Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2014 Work Plan

Date of Report: May 14, 2014

Date of Next Status Update Report: December 31, 2014

Date of Work Plan Approval:

Project Completion Date: June 30, 2017

Does this submission include an amendment request? NO

PROJECT TITLE: Transitioning Minnesota Farms to Local Energy

Project Manager: Michael Reese

Organization: University of Minnesota West Central Research and Outreach Center

Mailing Address: 46352 State Hwy 329

City/State/Zip Code: Morris, MN 56267

Telephone Number: (320) 589-1711

Email Address: reesem@morris.umn.edu

Web Address: wcroc.cfans.umn.edu/

Location:

The research and conference will be conducted in Stevens County. Two workshops will be held in southern Minnesota. The impact will be statewide.

Total ENRTF Project Budget:		
	ENRTF Appropriation:	**$500,000**
	Amount Spent:	**$0**
	Balance:	**$500,000**

Legal Citation: M.L. 2014, Chp. 226, Sec. 2, Subd. 08d

Appropriation Language:
$500,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota for the West Central Research and Outreach Center in Morris to develop clean energy strategies for Minnesota farms in order to reduce fossil fuel energy use and increase local energy production. Any installation of infrastructure or improvements must be at the University of Minnesota West Central Research and Outreach Center. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

I. PROJECT TITLE: Transitioning Minnesota Farms to Local Energy

II. PROJECT STATEMENT:

The University of Minnesota West Central Research and Outreach Center (WCROC) has a strategic goal to reduce fossil energy consumption within production agriculture. This project will leverage current efforts by further developing clean energy strategies for Minnesota swine farms. The 2008 MN Climate Change Advisory Group Final Report indicates agriculture contributes 14% of the total greenhouse gas emissions in the state; second only to electrical generation. Production agriculture's dependence on fossil energy carries significant economic and ecological risks. Current research at WCROC is focused on lowering the carbon footprint of grains and feeds through renewable synthetic fertilizer production and reduced field tillage. However, research is needed to optimize clean energy strategies for livestock facilities. According to the National Agricultural Statistic Service, Minnesota has 468,000 dairy cows and 7.8 million pigs (2012). The energy consumed within livestock facilities is the equivalent consumption of several large cities. Minnesota farmers historically have adopted technology to efficiently use resources and optimize production. However, implementation of clean energy technologies on farms has been extremely slow. In lieu of proven systems, farmers continue to opt for conventional fossil-based energy. Adoption of clean energy systems in crop and livestock production will position the State's agricultural sector to be globally competitive particularly as consumers are increasingly demanding low carbon footprint products. The overall project goals are to significantly decrease use of fossil energy, reduce carbon emissions within production agriculture, and to increase adoption of locally-produced renewable energy technologies. The project team proposes to evaluate applicability and implementation of clean energy technologies in swine production. The team will leverage current research by designing and testing integrated clean energy systems, conduct life cycle assessment, and provide producers with tested clean energy designs for swine facilities. Agricultural producers and secondary students will learn about clean energy strategies through research, demonstration, and hands-on learning experiences. Results from this project are anticipated to have a significant impact on transitioning commercial swine production facilities to locally produced, clean energy.

III. PROJECT STATUS UPDATES:

Project Status as of January 1, 2015:

Project Status as of July 1, 2015:

Project Status as of January 1, 2016:

Project Status as of July 1, 2016:

Project Status as of January 1, 2017:

Overall Project Outcomes and Results:

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Design clean energy systems for modern swine facilities

Description: The team will utilize the model swine facilities at the WCROC to determine baseline energy use. An engineering firm with experience in modeling and incorporating clean energy systems will use the information to recommend clean energy systems and rank them based on energy savings and / or return on investment. The engineering firm will complete designs incorporating thermal and electrical energy systems into swine facilities.

