**Basics of Off-The-Grid Solar ~ Part 2**

To continue our trek into the wilds of renewable energy I would like to briefly re-cap what was discussed in the last article of this series. The all-important first step of designing your independent home energy system is to understand your requirements. If you start your project without this knowledge and just buy a bunch of equipment hoping it'll do the job you may be very disappointed; or as my great Grandpa would say, "Put the cart after the horse laddie, it always works better!"

Electrical requirements in your home are described as loads. You can complete a load analysis[i] and it will tell you the number of watt-hours your loads are using. The total number of watt-hours then tells you how big your battery needs to be.

Your battery is akin to a gas tank and the amount of power it contains is described in amp-hours. So it's really simple: you know that when you fill your gas tank you can drive for a given period of time and then you need to put in some more gas. Similarly the size of your battery determines how long you can provide electricity to your household but it also tells you another little secret and that is how big your solar panel or wind generator or other charging source needs to be to fill that battery.

There are certain formulas that a professional system integrator[ii] will use to decide what solar panels to use; what size; and how many there should be. If there are additional charging sources such as a wind or a genset then how will they contribute? A common mistake that novices can make is sizing the battery too small or too large. A too-small battery won't store enough energy and you'll be 'cycling' it more often. A battery cycle is one discharge plus one recharge and the life of a storage battery is stated in hundreds or thousands of cycles. At the risk of stating the obvious, the more you cycle a battery the quicker it wears out. On the other hand a too-large battery means that it doesn't get fully charged and over time the battery becomes damaged by sulphation[iii].

Let's assume your load analysis told you that you need 2400 watt-hours per day, which translates to 200 amp-hours with a 12v battery. The useable capacity of a deep cycle battery is no more than 50% of it's rating which means you need to buy a 400 amp-hour battery. To maximize the life of a battery you just use half it's rated capacity or less. So you've purchased your battery and now you have to charge that beast up in a timely fashion

For this example we will use solar panels as the charging source. Look at the back of a solar panel and you will see a label that lists the "maximum power current" or Ipm, which is in amps. If you are looking at a 130-watt panel then the amps at 12 volts are around 7.35a. That's how much power will be produced by the solar panel per hour of full sun.

For the purpose of calculating total output I use 4 hours a day. That ends up being generous in the winter months as we only get about 3.4 hours of solar insolation[iv] but in the summer it is over 5.5 hours a day. So using 4 hours times 7.35 amps you would get 29.4 amp-hours. Solar panel ratings are based on STC or standard test conditions, which means they are tested under ideal lab simulating something closer to southern California than the Cariboo. Other factors include the efficiency rating of the solar panel, which depends on whether it is polycrystalline, monocrystalline, thin-film, or both mono and thin-film. And finally you want to consider the manufacturers tolerance rating. A 100-watt solar panel can actually be a 90-watt as manufacturing tolerances can be up to 10 percent. Some companies restrict their manufacturing tolerance much more tightly for example Sanyo guarantees 100% of the nameplate rating at the time of purchase.

If we assume 100% nameplate rating on the solar panel you buy and 4 hours of sun per day at your location then you will ideally get about 29 amp-hours per panel being returned to the batteries. If you are using 200 amp-hours each day then you obviously will need more than one panel unless you want to run your generator a lot. 200 amp-hours battery capacity used per day divided by 29 amp-hours per solar panel returned to your battery means about 7 panels will be needed for your system to fully recharge the batteries. But wait, there's more… there's always more. Batteries are very inefficient devices and you need to put back more energy than you took out just to get back to square one. If you take out 200 amp-hours you need to put back about 230 to fully charge the battery so make those 8 panels to be safe.

Now if you think you have it all figured out at this point, not so fast! Oh yeah… there's more. Do you really want to have a renewable energy system that only works for one day if the sun doesn't shine? You'll fill your batteries up then tomorrow it rains or snows or is just really overcast and you use up all your power then you're back to kerosene and board games. The question you have to ask yourself (and your pocketbook) is how many days of autonomy do I want? Another word for autonomy is freedom and if you want freedom from energy concerns and freedom from that noisy expensive carbon creating generator then the rule of thumb is to size a system for 3 – 5 days of autonomy if it's a full time home. If we start with three days of autonomy then we need to triple the size of the battery storage and triple the size of the solar charging system. Now it becomes much clearer why your appliances have to be chosen very carefully for maximum efficiency. Off-grid living requires discipline, using your power frugally and eliminating careless behaviours like leaving the computer and TV and lights on.

Having made your battery and solar panel selection there are still several other matters you need to consider including location of solar panels; type of solar panel mount; type of charge controller for the solar panels; size and type of inverter to use; and safety requirements.

Solar panels are usually mounted on a roof, on the ground or on a pole mount. My personal preference is a pole mount as it can solve a number of problems like snow clearing and seasonal adjustment while keeping clear of wildlife and foot traffic. Adjustability is an important consideration for your solar mount because the sun is much lower on the horizon in the winter than it is in the summer. If you can adjust the tilt of your mounting rack you will be able to set the surface of the panels perpendicular to the rays of the sun and get the maximum energy. Most roof mounts are not adjustable simply because most people don't want to be climbing around on their roofs; but pole mounts and ground mounts can be easily changed on a seasonal basis. A simple rule of thumb for the fixed angle of a solar array[v] is to use the latitude plus 15° which in the Cariboo means about 67°. You can use a flatter angle in the summer and a steeper angle in the winter. I am often asked about solar-trackers, which are motorized devices that follow the sun in the sky from morning to evening. Solar trackers can increase the output from a solar array by 15 – 20% but at a pretty high cost. Commercial trackers sell for upwards of $2500 depending on the number of panels they have to move. At today's low prices for solar panels you can easily increase your power production by 20% or more for that same cost and solar panels have no moving parts. Moving parts wear out and break.

Now speaking of wearing out and breaking I think I should congratulate you if you've read this far. Technical stuff can get pretty hard to plow through but I hope I've made my points clearly. Feel free to drop me a line if you need clarification on anything at: info@solareagle.com. Until next time…may your path be sunny.



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[i] **Load Analysis** http://solareagle.com/loadcalc.pdf
[ii] A **systems integrator** is a person or company that specializes in bringing together component subsystems into a whole and ensuring that those subsystems function together. *Wikipedia*
[iii] **Sulphation** occurs when a battery is stored too long in a discharged condition, if it is never fully charged, or if electrolyte has become abnormally low due to excessive water loss from overcharging and/or evaporation. *Windsun*
[iv] **Insolation** is the amount of **solar** energy that strikes a given area over a specific time, and varies with latitude or the seasons.
[v] **Solar array** a linked collection of solar panels.