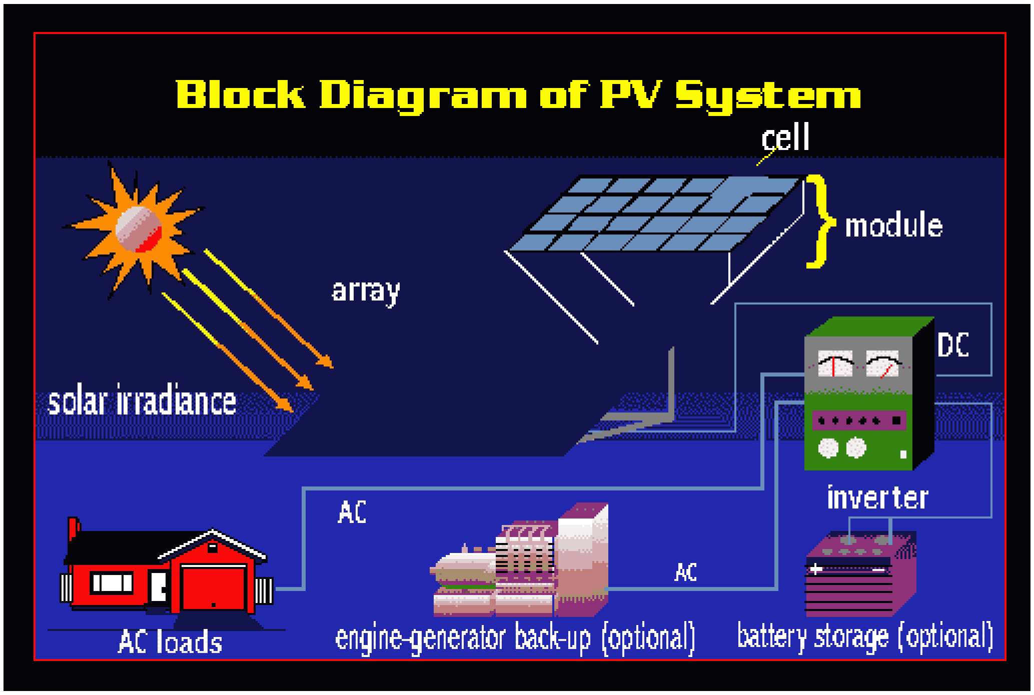
Education Matters: Electric Power

Skalitude: Our lodging structures are completely "off the grid". How we get our electricity from solar power...



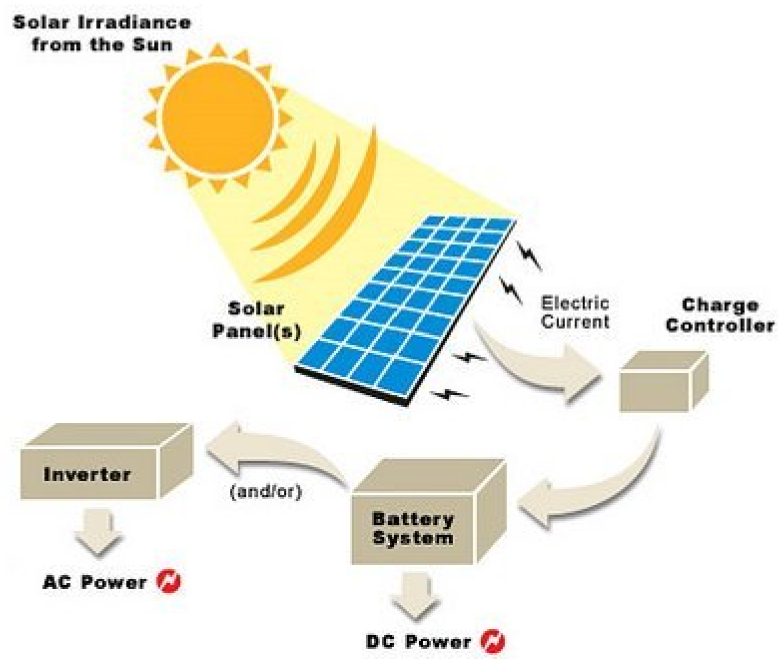
Living on solar power, life goes on as it would on the commercial grid. We just make a conscious effort to conserve, especially during the winter months when the days are very short and less sunny. Our electric power functions without interruption. During snow season we make use of a propane generator to recharge our batteries when there is not enough sunlight to keep us powered. The electrical current powering the lodge from the batteries is much more stable than it would be from the commercial grid. Therefore, the use of electrical devices that are susceptible to damage due to power surges is actually much safer.

We greatly reduce our electrical consumption by combining modern and rustic technologies. Propane is used for cooking with our 36 inch oven and stove top. There is also a wood-burning oven for those that would like a pioneer experience! The full-sized Sunfrost refrigerator in the lodge runs on DC electricity rather than AC, which makes it more efficient as then the current can come straight from the batteries and doesn't need to be converted by the inverter. Every time you switch from DC to AC or vice versa, a small amount of energy is lost in the conversion (more on that later!) The Sunfrost also has much thicker insulation than regular fridges.

