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

Project Title: **ENRTF ID: 149-E**

Innovative Solar Energy Utilization for Minnesota Swine Farms

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

Total Project Budget: $ 928,478

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

Summary:

Swine facilities will be energy-optimized using solar generation for innovative cooling and heating. Optimized systems should reduce water usage while lowering odor, greenhouse gases, dust emissions, and the carbon footprint.

Name: Lee Johnston

Sponsoring Organization: U of MN

Address: 450 McNamara Alumni Center, 200 Oak Street SE

Minneapolis MN 55455-2070

Telephone Number: (612) 624-5599

Email awards@umn.edu

Web Address wcroc.cfans.umn.edu

Location

Region: Central, NW, SW, SE

County Name: Becker, Beltrami, Benton, Big Stone, Blue Earth, Brown, Cass, Chippewa, Clay, Clearwater, Cottonwood, Crow Wing, Dodge, Douglas, Faribault, Fillmore, Freeborn, Goodhue, Grant, Houston, Hubbard, Jackson, Kandiyohi, Kittson, Lac qui Parle, Lake of the Woods, Le Sueur, Lincoln, Lyon, Mahnomen, Marshall, Martin, McLeod, Meeker, Mille Lacs, Morrison, Mower, Murray, Nicollet, Nobles, Norman, Olmsted, Otter Tail, Pennington, Pipestone, Polk, Pope, Red Lake, Redwood,

City / Township:

Alternate Text for Visual:

Swine production phases are shown including farrowing, gestation, nursery, and grow / finish with typical energy loads and conventional fossil energy systems. Under each phase is a list of energy loads. Energy-optimized production phases are shown as an alternative. Energy remodeling steps include: 1. Convert thermal loads to electric, 2. Include energy efficiency measures, and 3. Add renewable energy generation and controls.

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

PROJECT TITLE: Innovative Solar Energy Utilization for Minnesota Swine Farms

I. PROJECT STATEMENT

This proposal is a second phase of 2014 ENRTF 122E "Transitioning Minnesota Farms to Clean Energy". The project addresses an important question facing American pork producers, namely how to lower fossil energy use and reduce the carbon footprint of swine production systems. Minnesota has been a leader in addressing competing challenges within the nexus of food, environment, and energy. Pork producers need innovative housing systems that help address environmental and energy concerns while remaining competitive in the global market. Minnesota is a major pork producing state (3rd nationally). The Midwestern climate dictates considerable indoor environmental (temperature) control of production facilities to ensure efficient production and comfort of pigs and workers. This environmental control includes heating (fossil fuels) during cold conditions and cooling (electricity) during warm/hot weather for all phases of pig production. Producers are seeking solutions to their energy use, which fits well with the ten-year goal of the Univ. of MN's West Central Research and Outreach Center (WCROC). That goal is to reduce fossil energy consumption and reduce the carbon footprint of Minnesota farms. This goal was established as part of a strategic planning process that identified rising energy costs and changing market demands for low carbon footprint agricultural products as key agricultural issues in the next decade. In applying this strategic goal to the problem facing the Minnesota pork industry, the research team identified two innovative methods to cool pigs that will lower ventilation rates and thus emissions of odor, greenhouse gases, and dust in exhaust air, reduce water usage, and lower the carbon footprint of Minnesota-produced pork. The first cooling system uses liquid-cooled pads located in farrowing stalls to cool the sows while they nurse their piglets during summer. Sows will lie on the pads and heat will be transferred from their body to the liquid contained within the pad. The second cooling system will provide chilled drinking water (55 F) to both sows in a farrowing facility as well as market pigs in a grow-finish building. Sows and pigs provided cooled water drink less water, and are physically cooled by intake of the chilled water. Water cooling for both systems will be provided by air-source heat pumps that are powered by solar PV collectors mounted on the roof of the pig facilities. A third method of reducing pork producers' reliance on fossil fuels is to use solar energy to heat swine facilities in the fall, winter, and spring. Solar-powered electric heaters will take full advantage of the clean and locally-produced resource during seasons when heat is needed in the pig building. This project complements other ongoing state- and commodity-funded projects at WCROC that are investigating clean energy agricultural production systems.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: **Design, install, and evaluate the sow cooling pads in the farrowing facility $333,003**

The team will install a second 20 kW solar PV collector and research the effective cooling and heating of swine facilities. The use of chilled water will be evaluated as a means to cool sows using floor pads. The solar powered cooling system will be designed using a combination of internal expertise and an engineering firm. Commercially available floor pads will be installed in a farrowing room (room where sows give birth) at the WCROC facilities and be connected to the water cooling system. Evaluation of the cooling pad system will be completed to determine improvements in performance and comfort of sows and their piglets over two years of research.

