**Minnesota State Colleges and Universities**

**Minnesota West Community and Technical College**

**Research and Development of Renewable Electric Energy Technologies**

**Annual Report (April to December 2016)**

Project funding provided by customers of Xcel Energy through a grant from the Renewable Development Fund (RDF)



Minnesota West Community and Technical College
1593 11th Ave, Granite Falls, MN 56241

EXECUTIVE SUMMARY

Minnesota State – Minnesota West Community and Technical College

The Minnesota State Colleges and Universities, through Minnesota State Energy Center of Excellence, located at Minnesota West Community and Technical College, entered into an agreement with Northern States Power Company (doing business as Xcel Energy in Minnesota), with respect to a research grant with a total of $5.5 Million over three years. The funding was allocated from the Higher Education block grant component of the Renewable Development Fund, supported by the Xcel Energy ratepayers and managed by said utility company.

This project aims to award up to 14 projects across our system colleges and universities and aims to contribute to the expansion of the renewable electric energy sector in Minnesota. By advancing the market penetration of renewable electric energy generation sources we will benefit current Xcel ratepayers and the future of the energy production industry in Minnesota.

Taking on a grant project of this scope has brought attention to several areas of challenge for the system. To bring this grant to fruition has required our system to review and establish processes and protocols to effectively manage the grant program to assure compliance with both the RDF program requirements as well as state regulations of the education system.

Our initial work to establish this grant program has included significant systems building within. Extensive effort has gone into establishing the models and procedures necessary to operate and manage a grant program internal to our State system. We are happy to report those systems are now in place and contracts have been fully executed to get our first five projects moving forward. While we continue to work on clarifications of procedures and requirements with each partner college or university, each of the round one projects are moving forward. In all cases, the contracting delays have slowed start up so expenditures have been delayed. As each project completes their quarterly reporting due April 30, we anticipate we will have the first disbursements of funds to each institution.

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Higher Education Block Grant
HE4-1

**MSUM-1: Universal and Scalable Smart Grid Power Converter**

**Minnesota State University at Mankato: Dr. Vincent Winstead, Principal Investigator**

This project will focus on developing technical solutions to the interface of multiple renewable generation sources. Typical installations to date have required the systems be installed independently from one another, even though they may be collocated on a single site. With advancement in system designs to use multiple generation sources to provide stable electrical generation, control systems are needed that can measure system outputs and assure available energy from multiple generation sources to meet consumption needs. This project proposes to design and develop a control interface that sources available generation and provides management to distribute electricity to meet consumer demands.

The following statement is extracted from the executive summary of this proposal that describes the intended outcome of the research:

*"This project is intended to incorporate concepts from "smart grid" interfacing and protocols, trans active energy (TE) and universal interconnect hardware into a single scalable configurable component. In other words, we intend to develop a device which is configurable (in firmware) and is capable of connecting electrically to a variety of power generation and energy storage devices (i.e. renewable energy generators, battery systems, ultra capacitor systems, hybrid vehicles, etc.) and provide a universal interface to the grid of the future. We can call this the Universal and Scalable Smart Grid Power Converter (USSGPC)."*

This project offers a unique partnership between Minnesota State University Mankato and Riverland College in Albert Lea. They have completed the sub-contracting between the two institutions. In this project the design work will be completed in the engineering department at the State University, while the testing will largely be conducted at the college site in Albert Lea where several generating stations are already in place. Design development on the control system has begun along with ordering of many of the baseline supplies needed for those designs. This project has also created a model for managing the documentation of student research we will implement at other sites as each one moves forward.

**MSUM-2: Improving Vertical Axis Wind Turbine (VAWT) Performance with Placement Strategies**

**Minnesota State University, Mankato: Dr. Patrick Tebbe, Principal Investigator**

Use of VAWT systems in our state has been limited even though the cost, installation, and minimal maintenance present a very affordable alternative for energy production in smaller scale generation sites. In this study, the investigators will research whether placement of turbines can increase the efficiency of generation which in turn will improve the potential productivity and ROI for this sort of system installation. While this impact will improve applications in rural settings, the research also anticipates growing demands in densely populated areas where available space limits opportunities for larger generator systems.

