

Environment and Natural Resources Trust Fund 2019 Request for Proposals (RFP)

Project Title:

ENRTF ID: 192-EH

Showcasing Carbon-Neutral, Energy-Positive Transformation of an Occupied House

Category: H. Proposals seeking \$200,000 or less in funding

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

Total Project Budget: \$ 66,532

Proposed Project Time Period for the Funding Requested: June 30, 2021 (2 yrs)

Summary:

Showcase carbon-neutral and energy-positive transformation of an occupied house that becomes a model for the entire state, where utility pays homeowners for electricity while they significantly reduce their carbon footprint.

Name: Ned Mohan

Sponsoring Organization: U of MN

Title: Professor - UMN

Department: Electrical and Computer Engineering / CSE

Address: Keller Hall, 200 Union St SE

Minneapolis MN 55455

Telephone Number: (612) 625-3362

Email mohan@umn.edu

Web Address http://z.umn.edu/nedmohan

Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

A typical Minnesota house with energy audit, rooftop PVs, weatherization/insulation, replacement of all older and inefficient appliances and lightbulbs, the meter running backwards, zero-carbon footprint, indoor vegetable cultivation using LEDs.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity	_____ Readiness	_____ Leverage	_____ TOTAL _____%
_____ If under \$200,000, waive presentation?			



PROJECT TITLE: – Showcasing Carbon-Neutral, Energy-Positive Transformation of an Occupied House

I. PROJECT STATEMENT

Residential homes and buildings have a large carbon footprint. This project will showcase the process (not just the end-results) of transforming a typical house - modest and older - into a highly energy-efficient and a carbon-neutral home, while it remains occupied by a family. It will be done in such a way that it becomes **energy-positive** by generating more electricity than it consumes (i.e., the **utility pays the homeowner**) in order to payback the investments made for this transformation.

This project will be unique in many ways: 1) A modest house typical of Minnesota homes, preferably in a low-income neighborhood, will be selected while it remains occupied, 2) The project website will showcase the transformation process for everyone to follow along, 3) The electricity consumption of all the improvements will be carefully monitored to calculate the payback and hence the economic feasibility of every energy improvement, 4) The use of natural gas will be TOTALLY eliminated to make this house carbon-neutral, 5) The electricity will be purchased through, for example, the WindSource program of XCEL where 100 percent of the electricity is generated from Minnesota wind farms, 6) To make it an **energy-positive** house, a photovoltaic (PV) system will be installed that can generate **120 percent** of the electricity needs of the homeowner per year, thus qualifying for net-metering where the rate of purchasing electricity is the same as of selling, 7) In this project, leafy green vegetables will be grown for nutrition and food security using LEDs, 8) It will look into possible innovations, such as automatic opening of windows and shades to reduce space heating/cooling needs and the benefits of adding edible leafy greens production to air quality in a home and improving access to healthy, nutritional foods, and 9) It will be very useful for students in courses being taught at the University of Minnesota and promoted into Minnesota high schools through College-in the Schools (CIS) and Post-Secondary Education Option (PSEO) programs.

Climate change due to our emission of CO₂ is the *greatest* threat facing humanity. The amount of energy that we use in homes is an important source of this emission. The transformation proposed here can reduce the emission of greenhouse gases by **nearly 2 metric tons per capita per year** that as a percentage of nearly 16 metric tons per capita of the total emission in the U.S. is 1/8th - a very significant portion. For comparison, this reduction is more than the *total* per capita annual emission in India and four times that in Bangladesh.

We will deploy all the technologies in a house while it remains occupied by a family, and showcase this process through a website for everyone to follow along. The improvements proposed are as follows: 1) an energy audit will be performed through XCEL for home weatherization to plug-in leaks through windows and doors, 2) possible addition of attic insulation, 3) changing of all lights bulbs to LEDs, 4) installation of a state-of-the-art thermostat, 5) installing tank-less on-demand water heaters, 6) removal of the gas furnace and air-conditioner and their replacement by mini-split heat-pumps, 7) replacement of older energy-inefficient appliances and the entertainment system by highly-efficient Energy Star counterparts, 8) installation of an estimated 5 kW (peak) photovoltaic system, 9) signing up for Xcel's WindSource program and Xcel's time-of-use pricing when it becomes available in Minnesota, and 10) installation of indoor vegetable-growing system using LEDs.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: *Selecting a house, Creating a Website, PV Installation & Growing Vegetables with LEDs*

