

Plan your energy-independent home *before you begin construction*

By Paul Jeffrey Fowler

Over the years, as the owner of a successful solar electric business, I spoke with thousands of people about designing and installing a solar electric system. The majority of the customers who were building their homes contacted me after their homes were mostly completed, when many of their designs were irreversible. I always wished I could have helped these people with their choices before they had begun to build.

Obviously, I could have helped them to orient their houses for proper exposure to the sun and to plan for the installations of a solar electric array, system controls, and a battery room. In most cases, they had done fairly well on these aspects from reading solar electric books. I really wish I could have reached them early enough in their planning process so they could have built true alternative energy homes, not just houses with solar electricity installed on them.

In homebuilding, it is difficult to be creative, since a house is built with very standardized methods and materials. However, innovation is necessary in designing an alternative energy home, because it will use electricity much differently than a conventional "on-the-grid" home. In an alternative energy home, the goal should be to build a home such that the people using it will feel that they are enjoying a conventional level of comfort, though their source of electricity is an independent system.

A grid home in our area pays about 10¢ per kilowatt-hour for electricity, while a solar-electric-system owner pays an average of 30¢ per kilowatt-hour. Furthermore, the owner must invest up front in the equipment to produce 10 to 20 years of this



The author's home, with solar electric modules on the house and garage

30¢/kilowatt-hour electricity. My personal goal has been to use only one-third as much electricity as a conventional home of similar size and comfort by designing conservation into my home. In truth, solar electric homes almost never utilize a solar electric system to meet the typical energy demands of a conventional home. Solar electric homes are successful because of *conservation* of electricity.

Before you build your dream independent home, examine those loads that would be energy hogs if they were powered by electricity. These are normally heating, hot water, and cooking. You should try to power any heating load by another energy source. In the Northeast, even most grid homes choose to purchase less-expensive LP gas to power the kitchen stove and the hot water heater, and heat the house with wood, oil, or gas in preference to using electric heat.

Heating and cooking

Plan to buy a pilot-model propane stove. Standard propane stoves now come with an electric ignition feature

that creates some problems when it's used with an inverter's load demand function. (An inverter is the part of a solar electric system that transforms the direct current—DC—from the battery bank into the alternating current—AC—used in the home.)

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Solar hot water, wood-heated hot water, or a summer/winter hybrid of the two provide a renewable-energy hot water system. Conventional LP hot water heaters work well, but I prefer our more efficient Aquastar tankless model. Using LP is certainly not energy independence, since you are married to the gas company. However, it is more commonly used than wood for cooking or heating water. A home often uses only a 100-pound tank of propane per month, so those living far into the outback can transport the LP themselves.

Heating your solar electric home with a conventional oil or gas furnace is a problem: furnaces use a lot of electricity to run circulating pumps in hot-water systems or circulating fans in hot-air systems. Your alternative energy home should be designed to be heated by wood stoves, LP space heaters, passive solar energy, or any combination thereof, because these methods of heating require no electricity.

Solar heating

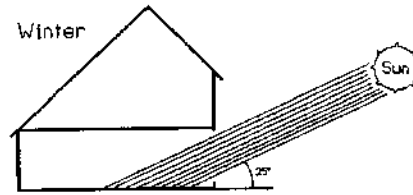
If you're planning to power your home with a solar electric system, you most likely have good solar exposure at your house site. I recommend incorporating some passive solar heating into your house design. This will require both south-facing windows and a heat sink (such as stone walls or concrete slab floors) that can absorb the heat of the winter sunlight. This will prevent the house from overheating during the day, while storing some heat for the night. Wood heat is a good partner for the passive solar heat.

...leafless branches in winter will reduce the solar energy by 35%

Many owners of independent homes find they are house-bound during the winter, because they can't leave their wood fires unattended for a weekend without the pipes freezing. Because you will not be using a furnace, you can plan for an LP space heater for backup heat.

