NorthWestern Energy USB 2004
Fire Station Solar Electric Demonstration Project

For additional information, contact:

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Table of Contents:

Section I: Project Overview

NorthWestern Energy is seeking applications from fire stations served by the NorthWestern Energy electric distribution system to participate in the 2004 Fire Station Solar Electric Demonstration Project. This project is being managed by The National Center for Appropriate Technology (NCAT), a 501c(3) not-for-profit organization headquartered in Butte, Montana. This project will install roof-mounted, utility-intertied photovoltaic (PV)—often called solar electric—systems on six (6) selected fire stations within NorthWestern Energy's electric distribution system. Two stations will each receive a 2-kilowatt PV system, two stations will get a 3-kilowatt PV system, and two stations will have a 4-kilowatt PV system installed. In addition, each station will have a battery bank to provide un-interruptible power supply (UPS), and will include a performance-monitoring component.

The primary objectives of this project are:

- to allow stations to generate their own "clean" electricity utilizing renewable energy resources;
- to provide community demonstrations of PV systems at work; and
- to provide the stations with a UPS.

The project is funded through NorthWestern Energy Universal Systems Benefit (USB) funds, created by Montana's 1997 utility restructuring legislation. USB funds new and existing energy conservation activities, low-income energy assistance, and renewable resource projects and applications.

Each PV project will be included in the federal Million Solar Roofs Initiative. Announced in 1997 by the Clinton Administration, this federal effort commits to installing solar energy systems on a million buildings by the year 2010.

How the Project Works

Who is Eligible to Apply

All fire stations that are NorthWestern Energy electric customers are eligible to apply. The solar electric system must be connected to a breaker panel that is serviced by a NorthWestern Energy electric meter. Interested stations must complete the enclosed application and submit it to Ray Schott at NCAT. Please read this entire application packet carefully to ensure that you fully understand the obligations of your station should it be chosen to participate.

Community Outreach

If NCAT deems it as necessary, stations selected to participate will agree to have an Open House within six months of installation to educate the broader community about how the system works and at least one Open House per year for six years for the purpose of providing community education opportunities. These Open Houses are to be advertised in local newspapers with public service announcements, as well as posted on the appropriate Internet websites.

Project Financing

The basic cost of the six PV systems will be funded by this project, including installation and metering. There may be electric utility metering costs or special site-condition costs that the stations may incur. Any additional costs will be identified prior to a final commitment on the part of the station. The stations will accept full ownership of the system and full responsibility for system maintenance. By accepting ownership of the system, the station will receive the full warranty provided by the system supplier/installer. Additionally, the station must commit to fully insure the system against damage for a 20-year period. There will be no additional funding available from NCAT or NorthWestern Energy after the system is installed and operational.

Realistic Expectations of the PV System's Performance

Solar electric systems will provide a portion of the electricity used by the building. Although in general between 2500 and 3500 kWh per year will be produced by a two-kilowatt system, actual performance will vary with local weather patterns. In some cases this will be only a small portion of a building's total annual electric energy consumption. The uninterrupted power supply component of the system will provide backup of only a limited amount of the building's total electric load. NCAT will work with fire station personnel to determine the electric loads that will be served by this back-up system.

Installation Contractor

NCAT will select a single contractor to install the solar electric systems in all participating fire stations.

What is Solar Electric Energy?

Solar energy is, simply, energy from the sun. The amount of energy from sunlight that falls on the earth each day is enormous. On an average day, a square meter on Earth collects an average of about 4.2 kilowatt-hours of energy. This figure varies by location and weather patterns. Deserts receive the most sun, more than 6 kilowatt-hours per day per square meter. Northern climates, as in Montana, receive closer to 3.6 kilowatt-hours.

Photovoltaic systems convert this sunlight directly into electricity. According to the U.S. Department of Energy's Photovoltaics Program, "PV modules covering 0.3 percent of the land in the United States could supply all the electricity consumed here."