ENRTF BUDGET: \$ 39,277

Outcome	Completion Date
1. <i>Select the house to start the project*</i>	<i>August 2019</i>
2. <i>Start the website to showcase the results to the rest of the state</i>	<i>September 2019</i>
3. <i>Energy audit, weatherization and insulation</i>	<i>October 2019</i>
4. <i>Install LED based vegetation indoors for growing food throughout the year</i>	<i>December 2019</i>
5. <i>Install Roof-top PV panels</i>	<i>December 2019</i>



Environment and Natural Resources Trust Fund (ENRTF) 2019 Main Proposal Template

* The selection of an appropriate house is extremely important. Such a house should have an unobstructed and preferably south-facing roof for installing PVs. The homeowner should allow these improvements and allow researchers to collect data and take pictures for the website.

Activity 2: Replacing inefficient old appliances, and conduct workshops

ENRTF BUDGET: \$27,255

Outcome	Completion Date
1. Replacing existing inefficient old appliances to improve energy efficiency	August 2020
2. On-going monitoring and updating the results on the website	June 2021
3. Nutritional analysis of vegetables grown indoors	June 2021

III. PROJECT PARTNERS:

A. Partners receiving ENRTF funding

Name	Title	Affiliation	Role
Prof. Ned Mohan	Prof. of Electrical & Computer Engineering	University of Minnesota	Lead-PI
Prof. John Erwin	Prof. of Horticultural Sciences	University of Minnesota	Co-PI
Dr. Narayan P.Dhakal	Board of Director	Member of MIPL	Project Manager
Dr. Mouli Vaidyanathan	Proprietor	Mouli Engineering, Inc.	Supply and Install PV

B. Partners NOT receiving ENRTF funding

Name	Title	Affiliation	Role
John Golle	CEO	GrowFilm, LLC	LEDs for Vegetables

IV. LONG-TERM- IMPLEMENTATION AND FUNDING:

This project is sure to succeed and its impact will be **transformational** - imagine that such transformed houses statewide (and nationwide) will pay homeowners, rather than the other way around, while significantly reducing their carbon footprints and improving nutrition. This project will teach all of us a great deal and will be extremely educational by showcasing the transformation process from the very beginning. The results of this project will be highlighted at the workshops that the PI regularly organizes, each attended by over 100 participants. These results will be included in the courses that the PI has been teaching at the University of Minnesota, which are also being taught in high schools through the College in the Schools (CIS) program.

For the long-term impact, the homeowner must agree to allow the data collection and to maintain the plants for at least three years beyond the project completion date. Researchers collecting the data and maintaining the website after the project completion date will be paid by the Oscar A. Schott Professorship that the PI has at the University of Minnesota. Other homeowners will be encouraged to follow suit. Providing *free* consulting to homeowners will become an outreach activity of the University of Minnesota Center for Electric Energy (UMCEE) that is supported by six regional utilities.

V. TIME LINE REQUIREMENTS:

Year 1:

1. Find a "typical" occupied house with a roof having an unobstructed exposure, preferably facing south.
2. Create an ongoing website to document the project progress.
3. Monitor initial energy consumption including some summer and winter months.
4. Conduct energy audit to add insulation, prevent thermal leaks through windows and doors, etc.
5. Install 5 kW (peak) rooftop PV panels
6. Install the indoor vegetable system using LEDs.

Year 2:

1. Replace existing inefficient appliances such as refrigerators, washers, dryers, etc; lamps by LEDs.
2. Replace gas furnace and air-conditioners by heat pumps; install tank-less on-demand water heaters.
3. Hold workshops to disseminate the results. Use this information in high schools and university courses.

