Environment and Natural Resources Trust Fund

M.L. 2021 Approved Work Plan

General Information

ID Number: 2021-169

Staff Lead: Michael Varien

Date this document submitted to LCCMR: July 21, 2021

Project Title: Storing Renewable Energy In Flow-Battery For Grid Use

Project Budget: $2,408,000

Project Manager Information

Name: Bryan Herrmann

Organization: U of MN - Morris

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Project Reporting

Date Work Plan Approved by LCCMR: July 20, 2021

Reporting Schedule: December 1 / June 1 of each year.

Project Completion: June 30, 2024

Final Report Due Date: August 14, 2024

Legal Information

Legal Citation: M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 07b

Appropriation Language: $2,408,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota, Morris, to implement a rural, community-scale project that demonstrates how a large flow battery connected to solar and wind generation improves grid stability and enhances use of renewable energy.

Appropriation End Date: June 30, 2024

Narrative

Project Summary: Our project team will implement a rural, community-scale project, which demonstrates how a large flow-battery connected to solar and wind generation improves grid stability -- and enhances usage of renewables.

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

On a cost-per-unit-energy basis, Minnesota's wind and solar resources now outcompete traditional fossil fuel generation and prices continue to drop. Minnesota produces a lot of solar during the day -- and wind both day and night. These energy resources are intermittent and complementary. If we want to maximize the economic, environmental and social benefits of renewables for rural/farm-scale operations and urban-integration we will need to test storage solutions. With storage, utilities and consumers have the ability to store overproduction and time-shift the energy usage to when grid demand is highest and energy prices are highest. In high-tech states, universities work with regulators to improve their understanding of emergent technologies and how they would integrate them into the evolving power system. UMN Morris, as a nexus of research, implementation and outreach in renewable energy, is an ideal host site for this project. The campus has experience working successfully with various federal funding agencies (e.g., Department of Agriculture, National Energy Technology Laboratory (NETL) and the State of Minnesota, as well as with private partners, to help fund a vigorous energy research program. UMN Morris produces the most on-site energy per student in the entire United States.

What is your proposed solution to the problem or opportunity discussed above? i.e. What are you seeking funding to do? You will be asked to expand on this in Activities and Milestones.

Flow batteries hold the greatest potential for large-scale storage. Flow batteries use less expensive materials than lithium-ion batteries; need significantly less energy for ventilation and cooling; perform better at low-temperature; and can cycle continuously without degradation. In short: they have great potential to be adapted to Minnesota's punishing temperature extremes. This proposal adds a 1MW/4MWh flow battery and 175 kW of solar PV generation to UMN Morris's unique, renewable-energy-intensive microgrid, in a research-and-demonstration project aimed at accelerating the pace of Minnesota's transition to clean, reliable, and local energy. The UMN Morris microgrid is an ideal test-bed to explore the optimization of battery-charging and dispatch as part of a dynamic, intermittent system -- the optimizing multiple benefits will be a major determinant of the economic viability of an installation. The campus is a member of the award-winning initiative called the Morris Model. Our community partnership focuses on clean energy, energy-efficiency and community resilience, and was inspired by our close partnership with the rural town of Saerbeck, Germany. Morris Model partners include the city of Morris, UMN West Central Research Outreach Center, Morris Area School District, Stevens County, Stevens Community Medical Center, and Otter Tail Power Company.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

Wind and solar are strategic resources. We are not maximizing the potential of these resources in Minnesota to provide clean energy. Pollution from power plants has human and environmental impacts. For example, increased rates of asthma makes people vulnerable to respiratory diseases. Energy storage is a key enabling-technology that will provide an enhancement of our ability to utilize wind and solar. Renewables and storage can be paired to stack benefits. On less than 10 acres, you can install 1000kW solar, and generate over 1M kWh. Solar-storage installations on-farm can provide shading for animals, increase pollinator habitat, and time-shifted electricity production.

Project Location

What is the best scale for describing where your work will take place?

