Environment and Natural Resources Trust Fund
2016 Request for Proposals (RFP)

Project Title: **ENRTF ID: 148-E**

Utilization of Dairy Farm Wastewater for Sustainable Production

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

Total Project Budget: $ 1,451,125

Proposed Project Time Period for the Funding Requested: 3 years, July 2016 to June 2019

Summary:

This project will develop and demonstrate an integrated facility to recycle nutrients from dairy farm wastewater as well as simultaneously produce “green” energy, clean water, food, and livestock feed.

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Sponsoring Organization: U of MN

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Schematic representation of the integrated photo-bioreactor, hydroponics, and aquaponic facility and outcomes.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%

PROJECT TITLE: Utilization of dairy farm wastewater for sustainable production

I. PROJECT STATEMENT

This project will develop and demonstrate an integrated facility to utilize and recycle nutrients from dairy farm wastewater, as well as carbon dioxide emissions on-site to simultaneously produce "green" energy, clean water, food, and livestock feed. Nutrient laden wastes are a direct result of the dairy industry in Minnesota. As such, the dairy industry has been proactive in using anaerobic digestion to capture value from the carbon content in dairy wastes. Thus, anaerobically digested wastewater is comparatively poor in organic matter but typically rich in nitrogen and phosphorus. This wastewater is used to irrigate agricultural cropland; however, runoff of excess nitrogen and phosphorus leads to anthropogenic eutrophication of Minnesota watersheds and rivers. Reduction of the nitrogen and phosphorus in dairy wastewater through engineered algal, hydro-, and aquaponics systems will allow for more control of the nutrient content in cropland irrigation water while supply feed for livestock. Other systems partly fix the problem by removing some nutrients, such as organic matter or sulfur. Overall, an integrated approach is needed and the proposed system represents a more intelligent nutrient recycling strategy that mitigates adverse environmental consequences such as eutrophication and pollution of Minnesota watersheds.

Specifically, we will develop and evaluate a novel, integrated facility consisting of a microalgae photobioreactor, a hydroponic system, and an aquaponic system, which will be operated next to an existing underground anaerobic manure digester. This combination of systems will be utilized to maximize nutrient utilization from waste streams. Briefly, wastewater discharged from the anaerobic manure digester contains substantial amounts of nutrients that are well suited to serve as a water and nutrient source for the integrated system, yielding simultaneous growth of microalgae and vegetables. Subsequently, the clean water will then flow to the aquaponic system where fish will be raised. Excess clean water after from the systems may be utilized for other applications (e.g. washing the dairy barn or irrigation). The outcomes of the proposed system will be clean water and air, vegetables, fish, microalgae as a livestock feed, and electricity.

In addition, we will utilize the microalgae biomass produced from the system to conduct on-farm research trials directed at the potential use of microalgae as livestock feed for cattle and swine. This technology will enable dairy producers to meet greenhouse gas emission reductions and other current and future environmental regulatory requirements. The West Central Research and Outreach Center in Morris, is uniquely positioned as an excellent resource to use for conducting this research because of its national prominence in research and outreach involving renewable energy, environmental sustainability, and alternative livestock production systems.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: *Development of an integrated system to recycle and more effectively utilize nutrients in dairy wastewater to reduce agricultural runoff.* **Budget: $1,046,909**

We will develop an integrated facility and test the microalgae photobioreactor, hydroponic system, and an aquaponic system. The team will utilize the facilities at the Morris research and outreach center and at the Department of Bioproducts and Biosystems Engineering facilities in St. Paul to develop the integrated facility.

