Environment and Natural Resources Trust Fund

2024 Request for Proposal

General Information

Proposal ID: 2024-237

Proposal Title: LiDAR Technology Preventing Wildlife Fatalities from Wind Turbines

Project Manager Information

Name: Sayan Biswas

Organization: U of MN - College of Science and Engineering

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Project Basic Information

Project Summary: Create a low-cost and advanced LiDAR package to detect and prevent wildlife collisions with wind turbines, safeguarding bats, birds, and other wildlife from fatal accidents.

Funds Requested: $550,000

Proposed Project Completion: June 30, 2026

LCCMR Funding Category: Methods to Protect, Restore, and Enhance Land, Water, and Habitat (F)

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 is a cost-competitive and clean energy source, but it has an undesirable environmental impact on wildlife, particularly birds and bats. Nearly 1.7 million birds and bats (including endangered species) are killed from collisions with wind turbines in North America each year, which is a significant fatality rate considering that wind energy accounts for only 7.3% of generation in the US. This problem will only get worse if more states commit to wind energy in the future. LiDAR (Light Detection and Ranging) technology can help prevent bird and bat fatalities with wind turbines by providing real-time data on the flight patterns of these wildlife near the turbines. By installing LiDAR sensors on wind turbines, wind turbine operators can track the movement of birds and bats in the vicinity of the turbines, enabling operators to adjust the turbines' operation and lower the collision risk. Unlike regular camera imaging that works only in daylight or a thermal camera that is expensive, a long-range LiDAR system combined with bioacoustics sensors can precisely estimate the 3D flight paths of wildlife near wind turbines. The project aims to develop a low-cost and advanced LiDAR package to prevent wildlife fatalities with wind turbines.

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.

LiDAR works by emitting a laser beam that bounces off objects and returns to the sensor, creating a 3D map of the surrounding environment. A cost-effective long-range LiDAR detection technology that can detect bats and birds from 0.3-0.5 miles away will be developed to precisely estimate the location, attitude, and 3D flight paths of bats and birds. In conjunction with LiDAR, ultrasonic bioacoustic detectors will be used to identify different bird and bat species. A computationally inexpensive machine learning algorithm will be developed to predict the direction of travel of these bats and birds. Our LiDAR-based sensor package will be deployed and tested at the University of Minnesota's 2.5 MW wind energy research station in Rosemount, Minnesota. This test site is just 2 miles from the western bank of the Mississippi River and attracts a large number of Minnesota birds (eagles, hawks, songbirds, waterfowl, and grouse) and bats (hoary, big brown, eastern red, silver-haired, and little brown bats). We will collaborate with the UMN Office of Technology Commercialization to bring this technology to market. The technology will be commercialized in the future and can help save millions of birds and bats while promoting clean wind energy.

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?

Minnesota is home to 400 bird species including bald eagles, golden eagles, hawks, falcons, songbirds, waterfowl, and 8 major bat species, with four listed as Special Concern by the Minnesota Department of Natural Resources, including the northern long-eared bat which is also protected by the Federal Endangered Species Act. Growing demands for clean wind energy threaten the bird/bat population, making them critically endangered. These bird and bat species are vulnerable during migration when they can come into contact with wind turbines while flying at low altitudes. Our LiDAR technology will help design reliable wildlife deterrence or mitigation technologies.

Activities and Milestones

Activity 1: Development, instrumentation, and integration of LiDAR-based sensor systems

Activity Budget: $220,000

Activity Description:
In this activity, the LiDAR, camera imaging, bioacoustics, and data acquisition sensors will be calibrated, tested, and prepared for field testing. In addition to PI Biswas's two Luminar LiDAR systems, three additional long-range LiDAR systems will be acquired for this project with a 0.3-0.5 miles range and spatial accuracy of less than 2 cm. PI Biswas possesses high-speed and infrared thermal cameras that will be synchronized with LiDAR systems as a reference measuring system. Different LiDAR systems will cover upstream and downstream air space of the wind turbine, blades, and meteorological (met) tower. Co-PI Feist's noise logger, weather station, and a wind speed LiDAR system will be used to monitor the weather conditions and wind speed/directions. WEST, Inc. will acquire/provide 14+ ultrasonic microphones and acoustic detectors to identify bat species. The centerpiece of the Eolos Wind Energy Research Consortium is the field research station at UMore Park in Rosemount, MN. The focal points of the site are a Clipper Liberty 2.5 MW wind turbine and a 130-meter-tall met-tower constructed 170 meters south of the turbine. The sensor system will be deployed at the Rosemount test site and the immediate surrounding area.