The word 'photo' means light, and 'voltaic' refers to the electrochemical process of producing electricity. When sunlight strikes a PV cell, it is changed directly into electricity without creating any air or water pollution. PV cells are made of at least two layers of semiconductor material. One layer has a positive charge, and the other has a negative charge. When light enters the cell, some of the photons from the light are absorbed by the semiconductor's atoms, freeing electrons from the cells' negative layer to flow through an external circuit and back into the positive layer. This flow of electrons produces an electric current.

Benefits of Photovoltaic Systems

Photovoltaics has proven itself over the past 20 years as an effective, quiet, reliable, and increasingly economical approach to generating pollution-free energy and reducing greenhouse gas emissions. In Montana, for example, a 2-kw PV system installed on a station will eliminate about 3,000 pounds of carbon dioxide, about 15 pounds of sulfur dioxide, and nearly 7 pounds of nitrogen oxides annually.

In addition, PV systems have low operating costs, since their fuel (sunlight) is free and there are few moving parts. The systems that will be used in stations are modular, allowing power output to be increased by adding more modules, as well as versatile, operating well in nearly any climate. They are also safe, nonflammable, UL listed, and compliant with the National Electrical Code.

Solar energy, because of its decentralized and easily distributed nature, is ideal for certain residential and commercial applications. Solar energy, for example, is well-suited to provide a portion of most homes' energy needs. Solar systems equipped by battery backup have been found to be extremely valuable in responding to the power needs of communities that have experienced hurricanes and other natural disasters. In the construction of new homes and commercial structures, "building integrated" PV systems are successfully being designed right into the façade and/or roof of these new buildings.

Today, more than 2 billion people in the world do not have electricity. Extending the utility grid to these areas is very expensive. Thus, in an increasing number of cases, solar energy is being tapped to provide less-expensive and much cleaner electricity to people in rural communities who would otherwise use noxious diesel and kerosene fuels. Several studies in the U.S. and elsewhere have cited the economic and health benefits the public can derive from the installation of PV systems, rather than building new coal- or oil-fired plants.

Photovoltaics are used to generate power for a wide variety of applications, including pocket calculators, water pumping, emergency power, sophisticated telecommunications equipment, street lighting, space satellites, lighthouses, and residential and commercial electricity.

How a Utility-Intertied Photovoltaic System Works

A utility-intertied—sometimes called grid-connected—PV system, such as those that will be installed under Fire Stations project, generate electricity that is supplemented by the energy provided by the existing utility grid. While a PV system can be designed to provide all of a building's electrical needs, most systems provide only a portion of the total electricity requirements. The systems to be installed under this project will provide only a portion of the station's total electricity needs. Additionally, the systems will include a battery bank to ensure that the station's critical loads will continue to function in the event of a grid failure. An intertied system uses a specially programmed meter that is able to turn backward in case the PV system produces more energy than the station is using. The station will be required to sign a "net metering" agreement with NorthWestern Energy in order to have the meter installed and as a condition of participation.

Since PV modules are only capable of producing direct current (DC) electricity, an inverter is required to convert the DC output produced by the PV array into alternating current (AC) power. AC electricity is needed to run computers, refrigerators and other appliances, and lighting. Utility interactive inverters have built-in safety features that prevent them from operating if there is an interruption in grid-supplied power. The inverter uses the prevailing line-voltage frequency of the utility line as a control meter to ensure that the PV system's output is fully synchronized with the utility power.

The basic building block of a PV panel is the PV cell, which is a solid state, or non-mechanical, device. A solar system uses a number of PV panels, each made of silicon, plus boron and phosphorous. The output of a single cell under direct sunlight is about one watt. To increase their effectiveness, dozens of individual cells are interconnected together in a sealed, weatherproof glass package called a module. Modules come in a range of wattages, and their nature allows for great flexibility in designing systems that meet a variety of electrical needs.

Durability of Solar Systems

Solar panels are made of rugged tempered glass and will withstand nearly any natural occurrence of rain, snow, hail, or wind. When the panels are covered with snow, bright sunlight penetrates the snow and melts it from underneath. Systems can be ground-, roof, or pole-mounted.

Why Are Fire Stations a Good Choice for Solar Energy Demonstrations?

