

**Environment and Natural Resources Trust Fund  
2019 Request for Proposals (RFP)**

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**Project Title:**

**ENRTF ID: 182-E**

Optimization of a Net-Zero Dairy System

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**Category:** E. Air Quality, Climate Change, and Renewable Energy

**Sub-Category:**

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**Total Project Budget: \$** 876,706

**Proposed Project Time Period for the Funding Requested:** June 30, 2022 (3 yrs)

**Summary:**

This project will develop and optimize energy efficient lighting and thermal energy storage systems at the WCROC in Morris, MN.

**Name:** Bradley Heins

**Sponsoring Organization:** U of MN

**Title:** Associate Professor

**Department:** West Central Research and Outreach Center

**Address:** 46352 State Hwy 329  
Morris MN 56267

**Telephone Number:** (320) 589-1711

**Email** hein0106@umn.edu

**Web Address** https://wcroc.cfans.umn.edu/

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**Location**

**Region:** Statewide

**County Name:** Statewide

**City / Township:**

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**Alternate Text for Visual:**

Thermal energy will be collected via heat pump from fresh milk and moved to an insulated thermal storage tank.

<input type="checkbox"/>	Funding Priorities	<input type="checkbox"/>	Multiple Benefits	<input type="checkbox"/>	Outcomes	<input type="checkbox"/>	Knowledge Base	
<input type="checkbox"/>	Extent of Impact	<input type="checkbox"/>	Innovation	<input type="checkbox"/>	Scientific/Tech Basis	<input type="checkbox"/>	Urgency	
<input type="checkbox"/>	Capacity Readiness	<input type="checkbox"/>	Leverage	<input type="checkbox"/>		TOTAL	<input type="checkbox"/>	%
<input type="checkbox"/> If under \$200,000, waive presentation?								



**PROJECT TITLE: Optimization of a Net-Zero Dairy System**

**I. PROJECT STATEMENT**

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 the agricultural industry. This proposal will leverage current efforts by further developing thermal energy storage and utilization strategies, as well as energy efficient lighting for Minnesota. The agricultural industry consumes an immense amount of fossil-fuel in the production of food, feed, fiber, and energy. From the electricity that cools milk, to the fuel that is burned in combines and tractors in grain fields, to the trucks that bring goods to market, and to the nitrogen fertilizer that nourishes plants; the agricultural industry is captive to large and constant supplies of a wide range of fossil energy. Agriculture’s dependence and thirst for fossil-fuel carries significant economic, environmental, and social risks for the nation and world. The overall objective of our project is to integrate renewable technologies into dairy production systems to provide enough energy to make the milking parlor “Net-Zero”. The project team proposes to evaluate applicability and implementation of thermal storage systems, as well as improving energy efficient lighting systems that will improve energy systems on dairy farms around Minnesota. The team will leverage current research by testing thermal energy storage and lighting systems and provide farmers and consumers with an evaluation of renewable energy systems for livestock facilities. The knowledge and information generated will be disseminated to agricultural producers, energy professionals, students, and other stakeholders through Extension websites, social media, and field days hosted at the WCROC. The WCROC dairy milks about 250 cows twice daily and is representative of a mid-size Minnesota dairy farm. The WCROC dairy provides an ideal testing opportunity to evaluate and demonstrate the effect of on-site renewable energy generation and improving greenhouse gas emissions.

**II. PROJECT ACTIVITIES AND OUTCOMES**

**Activity 1: Optimize thermal energy systems for dairy facilities.**

Thermal storage systems offer the advantage that heat from other sources like solar thermal collectors and a manure lagoon can also be collected and used by the dairy. The proposed project would improve dairy parlor heating using the existing heat pump system and add a series of loops using plastic tubing to the bottom of the manure lagoon behind the milking parlor. The loops are similar to what would be typically buried in the ground for a ground source heat pump. The advantage is that no excavation is needed and the manure lagoon is generally warmer than the ground due the daily influx of waste water from the dairy. This arrangement will allow the heat pump to store hot water at any time of day – not just while milking – creating an efficient way to store electricity in the form of hot water. This kind of system could also be applicable to other industries with a steady electric and hot water load like laundry mats, hotels, fitness centers, etc.

