Environment and Natural Resources Trust Fund
2018 Request for Proposals (RFP)

Project Title: **ENRTF ID: 162-E**

Lowering Costs of Solar Energy in Minnesota

Category: E. Air Quality, Climate Change, and Renewable Energy

Total Project Budget: $ 410,692

Proposed Project Time Period for the Funding Requested: 3.5 years, July 2018 to December 2021

Summary:

This project will reduce the cost of PV solar projects in Minnesota by creating structural design methodologies to improve the accuracy of load estimation for both wind and snow loading.

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Sponsoring Organization: U of MN

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Images of snow covered solar arrays demonstrates drifting and loading that occurs in MN. This adds costs to solar installation, which we will reduce through the research proposed in this project.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%

PROJECT TITLE: Lowering costs of solar energy in Minnesota

I. PROJECT STATEMENT

Project Motivation: Solar energy is a cost competitive, clean energy source that offers big benefits for Minnesota. By installing more solar on homes, businesses and ground-mounted solar farms we can reduce reliance on conventional energy technologies thus reducing water use from our lakes and rivers and discharge of undesirable byproducts into our air. Electricity from solar will directly benefit Minnesota water and air.

Project Objective: The cost of solar remains a barrier to greater adoption in the state. **Half of the cost of utility and commercial scale solar PV projects is associated with Balance of System costs** (e.g. professional design services required for code compliance and permitting, racking system design, and materials/construction of the racking and PV modules). As with any structural installation, a solar project must demonstrate that it meets the appropriate design loads from wind and snow accumulation. The structural design standards used by professional engineers in MN do not directly address wind and snow loading on solar arrays; there is a gap in knowledge about how wind and snow interact with the structures. Racking systems are overdesigned with over-sized structural members and foundations to compensate for lack of accurate wind and snow modeling. ***This project will reduce the cost of large PV solar projects in Minnesota by creating structural design methodologies to improve the accuracy of design load estimation for both wind and snow loading.***

Project Outcomes: The project will provide predictive models able to minimize the installed cost of solar arrays, especially for larger installations on commercial buildings and ground-mounted solar plants. At a lower cost, solar energy will be more accessible to businesses and developers and installations will increase in the state.

Roadmap to Our Objective: Research is required to achieve this objective. SAFL-UMN and MBJ, our structural engineering partner, bring together a strong combination of fundamental knowledge, unique facilities, and professional design expertise. We will carry out research experiments in SAFL-UMN's large wind tunnel and SAFL's roof, as well as supercomputer simulations to generate accurate loading information for solar arrays on the ground and on roof-tops. The research data will be used to create computer-based loads assessment tools to assist industry in wind and snow loads characterization. We will transfer the tool immediately to manufacturers and designers for incorporation into their products and projects; directly contributing to lowering the cost of PV solar and increasing PV solar deployment in the state of Minnesota.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Finalize project roadmap – Research, tool design, and transfer to industry **Budget: $35,843**

This task will focus on developing final project goals and carrying out effective management of the project and research efforts. Meetings will include a kick-off meeting as well as at least six meetings, distributed throughout the project, between the research team and external partners.

Outcome	Completion Date
1. Finalize project objectives with external partners and publish on project website	August 2018
2. Complete and publish literature survey	December 2018

Activity 2: Wind tunnel, roof-top and computational modeling of wind and snow loading **Budget: $309,768**

Scale models of solar arrays will be fabricated and studied in SAFL's wind tunnel with snow and wind loading. Wind tunnel studies will include ground-mounted and roof top deployments. We will also deploy a full-scale array on SAFL's rooftop to record wind and snow loading. Loads will be measured over the whole array and under different wind speeds, tilt angle, turbulence, and direction. Supercomputer simulations will also be carried using wind tunnel data to validate the models. Computation model will be used for additional simulations.

Outcome	Completion Date
1. Collect data from 12 month of wind and snow loading information for **full-scale, rooftop solar array.**	June 2018

2. Develop wind and snow loading design maps for ground mounted and roof-top mounted solar arrays from the **wind tunnel data**.	March 2020
3. Develop a validated numerical model for simulating wind and snow loading, usable for ground-mounted and roof-top solar arrays.	July 2020

Activity 3: Develop design tools to lower costs of MN solar array projects **Budget: $65,081**

This task will focus on analysis and synthesis of the experimental and numerical data. Working closely with our industrial partners, we will distill the data and observations into computer-based design tools. The tools will be used by: a) manufactures of racking systems to lower cost of racking, b) structural engineers to evaluate loading on foundations and rooftops, and c) building code officials to accelerate the permitting process of projects. Results of the work will be shared with state and national structural engineering organizations such as American Society of Civil Engineers and the Minnesota Solar Energy Industry Association (MNSEIA).