2019 Proposal Budget Spreadsheet

Project Title: Showcasing Carbon-Neutral, Energy-Positive Transformation of an Occupied House

IV. TOTAL ENRTF REQUEST BUDGET [2] years

BUDGET ITEM (See "Guidance on Allowable Expenses")	AMOUNT
Personnel: Research Assistant (1) Name: TBD Time: 10.5% time for 9 months Salary: \$3,823(Year 1), \$3,899 (Year 2) Fringe Benefits and Tuition: \$3,769(Year 1), \$3,781 (Year 2) Responsibilities: Manage growlight setup, and measure plant growths and yields	\$ 15,272
Personnel: Undergraduate Student Name: TBD Time: 25% time for 9 months Salary: \$4,485(Year 1), \$4,575 (Year 2) Benefits: None Responsibilities: Data collection, deploying data to website and assisting with preparation of educational material.	\$ 9,060
Professional/Technical/Service Contracts: Manager, Hourly Subcontract (1) Name: Dr. Narayan Dhakal Time: 200 hours in Year 1 and 100 hours in Year 2 at \$50/hr Benefits: None Responsibility: Overseeing day-to-day operations; liaison with home owner & project team	\$ 15,000
Professional/Technical/Service Contracts: Mouli Engineering, Contractor Description: 5 KW peak Rooftop Solar PV system Installation Including reroofing	\$ 13,200
Equipment/Tools/Supplies: Website, Data Collection Tools and Posters etc.	\$ 3,000
Equipment/Tools/Supplies: Insulation and Weatherization	\$ 1,000
Equipment/Tools/Supplies: Energy efficient appliances and installation	\$ 5,000
Equipment/Tools/Supplies: Lab Services Tissue Sample Analysis	\$ 5,000
Acquisition (Fee Title or Permanent Easements):	\$ -
Travel:	\$ -
Additional Budget Items:	\$ -
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND \$ REQUEST =	\$ 66,532

Note: 1. Base salaries listed are for the current University appointment. Calculation of the amount of salary requested in each budget period includes inflation of 2% effective July 1 of each fiscal year, prorated to the budget period, and adjusted if appointment is less than 100%. If this award is reduced, effort obligations will be reduced proportionately.

2. The current fringe benefit rate for faculty at the University of Minnesota is 33.5% of salary.

3. The current fringe benefit rate for Postdoctoral Fellow at the University of Minnesota is 21.4% of salary.

4. Maximum GRA appointment is 12-month 50% appointment (20 hours per week). Salary is \$26.65 per hour, fringe benefits include health insurance for the full 12 months and tuition reimbursement benefits for the nine month academic year only. Fringe is calculated 15% of salary, plus tuition reimbursement of \$19.51 per hour worked (academic year = 780 hrs; summer = 260 hrs.).

V. OTHER FUNDS (This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State \$ To Be Applied To Project During Project Period	N/A	N/A
Other State \$ To Be Applied To Project During Project Period:	N/A	N/A
In-kind services To Be Applied To Project During Project Period: PI time donated - Prof. Ned Mohan (0.5 month each summer) Salary+Fringe: \$15,084 (Year 1) \$15,386 (Year 2)	\$ 30,470	Secured
In-kind services To Be Applied To Project During Project Period: PI time donated - Prof. John Erwin (1% time) Salary+Fringe: \$1,256 (Year 1) \$1,281 (Year 2)	\$ 2,536	Secured
In-kind services To Be Applied To Project During Project Period: Use of LI-6400 portable photosynthesis meter available with Prof. John Erwin	\$ 50,000	Secured
In-kind services To Be Applied To Project During Project Period: LED Panels to be donated by GrowFilm, LLC	\$ 5,000	Committed
In-kind services To Be Applied To Project During Project Period: Discount on PV System cost by Mouli Engineering, Inc	\$ 5,800	Committed
Past and Current ENRTF Appropriation:	N/A	N/A
Other Funding History:	N/A	N/A

Showcasing Carbon-Neutral, Energy-Positive Transformation of an Occupied House

1. Select a MN House

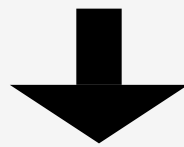


2. Conduct Energy Audit

- Measure energy consumption patterns
- Find insulation leaks
- Identify inefficient appliances



