Environment and Natural Resources Trust Fund

2026 Request for Proposal

General Information

Proposal ID: 2026-538

Proposal Title: Wind Resource Assessment for Minnesota Energy Resiliency

Project Manager Information

Name: Lian Shen

Organization: U of MN - St. Anthony Falls Laboratory

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Project Basic Information

Project Summary: To enhance Minnesota's energy resiliency, we will develop a high-resolution wind resource forecasting tool validated by in-situ measurements, specifically targeting improved predictions during extreme winter weather and turbine icing events.

ENRTF Funds Requested: $289,000

Proposed Project Completion: June 30, 2029

LCCMR Funding Category: Small Projects (G)
Secondary Category: Resiliency (A)

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 and In the Future

Narrative

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

Wind energy accounted for approximately 25% of Minnesota's electricity production in 2023, reaching an installed capacity of over 4,500 megawatts (MW). The sector has attracted substantial capital investment and supports employment across more than 100 active manufacturing facilities statewide. However, Minnesota faces growing electricity demands driven by rapid expansion in data centers, positioning the state as an emerging national hub. Additionally, recent uncertainties surrounding US-Canada electricity trade—including potential tariffs and supply disruptions—highlight the critical need to enhance Minnesota's own renewable energy capacity. Reliable wind energy forecasting is essential to sustainably meeting this increased demand and ensuring stable grid operations. Currently, statewide wind forecast models have a resolution limited to approximately 2 kilometers, insufficient for capturing local site-specific variations. Moreover, Minnesota's severe winter conditions introduce unique forecasting challenges, as existing models often miss significant power losses due to turbine icing or shutdowns during extreme cold events, such as those induced by polar vortex breakdowns. Therefore, developing higher-resolution predictive models specifically addressing these cold-weather impacts is essential to optimize wind farm performance, improve operational planning, and ensure consistent energy delivery.

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

We propose developing a locally tailored, high-resolution wind resource map for Minnesota using an advanced numerical weather prediction model to enhance wind energy forecasting at targeted wind farm locations. Our simulations will significantly enhance the accuracy of day-ahead forecasts, enabling more effective grid management and improved integration of renewable energy resources. The reliability of our modeling approach will be ensured by validating results against comprehensive meteorological tower measurements and operational data from existing wind farms. To address Minnesota's distinctive climatic conditions, our simulations will integrate global-scale weather patterns with localized computational forecasts, with a particular focus on predicting extreme cold weather events, such as polar vortex occurrences. Additionally, a specialized turbine icing model will be incorporated to anticipate icing conditions, enabling proactive operational responses and minimizing turbine downtime. Our methodology directly addresses cold-weather-related forecasting challenges, thus enhancing energy resiliency and grid reliability throughout the year. This project will deliver refined predictive capabilities, leading to reduced downtime, increased efficiency in energy production, and strengthened renewable energy infrastructure. Ultimately, our work supports Minnesota's renewable energy objectives by providing precise and reliable wind forecasting tools tailored to the state's unique environmental conditions and energy demands.

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?

The project outcomes will contribute to protecting Minnesota's natural resources by advancing the state's renewable energy capacity and grid resiliency. Improved wind forecasting accuracy will facilitate the efficient integration of wind energy, reducing reliance on fossil fuels and mitigating greenhouse gas emissions. Enhanced predictive models specifically targeting extreme winter weather and icing conditions will minimize downtime and resource waste, thereby optimizing wind turbine operation and prolonging the lifespan of infrastructure. The publicly accessible wind resource database and predictive tools developed will empower informed decision-making among policymakers, industry stakeholders, and communities, ultimately supporting Minnesota's goals for environmental sustainability and energy independence.

Activities and Milestones

Activity 1: Comprehensive Wind Resource Database Development

Activity Budget: $80,000

Activity Description:
This activity aims to develop an extensive and high-quality wind resource database for Minnesota, capturing essential meteorological variables such as wind speed, direction, air temperature, humidity, and atmospheric pressure. The database will encompass a wide range of weather conditions, including extreme winter events, enabling the precise validation and calibration of the predictive wind modeling tool. Historical weather records will be sourced from operational wind farms and the University of Minnesota's wind research field station. Real-time data acquisition will continuously enrich the database, thereby facilitating its applicability across seasonal variations and enhancing the reliability of day-ahead forecasting. The compiled dataset will be structured to enable seamless integration into high-resolution wind models, such as the Weather Research and Forecasting (WRF) system. Outcomes of this activity will significantly enhance forecasting accuracy, thus aiding grid operators in managing renewable energy integration effectively. The database will be publicly accessible, providing valuable resources for future research and renewable energy development. Activity outcomes will be evaluated through comprehensive quality assurance checks, data validation against known meteorological events, and stakeholder feedback to ensure utility and reliability.