Outcome	Completion Date
1. Develop design tool for **wind loading** on solar array, ground-mounted and rooftop.	December 2020
2. Develop design tool for **snow loading** on solar array, ground-mounted and rooftop.	December 2020
3. Reduce installed cost of solar by providing design tools to manufacturers, design engineering community, and state building code officials. Provide training on the tool and develop user-manual to accompany the tools.	June 2021

III. PROJECT STRATEGY

A. Project Team/Partners

The project will be carried out by staff and faculty from the ***St. Anthony Falls Laboratory***, Univ. of Minnesota (SAFL-UMN) and professional structural engineers with ***Meyers-Borgman-Johnson Structural Design and Engineering*** (MBJ). Industry stakeholders support this proposal and have agreed to serve as external advisors meeting regularly with the project team and helping guide the project. They include ***Minnesota Department of Labor and Industry, Construction Codes*** and ***Blattner Energy*** a Minnesota-based engineering-design-and construction firm with vast experience in large solar projects. We will also seek to add two manufacturers to our external advisory group.

B. Project Impact and Long-Term Strategy

The cost of solar remains a major barrier to greater penetration of this clean energy technology in Minnesota. This project will directly and indirectly help cut costs of installed solar arrays. Newly constructed buildings, as a matter of practice, will seek to accommodate solar arrays. **This project will generate design tools to help with the design and evaluation of solar array placement on new construction**. It will also lower the costs of solar array racking systems and foundations and ultimately lower the costs for project developers.

This project will generate much needed datasets and tools to reduce the cost of these installations, improving the financial viability of solar energy and increasing confidence of structural design. Project deliverables will lead to improvements in design standards and state building codes that will provide a path for solar projects to be safely installed at a commercial scale on rooftops. The research team will work with local and national organization to transfer results to industry.

C. Timeline Requirements

This project is planned for 3 years beginning on July 1, 2018 and ending on June 30, 2021.

2018 Detailed Project Budget

Project Title: Lowering costs of solar energy in Minnesota

IV. TOTAL ENRTF REQUEST BUDGET 3 years

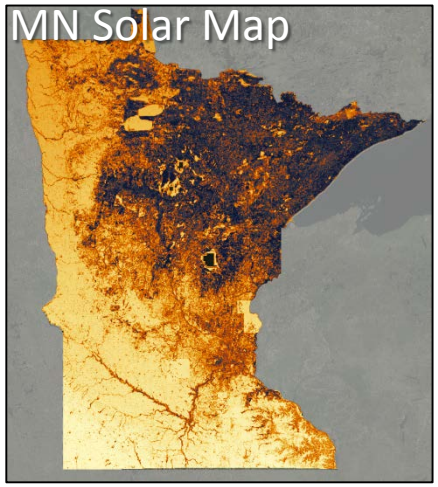
BUDGET ITEM	AMOUNT
Personnel:	$ 318,102
Jeff Marr, Project Manager, 75% salary, 25% benefits; 6% FTE for year 1 & 2, 3% FTE year 3; ($19,818)	
Michele Guala, Research Advisor, 75% salary, 25% benefits; 2% FTE for years 1 & 2, 1% FTE year 3; ($9,675)	
Lian Shen, Research Advisor, 75% salary, 25% benefits; 2% FTE years 1 & 2, 1% FTE year 3; ($11,192)	
Filippo Coletti, Research Advisor, 75% salary, 25% benefits; 1% FTE year 1, 5% FTE year 2; ($10,004)	
Chris Ellis, Engineer, 75% salary, 25% benefits; 1% FTE year 1; ($1,455)	
Chris Feist, Project Engineer, 79% salary, 21% benefits; 47% FTE for years 1 & 2, 24% FTE year 3; ($82,880)	
Matt Lueker, Engineer, 79% salary, 21% benefits; 5% FTE year 1; ($3,688)	
Rob Gabrielson, Tech, 79% salary, 21% benefits; 33% FTE year 1 and 2; ($35,873)	
Richard Christopher, Tech, 75% salary, 25% benefits; 11% FTE year 1, 1% year 2; ($10,548)	
Erik Steen, Fabricator, 79% salary, 21% benefits; 16% FTE year 1; ($10,658)	
Ben Erickson, Tech, 79% salary, 21% benefits; 5% FTE years 1 and 2, 2% year 3; ($9,100)	
Charles Nguyen, IT, 75% salary, 25% benefits; 8% years 1 & 2, 4% year 3; ($20,000)	
Graduate Student, 59% salary, 41% benefits; 50% FTE year 2; ($46,166)	
Graduate Student, 59% salary, 41% benefits; 50% FTE years 2, ($46,166)	
Professional/Technical/Service Contracts:	
Subcontract: Meyers-Borgman-Johnson Structural Design and Engineering (MBJ)	$ 39,200
Equipment/Tools/Supplies:	$ 51,390
Materials/Supplies ($41,390); sensors, data acquisition system, solar array construction	
Capital Equipment ($10,000); sensor system for field experiments	
Travel: In-state travel reinbursements for industrial partners to participate in meetings ($2,000)	$ 2,000
Additional Budget Items:	$ -
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	**$ 410,692**

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: N/A	N/A	*NA*
In-kind Services To Be Applied To Project During Project Period: Unrecovered UMN overhead (54% MTDC)	$ 192,430	Secured
In-kind Services To Be Applied To Project During Project Period: N/A	N/A	N/A
Past and Current ENRTF Appropriation: N/A	N/A	N/A
Other Funding History: N/A	$ -	

Title: Lowering costs of solar energy in Minnesota

Principal Investigator: Jeff Marr, St. Anthony Falls Lab - UMN



Supporting the growth of solar energy in Minnesota will help secure clean water, soil and air for our citizens.

