APPALACHIA - SCIENCE IN THE PUBLIC INTEREST
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Rural Solar Photovoltaic Use

ASPI Technical Series

INTRODUCTION

Solar photovoltaic (PV) electricity is a technology whose time has come. It has many applications in rural areas. These include the powering of lighting, fencing, water pumping, tools, fans, outbuildings, and even whole houses.

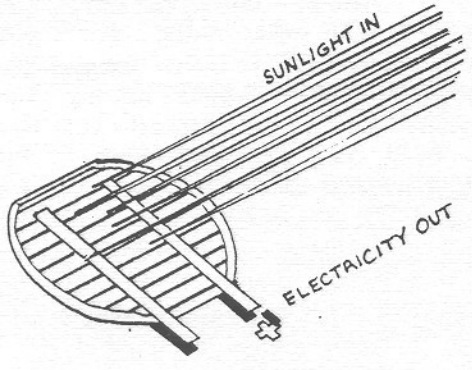
WHOLE HOUSE SYSTEMS

Photovoltaic panels make electricity directly from sunlight in a high tech semi-conductor material that is mostly silicon (sand/glass) with some exotic additives.

In rural areas where power lines have not yet been brought in, solar electric systems can be a cheaper alternative for providing moderate amounts of electricity. As with all systems, whether solar or not, efficiency is essential for economical operation. Electricity is very high grade energy and should be used only where a less costly (including environmental and other costs) alternative does not exist. These uses include lighting, electronics, and motors. Even within these uses, alternatives exist that may be better than conventional technologies. Coiled tube fluorescent light bulbs use 1/4 as much power as incandescents and put out the same quantity and quality of light. Super efficient refrigerators are available using 1/10 the energy of a standard refrigerator. Adding insulation to the one you've got and putting it through the wall with compressor and condenser outside (north wall) can reduce energy use. (Propane and kerosene fridges are also available.)

Electricity should not be used to make heat, it is too expensive. Cook and heat with the sun, wood, gas or propane. Butane clothes irons are also available.

When a household has reduced its electricity needs to a reasonable level, solar electricity begins to make sense.



Domestic solar systems consist of multiple panels, mounts, wiring, controls, batteries, fusebox, and loads.

Standard panels are around 1'X4' and put out 30-50 Watts in full sun. They generally put out 12 Volt nominally, 13.5-16.5V actual under load. Cost is around $300 each. They are fully modular and can be connected together for more power output. You can start small and add more panels as your needs grow. Panels are very durable. Standard warranties are ten years or longer, expected life is twenty years or more. Panels are put on roof, pole, or ground mounts to orient them toward the sun. Tracking mounts are available that follow the sun as the day goes by. As the cost of panels comes down, and costs of tracking mounts go up, trackers become less economical. Panels are normally adjusted up and down seasonally to maintain good sun angle for high power output. Four adjustments annually with three positions (spring and fall are the same) are adequate.

Panels are wired to charge controllers which protect storage batteries from overcharging and prevent reverse discharge at night. Some controllers have a load diverter function that reroutes excess power when the batteries are charged. Volt and amp meters are used to monitor the system. Panel grounding is important for safety, as is a shutoff switch to allow electrical disconnection of the panels from the batteries.

Deep cycle batteries are needed to withstand the ups and downs of charging and discharging. Auto batteries will not last. Marine/RV (recreational vehicle) batteries are not true deep cycle. For medium sized systems, golf-cart batteries are the most economical alternative. They should last 5 to 7 years. Deep cycle batteries should not be discharged below 80% (11.9V at rest). The less deeply discharged, the longer the battery life. New methods involving special additives are being developed to allow this life to be extended.

Whole House Systems cont...

Power from the batteries should be run through a fusebox before connection to house wiring and loads. Fuses offer protection from short circuit and possible fire. RV type fuseboxes using automotive type fuses are commonly used. More conventional circuit breakers are also available.

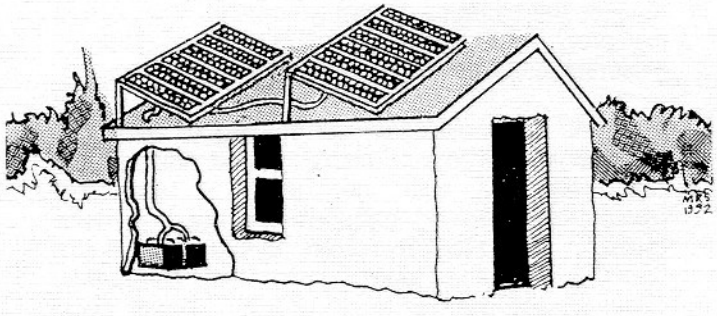
Solar electricity can be used to run most electric appliances. Many are available in 12V versions thanks mostly to the RV industry. Inverters are available to make 120 V house current from 12V and can even run computers, TV's, and other sensitive electronics. Inverters cost around $1/watt in smaller versions, less in larger versions. They introduce another inefficiency in the system so should be used only when needed.