Activity Milestones:

Description	Approximate Completion Date
Set up and synchronize LiDAR, cameras, and bioacoustic sensors	December 31, 2024
Complete testing of the sensor system in a laboratory setting	February 28, 2025
LiDAR systems capable of detecting bats and birds from 500+ meter distance	April 30, 2025
Activity 1 summary report	May 31, 2025

Activity 2: Comprehensive field testing of bird and bat interactions with wind turbine using LiDAR

Activity Budget: $160,000

Activity Description:
A full season, June to October (5 months), when wildlife birds and bats are most active in central Minnesota, will be dedicated to field testing at the University of Minnesota's state-of-the-art 2.5 MW wind energy research station in Rosemount, Minnesota. Some of the major bird species that are threatened by wind turbines in Minnesota include bald eagles, golden eagles, hawks, falcons, songbirds, and waterfowl. The common bats encountered in central Minnesota are hoary bat, big brown bat, eastern red bat, and silver-haired bat. Every day during the season, the LiDAR and imaging data will be recorded all day and night, from sunset to sunrise. LiDAR and cameras will be remotely monitored and will be checked in person on a weekly basis. PI Biswas is currently working on a machine-learning algorithm to develop an automated triggering system to start recording LiDAR and camera data once a bird or bat is detected. This would significantly reduce the man hours needed to review the data to find bat activities in the LiDAR videos. The aim of this task is to determine the appropriate operating parameters for the LiDAR technology and to calibrate and incorporate the LiDAR sensor with the bioacoustic sensor.

Activity Milestones:

Description	Approximate Completion Date
Deploy LiDAR sensing systems for field testing	June 30, 2025
Complete the first field testing campaign	October 31, 2025
Calibrate and optimize the LiDAR system	November 30, 2025
Complete analysis of LiDAR data of bats and birds interacting with wind turbine	December 31, 2025

Activity 2 summary report	December 31, 2025

Activity 3: LiDAR package development, calibration, data analysis and hypotheses testing

Activity Budget: $80,000

Activity Description:
The use of high-precision LiDAR data will assist us in comprehending the underlying theories as to why birds and bats are drawn to wind turbines. We plan to vary the speed of the turbine blades as much as possible to analyze the impact of the turbine's operational parameters on birds and bats. This information will be invaluable not only in using deterrent technologies to mitigate fatalities but also in identifying long-term solutions. Currently, the major deterrent technologies are: acoustic Deterrents, visual Deterrents, and blade-mounted Acoustic Devices. Our LiDAR technology will dramatically improve the effectiveness of our deterrents. The following key hypotheses address why birds and bats collide with wind turbines.
H1) Birds flying in flocks are less likely to fly near turbines.
H2) Birds flying during light hours are less likely to fly near turbines than birds flying at night.
H3) Bird flight in relation to turbine heading (wind direction) is the same.
H4) Migratory bird flights are predicted by weather fronts.
H5) Bats are attracted to operating turbines. Blade movement (visual stimulus) or sounds may attract bats.
H6) Bats use turbines as roosts.

Activity Milestones:

Description	Approximate Completion Date
Complete LiDAR video processing and data analysis	March 31, 2026
LiDAR + bioacoustics sensor integration and sensor package development	April 30, 2026
Detailed testing of LiDAR sensor package in the field, calibrate and optimize the LiDAR sensor	May 31, 2026
Activity 3 summary report	May 31, 2026

Activity 4: Additional field testing to fine-tune LiDAR package, if necessary (optional)

Activity Budget: $20,000

Activity Description:
If our team realizes that we need additional field test data towards a specific situation with a specific sensor arrangement, in case a) we did not obtain conclusive results in the first field testing or b) we found interesting bird and bat behavior that requires additional field testing. The same UMore park wind turbine facility will be used to gather a few more weeks' worth of field data in the following season Y2025, between March to May, which covers the spring bird and bat migration time period. If, for some reason, we do not find enough wildlife activities at the Rosemount wind facility, our backup option is Xcel Energy's Blazing Star wind farm with a 200 MW capacity located in southwest Minnesota's Lincoln County. Xcel Energy is extremely supportive and enthusiastic about our project (please see their support letter), and they will partner with us if we are successful in receiving funding.

Activity Milestones:

Description	Approximate Completion Date
Complete additional field testing to recalibrate and fine-tune the LiDAR system, if necessary	May 31, 2026

Activity 5: Reporting, IP and patent filing, results dissemination, and journal paper writing

Activity Budget: $70,000

Activity Description:

This phase of the project will focus on the final data analysis and report writing. In addition to meeting the deliverable requirements of the LCCMR Fund, the project team will prepare manuscripts for submission to peer-reviewed journals and will communicate the results of the project to the wind industry as well as companies that produce bat detection and deterrent systems.