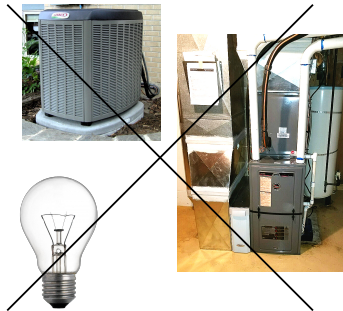
3. Install Rooftop PV System



4a. Weatherization and Insulation



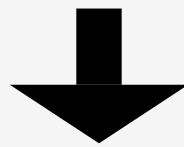
4b. Replace Inefficient appliances with efficient ones



(Central AC, Gas furnace, Incandescent lamps)



(Mini-Split ACs, Energy Star Certified Appliances, LED Lamps)



Meter runs backwards!

Utility pays for surplus solar energy



Carbon Neutral Home!



Home has a net zero carbon footprint

Fresh home grown food!



LED-powered indoor cultivation

Prof. Ned Mohan (Project Lead PI) has been teaching and doing research at the University of Minnesota for the past **42** years where he is Oscar A. Schott Professor of Power Electronic Systems and Morse-Alumni Distinguished Teaching Professor. He did his PhD in Electrical Engineering and Master's in Nuclear Engineering, both from the University of Wisconsin – Madison. He has written **5** textbooks and cumulatively they have been translated into **8** languages including Chinese and Spanish. He has graduated **46** PhD students who have gone on to work in iconic companies such as GE, GM, Ford, Tesla, Apple, etc; many of his students are professors at universities such as the University of Wisconsin – Madison, the Arizona State University, Oregon State University, Marquette, etc.

Prof. Mohan's research is focused on increasing the penetration of renewables into the utility grid. He is the Director of the University of Minnesota Center for Electric Energy (UMCEE) which he helped establish in 1981 and that is supported by 6 major utilities in the region including Xcel, GRE and Minnesota Power.

He is passionate about combating climate change and has developed courses that are some of the most popular courses in the Department of Electrical and Computer Engineering. One of these courses is being taught in high schools as well through the College in the Schools (CIS) program at the University of Minnesota.

For his teaching and research, he has received many research and educational awards. Prof. Mohan is a Fellow of the IEEE and in 2014, for his achievements in research and teaching, he was elected to the National Academy of Engineering.

Prof. John Erwin has been a faculty member in the Department of Horticultural Science at the University of Minnesota since 1989. His research responsibilities revolve around the physiology of plants grown in controlled environments and greenhouses, statewide controlled environment agriculture, and he teaches three courses on crop production.

He was elected to the Minneapolis Park and Recreation Board as a Citywide Commissioner and served as its' President for four years. He is a national agriculture crop consultant helping to grow crops that are sold nationally including at Whole Foods, Trader Joes, Home Depot and many other retail outlets in our community. John developed techniques that are used worldwide to reduce energy and chemical inputs, including neonics, in ornamental (indoor and outdoor) and food crop production (indoor). His recent research focuses on a) improving stress tolerance of plants, b) improving the nutritional value of crops grown in controlled environments, and c) new crop introduction to meet the needs of our changing communities.

Narayan P. Dhakal (Manager) has PhD in Conservation Biology from the University of Minnesota. Narayan's research was in social, economic and environment wellbeing of voluntary resettlement program. He is a board of director of the Minnesota Interfaith Power and Light (MNIPL). He was a board adviser (2015 – 2017) for Association of Nepalese in Minnesota (ANMN). He was a member of the Board of Directors (2012-2015) for College of Food, Agriculture and Natural Sciences (CFANS) Alumni Board. He was a president (2013 -2015) Religion and Conservation Biology group of the Society of Conservation Biology (SCB). Between 2011 and 2013 and was a developer of Experiential Learning Semester Program with CFANS/UMN. I was instrumental in generating Earthquake relief funds during 2015 devastated Earthquake in Nepal.

GrowFilm, LLC (Donating LED panels) is one of a family of lighting companies owned by common investors that first started in the lighting business in 2001. The Company's GrowFilm™ light sheet is unique because it uses a flexible circuit board. That board is manufactured using proprietary techniques that help minimize cost. The flexibility and minimal weight (1.2 oz/ft²) of the board also enable the creation of unique applications.