Most pork production systems consist of three distinct phases: breeding-to-wean, nursery, and finishing. The breeding-to-wean phase includes adult sows that are mated, housed during pregnancy, give birth to piglets, and

raise piglets to weaning age of about 21 days. When piglets are weaned, they are moved to the nursery phase. The nursery phase entails raising a piglet from 3 weeks of age (about 12 lb body weight) to 9 weeks of age (about 50 lb body weight). At the end of the nursery phase, pigs are moved to the finishing phase which houses the pig until about 25 weeks of age (265 lb body weight) when they are marketed. In some production systems, the nursery and finishing phases are combined. During each phase of production (breed-to-wean, nursery, finishing), pigs have very different requirements for the ideal environmental temperature which demands very different inputs of fossil fuels. Previous researchers (Lammers et al. 2010, 2012) have reported the energy use for pork production systems in the Upper Midwest region of the U.S. However, these researchers relied solely on data from the scientific literature to estimate energy use in a variety of pork production systems. They never actually measured the energy consumption of operating, commercial pork production systems.

The study proposed herein will provide actual energy consumption data for commercial pork production systems. The data will be invaluable to our group and other researchers that seek to improve the energy efficiency of pork production systems. We propose to monitor the energy consumption of operating, commercial pork production systems for one calendar year. One year of monitoring is essential to understand influences of seasons and weather patterns on energy use in commercial systems. We will identify commercial pork producers that operate swine facilities that are characteristic of production systems in Minnesota. We will select 2 breed-to-wean, 2 nursery, and 2 finishing farms for monitoring. At each farm, we will record monthly the consumption of electricity and heating fuel. Electric metering / sensing devices will be installed at each farm to record the total amount of electricity used by the farm. Most farms use liquid propane to heat their buildings so we will record the gallons of liquid propane used each month. In some cases, natural gas may be used to heat barns. In those cases, we will use their existing gas meter to record monthly consumption. In addition, we will record monthly inventory of pigs in the building and monthly output of pigs from the farm. The pig outputs on the breed-to-wean farms will be weaned piglets and cull sows. The pig outputs in the nursery phase are the number of pigs moved to finishing and the pig outputs from the finishing phase are the number of pigs marketed for harvest. In addition, we will collect monthly weather conditions from the NOAA weather observation site closest to each pig production farm that we are monitoring.

Based on the analysis of the data, the AKF Group (or an equivalent firm) will model clean energy alternatives for conventional Minnesota swine facilities and will assist in projecting Return-on-Investment for the clean energy systems. As a full service consulting engineering company, the Minneapolis office of the AKF Group has considerable experience in energy design and modeling. AFK has specific experience modeling the variable energy production of on-site renewable energy systems and then matching the generation technologies to the loads. The engineering firm will utilize the baseline energy consumption data measured at the WCROC and on-farm swine facilities to model energy-optimized retrofits. The project team will direct an undergraduate student intern to project the Return-on-Investment (ROI) for a suite of energy-optimized retrofits. The student will also evaluate the impact of Minnesota's new solar incentives on the ROI for producers.

Within the model, potentially all energy loads may be converted to electricity and these loads will be made as small as possible with efficiency upgrades. Eventually, on-site renewable electric generation could supply some or the entire electric load allowing the buildings to approach net-zero (producing as much energy as is used). For example, the swine nursery at the WCROC is representative of current industry practices and uses about 12,000 kWh of electricity and 7,500 therms of natural gas per year. The largest energy load in a nursery is space heating due to the small size of the pigs. In fact, some heating is often required even in the summertime. Heating loads can be efficiently converted to electricity by using a heat pump which has a Coefficient of Performance (COP) of about 2.5 in a Minnesota climate. The natural gas used in the nursery (7,500 therms) delivers about 132,000 kWh of actual heating energy assuming a 60% efficient furnace. This study will investigate potential heat sources for the heat pump including the ground and air, as well as other unconventional sources like manure lagoons. A heat pump will require about 53,000 kWh of electrical energy to replace the current gas furnaces. One of the goals of the study will be to see if enough energy savings can be obtained to make a building's energy usage less than what can be produced on the roof of that building with a

solar PV system. Additional generation could be provided by a small-scale wind turbine or ground mounted solar PV array.

A finishing barn does not have a significant heating load, but does require cooling (even in winter). Cooling is usually accomplished with large amounts of ventilation. Another possibility that will be investigated is using an air source heat pump to provide cooling using chilled beams. Chilled beams are an efficient way to cool a space, but require careful management of humidity to prevent condensation on the beams. Condensation is probably not an issue in a pig barn and may even provide more cooling by dripping water on the pigs. An advantage of chilled beams is they can be installed into existing barns without altering the existing ventilation system and do not place delicate cooling coils in the harsh environment of a pig barn. Cooling may even enhance pig performance on hot days and cooling loads naturally coincide with high solar resource days. One of the questions that will be answered with this study is whether or not the energy needed to provide cooling can be offset by reduced ventilation demands.