Insulation

It is also possible to design a simple and affordable passive solar home that requires no furnace or backup LP heater. Our own 1800 square-foot, passive-solar, well-insulated home uses two cords of wood per year and will not drop below freezing in the

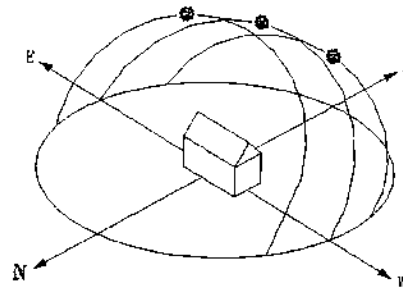


Design your house for passive solar heating.

worst sub-zero weather while we are away. If you do plan to use passive solar heat, you will need to insulate your home more heavily than is standard for your area. In my town, homes are commonly insulated with six inches of fiberglass, but I used eight inches. You should also insulate the outside walls of the basement, or the perimeter of the floor slab, with two inches of foam insulation. One benefit of extra insulation is that it will lower the number of cords of wood you will have to cut each year for the rest of your life.

Cooling

In hotter climates, you will have to plan ways to keep your home cool without using standard electric air conditioning. Ceiling fans can be powered by super-efficient low-voltage DC motors that use a tenth of the electricity of AC fans. There are evaporative air conditioners or "swamp coolers" that use only a small amount of electricity for small pumps. The house site can be landscaped, and overhangs can be designed, to shade the house from the sun in the hot



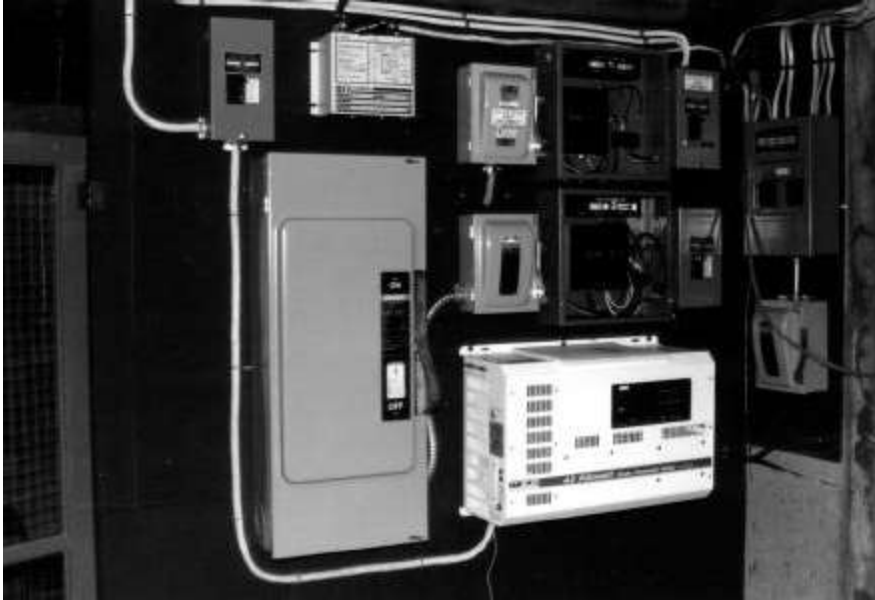
In an unobstructed site, you get maximum sun due south all year.

months. Once again, the home must be well-insulated. Brave people can abandon a conventional home in favor of an earth-bermed, or underground, home that utilizes the earth to cool it in the summer and insulate it from the cold in the winter.

Water

An independent home needs its own water supply, and water-pumping can be a heavy electrical load to reckon with. A minority of folks can supply water using a spring on a hillside above the home that flows by gravity. Most people will have to drill a well. In dry areas of the country with deep aquifers, expensive deep wells require pump motors that are too large to be powered by an inverter in a solar electric system. In this case, you need to get a specialty jack pump powered by a low-voltage DC motor and an appropriately large storage tank. Look for help designing this system before you start building the house.