As natural centers of community activity, fire stations provide an excellent opportunity for students and the broader community to become more familiar with energy issues in general and solar energy technologies in particular. Solar energy system demonstrations can:

- provide a valuable learning experience for community residents;
- increase awareness about the benefits of solar energy;
- help protect our environment by reducing the use of fossil fuels and the subsequent harmful greenhouse gas emissions;
- save money for the stations and community by allowing them to generate their own clean electricity from renewable energy resources; and
- help overcome current market barriers that prevent renewable energy systems from being more widely used in Montana.

Design of PV Systems for the Stations Project

Components

The PV systems installed under this project will include the following components:

- PV modules
- Inverter to convert DC to AC electricity
- A battery bank, sized to accommodate the stations critical loads
- One performance-monitoring system, which will allow access to periodic updates on the system's performance via an Internet website

- One external, visible AC Disconnect Switch, to be located outside near the building's main electrical entrance to allow a manual shutoff by NorthWestern Energy
- Installation hardware
- Cabling
- Mounting hardware

The specifics of these components will be determined once an equipment supplier/ installer is selected.

System Output

A 2-kw PV system will produce about 3,000 kilowatt-hours of electricity annually. System sizes installed may vary based on project costs. Output for each system could vary somewhat according to specific site variables, local weather patterns, and other factors.

Expected Annual Maintenance Cost of the System

As PV systems are virtually maintenance-free, significant maintenance costs are not expected. System modules should last about 30 years. However, inverter life could be shorter. Common estimates for inverter life range from 15-20 years. Maintenance costs may include replacing a faulty wire and ensuring that all electrical components remain secure. NCAT recommends that a licensed electrician perform these tasks, the cost for which will be the responsibility of each individual station. Each selected station will be provided with an annual maintenance checklist. Stations selected to participate will be required to commit to this annual maintenance for 20 years. **Again, the cost of system maintenance is the responsibility of each participating station.** Should major system components fail beyond the warranty dates, it will be the decision of the station whether to replace those components.

Site Installation and Technical Support

A contractor will be selected to provide and install the equipment for the project. This contractor will be responsible for all systems engineering, site assessment, physical installation, and proper interconnection to the NorthWestern Energy utility grid. In addition, the contractor will provide a warranty on its systems, which will be transferred to the station when it takes ownership of the system.

Section II. Stations Application Guidelines

Selection/Eligibility Criteria

Any station served by NorthWestern Energy's electrical distribution system is eligible to apply. Awards will be granted to stations that both meet all eligibility requirements and commit to an outreach effort to educate the community as a whole about the applications and benefits of solar energy, and that also meet physical site requirements.
Stations wishing to apply must satisfy the following criteria and complete the application on pages 10-12.

A Written Narrative of no more than 500 words must accompany the application, specifically addressing the issues below. See "Hints on Completing the Written Narrative" on pages 8-9 for additional direction.

Description of Structural Integrity of Building and Location of PV Array

Describe the condition of the roof and building, the proposed location of the PV array, size of roof area, roof orientation, and other physical features of the building.

As part of your application, you must complete a sun path diagram that will assist us in estimating the impact of shading on annual system performance (see the enclosure "Picking a Solar Site" for more information). You must also include several photos of the building and its surroundings, noting where the PV array would be installed (surroundings are best captured by taking the photos from the potential location of the PV array). Indicate directions on the photos (e.g., "View of building from South").

Hints on Completing the Written Narrative

1. *"Plan of Action" for Educational Outreach*

A goal of this project is to ensure that the solar installations become an important and on-going part of each station's activities. Thus, applicants will be judged heavily by their plans for community education and outreach. As part of your Plan of Action, note how your station will promote the installation to the community, involve students, and interact with the broader community about renewable energy issues.

Some possible outreach activities include:

- developing a committee to work with the city council or other governing body to pass a local solar ordinance.
- holding an annual energy fair to educate the community about solar and other renewable energy systems
- publishing articles in local newspapers about solar energy

Preference will be given to those stations that involve a broad cross-section of people in the community committed to making the station's installation a cornerstone of learning experiences.