Approximately 50% of cost of PV solar are Soft Costs
(foundation design, permitting, racking/framing and installation among others)

- *Structural evaluation methods are **inaccurate for snow and wind loading** for large solar arrays adding to project cost.*
- *Mounting systems (racking) are **overdesigned.** For large installations, costs are substantial.*
- *We can **lower installed costs** of PV Solar in MN through better structural design tools and evaluation methods, more effective design, and coordination with MN Code officials. Lower installed costs = Greater penetration of solar energy*

"Buried"- commercial roof-top solar

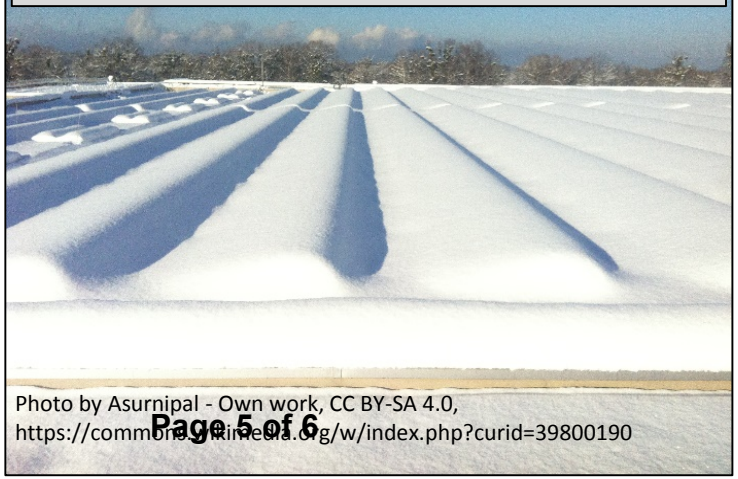


Photo by Asurnipal - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=39800190

"Challenging"- ground-mount installation

07/29/2017
Photo by Patriot Solar Group, Albion, MI.

Project Manager Qualifications & Organization Description

Project Manager

Jeffrey Marr is a licensed professional civil engineer in Minnesota and serves as the Associate Director of Engineering and Facilities at the St. Anthony Falls Laboratory (SAFL), University of Minnesota (UMN). He received both his BS (1996) and MS (1999) from the University of Minnesota, Department of Civil Engineering and has worked at SAFL for 21 years. Marr's research interests are broad and include topics in hydraulics and sediment transport, wind energy, river and delta systems, tailing ponds, deep water gravity currents, and reservoir sedimentation and erosion. In wind, Marr serves as the manager of the UMN wind engineering research program. Recent projects have included work in physical modeling experiments in transportation hydraulics, wind turbine noise, and complex fluid mechanics research involving public and private organizations. Jeff Marr manages SAFL's engineering services group, which supports ongoing faculty research and carries out applied research with public and private sponsors. Marr is an experienced project manager and principal investigator, having served as lead manager for the $16M renovation of SAFL completed in 2014 and the $3M project to establish UMN's wind energy research field station including our 2.5MW research turbine at UMore Park in Rosemount, MN.

Organizational Description

The St. Anthony Falls Laboratory (SAFL) has 42,000 square feet of laboratory research space dedicated to environmental fluid mechanics research and testing. SAFL is located on the banks of the Mississippi River in Minneapolis, MN. For this project, three highly unique facilities will be utilized. Our Atmospheric Boundary Layer Wind Tunnel, located on the top floor of SAFL, is highly unique because of its size and ability to control wind speed, turbulence, and temperature. This facility will be fully utilized in the study of wind and snow loading on PV arrays. In Rosemount, MN, SAFL operates our Wind Research Field Station, established in 2011 through funding from the U.S. Department of Energy. The Field Station is our primary location for our research efforts in wind energy and atmospheric flows (wind) but for this project, we will take advantage of the existing instrumentation, meteorological tower and data networks to support the proposed field study of wind and snow loading on a full scale model PV array. Finally, SAFL has an active numerical simulation research team and we own and operate several large computational clusters (supercomputers). These supercomputers were established through federal projects but will be fully utilized in this study to carry out the numerical simulation portion of the project.

The project team includes university faculty, professional research staff, and practicing engineers from industry. SAFL is experienced working in diverse industry-academic teams and we have demonstrated our ability to couple necessary fundamental and applied research to deliver research products that are informed by the needs of the industry and tools that can be utilized by practitioners.