield, this activity provides market-oriented data for landowners and local decision-makers to co-maximize energy and food production. This ensures future energy developments are fully compatible with Minnesota's agricultural heritage, keeping revenue streams within local rural communities while fostering energy independence.

Activity Milestones:

Description	Approximate Completion Date
Site preparation for plant growth studies	March 31, 2028
Replication 1 of plant growth studies for various target crops	December 31, 2028
Replication 2 of plant growth studies for various target crops	December 31, 2029
Data analysis and reporting of findings, development of guidance for agrivoltaics on Minnesota solar farms	June 30, 2030

Activity 2: Integrating Energy Production and Minnesota Row-Crop Commodities

Activity Budget: $196,075

Activity Description:
This activity will explore whether utility-scale energy production can be successfully integrated with Minnesota's primary agricultural commodities. This is to ensure that solar development does not compete with agriculture but instead serves as a tool for the sustained conservation of valuable farmland and the diversification of rural revenue streams.

Research, to be performed at the West Central Research and Outreach Center (WCROC) in Morris, will focus on the technical compatibility of solar arrays with six core Minnesota species used for livestock feed: corn, soybeans, oats, wheat, barley, and alfalfa. By characterizing the photosynthetic potential and biomass productivity of these crops under panels, we will develop market-based models that will allow farmers to maintain their agricultural production while securing energy independence.

Furthermore, this research provides a vital resilience strategy for a warming climate. The team will test in field experiments and model the synergistic effects of solar shading on soil-plant interactions, specifically by measuring soil

moisture retention and water-use efficiency. This technical data will be essential for protecting Minnesota's row-crop yields from extreme heat and weather volatility, ensuring the long-term economic viability of our state's agricultural landscape.

Activity Milestones:

Description	Approximate Completion Date
Site preparation for Crop growth studies	May 31, 2028
Replication 1 of plant growth studies for agronomic crops	December 31, 2028
Replication 2 of plant growth studies for agronomic crops	December 31, 2029
Data analysis and reporting of findings, development of guidance for agrivoltaics on Minnesota solar farms	June 30, 2030

Activity 3: Evaluate Dairy Grazing Compatibility with Agrivoltaic Solar Arrays

Activity Budget: $193,574

Activity Description:
Dairy grazing presents a significant opportunity for strategic land-use optimization and diversifying farm income, an area where the WCROC has conducted extensive research. At WCROC's dairy farm, a single row of tracking solar panels has been installed in a cow pasture to demonstrate the technical compatibility of energy production with livestock operations.

To protect agricultural assets, panels are mounted higher than usual, and we will test preventive measures—such as rub bars and moving electric fence wires—to prevent panel damage and ensure equipment longevity. Crucially, this research provides a vital resilience strategy for a warming climate by evaluating the animal-welfare benefits of solar shading for cow behavior and heat-stress mitigation.

Management strategies, including limiting extreme tilt angles and coordinating milking times, will be explored to optimize energy output while maintaining full agricultural productivity. This work aims to develop a best practices manual that empowers Minnesota dairy producers to achieve energy independence and rural economic stability without compromising their traditional dairy operations.

Activity Milestones:

Description	Approximate Completion Date
Install panel protective measures	June 30, 2028
Evaluate cow/panel interactions and test preventative methods	December 31, 2029
Create Solar Dairy Best Practices Manual and final report	June 30, 2030

Activity 4: Economic Opportunity Modeling and Rural Revenue Stability Assessment

Activity Budget: $421,167

Activity Description:
To assess the economic opportunities to Minnesota's agricultural communities, the team will develop a market-based modeling framework to quantify the combined net income from electricity and agricultural production on utility-scale integrated farms. The activity directly addresses priority F.1 to account for economic considerations when evaluating new land management practices.

The team will utilize an existing modeling framework developed by the UMN-TC researchers that integrates photovoltaic electricity generation with crop growth and soil water balance models to capture improved water retention and yield resilience under panels. This model will be calibrated with data from Activities 1–3 to address the full range of Minnesota's core commodities. Model outputs will provide required physical inputs, agricultural outputs, and energy outputs for various agrivoltaic panel configurations over corn, soybeans, oats, wheat, barley, alfalfa, and livestock systems. Additional data on variable labor requirements and fixed labor installation and capital requirements will be gathered during field trials. For each agrivoltaic system, a range of likely county prices will be utilized in Monte Carlo simulations to produce a distribution of likely net profits. The change in county-wide economic benefits for a utility-scale agrivoltaic solar farm will be assessed.