Finally, the engineering firm will provide professionally engineered design for installing a 20 kW solar PV system at the West Central Research and Outreach Center swine facilities. Efforts will be made to standardize the design of the solar installation as it potentially may then be utilized for similar on-farm swine facilities. The use of solar photovoltaic (PV) systems is a logical choice to performance test for the production of electrical energy for swine facilities. Standard swine buildings are generally configured in an east to west layout providing an almost ideal southern exposed roof. In addition, new solar PV programs were put in statute during the 2013 Minnesota Legislative Session. Combined with the availability of federal USDA REAP grants and declining costs for solar PV, swine producers may be able to cost effectively generate electricity to meet their load requirements. Solar PV also has peak production capacity during hot summer days which also matches high-energy load times for swine facilities (ventilation and water pumping).

Summary Budget Information for Activity 1:

ENRTF Budget: $ 162,340
Amount Spent: $ 0
Balance: $162,340

Activity Completion Date: August 31, 2015

Outcome	Completion Date	Budget
1. *Install energy meters at the swine facilities and record energy consumption data for one year*	7/30/2015	$85,835
2. *Model clean energy alternatives for Minnesota swine facilities and project return-on-investment*	7/30/2015	$39,058
3. *Complete designs of clean energy systems for field testing at the WCROC swine facilities*	8/31/2015	$37,447

Activity Status as of January 1, 2015:

Activity Status as of July 1, 2015:

Activity Status as of January 1, 2016:

Final Report Summary:

ACTIVITY 2: Field test clean energy systems and develop effective control strategies
Description: A 20 kW solar photovoltaic system will be installed at the WCROC swine facilities. Control systems will be installed and field tested. The control of farm-scale clean energy systems is deficient and a barrier to adoption of clean energy systems. The control system will integrate building control regimens with the often variable solar PV generation. The solar PV system will be performance tested for two years for production and reliability. Once installed, production data from the 20 kW solar PV system will be measured and analyzed over

a two year time frame to determine gross and net energy production including diurnal and seasonal variation. The project team will direct an undergraduate student intern to assist in collecting data and evaluating the results. The student intern will develop a written report and provide a public presentation summarizing the results from the field test of the solar PV system.

Summary Budget Information for Activity 2:

ENRTF Budget: $ 227,194
Amount Spent: $ 0
Balance: $227,194

Activity Completion Date: June 30, 2017

Outcome	Completion Date	Budget
1. *Install a 20 kW solar PV system at the WCROC swine facilities*	7/15/2015	$128,154
2. *Install automated control systems to integrate clean energy systems*	7/15/2015	$33,650
3. *Conduct field tests with control systems*	6/1/2017	$30,207
4. *Performance test of the solar PV system for up to two years*	6/30/2017	$35,183

Activity Status as of January 1, 2015:

Activity Status as of July 1, 2015:

Activity Status as of January 1, 2016:

Activity Status as of July 1, 2016:

Activity Status as of January 1, 2017:

Final Report Summary:

ACTIVITY 3: Perform a life cycle assessment

Description: A life cycle analysis will be performed on the WCROC swine nursery comparing conventional with the clean energy systems. This study will use life cycle assessment (LCA) to quantify the potential for energy conservation in swine production. Life cycle assessment is an accounting method used to track inputs and outputs in complex production and manufacturing systems. This work will build upon ongoing studies of the baseline energy consumption in swine, dairy, and cropping systems being researched at WCROC. In that work, the standard amount of energy used for producing pork, milk, and grain is also being analyzed using LCA methodology. This project will further refine the baseline fossil energy used in producing pork, and then assess the energy and greenhouse gas emission impacts of introducing energy-saving technologies into the swine production system. Technologies being investigated include adding solar PV panels to the facilities, bringing in more efficient ventilation systems, and possibly adding heat pumps. Each of these technologies will be selected based on the costs of retrofitting existing hog facilities, ease of use by producers, and potential to save energy.