Outcome	Completion Date
1. Install solar PV collectors (20 kW) on and floor cooling pads in the farrowing facility	*10/1/2016*
2. Design and install sow cooling systems including water-cooled pads for sows, heat pumps, and water delivery	*4/1/2017*
3. Field test and evaluate floor pad cooling and chilled water for several farrowing groups	*4/1/2019*

Activity 2: Design, install and evaluate chilled drinking water system for pigs $216,504

A 27 kW solar PV system has been installed (May 2015) on the WCROC grow-finish barn as part of an earlier ENRTF-funded project. In the second phase of this research, chilled drinking water cooling systems will be designed by U of MN and private consulting engineers. The systems will be installed and evaluated in both the grow-finish and farrowing buildings at WCROC and will be evaluated for their ability to provide chilled water to pigs consistently, robustness and cost of the system, and performance of pigs over two years of research.

Outcome	Completion Date
1. Design and install chilled drinking water system in both sow and grow-finish buildings	*4/1/2017*
2. Field test and evaluate chilled drinking water system in sow and grow-finish units	*4/1/2019*

Activity 3: ***Design, install and evaluate electric heat performance in both swine facilities.*** **$234,003**

Solar energy will be captured and converted to electricity year-round. When this energy is not used for cooling, electricity will be directed to the grid or electric heaters located in the same farrowing and grow-finish facilities used in Activities 1 and 2. These electric heaters will replace gas-fired units commonly used in swine production facilities. By reducing fossil fuels with solar-powered heat, the carbon footprint of pork production is reduced.

Outcome	Completion Date
1. Design and install electric heaters in the farrowing and grow-finish facilities	*10/1/2016*
2. Field test and compare renewably powered electric heaters to conventional gas heaters	*6/1/2019*

Activity 4: Perform economic analysis and disseminate results of system evaluations **$144,968**

A basic cost-benefit analysis will be developed comparing the conventional and energy-optimized systems. Outreach will be provided to swine producers and technical service providers through meetings and a "virtual" tour video. Swine facilities have limited access for visitors to prevent disease transmission to pigs so a virtual tour video will allow public viewing of the energy-optimized systems.

Outcome	Completion Date
1. Perform economic analysis on both cooling systems	*1/1/2019*
2. Produce a "virtual" tour of both cooling systems for use in outreach activities	*6/1/2018*
3. Conduct two informational meetings in key swine production areas of Minnesota	*6/1/2019*

III. PROJECT STRATEGY

A. Project Team/Partners: Dr. Lee Johnston, U of MN WCROC Director of Operations and Swine Scientist, will serve as the principle investigator and project manager. He will be responsible for all reports and deliverables. Dr. Larry Jacobson (U of MN Agricultural Engineer) will be a co-investigator and provide guidance on cooling system designs and testing in the swine facilities. He will also participate in the outreach activities. Mike Reese (WCROC Renewable Energy Director) will serve as a co-investigator and assist in the design, installation, testing, and control strategies of the solar energy portions of the cooling and heating systems. He will also assist in coordinating with other ongoing energy projects at WCROC and help disseminate results. An engineering firm will be solicited through a RFP and will provide consulting services for designing, commissioning, and control strategies. An agricultural economist (yet to be named) will assist in the economic analysis of the solar systems.

B. Long-Term Strategy and Future Funding Needs: The WCROC has a 10-year strategic plan to reduce fossil energy consumption and the carbon footprint within production agriculture. This proposal builds upon current projects including 2014 ENTRF funding for the solar PV system on the WCROC grow-finish swine facility, energy audit, and modeling ($500,000). Long-term funding will continue to be sought to research alternatives to fossil energy within all agricultural crop and livestock enterprises through federal, state, and stakeholder groups.