Statewide

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

During the Project

Activities and Milestones

Activity 1: Install, test and analyze flow battery initial performance

Activity Budget: $1,650,000

Activity Description:
UMN Morris and OTPCO will select, install, and test the initial performance of a flow battery at UMN Morris. UMN Morris has the capacity to implement a Request-For-Proposal (RFP) process to solicit competitive bids for equipment. Our project team will meet bi-weekly during the planning and installation phase and move to monthly meetings in the test/analysis-phase. We have assembled a team of partners with expert knowledge in developing microgrid controls and conducting energy-based financial analyses. We have a utility partner who knows how the utility sector operates and wants to better understand how to stack multiple-value chains to enhance the benefits of stored energy and its use on the grid.

Activity Milestones:

Description	Completion Date
Project Planning, Acquisition of Flow Battery	December 31, 2022
Installation and Commissioning of Flow Battery	July 31, 2023
Flow Battery Testing and Initial Experimentation	December 31, 2023

Activity 2: Install, test and analyze solar PV system and initial performance

Activity Budget: $548,000

Activity Description:
UMN Morris will select, install, and test the performance of a 175kW solar PV system connected to the UMN Morris microgrid. As described above, UMN Morris has the capacity to implement a Request-For-Proposal (RFP) process to solicit competitive bids for equipment. A system of this size will allow our team to research how wind and solar work integrate with battery storage on a community-scale grid. Wind is stronger at night and solar is strong in the daytime allowing battery storage across a 24-hr period. In other high-tech states, creating a testbed location that can test different storage solutions at-scale is important. This is what we are doing.

Activity Milestones:

Description	Completion Date
Project Planning, Acquisition of Solar PV system	July 31, 2022
Installation and Commissioning of Solar PV system	December 31, 2022
Solar PV Array Testing and Experimentation	December 31, 2023

Activity 3: Flow-battery and renewable integration research, optimization, and report production

Activity Budget: $210,000

Activity Description:
A large-scale demonstration of a flow battery will be the first-of-its kind in Minnesota. The team will analyze the performance of the combined system (battery/solar/wind); conduct an economic analysis of the combined system; prepare a final report; and disseminate the report broadly. Stored energy can be used in a number of different ways to improve grid performance. As more renewable energy is put on the grid, like wind, there is a reduction in the “electrical inertia” provided by these systems, which leads to frequency irregularities on the grid. Storage systems can supply or absorb power as needed in response to these frequency deviations in a special way, which enhances the stability of a

grid fed by clean energy. The Energy Transition lab has the capacity to help disseminate this information across Minnesota. An Energy-Transition-Lab-led delegation of scientists, engineers and policymakers traveled to California and Washington to visit several microgrid/battery installations, including leadership at the California Public Utilities Commission and California ISO. CA regulators work with universities and utilities to support pilot projects that increase their regulatory confidence as new technologies are integrated into their regional grid. This project is modeled on the cutting-edge progress we observed.

Activity Milestones:

Description	Completion Date
System Analysis (of combined battery/solar/wind integration)	July 31, 2022
Economic Analysis (of combined battery/solar/wind integration)	December 31, 2023
Final Data Analysis and Report completed -- dissemination to public/presentations	June 30, 2024

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Dr. Arne Kildegaard	Professor of Economics, University of Minnesota, Morris	Kildegaard has extensive experience in energy systems analysis and modeling particularly with respect to integrating distributed energy resources (DERs). He will work with the project team to take actual demonstration data to model implementation of the project and economic benefit to the overall grid, small communities and utilities.	Yes
David Heim	Chief Strategy Officer, OATI	Heim holds the positions of Associate Vice President and Chief Strategy Officer at USA Microgrids (USA MG) and Open Access Technology International, Inc. (OATI). Heim will be the lead on implementing controls to understand the best approach to maximize the utilization to meet the demonstration goals of the project.	Yes
Blaine Hill	City Manager, City of Morris	Hill leads the climate protection partnership agreement with the city of Saerbeck, Germany and has begun implementing projects to reduce energy use, identify renewable energy sources and ways to protect the environment. Hill will collaborate on the Flow-Battery project along with the demonstration as part of the Morris Model.	No
Jason Grenier	Manager, Market Planning, Otter Tail Power Company	Grenier has over 16 years in the electric utility industry, including 12 years with OTPCO. He oversees the development and marketing of OTPCO's energy conservation, demand response, e-business, small-scale solar, and electric vehicle customer offerings. Grenier will provide leadership in connection to OTPCO including the acquisition of the battery.	No

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.
The Morris Campus hosts many tours from visitors from across the world. We plan to present this information at conferences, through webinars, and campus website information. The goal will be to add data to the website to allow students, industry and curious citizens the opportunity to learn about the project and benefits. As part of the Morris Model, we participate in outreach across the state to serve as a demonstration platform for people to learn about these projects, including local conferences and visitors. The project will be shared through our regular University news service. The economic analysis has potential for publication. In all of these efforts we will acknowledge the support of the Environment and Natural Resources Trust Fund.