For homes with drilled or dug wells, there are choices for well pumps that work better with a solar electric system. If you can have a dug well close to the house, and the surface level of the water is less than 18 feet below the pump in the basement, you can utilize a centrifugal pump. The standard AC centrifugal pump (or its relative, a jet pump) is extremely inefficient. A better option is an efficient low-voltage DC pump that is powered from the battery bank. If you have a deeper well with a static water level that is lower than 18 feet, you can most likely use a 1/2 or 1/3 HP (horsepower) conventional deep-well pump. These pumps sit near the bottom of the well and push the water up, which is more efficient than pulling it up with a centrifugal pump. Deep-well pumps are normally 240VAC (240-volt alternating current), but they are also available in 120VAC, which is compatible with the 120VAC inverter in a solar electric system.



The inverter and controls, mounted on the basement side of the battery room wall

Getting enough sun

A solar electric home must have a daily minimum of six hours of solar exposure. Before you start building the house, you need to plot the daily path of the sun at your house site for the four seasons of the year. Shading trees must be removed. Even shading by leafless branches in the winter will reduce the solar energy by 35%. Most commonly, a solar house is oriented with one side facing due south (not magnetic south), with the ridge pole in an east-west line. The south wall can utilize extra windows for passive solar heating, and the roof can support the mounting structure for the solar electric modules.

Sometimes you can increase the total daily solar gain by shifting the orientation away from due south. For example, if there is a lack of solar exposure in the afternoon (maybe the sun passes over a ridge at 2 PM) and extra exposure earlier in the morning (an easterly valley), the orientation can be shifted 20° to the east to maximize your solar energy per day. Correspondingly, the house could be shifted to the west, if the ridge were to the east and the valley to the west.

Placement of modules, batteries, and controls

Solar electric modules may be installed on ground, wall, or roof-mounted structures. For a ground mount, you will need to plan for a ditch and a hole in the foundation wall for the underground cable from the module array to the battery bank. For a roof mount, you will need reinforced areas under the roof boards and between the rafters, where you will bolt the frame. You will also need a conduit, or interior wall space, to run the wires from the roof to the battery bank. If possible, the wires should be accessible after the house is finished to permit repairs and system upgrades. Solar electric module arrays send low-voltage DC electricity (usually at 12 or 24 volts) to the batteries. These wire runs should be kept as short as possible to reduce the need for thicker, more expensive cables.

The battery bank should not be inside the living area of the house. Lead-acid storage batteries smell when they are being charged hard, and they produce flammable hydrogen gas. Also, the batteries should not be installed in a cold environment,

because the cold reduces their electrical storage capacity. A battery bank is ideally installed in its own ventilated room in a basement. Ventilation to the outdoors is necessary, so plan to leave an appropriate hole when you pour the foundation.

The system controls and the inverter should be as close to the batteries as possible without actually being in the battery room. Inverters typically draw 100-400 amps from the low-voltage battery bank, requiring large cables, preferably no more than five feet long. The controls will arc sparks when DC circuits are opened and closed, which could ignite the hydrogen gas produced by the batteries. Usually the inverter and controls are mounted in a four-by-eight-foot area on the basement side of the wall that separates the basement from the battery area.

If you plan to have a small solar electric system with 12V appliances and no inverter, you may want to locate the battery bank centrally to reduce the length of the circuits that will feed 12V electricity to the house, thus avoiding long runs that require thick, expensive cables.

A standard 15-20 cubic foot 120VAC refrigerator uses more electricity per day than your whole solar electric system could produce.

Most solar electric systems today utilize an inverter to change the low-voltage DC electricity from the battery bank to standard 120VAC electricity. Now that these inverters have become reliable and efficient, most people don't use DC appliances in their homes. Therefore, it is necessary to wire your home with the standard number of AC outlets, fixtures, switches, circuits, and circuit breakers. You may feel you do not need them now, but remember that it's easier to

run wires before the walls are closed in.