Activity Milestones:

Description	Approximate Completion Date
Calibrate modeling framework with initial FIELDS field data	December 31, 2028
Complete county-scale input-output model and initial profit simulations	June 30, 2029
Finalize state-wide, county-level assessment of sustainability and income tradeoffs	December 31, 2029
Complete final Economic Opportunity Report and tech-transfer guidance	June 30, 2030

Activity 5: Web Repository and Stakeholder Outreach

Activity Budget: $149,248

Activity Description:
To make Minnesota-specific guidance readily available, a web-based repository will be created and shared by the Clean Energy Resource Teams (CERTs) and University of Minnesota Extension's Regional Sustainable Development Partnerships (RSDP). Content curation will be guided by an advisory group with agricultural and energy stakeholders, researchers, program managers, and technical assistance providers.

A strong focus will be on providing accessible on-ramps to agrivoltaics implementation: human-centered storytelling will introduce foundational concepts of agrivoltaics and inspire interest; a webpage, factsheets, and other plain-language materials will provide the next level of detail to those interested in learning more; and the webpage will provide ready access to the repository of scientifically sound technical resources for those who want to gain the comprehensive knowledge needed for implementation.

Resource dissemination strategies will make use of collaborators' extensive existing partnerships with organizations trusted by stakeholders, as well as identify potential new partnerships. These strategies include dissemination through partner communications, media engagement, hosting virtual and in-person events like webinars and tours, and speaking engagements and tabling at relevant events like FarmFest. Agrivoltaics information will also be integrated into collaborators' ongoing engagement with and direct technical assistance to agricultural producers and other stakeholders, broadening reach and deepening impact.

Activity Milestones:

Description	Approximate Completion Date
Ongoing website maintenance agreement established	December 31, 2027
Stakeholder advisory group established to guide curation of technical resources	December 31, 2027
Repository web page launched with curated technical resources	December 31, 2028
Plain language outreach resources developed based on curated technical resources	June 30, 2029
Minnesota-specific guidance developed in Activities 1-4 incorporated into web repository	June 30, 2030

Outreach conducted to stakeholders and technical assistance providers in the agricultural and energy sectors	June 30, 2030

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Vivian E. Ferry	University of Minnesota - Twin Cities	Vivian Ferry is an Associate Professor in the Department of Chemical Engineering and Materials Science at the University of Minnesota. She is an expert in innovative photonic concepts. She has experience in modeling outdoor photovoltaic technologies and plant growth in greenhouse and outdoor environments.	Yes
Nathan Eylands	University of Minnesota - College of Food, Agriculture, and Natural Resource Sciences	Nathan Eylands is an Assistant Professor in the Department of Horticulture. Professor Eylands is an expert on agrivoltaic systems with experience in specialty vegetable growth on commercial solar farms.	Yes
Bradley Heins	University of Minnesota - West Central Research and Outreach Center in Morris	Bradley Heins is a Professor of Organic Dairy Management in the Department of Animal Science at the University of Minnesota's West Central Research and Outreach Center in Morris. He has worked extensively on agrivoltaics and lifestock grazing and is the project director of a USDA-funded organic dairy research grant.	Yes
Nathan Springer	University of Minnesota - Institute on the Environment	Dr. Nathaniel Springer is a Research Scientist in Economics and Sustainability working at the intersection of input-output economics, industrial ecology, and sustainable finance. He specializes in the creation and application of economic and supply network models to assess the sustainability of alternative technical, policy, and investment decisions.	Yes
Aaron Hansen	University of Minnesota - Institute on the Environment	Mr. Hanson is an energy programs specialist at the Institute on the Environment. He has been involved in multiple agrivoltaics projects and will serve as technical advisor and coordinator for center outreach efforts.	Yes
Melissa Birch	Clean Energy Resource Teams	Dr. Birch co-directs the Clean Energy Resource Teams (CERTs). With staff based around the state, CERTs will serve as a two-way conduit for sharing research results and gathering community input through events, direct outreach and assistance, and strategic communications, including community engagement, developing accessible tools and guides, and media placement.	Yes
Shaylyn Bernhardt	Clean Energy Resources Team	Ms. Bernhardt is the CERTs communications manager. Her work will be on executing CERTs' mission to achieve achieve communications, engagement and outreach goals of this project.	Yes
Anna Peterson	Clean Energy Resources Team	Ms. Peterson is the Northwest CERT Coordinator and focused on non-residential renewable energy across Minnesota.	Yes
Jennifer Lindahl	Clean Energy Resources Team	Ms. Lindahl is the Southeast CERTs coordinator.	Yes
Peter Schmitt	US Solar	Peter Schmitt is a Director of Project Development focusing on US Solar's grid-scale developments across the country, ranging from 50-300+ MW each. He also spearheads the company's vegetation innovations, including the advancement of pollinator seed mixes, experimental crops, beehives, and the introduction of sheep to sites.	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.
The FIELDS project will feature a multitude of dissemination efforts to ensure research findings reach stakeholders who can benefit from the studied land-use optimizations. Through Activity 5, we will establish a centralized FIELDS Website Repository to host technical data, best-practice manuals, and economic reports. Our outreach strategy, in collaboration with CERTs and RSDP, includes annual conferences and rural workshops to facilitate knowledge transfer among farmers, utilities, and local governments.