Activity Milestones:

Description	Approximate Completion Date
Historical weather data collection completed	June 30, 2027
Real-time wind turbine data integration completed	September 30, 2027
Data compilation from UMN's wind research field station completed	December 31, 2027
Final data structuring and integration into a unified database	March 31, 2028
Public release of the wind resource database	December 31, 2028

Activity 2: High-Resolution Wind Resource Modeling for Minnesota

Activity Budget: $90,000

Activity Description:
The objective of Activity 2 is to develop a Minnesota-specific, high-resolution predictive wind resource modeling tool utilizing the Weather Research and Forecasting (WRF) model. This simulation tool will capture local meteorological phenomena influencing wind energy production, including land-induced variability and atmospheric boundary layer dynamics. Detailed land characterization and land-use data will be integrated into the WRF model to enhance predictive precision. Initial model configurations will focus on simulating baseline atmospheric conditions at selected wind farm sites, followed by extensive simulations covering typical annual weather scenarios. Validation will involve rigorous comparisons between model predictions and observed meteorological data from Activity 1. Outcomes will include a validated predictive tool capable of accurately forecasting wind conditions, enabling grid operators and energy planners to optimize wind energy utilization and ensure grid stability. Model performance will be continuously assessed through statistical metrics and feedback from industry stakeholders, with iterative refinements conducted as needed to meet forecasting objectives.

Activity Milestones:

Description	Approximate Completion Date
Initial WRF model setup and configuration	June 30, 2027
Land and meteorological data integration completed	September 30, 2027

Completion of initial wind simulations	December 31, 2027
Model validation using the Activity 1 database	June 30, 2028
Finalized model refinement and documentation completed	December 31, 2028

Activity 3: Enhancing WRF Predictive Modeling of Extreme Winter Weather Events

Activity Budget: $80,000

Activity Description:
Activity 3 focuses on enhancing the predictive capabilities of the WRF modeling tool specifically for extreme winter weather conditions, including polar vortex events. The primary task involves integrating North American Mesoscale (NAM) forecasts into the existing WRF framework to predict severe cold weather and potential disruptions to wind turbine operations. A detailed wind turbine icing model, recently developed at the University of Minnesota by Professor Lian Shen and coworkers, will be integrated to forecast icing events that can reduce turbine performance and energy output. Historical events will serve as validation benchmarks, ensuring that model enhancements accurately reflect the actual operational challenges of wind farms during extreme weather conditions. The outcomes of this activity will significantly improve proactive turbine management strategies during severe cold events, reducing downtime and improving grid reliability. Continuous evaluation through historical validation, scenario testing, and feedback from wind farm operators will ensure the practical utility and effectiveness of the predictive model enhancements.

Activity Milestones:

Description	Approximate Completion Date
Integration of NAM forecasts into the WRF model	December 31, 2027
Turbine icing model integration completed	June 30, 2028
Model validation with historical winter weather data	September 30, 2028
Optimized forecasting model for extreme winter events	December 31, 2028
Final validation and readiness testing	March 31, 2029

Activity 4: Stakeholder Engagement, Dissemination, and Training

Activity Budget: $39,000

Activity Description:
Activity 4 focuses on stakeholder engagement, the dissemination of project outcomes, and training to ensure the wide adoption and practical application of the developed tools. Project results, including the comprehensive wind database and the advanced WRF predictive model, will be disseminated through workshops, seminars, and online platforms targeting industry stakeholders, policymakers, utility operators, and academia. Training sessions will provide hands-on experience in using the new predictive tools, emphasizing practical applications for grid management and renewable energy integration. Additionally, educational resources, including detailed user manuals and training materials, will be developed to support independent use by stakeholders. The effectiveness of stakeholder engagement and training activities will be measured through participation rates, stakeholder surveys, and feedback mechanisms, which will guide ongoing refinements to ensure continued relevance and impact. Ultimately, this activity ensures that project outcomes translate into practical benefits for Minnesota's energy resiliency goals, enhancing the overall effectiveness and sustainability of the state's renewable energy infrastructure.