Lighting

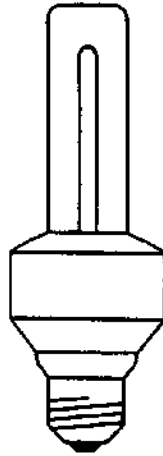
Lighting is a large load for your solar electric system. Furthermore, you will need more hours of electric lighting during the winter months when the days are short, which is also the time of year when we receive less solar energy to produce electricity. You can reduce your electrical consumption by choosing lighting fixtures that give you more light and supply that light where it can be best used. Avoid recessed fixtures that lose much of a bulb's light production to the black inside. Instead, seek out fixtures with globes or lenses that project the most light. Compact fluorescent bulbs are your most likely source of efficient and pleasing light. Unfortunately, these bulbs vary in size and shape. Try to select fixtures that can accommodate them. Some lights need to provide general lighting, while other lights need to be focused for detail work or reading. Choose your lights for where and how they will be used.

The best and most pleasing light for all activities is natural light. You can reduce the amount of electricity needed for lighting by matching window placement with areas that need light. For example, match your kitchen work areas to your kitchen windows so that electric lights are only needed at night. We rarely turn on a light in our home during daylight hours, because natural light does the job. Natural light is enhanced by white ceilings and walls to keep the light from being absorbed and lost.

Generators

Many solar electric homes use a generator to supplement their electrical needs in low-sun periods. If the generator is used often, it will need its own little shed or place in the garage, with an exhaust system to the out-

doors, hopefully out of noise range for the house and the neighbors. You will need to leave another hole in the foundation and a ditch for the underground line or conduit from the generator to the basement. If you have an LP powered unit, you will also have to plan for an underground LP gas line from the LP tank to the generator.



A compact fluorescent bulb

Cold storage

A standard 15-20 cubic-foot 120VAC refrigerator uses more electricity per day than your whole solar electric system could produce. Standard refrigerators are among America's most inefficient appliances and are not acceptable for an independent energy home. In sunny climates, you may choose a super-efficient low-voltage DC refrigerator. You will need to plan for an extra \$1,000-1,500 investment in your solar electric array to power it. In climates like the Northeast, where I live, it is difficult to run even a super-efficient DC refrigerator, because it is a constant load even when the sun does not shine for several weeks straight. Most independent homes use an LP refrigerator that consumes about seven gallons of propane per month.

There are low-voltage DC freezers, but they consume about twice as much electricity as a DC refrigerator to

maintain the lower temperature and to cool the room-temperature foods that are added to them. LP freezers are small and extremely expensive. Most solar electric homes have no freezer. To compensate for this, I recommend planning a root cellar or cold storage room into your house design if you live in an area with cold winters.

The simplest cold storage room consists of a small room, well insulated from the basement and the warm ceiling of the house above, located in the north corner of the basement. In winter, the cold exterior walls of the foundation keep the room cool. Additionally, you may add one four-inch ventilation pipe that runs from just above ground, outside the basement, into the cold-storage room and down to its floor, and a second four-inch pipe from the ceiling of the cold-storage room, to the outside, and up the wall of the house six or eight feet. When the outside temperature is colder than the cold-storage room, cold outside air circulates into the space and warmer air rises out of the space.

A garden works well with the cold-storage room, because it supplies fresh vegetables in the summer, when the cold storage area is not cold, thus further reducing the need for a freezer and a large refrigerator.

To plan and design an independent home powered by solar electricity, you will need a lot more information than the few pages of this article. I hope I have started you thinking about the many facets of design that could help you plan and build an independent home—a home that uses far less power than your old “grid home,” and at the same time provides you with a more comfortable existence, and a better and more sustainable life.

(Paul Jeffrey Fowler is the author of The Evolution of an Independent Home: The Story of a Solar Electric Pioneer, 1995, ISBN 0-9645111-7-7, distributed by Chelsea Green, available from *Backwoods Home Magazine*. He has written several successful how-to books on solar electricity.) D