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this be funded?
This 3-year project is another step in a multi-stage project. This project is focused on testing the feasibility and performance of flow batteries in our Minnesota climate. We will learn how batteries can integrate with renewable energy sources, resulting in a thorough, publicly-available, cost-benefit analysis and system-integration study. As described above, UMN Morris is a national leader in working with partners to demonstrate community-scale energy solutions for the 21st-century. After project completion, we will continue to advance this effort as part of our overall goal of being a model clean-energy-and-storage, research-and-demonstration site in the United States.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Project Economist		Part-time role to provide economic analysis of the project for consideration of fiscal benefits to the grid.			36.5%	0.6		$78,452
Project Engineer		Lead the installation and technical analysis of the project			36.5%	3		$322,738
							Sub Total	**$401,190**
Contracts and Services								
TBD - Selected Battery Manufacturer	Professional or Technical Service Contract	Installation contract for battery with selected flow battery manufacturer including Engineering support for startup. The cost to install the battery is 25% in addition to the total battery cost.				-		$550,000
TBD - Battery Manufacturer	Professional or Technical Service Contract	Operations & Maintenance for year 1, 2, 3 from flow battery manufacturer, $50,000 per year to ensure proper operation of the battery.				-		$150,000
USA Microgrids - an OATI Company	Professional or Technical Service Contract	Microgrid controls contract for Microgrid and grid tie optimization. USA Microgrids, an OATI company, provides a broad array of professional services related to DER and microgrid project development and implementation including DER/microgrid controls design expertise and integration.		X		0		$240,000
							Sub Total	**$940,000**
Equipment, Tools, and Supplies								
							Sub Total	**-**
Capital Expenditures								
		10% of Flow Battery Purchase Price	The University of Minnesota, Morris portion of the battery purchase to	X				$250,000

			account for the demonstration aspect of the public private partnership.					
		175 KW solar array	Demonstrate large scale solar supply to flow battery storage.	X				$448,000
		Site Controller for Battery Integration	Equipment to control when to charge the battery, at what rate of speed and when to discharge the battery.	X				$50,000
		Power Conversion System - 10 Inverters	Inverters will convert AC power to DC to be stored in the battery and then converted back to AC for use in the grid.	X				$300,000
							Sub Total	**$1,048,000**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Mileage, Lodging, Meals for 4 overnight trips per year, 8 day trips with only mileage charged. We will follow University of Minnesota, travel guidelines, rates and policies.	In-state travel for project engineer and economist to conduct outreach and attend meetings with partners.					$14,310
							Sub Total	**$14,310**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Printing	Printing 250 copies of publications. Printing of large posters and educational diagrams	Produce a guide for "Storing Renewable Energy in Flow-Battery for Grid Use and Resiliency" guide targeted at communities, researchers and utilities. Large printed posters to present research at public events. Printing educational diagrams and					$4,500