Activity Milestones:

Description	Approximate Completion Date
Initial stakeholder engagement workshop	August 31, 2028

Completion of user training materials	December 31, 2028
Statewide dissemination seminar	March 31, 2029
Final stakeholder training sessions completed	June 30, 2029

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Jeffrey Miroch	DOE Lawrence Livermore National Laboratory	Atmosphere Scientist in the Atmosphere, Earth and Energy Division	No

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 work be funded?

After project completion, we will ensure long-term data accessibility through established partnerships with the University of Minnesota and state agencies, integrating developed models into Minnesota's existing energy resiliency frameworks. Continued funding will be secured through collaborative grants from state and federal agencies, national laboratories—including Lawrence Livermore National Laboratory—and private sector partnerships to maintain model accuracy and address emerging forecasting challenges. Additionally, we will enhance public understanding and workforce readiness by organizing educational symposiums and training seminars at the St. Anthony Falls Laboratory (SAFL) and disseminating findings to industry stakeholders, policymakers, and the broader public.

Project Manager and Organization Qualifications

Project Manager Name: Lian Shen

Job Title: Professor

Provide description of the project manager's qualifications to manage the proposed project.

Dr. Lian Shen is a Distinguished McKnight University Professor at the University of Minnesota. He also holds the Kenneth T. Whitby Professorship in the Department of Mechanical Engineering and serves as the Director of the St. Anthony Falls Laboratory. He earned his Doctor of Science degree from Massachusetts Institute of Technology in 2001. After three years of postdoctoral training at MIT, he joined the faculty of Johns Hopkins University in 2004. In 2012, he was recruited by the University of Minnesota to join its faculty. Dr. Shen is a world expert in the research of environmental fluid flows and renewable energy, with more than 150 papers published. He is also a member of the editorial boards of five internal academic journals. Dr. Shen has organized several national and international conferences and symposiums and has participated in many research projects funded by federal and state agencies.

Organization: U of MN - St. Anthony Falls Laboratory

Organization Description:

This project will be performed at the St. Anthony Falls Laboratory (SAFL, http://www.safl.umn.edu) at the University of Minnesota. SAFL is an interdisciplinary fluid mechanics research and educational center. It has 22 faculty members and 27 research and administrative staff members. Each year, more than 100 postdocs and students conduct research at SAFL. SAFL is a world-renowned research laboratory specializing in environmental, geophysical, and engineering fluid mechanics. SAFL researchers have been performing many innovative environmental studies for Minnesota. Some of the projects were/are funded by the Minnesota Environment and Natural Resources Trust Fund. The proposed research leverages the unique and advanced capabilities of simulating and measuring environmental and geophysical flows at SAFL, which has 16,000 square feet of research space dedicated to research.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Project Manager		Oversee the whole project, supervise the research team, lead the research, and responsible for project reporting			26.8%	0.12		$40,348
Postdoctoral Associate		Conduct numerical weather prediction model simulations for Minnesota			20.6%	2.49		$204,975
Computer Scientist		Assist computational model setup and data sharing			24.4%	0.24		$25,090
Undergraduate Student Assistant		Assist data analysis and model validation against measurement data			0%	0.48		$16,320
							Sub Total	**$286,733**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
							Sub Total	**-**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
							Sub Total	**-**
Travel Outside Minnesota								

							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
		No Capital Equipment	Computer data storage for archiving the data of this project and data sharing					$2,267
							Sub Total	**$2,267**
							Grand Total	**$289,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
In-Kind	Unrecovered F&A	Support of SAFL facilities where research will be conducted.	Secured	$156,060
			Non State Sub Total	**$156,060**
			Funds Total	**$156,060**

Total Project Cost: $445,060

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 3a8786b4-52d.pdf

Alternate Text for Visual Component

This slide highlights Minnesota's 2040 renewable energy goal and identifies the coarseness of current wind resource maps as a problem. It presents a plan to develop a predictive modeling framework for accurate wind forecasts and outlines the project's expected outcomes....

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
Letter of University of Minnesota SPA	c021255b-8bb.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

N/A

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

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

Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?

No

Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care, treatment, education, training, instruction, or recreation to children")?

No

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:

Victoria Troxler

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

N/A