Activity Milestones:

Description	Approximate Completion Date
File IP and patents before any public disclose of research results	September 30, 2025
Finished writing the first draft of the journal/conference article	March 31, 2026
Activity 3 summary report	April 30, 2026
Final project report	June 30, 2026

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Christopher Feist	St. Anthony Falls Laboratory, University of Minnesota	Christopher Feist has been involved in SAFL and wind energy research on projects ranging from novel wind turbine drivetrains to health monitoring of wind turbine foundations to mapping the hearing abilities of bald and golden eagles. Chris will be in charge of the Rosemount wind turbine operation and sensor development.	Yes
Christopher Milliren	St. Anthony Falls Laboratory, University of Minnesota	Chris Milliren will provide technical support and develop the sensor systems used in examining wildlife-bat behavior near wind turbines.	Yes
Richard Christopher	St. Anthony Falls Laboratory, University of Minnesota	Richard Christopher will provide technical support for the development of the sensor system. Richard is also the safety officer of the research site and will develop safety plans for sensor installation at the wind energy research site.	Yes
Jennifer Stucker	Senior Research Biologist, Western EcoSystems Technology, Inc.	Dr. Jennifer Stucker is an expert in evaluating bat behavior and habitat selection in an ecological context. She has extensive experience using innovative measurement approaches to evaluate natural resources questions. She will help develop the sensor system and evaluate hypotheses. She has prior experience working at the Rosemount wind turbine.	Yes
Kevin Heist	Consulting Biologist, Western EcoSystems Technology, Inc.	Dr. Kevin Heist has a decade of experience in bat acoustic analysis, radar deployment, and analysis of imaging sensors to support bat and migration and ecology questions. He will help deploy the sensor system in the field and provide feedback on our hypotheses.	Yes

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?

Our project aims to develop an advanced yet affordable LiDAR and bioacoustic sensor package that can effectively detect birds and bats from long distances. By doing so, we intend to enhance deterrent technologies to minimize wildlife fatalities caused by wind turbines and gain insights into the behavioral patterns of birds and bats around wind facilities. We will share the outcomes of our project with the wind industry and companies that manufacture wildlife detection and deterrent systems. We will also collaborate with the UMN office of technology commercialization to license and patent our integrated sensor technology and bring it to market.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Behavioral Response of Bald Eagles to Acoustic Stimuli	M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 07d	$261,000

Project Manager and Organization Qualifications

Project Manager Name: Sayan Biswas

Job Title: Assistant Professor

Provide description of the project manager's qualifications to manage the proposed project.
Prof. Sayan Biswas, Benjamin Mayhugh Assistant Professor of Mechanical Engineering, is an expert in clean energy, LiDAR sensing, and novel laser-based sensing and diagnostics, will lead this project. PI Biswas has utilized LiDAR to solve challenging problems, including the detection of bald eagles and snow particles for self-driving cars. Besides LiDAR sensing, PI Biswas has extensive experience developing optical sensors for energy applications. His research has received support from the Department of Energy (DOE), Advanced Projects Research Agency-Energy (ARPA-E), Office of Naval Research (ONR), National Science Foundation (NSF), and several clean energy companies. He manages an annual research portfolio of $2.1M. Before joining the University of Minnesota in 2020, Dr. Biswas spent 3+ years at the Sandia National Laboratories and 5+ years at Purdue University, working on clean energy and developing advanced light/laser sensing systems. To date, PI Biswas has published 20+ journal articles, 40+ conference articles, 1 single-authored book, 6 book chapters, and holds 1 US patent. PI Biswas leads a highly diverse research group consisting of 8 PhD, 3 MS, and 10 UG students. His lab actively participates in educating the community about our energy future and in K-12 outreach activities, inspiring the next generation of scientists and engineers, and providing an open and equitable learning atmosphere for women, minorities, and indigenous students. Prof. Biswas serves on several technical and advisory committees, volunteering for his professional societies and local Minnesota-based organizations.

