RV Care Info Bulletin:
Solar Power Systems

Solar Power: Overview

Photovoltaic (PV) solar power uses solar cells to convert sunlight directly into electricity, which is either used immediately or stored in batteries for future use as required. In RV applications, the electricity generated by the solar panels is collected by a charge controller and transferred to 6 or 12 volt deep cycle batteries. Battery power is then used to operate DC (direct current) equipment such as interior lights and water pumps. The addition of an inverter would allow use of some 120V appliances such as microwaves, coffee makers and surround sound entertainment systems.

Solar electric systems are modular, which means one can start with a small system and add to it as requirements grow. They are ideal for operating low power items, such as blenders, microwaves, coffee makers, radios, lamps, stereos and computers. However, due to the very high power demands, appliances which produce heat or are used for cooking and storing food (stove, fridge, furnace) are generally not powered by solar.

Flat plate solar panels can make use of both direct light and indirect light (sunlight reflected off clouds, the ground or other objects) and southeast to southwest is the prime solar location. With no moving parts, the solar panels can last 20-30 years with proper maintenance, which includes cleaning with a damp cloth to remove dust, insects, leaves, bird droppings and/or snow, and repositioned twice a year (spring and fall) unless they have been installed at an angle that provides best average for different seasons. The panels can be placed on roofs, ground mounted or attached to a pole, as long as they are immersed in full sunlight on the south facing side.

Though the individual photovoltaic cells are solid-state devices with no moving parts and therefore highly reliable and long lived, the modules they are placed into are subject to failure, as is the remainder of the system. The failure of solar cells mostly involves cell cracking, interconnect failures (resulting in open circuits or short circuits), and increased contact resistance. Module-level failures include glass breakage, electrical insulation breakdown, and various types of encapsulant failures.

Basic Components of a Solar System

Solar systems are generally divided into and discussed as two main components: the photovoltaic modules (solar panels) and the “balance of system”, which is a catch-all phase to cover everything else.

The only function of the solar panels is to capture sunlight (either direct or diffused) from the environment and turn it into electrical energy. The balance of system does everything else – it captures and stores the electricity in batteries for later use and supplies electricity in DC (or AC*) format as required.

Key electrical components therefore include:

- Batteries – store electrical power for later use
- Blocking diode – prevents batteries from discharging when there is either limited or no output from solar cells, i.e. at night (usually built into the charge controller)
- Charge controller – feeds power to the batteries while preventing them from becoming overcharged (some charge controllers have built in inverters – see below)
- Low voltage disconnect – prevents batteries from being completely drained
- Varistor – protects system from power spikes or lightening strikes by shunting excess power to the ground
- Inverter – converts 12V, 24V or 48V DC power from the batteries to 120V AC power to run household appliances *(optional)*
- Generator – backup power *(optional)*
- DC and/or AC load centre – fuse box *(optional)*

Sizing Solar Systems

A solar panel's only function is to recharge batteries and therefore the shape and size of a panel doesn't matter. The important factor is how much wattage it produces. In general, you can hook up as many panels as you want (but for wattages above 15W a charge controller is required to ensure the panels do not overcharge the batteries). The number of solar panels required is determined by amount of power needed on a daily basis divided by an average of 5 hours of sunlight to recharge the battery bank to run appliances/loads, but total power generated can't exceed the limit of the charge controller.

A photovoltaic module's power output is reduced at high temperatures (the higher the temperature the more the molecules are moving and the more difficult then for photons to "hit" the electrons), but its lifespan is not affected by normal (outdoor) heat. Both the duration and intensity of sunlight have a greater effect on the output of a photovoltaic module than does temperature. A general "rule of thumb" for a crystalline silicon photovoltaic module (the most common type) is that the efficiency (and, therefore, the power output) is reduced about 0.5 percent for every degree C increase in temperature.

Photovoltaic modules are usually rated at module temperatures of 25°C (77°F) and generally run about 20°C over the air temperature. So on a hot day of 100°F, the module will be 120°F or 50°C, and so will have its power reduced by 12.5 percent.

The following chart of typical wattages of popular electronics and appliances can be used as a rough estimate of power requirements; however, the safest procedure is to check the wattage rating for each individual appliance to be used within a solar power system and add them up. Both continuous and surge power ratings (extra power draws required to start appliances) need to be considered.

Run Time Chart for Popular Electronics and Appliances	
Electronics & Appliances	*Typical Wattage*
Cordless phone	5
Portable stereo	10
Laptop computer	25
Television, 36”	133
Drill (3/8”)	300
Heating – warm air fan	312
Blender	385
HID flood lights (400W)	400
Sump pump – ½ hp	460
Furnace fan – 1/6 hp	500
Coffeemaker	600
Microwave oven	625
Shoc Vac, 1.7 hp	900
Chainsaw, 12”, ½ hp	900

When calculating power requirements, consider the loads of all appliances to be powered, their rated wattages and the number of hours per day they will be used.

Watts = Amps x Volts (total amount of electrical energy)
Based on the above, the equation can be manipulated so that Amps = Watts/Volts
The number of amps a 60 watt lightbulb will use is therefore dependent on the system voltage.
At 12 volts, 60 watts/12 volts = 5 amps.
At 120 volts, 60 watts/120 volts = 0.5 amps.

Once the daily energy requirements have been determined, the available solar energy for the various seasons needs to be identified. Weather information and solar radiation values for selected sites can be obtained from Environment Canada’s Meteorological Service at www.retscreen.net, or by checking with local airports and weather stations.

The amount of sun available can be used to determine number of solar panels required. Consider time of year (winter = days shorter, sun lower on horizon) and location (as you move further north changes in sun's position are more pronounced) when determining solar panel power generating requirements. Also consider the position of solar energy collectors may need to differ based on latitude and time of year.

As the solar panels generate DC electricity, it needs to be stored in 6 or 12 volt batteries until required for use. The number of batteries required is determined by the amount of power (in amp hours) needed in terms of daily requirements plus an allowance for extra days backup for when the solar panels are unable to produce enough electricity (i.e. heavy cloud cover).

The less a battery works, the longer it will last. Therefore a larger battery bank not only provides a larger reservoir, it extends battery life. Typical installations have a balance of 100 amp hours of battery capacity per 3 amps of solar panel current. In the long run, the general rule is to utilize the largest, best quality battery bank you can afford. As a mimimum, size the system to 50% depth of discharge.

Either conventional or gel/AGM batteries can be used, as long as the charge controller is rated to charge them. The sealed valve regulated products are generally the better choice in terms of both safety (less gassing so less ventilation required) and service life in smaller, properly sized systems. Batteries may require periodic equalization charges or filling (flooded only). A solar system installed in an extremely harsh environment may require a battery enclosure to protect the batteries.

The charge controller must be carefully matched to the batteries to prevent overcharge or too much discharge.

A useful source of additional information can be found in the "Solar Information" section of the Canadian Solar Industries Assocation (CanSIA) web site at www.cansia.ca.