We provide a large French press and a percolator to brew perfect gourmet coffee. Mounted on the roof of our lodge are large, solar hot water panels which heat the running water and also the radiant heated bamboo/tile floors. There is a back up propane on-demand hot water heater to insure adequate hot water supply in the winter months. The lodge is also heated by a large and efficient wood burning stove. (We supply all the wood you'll need and more. All of our seasoned fir is sourced from local and onsite forestry efforts.)

The Skalitude Lodge

This is how our solar power system works….



This, in a nutshell is how the sun provides electricity to Skalitude's lodge. If you're into science and/or are still curious, we've provided useful links to more in depth explanations of how individual components of the system work.

Typically, when the sun's light (irradiation) hits an object, it turns to heat. Heat as energy is great for frying eggs & bacon and such, but it won't power a standard household electrical outlet. To provide electricity to power a home, the sun's rays must be "harnessed", converted to a more organized form of energy, stored, and then converted to electrical current that can be used to power appliances and lights. Whew!

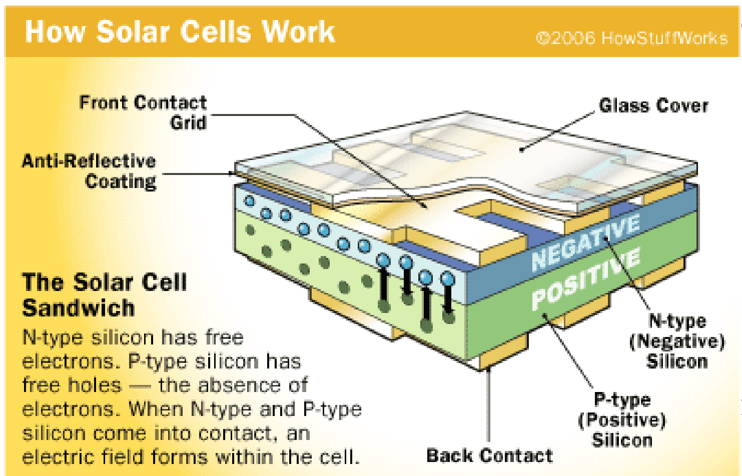
Here's how we make electricity from the sun…

Step 1: Catch some rays

When you are standing outside, facing the purple door of our lodge, look to your left. That's the lodge's solar array. A solar array is a group of solar panels. A solar panel is made up of a bunch of photovoltaic (solar) cells. Each solar cell contains silicon with some added element to create a charged electrical field. We say that this field is charged because it contains extra electrons. Electrons are the tiny subatomic particles that together form an electrical current.

Take a look at our array. The panels are made of glass and silicon. Pretty shiny and reflective stuff, but you'll notice that there is no reflection coming from the surface of the array, not even of the bright sun! That's because the panels are coated with super duper non-glare film. See, what a reflection is, is light rays (photons) *bouncing off* of a reflective surface. A solar panel's job is to collect all those photons, so you'll see no shine off their surfaces.

Step 2: Knock out those extra electrons, line them up, and call them DC current…



When the sun beams down on a solar cell, radiant energy bombards the charged silicon with photons. Those photons provide the extra oomph of energy needed to knock those extra electrons loose. Too be precise, in rapid succession, each photon knocks out exactly one electron, this creates a hole in the field that is rapidly filled with the next available electron, which is knocked out by the next available photon… and on and on so long as the sun is shining. Photons and electrons are some of the tiniest particles that scientists can study and the massive number of these photon-electron "bumps" happening in a solar cell at any given fraction of a second is really hard for us to estimate. It all happens really fast too. It happens so fast that the movement of the electrons can be seen as a steady flow in the direction away from the incoming photons. So, from this point on we'll start referring to all those electrons lined up and moving away from the photons and the electric field as electrical current.

Step 3: Incoming current… charge up the batteries.

Skalitude's lodge uses a 24 volt bank of rechargeable batteries that is located in the Ohm room. A proton, like an electron, is a type of subatomic particle. Electrons have a negative charge and protons have an opposite positive charge. Protons are a real drag on a battery. As a battery discharges, protons accumulate in its cells and slow down the production of electrons. This causes the battery to deteriorate.

The incoming current from the solar panels sends electrons into the battery cells. These new electrons attract the accumulated protons. This causes a chemical reaction that is the opposite of discharging… the incoming current causes charging! Recharging the battery restores its potential energy.

Step 4: Prepare DC current coming from lodge batteries for use… invert to make AC current.

So, now we have our batteries all charged up from our solar panels and ready to go. But there's one more step we've got to take to power the lights in the lodge. It's called inversion. The current that comes out of the battery bank is low voltage, direct (DC) current. This type of current won't work for powering household 110 and 220 outlets. It needs to be converted to a more stable alternating (AC) current. To convert DC to AC current we use a device called an inverter. Those of us who have boating or trailer-camping experience are probably familiar with inverters. Once we have AC current coming in, we've got electric power!