The following statement is extracted from the executive summary of this proposal that describes the intended outcome of the research:

*"This research will address how placement affects the performance and efficiency of VAWTs through a combination of numerical and experimental efforts. The unique numerical approach of Leaky Rankine Bodies (LRB) with superposition will be explored as an accessible consumer tool. The modeling work will be verified by and combined with on-site and scale model experimentation."*

A group of students has been identified to establish the research project objectives and timelines for each. As was recommended by one of the merit reviewers, this team has partnered with the wind tunnel research group at the University of Minnesota to understand how research at their site could be integrated or partnered in this project. At this point the group is working on establishing the modeling that will be used in the research project and the software protocols that will be used.

> **Goal 1:** Create a numerical tool that can aid in placement of VAWTs to improve their performance and efficiency. Most numerical methods of studying wind turbine flow fields involve complicated and costly fluid dynamics software. A simple, easy to use, low cost alternative would be an advantage to VAWT developers, installers, and consumers.
> **Goal 2:** Produce strategies that improve the performance and efficiency for the placement of VAWTs with regard to their surroundings, other VAWTs, and potentially HAWTs. Proper placement of VAWTs is necessary to ensure adequate electricity production and increased viability of future projects.
> **Goal 3:** Determine areas of high potential for the installation of VAWTs in Minnesota. Most current wind maps indicate speeds at elevations (e.g. 30 m) higher than typical 2 VAWT installation heights. A map that takes into account lower boundary layer flows and advantageous aerodynamic interferences could lead to future development of VAWTs and increase small-scale electricity production.

**SCSU-1: Microbial Power and Bioproduct Production from Using Food Waste from a College Campus**

**St Cloud State University: Dr. Mathew Julius, Principal Investigator**

Anaerobic digestion has been used in the upper Midwest for power generation for many years, most successfully in farming operations where methane gas produced from animal waste provides fuel to power local generation. Large dairy operations in Minnesota and Wisconsin have proven effective in this space. As we continue to look at waste streams and how to maximize consumption of waste products for use rather than disposal, test projects have been created to explore redirecting of waste streams into productive use. In this project, researchers propose to use food waste from a large producer (college campus) in combination with algae treatments to increase production of methane and electrical outputs. At the same time, the algae treatments will be adjusted to minimize waste outputs from the digester processes.

The following statement is extracted from the executive summary of this proposal that describes the intended outcome of the research:

*"This work involves anaerobic digestion of food waste streams for energy production and the utilization of other digester outputs for production of high value algal biomass research. The scientific "heart" of this research will be focused on minimizing waste stream outputs from the anaerobic digester while simultaneously creating an additional revenue stream. Variations organic inputs should illicit changes in anaerobic digester outputs. Researchers working with these variations will track and evaluate digester products as part of a life cycle analysis, quantifying greenhouse gasses, nitrogen, and phosphorus. A model to optimize waste stream reduction and biomass profits will be developed using information from the life cycle analysis data."*

At present the following processes are each moving forward:

1) Bioreactors ordered and being constructed
2) Mass cultures being grown for bioreactor inoculation
3) Preserve target algal cultures and sequence barcode genes

The new anaerobic digester (purchased with non-grant funding) has been shipped and should arrive at the campus soon. The digester will be installed upon arrival and be ready to begin processing food waste and production of electricity.

**SCSU-2: No waste: fine-tuning digesters' microbiome to maximize biogas production.**

**St Cloud State University: Dr. Ryan Fink, Principal Investigator**

This research project will study creation of a stable and mature microbial system in the digester. Using the campus food waste, likely supplemented from the state corrections facility, the research desires to manage a stable and steady input of food wastes to manage the internal digester system for stable electrical output driven by the produced methane gases. Primary work of this project will focus on improved outputs of the digester to maximize biogas production to maximize resulting power production.