Because an appliance at 12V needs ten times the current at 120V for the same power, care must be taken when sizing wires. Standard 12 or 14 ga wire may be adequate for lighting circuits but large wire may be needed for other circuits with larger loads. An inverter is often used where standard wiring has already been installed.

A system is generally sized by adding up the typical current use for all appliances for a typical day and dividing by average winter peak sun hours to get the necessary panel current output.

Power output is lowest in December and January, when lighting demands are generally highest. Special care or an auxiliary power or light source may be needed during that period.

During summer, output will be at its highest. Some controllers allow excess power to be diverted. Fans, small coolers, and dehumidifiers are good loads to consume this excess power. Power can also be diverted to a second set of batteries which can be used to power workshop and yard tools.



A refrigerator with outside coils is well matched to a solar electric system's output: maximum on sunny summer days, minimum on cloudy winter days.

A complete 100W system to run a light, fan, small TV, radio, and a small (4 cu.ft.) super-efficient, super-insulated through-the-wall fridge ($600 itself) utilizing used panels currently available is $1200 in materials, another $250 for professional installation, not including appliances and house wiring.

The cost of photovoltaic panels has been slowly coming down as the technology matures. Manufacturing improvements, quantity production, and technical breakthroughs are ongoing. Prices are expected to continue on their general downward trend.

WATER PUMPING

Solar electricity is well adapted to water pumping. One of its most common uses is providing water for farm animals. Water can be pumped from a cistern, pond, well, or creek to a stock tank. A variety of 12V pumps are available. Some are designed especially for use with solar panels. Float valves and pressure switches can be used to turn off the pump when the tank is full. Electronic water level sensors can also be used. Because of storage, a stock watering system often does not use a battery, pumping only when the sun shines. In this case, a device called a linear current booster will increase pump output in low light conditions.

Solar electric pumps can also be used for irrigation. They are well matched to this use as output will be highest on sunny days when need is greatest. Drip type or other water efficient irrigation is recommended.

Solar electricity can also be used for domestic water systems. Water can be pumped from a well, or a pond or creek if high quality filtration is used. Pumps and controls are available for use with standard pressure systems or gravity feed from elevated tanks.

Another natural use for solar-powered pumping is a solar water heater. A PV powered pump will automatically increase the pumping rate as the amount of sunlight increases.

OUTBUILDINGS

Where small amounts of power are needed in outbuildings some distance from a utility powered main house, installing a small solar electric system yourself may be cheaper than having conventional wiring done.

FANS

Solar electricity is well adapted to running fans, where demand usually coincides with bright sun.

Low voltage exhaust/intake fans are available for house or room ventilation. Desk type fans and ceiling fans are also available for use with solar power. Portable hat mounted fans are also interesting and useful gadgets. They can provide significant cooling under certain conditions.

Another rural use for a solar powered fan is a ventilation system for a composting toilet. A small integral panel/fan is available for venting excess heat from small greenhouses. It is also well adapted for use on a solar food dryer.

TOOLS

Many cordless electric tools are now available and lend themselves well to solar powering. Battery chargers are available in 12V versions to recharge the tool's battery packs directly from a 12V solar electric system. Drill/drivers are especially popular. Newly developed Bullet bits drill cleaner and more efficiently allowing more holes per charge. Various saws are also available. Narrow and carbide blades reduce the amount of power needed and extend battery life between charges. Other cordless electric tools include sanders, grinders, hedge trimmers, grass shears, and line trimmers.

Some tools are available which are run directly from 12V systems. These are generally attached directly to the batteries with terminal clamps. Those that would be useful in rural areas include drills, winches and a chainsaw.

Electric welders are now available that operate on 24VDC. Two batteries could be charged in parallel at 12V with excess power and rewired in series to power the welder.

At one time, General Electric made battery powered garden tractors. These are still available new and used from Kansas Wind Power and can be recharged from solar electric panels. In addition to being useful for mowing and tilling, the tractors can be used as portable power centers for powering electric tools. Cost is high, power and range are limited, and recharging could be slow without a large solar electric system. They are, however, cleaner and quieter, and more environmentally sensitive if solar charged than engine powered alternatives.