Organization: U of MN - College of Science and Engineering

Organization Description:
The University of Minnesota, Twin Cities is a public land-grant research university in the Twin Cities of Minneapolis and Saint Paul, Minnesota, and one of the most comprehensive research universities in the nation. The University leadership acknowledges that the University of Minnesota Twin Cities is built within the traditional homelands of the Dakota people. It is the flagship institution of the University of Minnesota System and is organized into 19 colleges, schools, and other major academic units. The University advances Minnesota state and US society through new ideas, technologies, treatments, and cures, and continues to create and transfer technology to companies for the development of new products and services that benefit the public good and foster economic growth. The University's College of Science and Engineering received $141.9 million in research funding in FY2015. The University of Minnesota College of Science and Engineering (CSE) ranks #4 in the country for the best bachelor's degree in engineering. In other rankings, CSE majors traditionally rank among the top 20.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Sayan Biswas		Principal Investigator			26.9%	0.16		$23,960
Richard Christopher		Co-Principal Investigator			26.9%	0.12		$12,514
Chris Feist		Co-Principal Investigator			26.9%	0.32		$30,606
Chris Milliren		Co-Principal Investigator			26.9%	0.12		$11,684
Research Assistant		Graduate Student			44%	1.5		$170,869
							Sub Total	**$249,633**
Contracts and Services								
Western EcoSystems Technoloy, Inc.	Professional or Technical Service Contract	provides environmental and statistical consulting services and contract research nationally and internationally. WEST offers a unique combination of field ecology and statistics to help solve ongoing and contemporary natural resource problems.				2		$170,000
Vertical Limit	Professional or Technical Service Contract	is a local Minnesota company who will help install the LiDAR and other sensors at the wind turbine and met tower. They are experts in mounting specialized sensors at tall structures.				2		$10,000
							Sub Total	**$180,000**
Equipment, Tools, and Supplies								
	Equipment	thermal imaging camera, sensor mounting	Thermal imaging of wildlife-bats near wind turbines at night					$2,000
	Tools and Supplies	Sensor mounting, lenses, weatherproof box for LiDAR, wiring supplies, plumbing parts, LiDAR maintenance and mechanical parts and fasteners	Tools and supplies (e.g., fasteners, sensor mounting boards, etc.) to add sensors to the turbine and surrounding area					$9,367
							Sub Total	**$11,367**
Capital Expenditures								

		LiDAR systems	LiDAR sensing system to measure the 3D flight path of bats and birds near wind turbines	X				$90,000
		bioacoustic sensors	Bioacoustics will provide us with information about bat species. Bioacoustic signature along with LiDAR sensing will provide the bat's activity near wind turbines.	X				$12,000
							Sub Total	**$102,000**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	a) Travelling to the wind energy test site, weekly 1-3 times for 6 months, b) One trip per year for one PI to a relevant conference	Testing campaign, knowledge dissemination and attract potential customers/end-users					$5,000
							Sub Total	**$5,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	Publication cost in open source journals	Open source journal let everyone access the research results at free of cost					$2,000
							Sub Total	**$2,000**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$550,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Capital Expenditures		LiDAR systems	To the author's knowledge, LiDAR sensing has never been used for bat sensing in the field. PI Biswas has been working in this area, wildlife detection using LiDAR for the last two years, and possesses two LiDAR sensing systems. However, for this project, 3 additional systems will be needed. A total of 5 LiDAR systems will be monitoring the wind turbine space simultaneously. This will help us understand and design the bat deterrent systems, which have not been understood and done before. The project's success is entirely reliant on simultaneous measurement of the entire air space using LiDAR. **Additional Explanation :** PI Biswas owns 2 LiDAR systems, 3 more ($25-30k each) will be purchased to cover the entire airspace near the turbines. The sensor system will be mounted on the wind turbine and met tower for monitoring. This capital equipment will be essential for our project that will pay off in two years. After two years, the PI can use these LiDAR and bioacoustic sensors for remediation of bat fatalities purposes. Bats can be detected using LiDAR and bioacoustic sensing, and different deterrent strategies will be used. These sensing systems can also be permanently installed in one of the Minnesota wind firms (e.g., Rosemount, Blazing Star, etc.) after the project life is over.
Capital Expenditures		bioacoustic sensors	Bioacoustic sensing is as important as LiDAR, since when they are combined with LiDAR sensing, a full picture of the flying wildlife, bat and bird behavior around the wind turbine can be understood. **Additional Explanation :** WEST possesses 10 bioacoustic sensors. 14+ additional sensors will be purchased to put across the 1 square mile area to detect the acoustic signature and echolocation from bats to learn which species they are.

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
In-Kind	unrecovered F&A calculated at 55% MTDC	Support of ME facilities where research will be conducted.	Secured	$218,066
			Non State Sub Total	**$218,066**
			Funds Total	**$218,066**

Attachments

Required Attachments

Visual Component

File: 728e3d89-cb3.pdf

Alternate Text for Visual Component

The visual illustrates the crisis wildlife birds and bats are facing due to growing wind energy demand in North America and Minnesota. Our proposed LiDAR-based detection technology package and its novelty/uniqueness, research team, planned experimental arrangement of LiDAR, and bioacoustic sensors in the Rosemount wind energy site are described...

Optional Attachments

Support Letter, Photos, Media, Other

Title	File
WEST, Inc. Support Letter	f3dc88fc-5dd.pdf
DOC-EERA Support Letter	56eded2d-aea.pdf
Xcel Energy Support Letter	fb867543-9ed.pdf
Ambient Particle Effects on LiDAR	b86efafe-f64.pdf
UMN Sponsored Projects Agency Letter	fc67593d-c6b.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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

Yes

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

Yes

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

No

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 design, construction, or renovation of a building, trail, campground, or other capital asset costing $10,000 or more?

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?

No