			banners on the battery to describe the project for visitors to the site.					
							Sub Total	**$4,500**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$2,408,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Contracts and Services - USA Microgrids - an OATI Company	Professional or Technical Service Contract	Microgrid controls contract for Microgrid and grid tie optimization. USA Microgrids, an OATI company, provides a broad array of professional services related to DER and microgrid project development and implementation including DER/microgrid controls design expertise and integration.	OATI selected as leading provider in Minnesota and partner on project. Founded in Minnesota and operating since 1995, OATI has provided technology and software solutions to the energy industry in transmission and reliability management, energy trading and risk management, and smart grid applications. More than 98% of North American energy industry organizations use OATI solutions. OATI is the leader in this area and providing a single source contract will make sure we have the best success in this project. In our research, the comparable vendors are limited in the ability to make this project successful. OATI is also providing in-kind resources on this project. **This is a single source contract.**
Capital Expenditures		10% of Flow Battery Purchase Price	Battery will continue to be used after the project time period for continued demonstration of this project. **Additional Explanation :** The battery will have a useful life of 20 years. The demonstration of the project will last long after the completion of the project.
Capital Expenditures		175 KW solar array	Solar Array will continue to be used after the project period for continued demonstration of this project and future demonstration renewable energy work on campus. **Additional Explanation :** The useful life of the solar array will be 20-25 years. The power will be supplied to the campus grid and will last as long as the battery if not longer.
Capital Expenditures		Site Controller for Battery Integration	Site Controller will continue to be used with the battery after the project time period for continued demonstration of this project. **Additional Explanation :** The useful life of the site controller will be 10-15 years. The demonstration of the project will last long after the completion of the project.
Capital Expenditures		Power Conversion System - 10 Inverters	Power conversion system will continue to be used with the battery after the project time period for continued demonstration of this project. **Additional Explanation :** The battery will have a useful life of 10-15 years. The demonstration of the project will last long after the completion of the project.

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
In-Kind	Unrecovered U of M indirect costs	Support provided to the project by Project Manager, overhead from the University.	Secured	$401,671
			State Sub Total	**$401,671**
Non-State				
In-Kind	USA Microgrids, an OATI Company	USA Microgrids will provide in-kind support for the installation and design of the control systems along with supporting the use cases to test in the microgird system.	Secured	$120,000
In-Kind	Otter Tail Power Company	Otter Tail Power Company will purchase 90% of the battery for use in the demonstration project to understand the interaction of the battery with the grid and how these technology could support resiliency across the state and their service territory.	Secured	$2,500,000
			Non State Sub Total	**$2,620,000**
			Funds Total	**$3,021,671**

Attachments

Required Attachments

Visual Component

File: 53218970-7b2.pdf

Alternate Text for Visual Component

Representation of wind and solar power feeding a flow battery for campus demand or Morris community grid. Two images of flow batteries in production. Map representing potential location of battery and solar on the University of Minnesota, Morris campus....

Optional Attachments

Support Letter or Other

Title	File
OATI - USA Microgrids Letter of Support	4dd18804-620.pdf
Otter Tail Power Company Letter of Support	3331eb1a-031.pdf
Background Check Certification	558f4342-4f2.pdf

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

The change in the workplan was to reduce the solar installation for the project from 500kW to 175kW. The focus of the project on the demonstration of the battery storage can still be achieved with a smaller solar installation.

Additional Acknowledgements and Conditions:

The following are acknowledgements and conditions beyond those already included in the above workplan:

Do you understand and acknowledge the ENRTF repayment requirements if the use of capital equipment changes?

Yes

Do you agree travel expenses must follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

Yes, I agree to the UMN Policy.

Does your project have potential for royalties, copyrights, patents, or sale of products and assets?

No

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

N/A

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

N/A

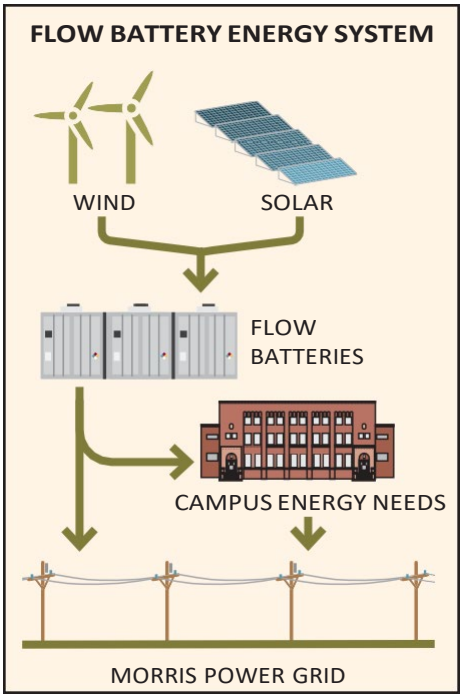
Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