Outcome	Completion Date
1. Develop and optimize parameters and production of algae for the integrated facility.	*7/1/2017*
2. Develop and test the microalgae photobioreactor, hydroponic, and aquaponic *systems.*	*7/1/2017*
3. Integrate and test the facility to determine the efficacy and efficiency of the systems.	*7/1/2017*
4. Optimize nutrient removal rate of algae production system with dairy wastewater.	*7/1/2017*

Activity 2: *Evaluate the technical and environment impact of an integrated wastewater management facility at the research and outreach center in Morris.* **Budget: $ 354,216**

A microalgae production system will be installed at research and outreach center's dairy facility for the production of various microalgae strains for use in livestock feeds. Dairy wastewater from the dairy will be utilized for the microalgae production system to produce quantities needed to conduct feeding trails and demonstrations of feeding diets containing microalgae to dairy and swine.

Outcome	Completion Date
1. Install an algae production system from dairy wastewater at the research center.	*7/1/2018*
2. Conduct feeding trials on algae potential as a livestock feed at the research dairy.	*7/1/2018*
3. Evaluate the potential of feeding algae from the algal production system.	*7/1/2018*
4. Evaluate the environmental impact of the dairy wastewater remediation system.	*7/1/2018*

Activity 3: *Educate producers and consumers about technology to recycle nutrients, prevent runoff and add value to nutrients in dairy wastewater.* **Budget: $ 50,000**

The most effective way to educate and motivate livestock producers to adopt new technologies is to demonstrate improved profitability and minimize the environmental impact of dairy wastewater. The results from Activity 1 and 2 will be used to demonstrate the potential of the microalgae system. The research and outreach center will be used as the demonstration site to showcase the opportunities to recycle nutrients and clean dairy wastewater, as well as generate new opportunities for the 5,000+ Minnesota dairy and pork producers to utilize a nutrient dense, alternative and sustainable feed ingredient.

Outcome	Completion Date
1. Identify and prepare the demonstration site for the integrated facility.	*6/30/2019*
2. Conduct workshops, webinars, and site visits of the integrated facility for producers.	*6/30/2019*
3. Prepare Extension factsheets to inform stakeholders of the demonstration sites.	*6/30/2019*

III. PROJECT STRATEGY

A. Project Team/Partners: Bradley Heins, U of MN Dairy Scientist, will serve as PI and project manager. He will be responsible for all reports and deliverables. He will also manage the activities of the dairy production system at the research and outreach center, conduct feeding trials, and manage the demonstration dairy site. Roger Ruan and Paul Chen (U of MN Bioproducts and Biosystems engineers) will design and develop integrated system for testing and demonstration. Rob Gardner (U of MN Renewable Energy Scientist) will develop the microalgae system at the research and outreach center. Gerald Shurson and Pedro Urriola (U of MN Swine Scientists) will be responsible for conducting swine feeding trials to demonstrate the nutritional value of microalgae. Chi Chen (U of MN Nutrition Scientist) will analyze the nutrient content of the products to characterize nutritional effects of algae, fish, and meat from this system.

B. Project Impact and Long-Term Strategy

The overall goal of the project is to develop and demonstrate a technology that will recycle nutrients and add value to nutrients in wastewater from dairy farms in Minnesota to reduce environmental impact. This collaborative project will build on current algal and nutritional activities of the project investigators. The proposed project does not need additional investment other than funding requested from the ENRTF to be completed. Additional long-term funding will be sought to conduct research to integrate this facility within large livestock operations within Minnesota. It may be necessary to acquire federal funding before large scale demonstrations of the integrated facility may be commercialized.

C. Timeline Requirements

This project is proposed for 3 years beginning July 1, 2016 and ending June 30, 2019. 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.

