

# Off Grid PV Systems

MIDWEST RENEWABLE ENERGY ASSOCIATION FACT SHEET



## What is "PV"?

PV systems, or photovoltaics, offer consumers the ability to generate electricity in a clean, quiet and reliable way. Because the source of light is the sun, they are often called solar cells. The word photovoltaic comes from "photo", meaning light, and "voltaic", which refers to producing electricity. Therefore, the photovoltaic process is "producing electricity directly from sunlight."

Photovoltaic (PV) cells convert sunlight directly into electricity without creating any air or water pollution. PV cells are made of semiconductor material. When light enters the cell, some of the photons from the light are absorbed by the semiconductor atoms, freeing electrons to flow through an external circuit and back into the cell. This flow of electrons is electric current.

## Off Grid PV Systems

An off grid PV system, sometimes called a stand-alone system, is designed to provide electricity to a home or business without drawing on supplemental power from the electrical utility. These systems consist of a PV array, control and safety equipment, a battery bank, and usually an inverter.

### PV Array

PV panels are grouped together to form 12, 24, 36, or 48 volt arrays. The number of panels in a PV array varies depending on the wattage of the PV panels and the desired output of the system. A typical home (with energy conserving appliances) will need between 8 - 20 panels.

The PV array can be mounted on a south facing roof, on a static frame at ground level, or on a tracker. A tracker is a PV rack that rotates on top of a pole. The tracker rotates to follow the sun across the sky during the day, thus insuring maximum solar exposure for the PV panels.

### Control and Safety Equipment

Each PV system has a controller to monitor the electrical input of the PV panels, and to guard against over charging of the batteries. Monitoring equipment includes voltage and amperage meters which display pertinent information about the electricity being produced, used, and available for future use. The safety equipment includes an electrical fuse

box.

### Battery Bank

Batteries are used to store energy for use at a later time, like night time or on cloudy days. The batteries used in a PV system are deep cycle batteries, similar to those that power electric golf carts. The number of batteries used in a system varies on the type of battery, and the anticipated storage needs.

### Inverter

An inverter converts the low voltage DC (Direct Current) power that is produced by the PV panels and stored in batteries, into 120 volt AC (Alternating Current) power. Most household appliances and lights require AC power to operate. Inverters are available in a wide range of wattage capabilities, from 100 - 10,000 watts.



PV Installation Workshop, Custer, WI.

Systems can be designed without an inverter. In these systems all appliances and lights must run off DC power. In general, DC appliances are more expensive and less available than traditional AC appliances and lights.

## Cost Considerations

A PV system designed to power a full-sized home can cost anywhere from \$10,000 - \$20,000, depending on the number of people in the home, and their lifestyle choices. While this may seem like an expensive choice, a PV system can be a cost effective alternative for providing electricity to remote locations, or locations where power lines do not exist. In these areas utility line extensions can cost \$10,000 or more per mile, ruin the look of the land, and provide a less reliable power source than PV panels.

PV systems can also replace gas generators for providing electricity in remote locations. While the initial capital investment is higher, PV provides electrical power at less than the cost of electricity from generator, based on life-cycle cost.. PV systems can deliver a positive cash flow in as little as 4-5 years of operation by displacing generator fuel, maintenance and replacement costs.

PV is the most reliable source of electric power ever invented and it is easily transported, easily installed, and virtually maintenance free. All of these reasons make PV the ideal power source for remote homes and businesses.

## Conservation Measures

Small PV systems are not practical for powering space-heating systems, water heaters, air conditioners, electric stoves, or electric clothes dryers. These loads require a large amount of energy to operate, which will increase the size and cost of the PV system. Therefore, it is important to select the most energy-efficient equipment available. For example, if the PV system will power lights, look for the most energy-efficient light bulbs. If the system will pump water for toilets and showers, look for the most water conserving fixtures. A good rule of thumb is each dollar spent on efficient appliances saves at least three dollars in PV system components.

## Site Requirements

There are three factors to consider when determining whether a site is appropriate for a PV installation.

First, systems installed must have a southern exposure. For maximum daily power output, PV modules should be exposed to the sun for as much of the day as possible, especially during the peak sun hours of 10 a.m. to 3 p.m.

Second, the southern exposure must be free of obstructions such as trees, mountains, and buildings that might shade the modules. Consider both summer and winter paths of the sun, as well as the growth of trees and future construction that may cause shading problems.

Finally, the unobstructed southern exposure must also have appropriate terrain and sufficient space to install the PV system.

Seasonal variations affect the amount of sunlight available to power a PV system. In Wisconsin the annual average "peak sun hours" is approximately 4.25 hours per day.

## System Sizing

The size of the PV system (number of panels, batteries, etc.) is dependent on how much electricity must be generated to power the home's loads. The procedure for determining system size requires looking at the wattage required for each appliance and light bulb in the house and multiplying it by the number of hours it will be used each day. This number is the total daily consumption. (The MREA has a worksheet to help you complete these calculations..) This is the electricity that must be generated by your PV system on average.

## System Maintenance

No PV system is maintenance-free. Regular inspections of the system will ensure that the wiring and contacts are free from corrosion, the modules are clear of debris, and the mounting equipment has tight fasteners.

Storage batteries will also require regular maintenance. This will consist of a monthly check of the electrolyte levels, occasional addition of distilled water to the battery cells, and routine equalization of the batteries.

## For More Information

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## References

*The Solar Electric House*, Steve Strong, Sustainability Press, Still River, MA 1993

*The New Solar Electric Home*, Joel Davidson, AATEC publications, 1987

*Home Power Magazine*, Home Power, Inc., P.O. Box 520, Ashland, OR 97520; (916)475-3179; www.homepower.com

*The Solar Electric Independent Home Book*, Fowler Solar Electric, Inc., 1991

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