Here are some facts about solar charging and energy use…

Our panels charge at a rate of about 30 amps in full sun, although they can get up to about 34 amps in summer. This means that for every hour of full sunlight, we have 30 amp-hours of power to use. One light bulb uses 2 to 3 amps, having a light turned on for one hour uses about 2.5 amp-hours. So having that light on for 10 hours uses 25 amp hours, or almost one hour of full sun!

In the summer we get consistent sun and don't need lights on very much, so we usually have more power than we need for basic requirements. In the middle of winter however, it is a different story! Around the winter solstice, we get about 5 hours of sun, but our panels charge at a full rate for only part of that time due to the low angle of the sun. Some power is lost to the inverters, which convert the electricity from DC to AC to power our appliances. So we only gain about 100 amp hours on a fully sunny day in winter.

Using electricity responsibly…

Even though lights don't use much energy they may be used for long periods of time. That’s why they represent our greatest use of energy, especially in the winter. Any time you convert electricity to heat, it uses huge amounts of energy and is very inefficient. The toaster uses about 35 amps, but since it is usually only on for one or two minutes, it doesn't add up to much. Crock pots and hair dryers are the greatest users of power, as they convert the energy to heat and tend to be on for a long time. Things like TVs and computers are moderate users of energy, both in amps and time used.

Some appliances, like the stereo and the toaster, have a 'stand-by' mode where they use power even when they are turned off, so we have to unplug them when not using them.

…but what happens when there is no sun for days? The Back-up Propane Generator

During the spring, summer, and fall we have ample sunlight so we rarely need any other power source to keep our batteries charged enough to power the lodge without interruption. However, the months of December and January, peak snow season, can be challenging for those of us living off the grid. The days are really short and many are cloudy. We conserve as best we can. We don’t leave lights on in unoccupied areas. We turn off our desktop computers and televisions. Instead we use ipads, kindles, laptops, and we read books. Best of all we get out and play!

No matter, our efforts to conserve are never enough in the middle of the winter. We usually end up running our propane powered generator to charge up the batteries every couple of days. It’s no big deal. Well, except for the cost.

The generator uses about one gallon of propane per hour that it is running. The rate that it charges the batteries varies depending on the batteries state of charge. When the batteries are highly discharged, or low in power, they will charge at a much higher rate. As the batteries become more full, they will charge at a lower rate. It is kind of like the electricity coming from the generator to the batteries has to go though a funnel – when the batteries are near empty, the amps can pour right in. As the batteries get more full, it is harder to squeeze those extra electrons in, so it charges more slowly.

Batteries have a 'memory', you never want to completely discharge a battery as it 'remembers' that state and is hard to charge back up again. At Skalitude we try to never discharge the batteries lower than 65%. We use the generator to get the batteries back up around 85% or 90%, after that it is too inefficient for the big generator to try to squeeze those electrons in. This usually takes about 4 hours of generator run-time, or about 4 gallons of propane, at $2.90 per gallon that is $11.60. During that time we gain about 280 amp hours, which works out to 4 cents per amp hour. For those living on the grid in eastern Washington, electricity rates are usually around 4 cents per kilowatt hour – a huge difference!! (Watts = volts x amps, so one watt hour is 110 amp hours, one kilo watt hour would be 110,000 amp hours). So while solar power is free in the summer, we have to be careful in the winter!

For those that really want all the nitty-gritty details, our batteries are AGMs, which stands for Absorbed Glass Mats. This means that the electrolyte is stored in a flberglass mat separator. These batteries are sealed, so they require no maintenance, compared to regular flooded lead acid batteries, which require water to be added periodically. We like the AGMs as we feel they hold their charge better than lead-acid batteries, plus the fact that they are maintenance free makes them safer and easier.

The Basic Stats:

At the Lodge, we have eight 170 watt panels, for a total 1.36 kilowatts, the battery bank is 1200 amp hours. At the Cabin, there are six 80 watt panels, and two 125 watt panels, for a total of 730 watts, with a 660 amp hour battery bank. Both of these systems are backed up by the propane generator.

Each bermhouse room has just one 85 watt panel and 220 amp hours of battery storage, with no generator backup. These rooms just have DC lights and a DC fan on the composting toilet, so very little energy is ever used.

The cottage and the pond are also free-standing systems, with no generator backup. The cottage has 600 amps hours of battery, with 700 watts of panels. The pond runs the pond pump with six lead acid batteries and four 85 watt panels.

Resource link: how solar cells work
http://science.howstuffworks.com/environmental/energy/solar-cell.htm

[SCHEMATIC OF CELL, PANEL, ARRAY science.nasa.gov]

For more info on how solar panels work go to
http://www.scientificamerican.com/article.cfm?id=how-does-solar-power-work