2016 Detailed Project Budget

Project Title: ***Utilization of farm wastewater for sustainable dairy production***

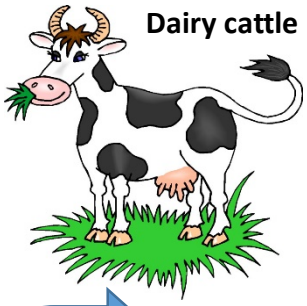
IV. TOTAL ENRTF REQUEST BUDGET: 3 years

BUDGET ITEM	AMOUNT
Personnel:	
Bradley Heins, Project Manager, 2.5% FTE in year 1, 2, and 3; 33.7% fringe rate	10,750
Robert Gardner, Assistant Professor, 2.5% FTE in year 1, 2, and 3; 33.7% fringe rate	9,761
Roger Ruan, 2.5% FTE in year 1, 2, and 3; 33.7% fringe rate	16,016
Paul Chen, 20% FTE in year 1, 2, and 3; 33.7% fringe rate	69,074
Gerald Shurson, 2.5% FTE in year 1, 2, and 3; 33.7% fringe rate	14,570
Pedro Urriola, 10% FTE in year 1, 2, and 3; 33.7% fringe rate	36,896
Chi Chen, 2.5% FTE in year 2 and 3; 33.7% fringe rate	7,540
P& A Scientists,1-5%, 1-100% in year 1, 2, and 3; 33.7% fringe rate	180,226
5 Graduate Research Assistant, data collection, monitoring and analysis, 50% FTE for 3 years, The RA fringe rate is 17.6% plus tuition during the academic year	500,331
Total Personnel:	845,164
Professional/Technical/Service Contracts:	
General Contractor TBD - Installation of algal system pumps and plumbing for calf system	10,000
Total Contracts:	10,000
Equipment/Tools/Supplies:	
Column, reagents, HPLC vial, chemical standards, biochemical kits for Chi Chen laboratory	32,000
Algal cultivation systems supplies for the research and outreach center demonstration	46,824
Supplies for scoping parameters for the photobioreactor system for Roger Ruan laboratory	38,637
Urban automatic calf feeder for feeding algae as a probiotic to pre-weaned dairy calves	35,000
Small research and aquaponic facility and vacuum ammonia stripping (for both ammonia sulfate production and enhancement of the anaerobic digestion process	146,500
Algal cultivation system, centrifuge to harvest algae, pumps for moving water and wastewater throughout system at the research and outreach center	221,500
Swine animal ultra sounding to determine response of algae to backfat and loin eye production	5,000
Animal Care, housing, bedding, and feed storage for dairy calves, cows, and swine at the research and outreach center. Costs also include Extension programming, workshops, and dissemination of information.	45,000
Feed diets nutrient analysis for dairy and swine diets with algae	1,500
Total Equipment/Tools/Supplies	571,961
Travel:	
Travel by team members between St. Paul, Morris, and demonstration farms	10,000
Travel to conferences in Minnesota by team members to present results of research	5,000
Total Travel	15,000
Additional Budget Items:	
Publications of research in Open Access Journals: 5 publications	9,000
Total Additional	9,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 1,451,125

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
In-kind Services To Be Applied To Project During Project Period: *The 52% in foregone federally negotiated ICR funding constitutes the University of Minnesota's cost share to the project.*	$ 754,585	*Secured*

Environmental and Natural Resources Trust Fund
2016 Visual Graphics
Project Title: Utilization of dairy farm wastewater for sustainable production
Graphics 1. Schematic representation of the integrated photo-bioreactor, hydroponics, and aquaponic facility and outcomes.



Environmental and Natural Resources Trust Fund
2016 Project Manager Qualifications and Organization Description
Project Title: Utilization of dairy farm wastewater for sustainable production

Bradley J. Heins, Principle Investigator / Project Manager

For the past five years, Dr. Heins has been an Assistant 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 a University of Minnesota Rapid Agricultural Response Fund grant that will reduce fossil-fuel consumption in dairy and swine production systems through renewable energy generation, energy conservation, and energy optimization. Dr. Heins has also trained 5 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.

The primary organization is the University of Minnesota with researchers from the West Central Research and Outreach Center (WCROC), Animal Science, and Bioproducts and Biosystems engineering 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. 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 and the swine program is one of a handful to co-locate conventional and alternative production systems. 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.