C. Timeline Requirements: The project is proposed for three full years beginning July 1, 2016 and ending June 30, 2019. Ideally, two years of performance data will be collected to account for seasonal and annual variation.

2016 Detailed Project Budget

Project Title: Innovative Solar Energy Utilization for Minnesota Swine Farms

IV. TOTAL ENRTF REQUEST BUDGET - 3 years

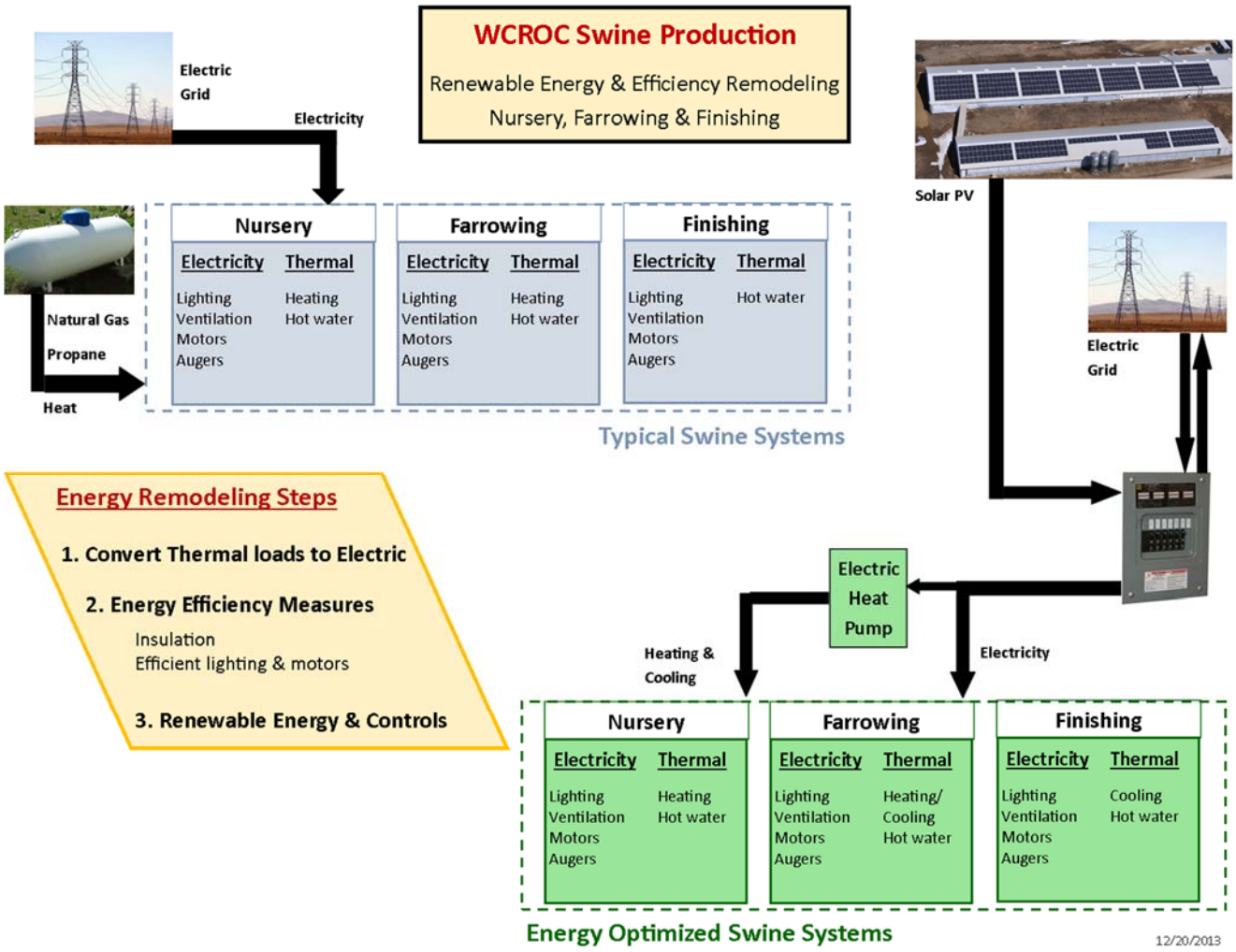
BUDGET ITEM	AMOUNT
Personnel:	
Project Coordinator - Eric Buchanan (50% FTE - 3 Yrs) 27.4 % fringe rate	$ 103,994
Junior Scientist - Technician for data collection, system testing (100% FTE - 3 Yrs) 27.4 % fringe rate	$ 156,444
Brian Hetchler, Research Fellow, Facility data collection and testing (50 % FTE - 3 Yrs) 33.7 % fringe rate	$ 129,847
Undergrad Student Interns - Clean Energy Technology for MN Swine Facilities (2 Yrs) $10/hr & No Fringe	$ 11,432
Undergrad Student Interns - Life Cycle and Economic Analysis (2 Yrs) - $10 / hr and No Fringe	$ 11,432
TOTAL PERSONNEL	**$ 413,149**
Professional/Technical/Service Contracts:	
Engineering Firm TBD with RFP - Design and Commissioning Engineering Professional Services	$ 45,000
General Contractor TBD with RFP - Installation of Cooling and Heating Systems	$ 75,000
General Contractor TBD with RFP - Installation of Solar PV system	$ 34,000
Mechanical Contractor TBD with RFP - Installation of energy meters and temp meters	$ 4,200
Mechanical Contractor TBD with RFP- Installation of control systems in swine facilities	$ 10,000
TOTAL CONTRACTS	**$ 168,200**
Equipment/Tools/Supplies:	
Chillers / Air Source Heat Pumps (Up to 7 @ $10,000 ea) and Cooling Pads (16 @$1,250 ea)	$ 90,000
Electric Heating Systems (Up to 10 units for each building @ $8,000 ea)	$ 80,000
20 kW Solar Photovoltaic System for Swine Farrowing Facility	$ 100,000
Controls for Heating and Cooling Systems (2 systems at $16,300 ea)	$ 32,600
Energy Meters, Air & Water Temp/Flow, & Air Quality Sensors for Swine Buildings (48 sensors @ $250ea)	$ 12,000
Data Loggers for Swine Buildings - Two @ $2,700 ea.	$ 5,200
TOTAL EQUIPMENT AND SUPPLIES	**$ 319,800**
Travel:	
20 trips by Jacobson/Hetchler from St. Paul to Morris, MN (330 miles @ $.565 / mi)	$ 3,729
In-State travel by project team to regional outreach events and meetings (18 meetings- 6 per year - Avg 280 miles roundtrip at ($.565 / mi), one night hotel per meeting at $80 per night, and meals ($31 /person / mtg - avg. 2 people per meeting)	$ 5,400
TOTAL TRAVEL	**$ 9,129**
Additional Budget Items:	
Virtual Tour Video (Professional service to comprehensively video energy-optimized system for outreach - limited public access due to biosecurity concerns)	$ 12,000
Publication and printing (~1000 reports at $6.20 each)	$ 6,200
TOTAL ADDITIONAL BUDGET ITEMS	**$ 18,200**
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	**$ 928,478**