**ENRTF BUDGET: \$550,853**

<b>Outcome</b>	<b>Completion Date</b>
<i>1. Complete designs of thermal energy systems for field testing at the WCROC</i>	<i>12/1/2019</i>
<i>2. Install lagoon tubing and parlor ducting for efficient thermal systems at the WCROC dairy.</i>	<i>7/1/2020</i>
<i>3. Evaluate the environmental impact of the thermal energy storage systems.</i>	<i>7/1/2021</i>
<i>4. Model thermal energy alternatives with projected return-on-investment</i>	<i>7/1/2021</i>

**Activity 2: Design and evaluate energy efficient lighting systems for dairy facilities.**

We will design and evaluate energy efficient lighting systems to be installed and tested for powering dairy farms. The lighting systems will be tested for two years for production and reliability.



**Environment and Natural Resources Trust Fund (ENRTF)  
2019 Main Proposal**

**ENRTF BUDGET: \$296,353**

<b>Outcome</b>	<b>Completion Date</b>
1. <i>Install energy efficient lighting systems at the dairy at the research center</i>	7/1/2020
2. <i>Install energy meters and record energy consumption data for one year</i>	7/1/2020
3. <i>Model lighting energy alternatives with projected return-on-investment</i>	7/1/2020

**Activity 3: Educate consumers, industry representatives, dairy producers and the general public about technology to generate, store, and utilize thermal energy and lighting technologies.**

The most effective way to educate livestock producers and consumers to adopt new technologies is to demonstrate improved thermal energy storage systems and efficient lighting systems. The results from all activities will be used to demonstrate the potential of the renewable energy storage systems. The research and outreach center will be used as the demonstration site to educate all of Minnesota about renewable energy technologies.

**ENRTF BUDGET: \$29,500**

<b>Outcome</b>	<b>Completion Date</b>
1. <i>Host a tour and demonstration of the site and storage facility during our Midwest Farm Energy Conference at the WCROC.</i>	5/30/2020
2. <i>Conduct energy workshops across the State.</i>	6/30/2022
3. <i>Prepare Extension factsheets to inform stakeholders of the optimization technologies.</i>	6/30/2022

**III. PROJECT PARTNERS:**

**A. Partners receiving ENRTF funding**

<b>Name</b>	<b>Title</b>	<b>Affiliation</b>	<b>Role</b>
Dr. Bradley Heins	Associate Professor	University of Minnesota	Project Manager
Michael Reese	Renewable Energy Director	University of Minnesota	Manage energy activities
Dr. Lee Johnston	Professor	University of Minnesota	Outreach activities
Eric Buchanan	Renewable Energy Scientist	University of Minnesota	Project coordinator
AKF Engineering			Consulting services

**IV. LONG-TERM-IMPLEMENTATION AND FUNDING:** 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 activities of the project investigators. Previous funding has been received through the U of MN Initiative for Renewable Energy and the Environment, Xcel Energy RDF, and Environment and Natural Resources Trust Fund to measure energy consumption within the WCROC dairy and partnering dairy farms. This proposed project will facilitate and demonstrate the need for thermal energy storage and lighting systems in an agricultural setting. Additional long-term funding will be sought to conduct research with alternatives to fossil energy within all agricultural crop and livestock enterprises.

**V. TIME LINE REQUIREMENTS:**

This project is proposed for 3 years beginning July 1, 2019 and ending June 30, 2022. This time frame will allow for adequate opportunity for research, data collection, education efforts, and peer-review of the information by the members of the team, industry professionals and consultants, and dairy producers. Research and outreach information will be disseminated after the data are collected, analyzed, and summarized.