When articulating your Plan of Action, describe the following points:

a. Identify a Solar Program Coordinator and the specific steps he or she will take to ensure that the entire station is made aware of the PV system.

b. Describe how the station will link with the local community and businesses through, for example, outside speakers, to build awareness of the particular installation and solar energy in general.

c. The station must be willing to hold a 'Community Open House' or other public event within six months of the installation, as well at least one Open House per year for six

years, so that the general community can learn how the system works. Explain your plans for these public-outreach events.

2. Site Requirements

Several physical requirements must be met in order for a site to be considered appropriate for a PV system. Applicants must inspect their station prior to applying to determine that the building meets the following requirements. Address the following in your Written Narrative:

a. ***Orientation*:** the building must have a southern exposure. For maximum daily power output, the installed PV modules must face due south (180 degrees), plus or minus 30 degrees (i.e., 150-210 degrees) and be exposed to the sun for as much of the day as possible, especially during the peak hours of 9 a.m. to 3 p.m.

b. ***Shading*:** Significant shading from trees, buildings, mountains, and other obstructions on the roof between 3 hours before and after solar noon during the months of April through October will reduce solar energy collection. Solar noon is the midpoint between sunrise and sunset times. The installation site should have no large roof protrusions, such as dormers and ventilation pipes, near the south, east, or west sides of the array.

c. ***Roof Type and Pitch:*** The station's roof should be in good condition. Preference will be given to flat roofs or those with a slope between 30 and 60 degrees.

d. ***Roof Area:*** The roof area required for installing and working around the PV modules in a 2-kW system is approximately 400-600 square feet.

e. ***Roof/Electrical System Access:*** Convenient access to both the roof and the building's electrical system is required to install the PV system.

f. ***Electrical System:*** The building must have a 120-volt, single-phase circuit. The breaker box for this current must be reasonably accessible to the PV array.

g. ***Battery Bank:*** There must be a miminum of approximately 16-20 square feet of conditioned floor space for an enclosed battery bank. The batteries will be non-maintenance; the enclosure is intended to prevent contact with the battery terminals and keep the batteries clean.

h. ***Telephone:*** The building must have an analog telephone line. The line will be used for communicating with the data monitoring system. The line does not have to be dedicated modem line; with a phone line manager the data monitoring equipment can share a voice line.

Section III: Tentative Project Schedule

1. Systems will be awarded on the promptness of submission, completeness of the application, and geographic balance across the NorthWestern Energy electric service area. The evaluation team will review applications, select, and notify the applicant.

2. Stations must sign and return a contract outlining their obligations under the program. Appropriate station officials must sign this contract by May 14, 2004, in order to continue as a participant in the project. It is your responsibility to determine, according to your fire district's policy, who has the authority to approve participation in this project.

3. Systems will be installed by approximately October 29, 2004. Stations will assume ownership of the systems upon complete installation and final inspection and acceptance by station personnel.

Section IV: Stations Application

Please complete this application and return to:

Ray Schott
Fire Stations
c/o NCAT
P.O. Box 3838
Butte, MT 59702

If you have questions or would like assistance in preparing this application please call Ray Schott at 1-866-723-8677.

Name of Station

Mailing Address

Designated Project Coordinator _____

Project Coordinator Contact Information:
Mailing Address_____
Work Phone: _____
Fax: _____
E-mail: _____

List all NorthWestern Energy Electric Service Account Numbers for the station. Attach copies of a typical winter NorthWestern Energy bill and a typical summer NorthWestern Energy bill **for each account**. *Include the annual electrical (kilowatt-hour) consumption for each account*. Upon notice of award, the station will be required to provide copies of all electric bills for the preceding 16 months.

_____
_____
_____
_____
_____
_____

1. Number of members in the station: _____

2. Describe any energy conservation or efficiency measures that the station has undertaken over the past three years.

_____
_____
_____
_____
_____

3. What type of electrical service does your station have?

____120/240 single-phase ____120/208 three-phase wye
____277/480 three-phase wye ____120/240/208 Delta (three-phase)
___Other (specify)_____

4 . What material is the roofing made of?