STAND ALONE LIGHTING

One of the simplest and cheapest rural applications for solar electricity is path lights. These individual units incorporate a panel, battery, light, and photoswitch. They are generally attached to a stake which is stuck into the ground. The batteries are charged during the day to provide light at night. The light is not very bright, and only lasts a few hours, but is generally adequate for marking paths. Costs range from $20.00 to $80.00.

Stand alone security lights are also available. These incorporate motion detectors which turn the lights on when someone approaches. These lights are brighter than path lights. Costs range from $100 to $400.

Solar electricity can also be used to charge batteries for flashlights. Nickel-cadmium batteries are the most common rechargeable batteries. Standard ones have only 1/3 the capacity of alkaline batteries. High capacity ones are more similar to alkalines. Another type of rechargeable flashlight battery has recently become available: nickel hydride. They do not contain cadmium, a toxic metal. Their capacity is close to alkalines. An extra set of rechargeables is generally recommended so there will be a charged set available when a set is discharged. Rechargeable flashlight batteries are $2.50 to $10.00 each but quickly pay for themselves in savings over disposable batteries. Small solar battery chargers are available for $20.00 to $100.00 depending upon size and capacity.

Some flashlights are available with built in panels. Solar powered lanterns are also available with attached or separate panels. Lanterns cost $100.00 to $150.00.

ELECTRIC FENCE

Solar electric fence chargers are available from farm supply stores and other sources. They are popular for remote locations. They can be used with conventional fixed electric fence and with newly available portable electric fence.

These portable fences often incorporate fine wires into plastic cord or mesh fences for handling ease. Mounted on plastic stakes, they are easy to move around for controlled intensive grazing management, as well as garden protection.

Another farm application for solar electricity is an automatic gate opener. It operates with a remote control like a garage door opener. It will open a gate and automatically close and latch it after a preset time. Cost is around $700.00.

REFERENCES

The Solar Electric Independent Home, Paul Jeffrey Fowler.

The New Solar Electric Home, Joel Davidson, AATEC, 1987.

The Solar Electric House, Steven G. Strong, Rodale Press, 1987.

Practical Photovoltaics, Richard J. Komp, AATEC, 1984.

Home Power, 6/yr $6, P.O. Box 130 Hornbrook, CA 96044 0130.

SOURCES

(There are many other companies selling solar electric hardware, check Home Power for one near you).

EKAT (Eastern Kentucky Appropriate Technology) 150 Gravel Lick Branch Rd. Dreyfus, KY 40426-9700 (606) 986-6146 (local dealer and installer).

Alternative Energy Engineering P.O. Box 339 Ridgeway, CA 95560 (800) 777-6609.

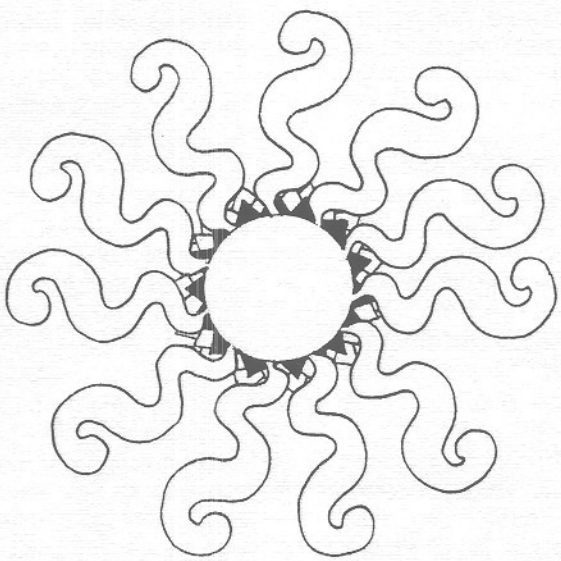
Backwoods Solar Electric Systems 8530 Rapid Lightning Creek Rd. Sandpoint, ID 83864 (208) 263-4290.

Jade Mountain P.O. Box 4616 Boulder, CO 80306-4616 (800) 442-1972.

Photocomm 7681 East Gray Rd Scottsdale, AZ 85260 (800) 223-9580.

Kansas Wind Power Rt. 1 Holton, KS 66436 (913) 364-4407.

24 volt welder: **Bailey's** P.O. Box 9088 Jackson, TN 38314 (800) 322-4539.



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