The following statement is extracted from the executive summary of this proposal that describes the intended outcome of the research:

*"The principal scientific goal for this project is to produce a mature microbial community in a digester that is stable in terms of output and that can easily be manipulated through the organic waste input to maximize biogas production or, if needed, nutrient rich digestate for agribusiness."*

The primary goals of this project that are being developed at present include:

1. Characterize initial microbial composition from the inoculate and the establishment of a mature microbial community.
2. Characterize annual community patterning over a 1-year period.
3. Experimental manipulation of input streams.

As with the SCSU-1 project, actual production of electricity will not happen until the anaerobic digester is installed. The project director and students are doing the preliminary testing and establishing the protocols for managing the microbial community in preparation to digester operation.

**Century-1: Investigate strategies to minimize the negative impacts of soiling on photovoltaic (PV) panel efficiency**

**Century College: Scott Randall, Principal Investigator**

This research project will analyze what particles are "naturally" appearing on solar panels in the Midwest region. Through this project, research teams will consider varied treatment process of solar panels to improve the cleaning and shedding of soiling on the panels. It is known that cleaner panels maximize electrical outputs. Through this project researches will consider the impact of weather conditions and how cleaning products may impact, either positively or negatively, the electrical capacity of solar output.

The following statement is extracted from the executive summary of this proposal that describes the intended outcome of the research:

*"to conduct a research study to investigate strategies to minimize the negative impacts of soiling on photovoltaic (PV) panel efficiency and reduce the cost-per-kilowatt hour of electricity produced within the context of Minnesota's mid-latitude, mid-continental climate."*

This project has experienced several logistical challenges. Due to some issues discovered on the campus, it was necessary to move the planned solar installation to a new location on the campus. When the drawings for the new site were completed, in the permitting process it was discovered the campus was excluded by city ordinance from being able to install solar arrays on the campus. It was necessary to prepare documents and obtain city approval to change the ordinance to allow the installation. This has all been completed and permits have been issued. All major components have been ordered and contractors are secured to complete the installation this month.

In spite of these challenges, the background work has continued to develop so the research project will be able to launch as soon as the installation is completed. The college is now clarifying additional sub-projects that will support the analysis of meteorological conditions to assure strong understanding of conditions affecting solar output of the array.

Round 1 summary statement:

Minnesota is considered a leader in deployment of renewable electric energy sources. As you look across the renewable landscape in our state, we see large investment in large wind and growing investment in solar. As the technologies that drive these generation sources continues to refine, we continue to see improvement in generation outputs from these systems. The drive to improve efficiencies in existing systems as well as designing new technologies continues to drive the advancement of the renewable electric industry in our state.

As we see the growth of the industry, we also see areas where new technologies and applications may offer enhanced performance and new applications to enhance the deployment of renewable technologies across our state. Each of these projects has been selected to look at various renewable electric energy production systems. We have chosen a variety of different generation sources to study to assure breadth across multiple generation systems.

As a group we have learned a great deal about our state system and the challenges of launching such a project in a time of funding challenges for the system. While that may seem counter-intuitive, the concerns about long-term budget implications have proven a consistent barrier we have needed to overcome in each project. We are happy to be able to report that all five projects have cleared those hurdles and are on the way to active research work.

To this point no funding has been distributed to the campus projects. In our system, we require quarterly progress reports to include expenditures made for each project. Once approved, funds are then released from our central account. I anticipate getting our first round of billings in the month of April which will trigger our first disbursements. From that point forward we will have a significant upturn in spending levels on each project.

Further, we are well into the review process of Round 2 proposals. In this round we have identified five projects to further for merit review and possible funding. We anticipate having those projects finalized and contracts completed during the summer of 2017.

Respectively submitted by:
Bruce Peterson, Executive Director, Minnesota State Energy Center of Excellence.