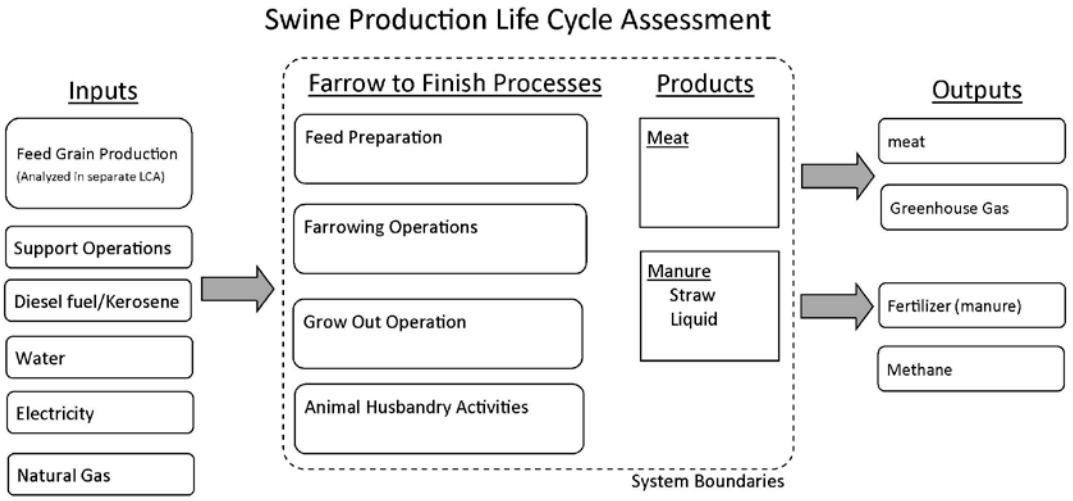
For this project, the LCA methodology involves first identifying all inputs and outputs associated with producing hogs. This work will be done using WCROC's swine production research facilities as an energy test bed. An analysis will be conducted to identify high energy inputs such as heating and cooling facilities, feeding animals, construction/operation of the farm buildings and equipment, and all activities related to manure management. Seemingly smaller inputs into the system (like water, medications, and office facilities for staff) will also be documented. Each of these inputs is analyzed in terms of how much fossil energy was needed to incorporate the specific input into the swine production system. The next step is to examine the outputs from the system; in this case the main outputs will be live pigs leaving the facility and manures which will be used as fertilizer.

Using specifically designed LCA software, these inputs and outputs will be linked together in a complex model that ties the amount of inputs (i.e. BTUs of fossil energy) to the units of output (lbs of live pig). The final analysis

will examine how many BTUs of fossil energy are needed to produce 1 pound of live pig leaving the facility. This energy input data will be used for a calculation of how much greenhouse gas is emitted in the production of 1 pound of live pig.

The LCA will be performed with appropriate ISO standards and the National Pork Board Lifecycle Assessment Study as guides for data collection and analysis. The LCA will focus on activities directly related to swine husbandry using per pound pork as a functional unit (see Figure 1).

Figure 1. Swine production life cycle assessment schematic



This LCA sets the production boundary at the farm gate and does not consider transportation/manufacture/or marketing of pork products. LCA data for inputs not inside the pork production system, such as grain production, will use both standard literature reference values and data from our separate LCA of WCROC's agronomic activities. One challenge in this system is estimating the impact of swine production system size (scale) on energy savings from particular technologies. Energy and GHG impacts from implementing conservation measures at large farms will likely be different than at smaller farms. Using our fairly modest production system, we will be able to look at the savings at smaller operations. However, scaling factors may need to be developed that can estimate how larger or smaller operations will benefit from these technologies.

Summary Budget Information for Activity 3:

ENRTF Budget: $ 61,655
Amount Spent: $ 0
Balance: $61,655

Activity Completion Date: April 1, 2017

Outcome	Completion Date	Budget
1. *Complete a life cycle assessment of the WCROC conventional swine facilities using field data and literature values*	4/1/2017	$61,655

Activity Status as of January 1, 2015:

Activity Status as of July 1, 2015:

Activity Status as of January 1, 2016:

Activity Status as of July 1, 2016:

Activity Status as of January 1, 2017:

Final Report Summary:

Activity 4: Educate farmers and students about clean energy strategies for Minnesota farms

Description: Perhaps the most effective approach to change the way energy is used in crop and livestock systems is to educate agricultural students about clean energy technologies. Based on the research results and literature review, curriculum will be developed for secondary and technical students. Agricultural producers and other key stakeholders will be provided with educational opportunities including an agricultural energy conference and tour, two regional agricultural energy workshops across the State, and the completion of a bulletin entitled "Energy Strategies for Minnesota Swine Facilities".

