10 - OFF GRID SYSTEM DESIGN

SYSTEM SIZING INFORMATION

The size of a solar electric system depends on the amount of power that is required (watts), the amount of time it is used (hours) and the amount of energy available from the sun in a particular area (sun-hours per day). The user has control of the first two of these variables, while the third depends on the location.

Conservation

Conservation plays an important role in keeping down the cost of a photovoltaic system. The use of energy efficient appliances and lighting, as well as non-electric alternatives wherever possible, can make solar electricity a cost competitive alternative to gasoline generators and, in some cases, utility power.

Cooking, Heating, & Cooling

Conventional electric cooking, space heating and water heating equipment use a prohibitive amount of electricity. Electric ranges use 1500 watts or more per burner, so bottled propane or natural gas is a popular alternative to electricity for cooking. A microwave oven has about the same power draw, but since food cooks more quickly, the amount of kilowatt hours used may not be large. Propane and wood are better alternatives for space heating. Good passive solar design and proper insulation can reduce the need for winter heating. Evaporative cooling is a more reasonable load than air conditioning and in locations with low humidity, the results are almost as good. One plus for cooling—the largest amount of solar energy is usually available when the temperature is the highest.

Lighting

Lighting requires the most study since many options exist in type, size, voltage and placement. The type of lighting that is best for one system may not be right for another. The first decision is whether your lights will be run on low voltage direct current (DC) or conventional 110 volt alternating current (AC). In a small home, an RV, or a boat, low voltage DC lighting is often the best choice. DC wiring runs can be kept short, allowing the use of fairly small gauge wire. Since an inverter is not required, the system cost is lower. When an inverter is part of the system, a home will not be dark if the inverter fails and the lights are powered directly by the battery. In addition to conventional-size medium-base low voltage bulbs, the user can choose from a large selection of DC fluorescent lights, which have 3 to 4 times the light output per watt of power used compared with incandescent types. Halogen bulbs are 30% more efficient and actually seem almost twice as bright as similar wattage incandescents given the spectrum of light they produce. High quality fluorescent lights are available for 12 and 24 volt systems.

In a large installation or one with many lights, the use of an inverter to supply AC power for conventional lighting is cost effective. AC compact fluorescent lights will save a tremendous amount of energy. It is a good idea to have a DC-powered light in the room where the inverter and batteries are in case there is a problem. AC light dimmers will only function properly on AC power from inverters that have pure sine wave output.

Refrigeration

Gas powered absorption refrigerators are a good choice in small systems if bottled gas is available. Modern absorption refrigerators consume 5-10 gallons of LP gas/month. If an electric refrigerator will be used in a stand-alone system, it should be a high-efficiency type. Some high-efficiency conventional AC refrigerators use as little as 1200 watt-hours of electricity/day at a 70º average air temperature. A comparably sized Sun Frost refrigerator/freezer uses half that amount of energy and a Sundanzer refrigerator (without a freezer) uses less than 100 watt-hours per day. The higher cost of good quality DC refrigerators is made up by savings in the number of solar modules and batteries required.

Major Appliances

Standard AC electric motors in washing machines, larger shop machinery and tools, swamp coolers, pumps, etc. (usually 1/4 to 3/4 horsepower) require a large inverter. Often, a 2000 watt or larger inverter will be required. These electric motors are sometimes hard to start on inverter power, they consume relatively large amounts of electricity, and they are very wasteful compared to high-efficiency motors, which use 50% to 75% less electricity. A standard washing machine uses between 300 and 500 watt-hours per load, but new front-loading models use less than 1/2 as much power. If the appliance is used more than a few hours per week, it is often cheaper to pay more for a high-efficiency appliance rather than make your electrical system larger to support a low-efficiency load. Vacuum cleaners usually consume 600 to 1,000 watts, depending on how powerful they are, about twice what a washer uses, but most vacuum cleaners will operate on inverters larger than 1,000 watts since they have low-surge motors.

Small Appliances

Many small appliances such as irons, toasters and hair dryers consume a very large amount of power when they are used but by their nature require very short or infrequent use periods. If the system inverter and batteries are large enough, they will be usable. Electronic equipment, such as stereos, televisions, VCR's and computers have a fairly small power draw. Many of these are available in low voltage DC as well as conventional AC versions. In general, DC models use less power than their AC counterparts.

Use this worksheet to determine the total energy in amp-hours per day used by all the AC and DC loads in your system.

Calculate your AC loads

If there are no AC loads, skip to Step 5

1. List all AC loads, wattage and hours of use per week in the spaces provided. Multiply watts by hours/week to get watt-hours per week (WH/Wk). Add up all the watt hours per week to determine AC watt-hours per week. Use a separate sheet of paper if you need to list more loads than the space below allows

NOTE: Wattage of appliances can usually be determined from tags on the back of the appliance or from the owner's manual. If an appliance is rated in amps, multiply amps by operating voltage (120 or 240) to find watts.

Description of AC loads run by inverter	Watts	x	Hours/Week	=	Watt Hours/Week
	Total Watt Hours / Week				

2. Convert to DC watt-hours per week. Multiply line 1 by 1.15 to correct for inverter loss. ______________

3. Inverter DC input voltage; usually 12, 24 or 48 volts. This is DC system voltage. ______________

4. Divide line 2 by line 3. This is total DC amp-hours per week used by AC loads. ______________

Calculate your DC loads

5. List all DC loads in the space provided below. If you have no DC loads, enter "0" in line 7 and proceed to line 8.

Description of DC loads	Watts	x	Hours/Week	=	Watt Hours/Week
	Total Watt Hours / Week				

6. DC system voltage. Usually 12, 24, or 48 volts. ______________

7. Find total amp-hours per week used by DC loads. Divide line 5 by line 6. ______________

8. Total amp-hours per week used by AC loads from line 4. ______________

9. Add lines 7 and 8. This is total amp-hours per week used by all loads. ______________

10. Divide line 9 by 7 days. This is total average amp-hours per day that needs to be supplied by the battery.______________
Enter this number on line 1 on the PV Array Design Worksheet on page 12, and on line 1 of the Battery Sizing Worksheet on page 99.