___Asphalt ____Standing seam metal ___Corrugated metal
___Slate or tile ____Rubber membrane (flat roof) ___Wood shingle
___Other (specify)_____

5. What is the roof structure?

___Wood-framed ___ Steel-framed ___ Wood and steel joists
___Other (specify)_____

6. What is the structural roof sheathing? What is the rafter spacing?

___Wood board ___Plywood ___Steel –folded plate ___Concrete

Spacing?_____

7. Is the roof in good condition? _____

8. Which direction does the main entrance of the station face? _____

9. Where do you think the PV array should be installed?

_____
_____
_____

10. Is the roof sloped? _____
If yes, what is the approximate slope (in degrees)? _____

11. How many years ago was the existing roofing material installed?

____ 0-5 years ____5-10 years ____15-20 years ____20+ years

12. How many feet above the ground is the structure that will support the PV modules?
_____

13. Does the building's electrical system meet the current electric code?
_____

14. Where is the electrical service entrance and meter in relation to the proposed PV array location?
_____
_____
_____

15. Where is the 120-volt, single-phase electrical breaker box that will be used to connect the PV system to the existing electrical system in relation to the proposed PV array location?
_____
_____
_____

16. Do you have space for the battery bank? This varies, but plan for approximately 16-20 square feet of floor space as the minimum.
_____

Written Narrative

- ❑ Attach your Written Narrative, described on page 9

Letter of Commitment

- ❑ Attach a letter of commitment signed by an appropriate station official. Your specific station policy will dictate who has the authority to approve participation in this project. This letter is intended as a demonstration of the station's commitment to the project. A final agreement will be signed prior to installation.

Also attach:

- ❑ Completed Sun Path Diagram
- ❑ Photos of your station building, its surroundings, a southern panorama, and the potential installation location(s)

Section V: Obligations of Participating Stations

Stations selected to participate in the project must agree to fulfill the following obligations:

1. To accept full ownership of the pre-selected hardware components (as outlined in the Program Description portion of this packet) that comprise the PV system.
2. To provide assurance of the building's structural integrity.
3. To maintain full legal and financial responsibility for the system once installed.
4. To sign a NorthWestern Energy Net Metering Agreement and send it to the program manager at NorthWestern Energy.
5. To arrange for installation of the NorthWestern Energy net meter by contacting the program manager at NorthWestern Energy after the final electrical inspection of the PV system.
6. To agree to insure the system against damage for 20 years.
7. To commit to an education/outreach effort that will promote solar energy within the broader community.
8. To designate an individual/team that will "champion" the project.
9. To gain approval for project participation by the station's governing body.
10. To hold one Open House within six months of installation, as well as at least one Open House annually for six years, to educate the general community about how the system works.

Indemnification

By applying for participation, each station hereby expressly agrees to defend, indemnify, and hold harmless both NCAT and NorthWestern Energy from any and all claims, liabilities, obligations, damages, demands, losses, causes of action, cost of expenses or whatever kind or nature, including attorney's fees in all pre-litigation and litigation issues, including trial and appellate levels and in bankruptcy or insolvency proceedings for injury to or death of any person and for damage to or destruction of any property resulting, in whole or in part, from errors, omissions, or any negligent, willful, wanton reckless, or intentional act(s) of the fire station in connection with the performance of the terms and conditions of this application, to the extent caused in whole or in part by said acts, errors, or omissions of the contractor or subcontractor.

Final Application Checklist

Before submitting your application, have you:

- ***Enclosed****:*
  - Completed application form?
  - Written Narrative?
  - Copies of a typical winter NorthWestern Energy bill and a typical summer NorthWestern Energy bill **for each account**, indicating all account numbers for the station?
  - Annual kWh consumption **for each account**?
  - Completed Sun Path Diagram?
  - Photos of building, surroundings, and potential installation location?
  - Letter of commitment, signed by a person authorized to approve the station's participation in this project?

- ***Read and approved*** of your station's obligations should it be chosen to participate in this project?