The information developed as a result of this project will be transferred to producers through several outreach efforts. The primary method will be through a statewide conference and tour at the West Central Research and Outreach Center. The conference will provide producers actionable information they can use to improve energy utilization in swine facilities. Producers appreciate experiencing first-hand new systems and technology, so a bus tour will be held in conjunction with the workshop. Producers will tour the renewable energy systems at the WCROC (and other systems within close proximity) including solar thermal, solar PV, large and small scale wind, geothermal heat pumps, and energy efficient systems and controls. Two regional workshops will be presented in regions with high concentrations of swine producers (south central and southwest Minnesota). The workshops will present practical information that swine producers can use in their swine facilities including results from this project. Though not a deliverable of this project, the results are likely to be published in peer-reviewed swine production journals as well as industry magazines. The information generated as a result of this project will also be included on the WCROC Renewable Energy Program website.

Summary Budget Information for Activity 4:

ENRTF Budget: $ 48,811
Amount Spent: $ 0
Balance: $48,811

Activity Completion Date: June 30, 2017

Outcome	Completion Date	Budget
1. *Develop agricultural energy curriculum for secondary and technical students*	8/1/2016	$11,455
2. *Host an agricultural energy conference and tour to showcase clean energy systems*	6/30/2017	$11,313
3. *Conduct two regional agricultural energy workshops in southern Minnesota*	4/15/2017	$7,370
4. Complete a "Energy Strategies for Minnesota Swine Facilities" bulletin	6/15/2017	$14,320
5. Submit semi-annual reports and a comprehensive final report	6/30/2017	$4,353

Activity Status as of January 1, 2015:

Activity Status as of July 1, 2015:

Activity Status as of January 1, 2016:

Activity Status as of July 1, 2016:

Activity Status as of January 1, 2017:

Final Report Summary:

V. DISSEMINATION:

Description: The dissemination of the information generated in this project is described in Activity 4. The project team will develop curriculum for secondary and technical students. A statewide agricultural energy conference and tour will be held at the WCROC in Morris to showcase clean energy systems. Two regional workshops will be held in key swine production areas within the state. A bulletin will be developed titled "Energy Strategies for Minnesota Swine Facilities". The bulletin will be made available both in paper and electronic formats. The information generated as a result of the project will be placed on the WCROC Renewable Energy Program website at wcroc.cfans.umn.edu/RenewableEnergy and other groups such as the Clean Energy Resource Teams (CERTS) and swine producer organizations will be encouraged to link to the site.

Status as of January 1, 2015:

Status as of July 1, 2015:

Status as of January 1, 2016:

Status as of July 1, 2016:

Status as of January 1, 2017:

Final Report Summary:

VI. PROJECT BUDGET SUMMARY:

A. ENRTF Budget Overview:

Budget Category	$ Amount	Explanation
Personnel:	$ 220,003	1 project coordinator at 20%, 40%, 20% FTE in years 1,2, and 3 respectively; 1 life cycle analysis researcher at 5% FTE for 3 years; 1 junior scientist at 100% FTE for 2.5 years; and 1 undergraduate student intern for two years during summer term
Professional/Technical/Service Contracts:	$124,354	1 contract with AKF Engineering or equivalent firm for modeling, pre-design, design, and commissioning; Up to 6 contracts with swine producers for stipends to participate in baseline energy auditing study, 1 contract with a general contractor for the installation of the solar PV system; and 1 contract with a mechanical contractor for installation of control systems and meters
Equipment/Tools/Supplies:	$8,400	Energy meters and data loggers for the swine facilities.
Capital Expenditures over $5,000:	$126,000	20 kW solar PV system at the WCROC swine facilities; control systems for the WCROC swine building(s)
Printing:	$5,400	Publication and printing of curriculum, Ag

		Energy Conference materials, regional workshop materials, and extension bulletins
Travel Expenses in MN:	$5,243	Mileage, lodging, meals
Other:	$10,600	Three buses for the Ag Energy Conference tour; software for life cycle analysis
TOTAL ENRTF BUDGET:	**$500,000**	

Explanation of Use of Classified Staff: Not Applicable

Explanation of Capital Expenditures Greater Than $5,000: One solar photovoltaic system is being purchased and installed at the University of Minnesota West Central Research and Outreach Center. The system will be performance tested with results added to the models for optimizing commercial swine facilities. In addition, a control system will be purchased for the WCROC swine nursery which will enable data acquisition and assist with field testing and modeling integration of energy systems. Following the project, the WCROC will continue to use the equipment on similar projects for its expected serviceable life. If the equipment is sold prior to the end of its serviceable life, the proceeds will be paid back to the Environment and Natural Resources Trust Fund.

Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation: ~4.0 (~1.33 FTEs for three years)

Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation: Not applicable. The contracts are for professional engineering services and equipment installation.

B. Other Funds:

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
Non-state			
University of Minnesota – Unrecovered Indirect Costs (ICR) used as in-kind match.	$155,296	$	Indirect costs
State			
	$	$	
TOTAL OTHER FUNDS:	**$**	**$**	

VII. PROJECT STRATEGY:

A. Project Partners: Michael Reese, U of MN WCROC Renewable Energy Director, will serve as the principle investigator and project manager. He will be responsible for all reports and deliverables. Dr. Lee Johnston (U of MN Swine Scientist) will be a co-principle investigator managing the activities within the WCROC swine facilities and assisting in interfacing with the collaborating swine producers. Dr. Larry Jacobson (U of MN Agricultural Engineer) and Dr. Brad Heins (U of MN Dairy Scientist) will be co-investigators and provide guidance on clean energy designs and testing in livestock facilities. They will also participate in the outreach activities. Dr. Joel Tallaksen (WCROC Renewable Energy Scientist) will serve as a co-investigator and be responsible for the life cycle analysis and oversee the basic economic evaluation. Eric Buchanan (WCROC Renewable Energy Scientist and Engineer) will be the project coordinator assisting in the design, installation, testing, and control strategies of the clean energy technologies. He will also assist with the outreach and dissemination of results. AKF

Engineering (Minneapolis) or equivalent will provide consulting services for clean energy modeling, designing, commissioning, and control strategies.

B. Project Impact and Long-term Strategy: There are approximately 7.8 million pigs in Minnesota. Past research at the WCROC has shown significant energy and cost savings with off-the-shelf technologies. Proven energy optimized systems have the potential to significantly lower the energy consumed in swine facilities and begin the transition to locally-produced, clean energy. The WCROC has a 10-year strategic plan to reduce fossil energy consumption and the carbon footprint within production agriculture. This proposal will leverage and build upon current projects. Funding has been received through the U of MN Initiative for Renewable Energy and the Environment ($350k) to measure energy consumption within a model dairy and test clean thermal energy systems. The funded project will also evaluate greenhouse gas emissions within portions of crop and dairy production. Long-term funding will be sought to research alternatives to fossil energy within all agricultural crop and livestock enterprises.

C. Spending History:

Funding Source	M.L. 2008 or FY09	M.L. 2009 or FY10	M.L. 2010 or FY11	M.L. 2011 or FY12-13	M.L. 2013 or FY14
U of MN IREE (Crops and Dairy)				$350,000	
U of MN RARF (Dairy and Swine) – The swine portion of this project is related to diurnal control of temperature or lowering the temperature during evening hours to conserve energy.				$167,061	
Xcel RDF Pending PUC Approval (Dairy facilities only – If approved, the project will add small wind and solar system to the WCROC dairy parlor)					$982,408