V. OTHER FUNDS *(This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)*

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period:	NA	*NA*
Other State $ To Be Applied To Project During Project Period:	NA	*NA*
In-kind Services To Be Applied To Project During Project Period: **The foregone federally negotiated ICR funding constitutes the University's cost share to the project. The total cost share is $229,049 and has been determined using the federal IDC rate of 52% with exclusions for equipment and capital expenditures.*	$ 229,049	*Pending*
Funding History: $500,000 was awarded as part of the 2014 ENRTF 122E "Transitioning Minnesota Farms to Clean Energy". On July 1, 2016, ~$437,224 will have been spent from this current ENRTF project. This project will end on June 30, 2017. The College of Food, Agricultural, and Natural Sciences funded $167,061 for additional research support through June 2015. Not included in the amount but related to this research is a pending award from the Xcel Renewable Development Fund (RDF) for $982,408. The RDF research will focus on integrating solar electric and small-scale wind generation into midwest dairies.	$ 604,285	Secured
Remaining $ From Current ENRTF Appropriation: This proposal is related to the 2014 ENTF project (122E - Transitioning Minnesota Farms to Clean Energy) and builds upon this phase of the research by evaluating technologies that can better utilize solar electric and other renewable generation. ~$216,530 will be spent from ENRTF 122E as of the proposal submission date on May 11, 2015. Additional funds of ~$120,000 are legally obligated for the installation of a 27 kW solar PV system. The remaining funds will be spent from ENRTF 122E prior to the end of the project on June 30, 2017.	$ 216,530	*Unspent and a portion legally obligated ($120k)*