Scientific rigor will be maintained through peer-reviewed publications for Activities 1-4, ensuring the long-term technical impact and longevity of the research products. To promote behavioral changes that protect and enhance Minnesota's resources, results will be shared through accessible media and presentations to groups like the MN Fruit and Vegetable Growers' Association.

In compliance with LCCMR requirements, all project signage, publications, and electronic media will prominently feature the ENRTF logo and attribution, acknowledging the Trust Fund's support in securing Minnesota's energy resilience and agricultural future. This multifaceted dissemination plan will ensure that the work is transparent, accessible, and directly improves the management of Minnesota's natural resources.

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 FIELDS project secures Minnesota's long-term agricultural stability and energy future. Results will be disseminated through a centralized website repository and stakeholder outreach, providing evidence-based strategies for land-use optimization and diversified income. We anticipate significant interest from state and federal agencies and the energy industry. The team will pursue future research funding from the U.S. Department of Agriculture, the National Science Foundation, and the Minnesota Department of Agriculture. Research infrastructure will foster collaborations with utilities and developers to ensure energy production remains compatible with Minnesota's agricultural heritage.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Environment-Friendly Decarbonizing of Steel Production with Hydrogen Plasma	M.L. 2023, , Chp. 60, Art. 2, Sec. 2, Subd. 07e	$739,000

Project Manager and Organization Qualifications

Project Manager Name: Uwe Kortshagen

Job Title: Professor, Mechanical Engineering; Member, National Academy of Engineering

Provide description of the project manager's qualifications to manage the proposed project.
Uwe Kortshagen is a Professor of Mechanical Engineering at the University of Minnesota-Twin Cities and a Member of the National Academy of Engineering, one of the highest professional honors accorded to an engineer. He holds the Ronald L. and Janet A. Christenson Chair in Renewable Energy and has published over 250 scientific articles.

Demonstrating his commitment to market-oriented economic impacts, Professor Kortshagen holds four patents licensed to five industrial partners, which have generated over $1M in royalty income and launched two start−up companies. He has extensive fiscal and administrative experience, having served for ten years as Head of the Department of Mechanical Engineering, where he managed an annual ~$10M budget and led over 80 faculty and staff. His leadership of major interdisciplinary groups funded by the National Science Foundation and the Army Research Office ensures he can execute complex, multi-stakeholder projects that provide tangible benefits to Minnesota's environment and economy.

Organization: U of MN - College of Science and Engineering

Organization Description:
The University of Minnesota–Twin Cities is the state's flagship research institution, with annual research expenditures of ~$1.4B in 2024, providing the scientific and fiscal capacity to lead high-impact state initiatives. Faculty in the College of Science and Engineering bring decades of expertise in protecting Minnesota's natural resources and developing strategies for the state's energy resilience. Through synergistic collaborations with the College of Food, Agricultural, and Natural Resource Sciences (CFANS), this expertise has expanded into the frontier of agrivoltaics to achieve strategic land-use optimization that protects and enhances Minnesota's agricultural lands and productivity.