VIII. ACQUISITION/RESTORATION LIST: Not applicable

IX. VISUAL ELEMENT or MAP(S): Please see the end of this document for the visual elements

X. ACQUISITION/RESTORATION REQUIREMENTS WORKSHEET: Not applicable

XI. RESEARCH ADDENDUM: As detailed in the activity sections

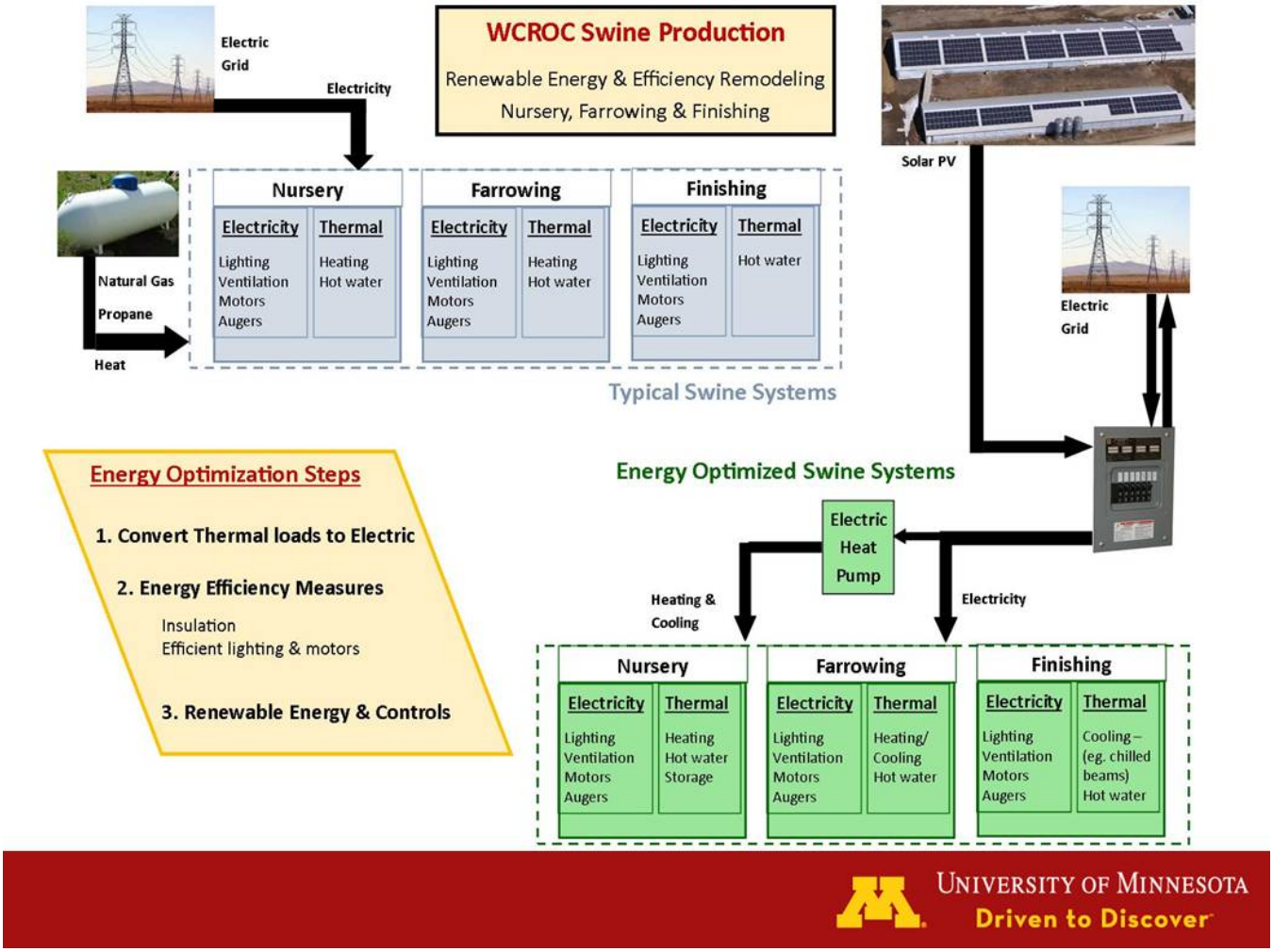
XII. REPORTING REQUIREMENTS:
Periodic work plan status update reports will be submitted no later than January 1, 2015; July 1, 2015; January 1, 2016; July 1, 2016; and January 1, 2017. A final report and associated products will be submitted between June 30 and August 15, 2017.

Literature Cited

Lammers, P. J., M. S. Honeyman, J. D. Harmon, and M. J. Helmers. 2010. Energy and carbon inventory of Iowa swine production facilities. Agric. Systems 103:551-561.

Lammers, P. J., M. D. Kenealy, J. B. Kliebenstein, J. D. Harmon, M. J. Helmers, and M. S. Honeyman. 2012. Energy use in pig production: An examination of current Iowa systems. J. Anim. Sci. 90:1056-1068.