## 2019 Proposal Budget Spreadsheet

**Project Title: Optimization of a Net-Zero Dairy System**

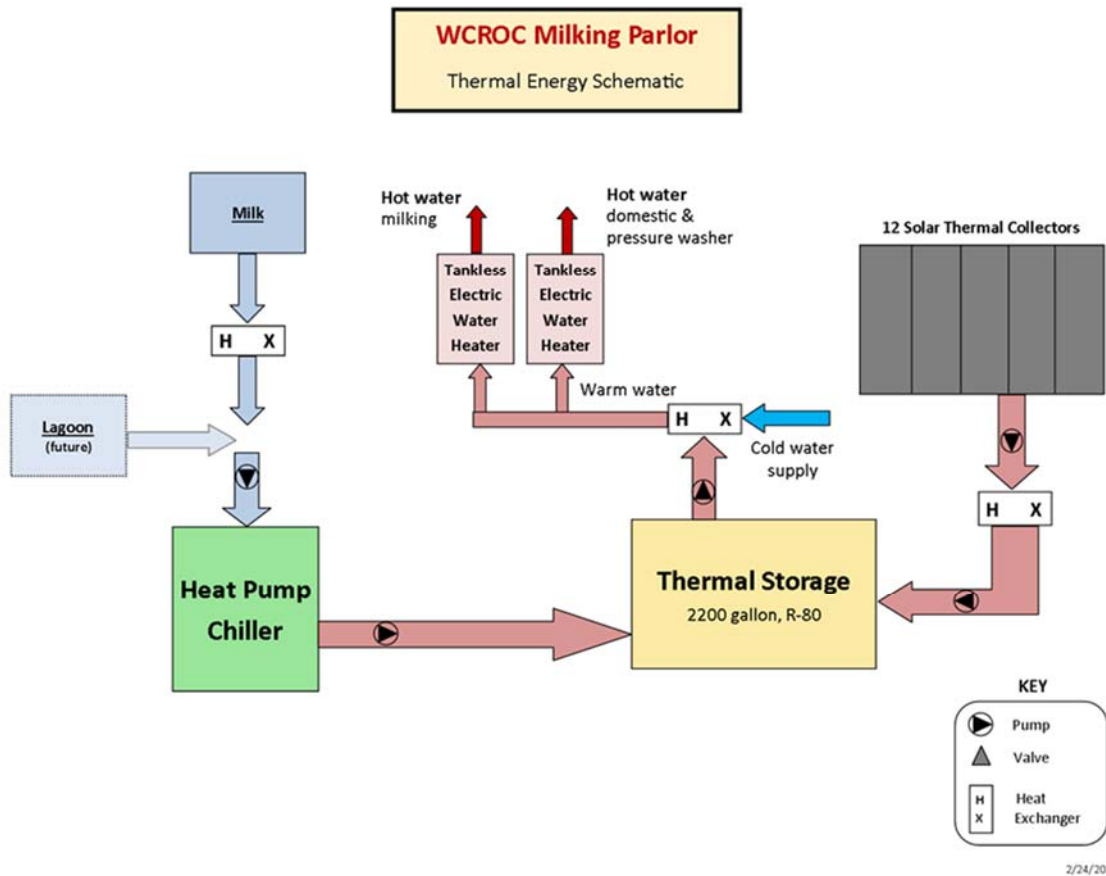
### IV. TOTAL ENRTF REQUEST BUDGET: 3 years

BUDGET ITEM (See "Guidance on Allowable Expenses")	AMOUNT
<b>Personnel:</b>	\$ 486,706
Bradley Heins, PI/PD, 1 month/year, including 33.5% benefits, leading and managing project,	\$25,000
PhD Graduate Research Assistant, data collection, monitoring and analysis, 50% FTE for 3 years, the	\$122,706
Research Scientist - System testing (50% FTE - 3 Yrs), 33.5% fringe rate	\$150,000
Research Scientist - Technician for data collection and monitoring (100% FTE - 3 Yrs)	\$171,000
<b>Undergrad Student Interns - Optimization of Milk Parlor Systems (3 Yrs)</b>	\$18,000
<b>Professional/Technical/Service Contracts:</b>	\$ 255,000
AKF Engineering (or equivalent firm) - Modeling, Pre-design, Design, Commissioning, and Control	\$40,000
Daikin Systems for Manure lagoon supplies for energy capture	\$200,000
Mechanical Contractor TBD - Installation of optimization and lighting systems	\$15,000
<b>Equipment/Tools/Supplies:</b>	\$ 95,000
Energy Meters for Dairy Facilities	\$20,000
Energy Efficiency Supplies and for lagoon and lighting systems	\$30,000
Energy Efficiency Lighting Systems for Dairy Parlor	\$30,000
Data Loggers for Dairy Facilities	\$15,000
<b>Travel:</b>	\$ 21,000
Lease of University of 100% electric vehicle. \$600/month X 24 months	\$15,000
Travel, Lodging and meals for WCROC project team at four Minnesota workshops to present results	\$6,000
<b>Additional Budget Items:</b>	\$ 19,000
UMN Midwest Farm Energy Conference 2020: This is the title of our Extension conference that we hold every 2 years at the WCROC in Morris, MN to showcase and demonstrate our renewable energy projects to industry professionals, farmers, and consumers. For this outreach event that we plan and conduct expenses are for travel expenses for speakers, brochures for the conference, printing of conference materials, and recording of presentations for posting on the WCROC website.	\$10,000
Publications of research in Open Access Journals: 5 publications	\$9,000
<b>TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND \$ REQUEST =</b>	<b>\$ 876,706</b>