Environmental and Natural Resources Trust Fund
2016 Visual Graphics
Project Title: Innovative Solar Energy Utilization for Minnesota Swine Farms

Graphics 1. Schematic representation of the energy-optimized WCROC swine facilities



The project team has received past funding from the Environment and Natural Resources Trust Fund to audit energy consumption and install a 27 kW solar photo voltaic system for the WCROC swine facilities. Funding is being requested from LCCMR in this proposal to install a second 20 kW solar photo voltaic system on a different barn used for farrowing (birthing) sows. These two solar electric generation systems will provide electricity for their respective buildings. The primary purpose of this proposal is to develop effective uses for the solar power generated on swine farms. So therefore, additional funding is being requested to evaluate and optimize the local use of the solar energy on Minnesota swine farms by installing electric heating and cooling systems within the facilities. Using novel solar electric-powered heating and cooling systems will enable the increased utilization of locally-produced renewable energy and have the added potential to lower ventilation rates and thus emissions of odor, greenhouse gases, and dust in exhaust air, reduce water usage, and lower the carbon footprint of Minnesota-produced pork.

Environmental and Natural Resources Trust Fund
2016 Project Manager Qualifications and Organization Description
Project Title: Innovative Solar Energy Utilization for Minnesota Swine Farms

Dr. Lee Johnston, Principle Investigator / Project Manager
Dr. Johnston has been a research faculty member and Extension Specialist at the University of Minnesota's West Central Research and Outreach Center (WCROC) for the past 27 years. During his entire tenure at the University, he has conducted research and educational programs for producers and professionals in the swine industry of Minnesota and the upper Midwest region. His research program has attracted $3.69 million in funding as principle investigator or co-principle investigator and this funding supported the publication of 88 papers in scientific journals, 4 book chapters, and over 150 scientific abstracts dealing with nutrition, management, and housing of pigs. He has been invited to present his research findings and educational programs in 8 foreign countries. Dr. Johnston has a deep understanding of the U.S. swine industry with many connections to pork producers, researchers, and industry professionals across the U.S. In 2014, Dr. Johnston was named a Pork Industry Master by the National Hog Farmer Magazine. He also was named the Distinguished Alumnus of Penn State University's Department of Dairy and Animal Science in 2014. Since 2010, Lee has served as Director of Operations at the WCROC and oversees an annual budget of almost $6 million and a staff of 32 people. In addition to Dr. Johnston, the project team includes faculty and staff with over forty years of experience in livestock production and energy-related research and outreach.

The primary organization is the University of Minnesota with researchers from the West Central Research and Outreach Center (WCROC) and Bioproducts and Bioengineering departments. The WCROC, located near Morris, will serve as the primary project location. The WCROC is a century-old 1,100-acre agricultural experiment station that focuses on applied research. The WCROC has several relevant program areas including renewable energy, swine and dairy production, 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 agricultural energy issues. The staff have considerable experience in developing and effectively implementing applied research, outreach, and extension programs at the farm-level and within agricultural service professions. WCROC has nationally unique facilities and programs that compare conventional and organic / alternative 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 community and farm-scale production systems. The renewable energy program features solar thermal, biomass energy, geothermal, wind energy, and renewable hydrogen and ammonia production systems. These systems are commercially available but have yet to see wide-scale adoption on farms. A primary goal for the renewable energy program is to significantly decrease fossil-fuel consumption in the agricultural sector. One of the main consumers of fossil-fuel in crop and feed production is the use of nitrogen fertilizer. To address this in an overarching project called the "Greening of Agriculture", the WCROC is operating a facility which uses wind energy to electro-chemically produce anhydrous ammonia (nitrogen fertilizer). In the second step of this project, we are looking to lower fossil energy consumption in swine and dairy production facilities and begin the transition of farms to locally-produced energy. The funding requested herein is designed to extend the reach of our project through the use of innovative approaches to capture and use more renewable energy on Minnesota swine farms. The project team strives to optimize energy efficiency, develop effective clean energy strategies, and improve long-term profitability for producers.