The West Central Research and Outreach Center (WCROC), part of CFANS, has partnered with Minnesota farmers for over a century. WCROC delivers excellence in applied agricultural research, focusing on market-based strategies that diversify farm income and secure the long-term economic sovereignty of rural communities. This interdisciplinary framework keeps the FIELDS project directly aligned with Minnesota's agricultural heritage.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Professor Uwe Kortshagen		Project Manager (UMN-TC)			27.8%	0.12		$59,330
Professor Vivian Ferry		Senior Investigator			27.8%	0.12		$32,661
Professor Nathan Eylands		Senior Investigator			27.8%	0.12		$30,086
Professor Nathan Eylands		Senior Investigator			27.8%	0.12		$22,508
Dr. Nathaniel Springer		Senior Investigator			27.8%	0.24		$37,613
Aaron Hanson		Outrech coordinator			27.8%	0.12		$12,920
Dr. Melissa Birch		CERTs co-director, outreach			27.8%	0.09		$11,100
Jennifer Lindahl		CERTs coordinator, outreach			27.8%	0.48		$43,306
Anna Peterson		CERTs coordinator, outreach			27.8%	0.48		$42,034
Shaylyn Bernhardt		CERTs communications director			27.8%	0.15		$20,488
Graduate Research Assistant, Horticulure		Researcher			45.7%	1.5		$202,780
Graduate Research Assistant, Animal Science		Researcher			47.6%	1.5		$186,097
Graduate Research Assistant,		Researcher			43.7%	1.5		$220,986

Chemical Engineering and Materials Science								
Post-doctoral associate, Institute on the Environment		Researcher			21.9%	1		$83,342
Summer Interns		Research assistants			0%	3		$105,000
							Sub Total	**$1,110,251**
Contracts and Services								
Contract Farmer	Service Contract	Site maintenance and farming work at Big Lake solar farm				1.02		$105,000
Crop Analysis	Internal services or fees (uncommon)	Laboratory work to characterize crop parameters				0.06		$15,000
Field prepration	Internal services or fees (uncommon)	Field preparation for activity 2				0.04		$5,000
General services, shipping	Internal services or fees (uncommon)	Shipping of materials and supplies				0.03		$1,500
							Sub Total	**$126,500**
Equipment, Tools, and Supplies								
	Equipment	Instrumentation to monitor solar radiation and soil parameters for 3 research sites: Pyranometers, weather station, soil moisture monitors, spectrophotometers	These instruments will be used to monitor and log data on environmental conditions (irradiation, soil and air temperature) and soil parameters (temperature, moisture at different soil depths).					$40,000

	Tools and Supplies	Materials and supplies for 3 field test sites and 3 years	This includes materials such as seeds, seedlings, farming supplies, etc.					$74,249
							Sub Total	**$114,249**
Capital Equipment								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Travel between/to research sites	mileage reimbursement for researchers, e.g., travel Twin Cities to Big Lake site throughout growing season.					$15,000
	Conference Registration Miles/ Meals/ Lodging	Three attendances at meetings/conferences/ workshops	Dissemination of project results					$19,500
							Sub Total	**$34,500**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	Website	Publish and maintain web page					$5,000
							Sub Total	**$5,000**
Other Expenses								
		Field day	Expenses for field days to highlight activities to stakeholders as part of outreach					$7,500
		Economic software license	Implan economic software					$10,000

							Sub Total	**$17,500**
							Grand Total	**$1,408,000**

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: $1,408,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 81f799b6-a97.pdf

Alternate Text for Visual Component

The image illustrates the different activities of the FIELDS (Farms Integrating Energy, Land, and Dairy Sustainability) project across its project sites: vegetable growth at the US Solar farm in Big Lake, and grazing and commodity row crops (shown at Rauenhorst Farm, Olivia, MN) at the West-Central Research and Outreach Center....

Supplemental Attachments

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

Title	File
Letter of support and commitment by US Solar	47dc50b8-181.pdf
Sponsored Research Administration endorsement letter	a53c1a8d-e51.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?

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:

Bradley Heins, West-Central Research and Outreach Center; Aaron Hansen, Nathan Eylands, Vivian Ferry, Nathaniel Springer, UMN-TC; Melissa Birch, CERTS.

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