### V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
<b>Other Non-State \$ To Be Applied To Project During Project Period:</b> The foregone federally negotiated ICR funding constitutes the University of Minnesota's cost share to the project. Additionally Co-Investigator unpaid effort.	\$ 455,887	<i>Pending</i>
<b>Other State \$ To Be Applied To Project During Project Period: NA</b>	NA	NA
<b>In-kind Services To Be Applied To Project During Project Period: T</b>	NA	NA
<b>Past and Current ENRTF Appropriation:</b> M.L. 2016, Chp. 186, Sec. 2, Subd. 07d, Titled: Utilization of farm wastewater for sustainable dairy production (\$183,882); M.L. 2017, Chp. 96, Sec. 2, Subd. 07c, Titled: Generation, Storage, and Utilization of Solar Energy (\$160,224)	\$ 344,106	Unspent
<b>Other Funding History:</b> Funding was provided by the U of MN Initiative for Renewable Energy and the Environment (IREE) and the College of Food, Agricultural, and Natural Resource Sciences. The original IREE source of the funding was through Xcel Energy customers through MN Dept. of Commerce. Xcel Energy RDF has also provided funding for research at the WCROC dairy. This proposal leverages past and current work implementing clean energy technologies, life cycle, and economic analysis of energy-optimized crop and dairy production systems.	\$ 1,350,000	<i>Secured</i>

## Optimization of a Net-Zero Dairy System



The project team has received past funding from the U of MN Initiative for Renewable Energy and the Environment to install and test the clean thermal energy systems and energy storage. The following schematic shows how the new thermal energy systems are expected to interact. Thermal energy will be collected via heat pump from fresh milk and moved to an insulated thermal storage tank. This will also result in milk reaching the bulk tank already at the desired storage temperature greatly reducing the load on the bulk tank refrigeration systems since they will now only have to maintain milk temperature until the tank is emptied – no more than two days. Thermal energy in the storage tank will then be used to preheat well water before being brought to final temperature by an instant (tankless) electric water heater. The project team will utilize Minnesota manufacturers for all the systems.

**Environmental and Natural Resources Trust Fund**  
**2019 Project Manager Qualifications and Organization Description**  
**Project Title: Optimization of a Net-Zero Dairy System**

**Bradley J. Heins, Principle Investigator / Project Manager**

For the past seven years, Dr. Heins has been 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 \$5 million in research projects including grazing and pasture management, profitability of dairy farms, 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 USDA grant that will enhance organic dairy farm efficiency, productivity, and profitability. He is also principle investigator on Environment and Natural Resources Trust Fund projects that will improve water quality, renewable energy generation, energy conservation, and energy optimization. Dr. Heins has also trained 8 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 and Minnesota Institute for Sustainable Agriculture. In addition to Dr. Heins, the project team include faculty with over 25 years of experience in livestock production and bioengineering research and outreach.

The primary organization is the University of Minnesota with researchers from the West Central Research and Outreach Center (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 swine production, renewable energy, and conventional and organic crop production. The WCROC was selected as the 2011 Outstanding Conservationist for Stevens County by the Stevens Soil and Water Conservation District Board. The WCROC is ideally positioned to address critical dairy production and agricultural water quality issues and renewable energy systems. 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 solar thermal, wind energy, and algal production systems. A primary goal for the renewable energy program is to significantly decrease fossil-fuel consumption in the agriculture sector. The project team strives to optimize energy efficiency, develop effective clean water strategies, and improve long-term profitability for producers.