Visual Element: Basic Schematic of Conventional and Optimized Energy Systems for Swine Facilities



Environment and Natural Resources Trust Fund

M.L. 2014 Project Budget

Project Title: *Transitioning Minnesota Farms to Local Energy*
Legal Citation: M.L. 2014, Chp. 226, Sec. 2, Subd. 08d
Project Manager: *Michael Reese*
Organization: *University of Minnesota West Central Research and Outreach Center*
M.L. 2014 ENRTF Appropriation: $ *500,000*
Project Length and Completion Date: *3 Years, June 30, 2017*
Date of Report: *January 15, 2014*

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget	Amount Spent	Activity 1 Balance	Activity 2 Budget	Amount Spent	Activity 2 Balance	Activity 3 Budget	Amount Spent	Activity 3 Balance	Activity 4 Budget	Amount Spent	Activity 4 Balance	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM	***Design clean energy systems for modern***			***Field test clean energy systems and develop***			***Perform a life cycle assessment***			***Educate farmers and students about clean***				
Personnel (Wages and Benefits)	$64,650	$0	$64,650	$64,650	$0	$64,650	$55,856	$0	$55,856	$34,847	$0	$34,847	$220,003	$220,003
Project Coordinator - Eric Buchanan (FTEs =20% Year 1, 40% Year 2, 20% Year 3) 36.8 % fringe rate														
Life Cycle Analysis Researcher - Dr. Joel Tallaksen (5% FTE) 36.8 % fringe rate														
Junior Scientist - Technician for data collection, system testing (100% FTE - 2.5 Yrs) 36.8 % fringe rate														
Undergrad Student Intern - Clean Energy Technology for MN Swine Facilities (2 Yrs) 7.44% Fringe Rate														
Professional/Technical/Service Contracts														
AKF Engineering (or equivalent firm) - Modeling, Pre-design, Design, Commissioning, and Control Optimization Engineering Professional Services	$62,000	$0	$62,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$62,000	$62,000
Farmer Contracts -TBD - Funds for monitoring of on-farm systems	$24,000	$0	$24,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$24,000	$24,000
General Contractor TBD - Installation of the solar PV system	$0	$0	$0	$28,154	$0	$28,154	$0	$0	$0	$0	$0	$0	$28,154	$28,154
Mechanical Contractor TBD - Installation of energy meters / control systems	$2,550	$0	$2,550	$7,650	$0	$7,650	$0	$0	$0	$0	$0	$0	$10,200	$10,200
Equipment/Tools/Supplies														
Energy Meters for Swine Building(s) to measure energy consumption	$4,800	$0	$4,800	$0	$0	$0			$0			$0	$4,800	$4,800
Data Loggers for Swine Building(s) for data collection and acquisition	$3,600	$0	$3,600	$0	$0	$0			$0			$0	$3,600	$3,600
Capital Expenditures Over $5,000														
20 kW solar photovotaic (electric) system			$0	$100,000	$0	$100,000			$0			$0	$100,000	$100,000
Control system for WCROC Swine Facilities			$0	$26,000	$0	$26,000			$0			$0	$26,000	$26,000
Printing Curriculum, Ag Energy Conference materials, regional workshop materials, and extension bulletin printing.			$0			$0			$0	$5,400	$0	$5,400	$5,400	$5,400
Travel expenses in Minnesota Eight trips by Dr. Jacobson from Saint Paul to Morris, MN (330 miles @ $.56 / mi); Travel by project team to two regional workshops across the State (2 trips, 400 miles each, $.56 / mi); Lodging and meals for WCROC project team at two regional workshops (4 people / 2 nights @ $80 / room and $40 ea for meals); Travel, lodging and meals for Larry Jacobson at two regional workshops (400 miles and 2 trips @ .56, 2 nights @ $80 / room and $40 ea for meals); Travel, lodging, and meals for six ag energy conference speakers (6 @ 330 mi and $80 / room and $40 ea for meals)	$739	$0	$739	$739	$0	$739	$0	$0	$0	$3,765	$0	$3,765	$5,243	$5,243
Other														
Buses for the ag energy conference tour (3)										$4,800	$0	$4,800	$4,800	$4,800
Life cycle analysis software to perform the study			$0			$0	$5,800	$0	$5,800			$0	$5,800	$5,800
COLUMN TOTAL	**$162,339**	**$0**	**$162,339**	**$227,193**		**$227,193**	**$61,656**	**$0**	**$61,656**	**$48,812**	**$0**	**$48,812**	$500,000	$500,000