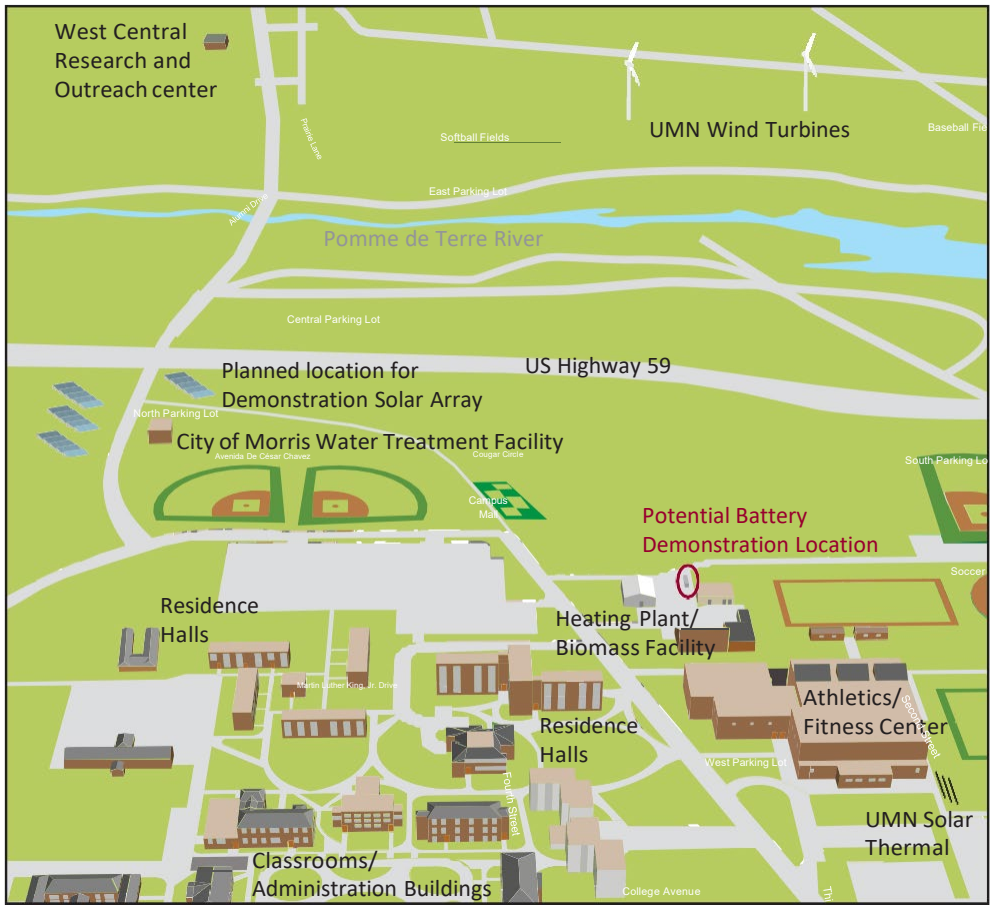
Yes, Sponsored Projects Administration

B. Visual Component or Map



exterior of flow batteries

interior of flow battery



University of Minnesota Morris campus and surrounding area

BATTERY BENEFITS

- Builds resiliency of energy supply
- Demand-reduction
- Provides for time-shifting of energy
- Improves grid services

FLOW BATTERY BENEFITS

- Improved cold weather performance
- Reduced need for HVAC for cooling
- Unlimited number of cycles—no degradation over time
- Reduced end-of-life challenges
- Less need for rare earth metals
- Workforce development and serviceability

WHY MORRIS?

Morris is the ideal location for a large scale flow-battery project.

- UMN Morris campus functions as a city within a city
  - Campus is 1 million square feet, powered by renewable-energy
  - 5,349 residents of Morris and about 2,000 people each day on campus
- Main industries of the region: agriculture, manufacturing, education, and healthcare.

The award-winning Morris Model partnership provides for natural collaboration among its members:

- UMN Morris
- UMN West Central Research and Outreach Center
- USDA ARS North Central Soils Conservation Research Lab
- Morris Area School District
- Stevens Community Medical Center
- Otter Tail Power Company

University of Minnesota Morris

Otter Tail Power Company

This project is a unique opportunity to collaborate through a public and private investment in the state's future.