

PARTS OF A SIMPLE SOLAR ELECTRIC SYSTEM

Photovoltaic panels - Often called solar panels. Turns sunlight into electricity.

Charge controller-An electronic box that controls the charging of batteries.

Battery bank - One or more batteries used to store power from photovoltaic panels or any other power source.

Generator - A fuel-powered engine attached to a generator used to produce electricity.

Converter or battery charger - An electronic box that changes 120 volt alternating current to direct current, which can charge the battery bank.

Voltmeter - A meter used to monitor the voltage of the battery bank.

Inverter- An electronic box that changes 12 volt direct current to 120 volt alternating current.

Safety disconnect - A device that allows the user to break the connection between the battery bank and the appliances using electricity.

The Photovoltaic Panel

What it does

Turns sunlight into electricity

What it costs

About \$6 per watt (as of 2009) (As low as \$2.50 per watt in 2011)

Advantages

- ⊗ Easy to wire.
- ⊗ Expandable. Panels can be added as needs and budgets allow.
- ⊗ Panels last for decades as they have no moving parts. (Panels on satellites launched in the 1960's are still functional.)

Disadvantages

Expensive. Initial cost per watt is much higher than grid electricity. Over time, photovoltaic panels are an excellent value.

The Charge Controller

What it does

Controls the charging of the battery bank. Without the controller, the batteries could be overcharged and destroyed. Some controllers protect the batteries against being discharged too deeply.

What it costs

\$60 - \$100's Depending on the size of the system controlled.

New Information (2004)

The new MPPT (Maximum Power Point Tracking) controllers can boost available current from photovoltaic panels by as much as 30%. This is a tremendous boost in efficiency. Cost up to 30% more than standard controllers.

General Information

Some controllers can double as voltage meters.

Some controllers have a switch that will allow batteries to be equalized [see batteries].

The Battery Bank

What it does

The battery bank stores power for later use.

What it costs

Six-volt golf cart batteries are the most popular for small systems at \$120 each (as of 2008). There are many types of batteries, varying greatly in price.

General Information

Batteries are very heavy. Remember this when you make your purchase. You may end up with a monster you cannot move. You may want to purchase very heavy batteries because they will be difficult to steal.

Recommendation

I recommend the 6-volt golf cart batteries for the following reasons:

1. They are affordable at about \$120 (as of December 2008).
2. They are available just about everywhere.
3. They weigh about 65 pounds. This is a manageable weight for most people.
4. They are dependable and easy to maintain.

Safety Alert

When they are being charged or discharged, most batteries create explosive hydrogen gas. Batteries need to be contained in an airtight box built of 3/4-inch plywood that is vented to the outside with a 2-inch PVC pipe.

NOTE: My favorite solar expert for missionaries is Les Eldeen, He recommends DEKA golf cart batteries for price and reliability. (2009)

How to Keep Batteries Alive for Years and Years

(Credit for much of this list goes to Windy Dankoff of Dankoff Solar Products, Inc. 2003. I added several items. Jack)

Note: Don't let the length of this list scare you. I spend about one minute a day on my batteries. About every six months I do a thorough check of the battery bank. It's easy!

Though most consider lead-acid batteries the weak link in renewable energy systems, today's renewable energy batteries are better than ever, and so are the devices that regulate and protect them. Battery failures are rarely the fault of the batteries themselves! Follow these guidelines to avoid the vast majority of all battery problems.

1. Size the battery bank and PV array properly. The battery bank should have a five day load capacity at a minimum. The PV array, should produce (on average) 30% more energy than the load requires. (This is a best case scenario. You may not be able to afford such a perfect system. Jack)
2. Buy high-quality batteries selected for your needs. You get what you pay for! Good deep-cycle batteries can be expected to last for 5 to 15 years, and sometimes more. Cheap batteries can give you trouble in half that time.
3. Connect the two main cables to opposite corners of the battery bank and maintain symmetry in wire size and lengths. This will help to distribute current evenly through the bank.
4. Arrange batteries to maintain even temperature distribution throughout the bank. Avoid uneven exposure to heat sources. Leave at least ½-inch of air space around each battery to promote even cooling.
5. Prevent corrosion. Once corrosion gets hold, it is hard to stop. The good news—it is easy to prevent! Apply a non-hardening sealant to all of the metal parts of the terminals BEFORE ASSEMBLY. A product called NO-CO NCP2 battery corrosive preventative works well. Vaseline or bearing grease will also work.
6. Moderate the temperature. Batteries lose approximately 25% of their capacity at 30 degrees Fahrenheit, compared to a baseline of 77 degrees Fahrenheit. At higher temperatures they deteriorate faster.

7. Install the batteries over a floor drain, or in a space without a floor, so that they can be rinsed with water easily. Washing the battery tops about twice a year will remove accumulated moisture (acid spatter) and dust. (I couldn't put my batteries in an area with a drain. I wash them off with a damp paper towel.)
8. Avoid multiple parallel strings.
9. Use a charge controller, power center or battery charger with temperature compensation. Better yet, place the batteries in a room that is temperature regulated, i.e. heated, insulated, shaded and ventilated.
10. Use an inverter or charge controller with a low-voltage disconnect or get a separate one. Discharging a battery to exhaustion will cause immediate, irreversible loss of capacity and life expectancy.
11. Equalize lead acid batteries once a month. Equalizing means bringing the batteries to a boil at about 15.5 volts for a few hours. This helps remove sulphate from the battery cells. Some charge controllers automatically equalize the battery bank, Other controllers have an equalization switch. Sealed batteries are not equalized.
12. Install a System Monitor, at least a digital voltmeter. Would you drive a car with no dashboard? Metering is not just bells and whistles. I use a BCM-12 LED meter (\$42).
13. Add distilled water as needed. Most batteries require additional water every 6 to 12 months.
14. Avoid sealed marine batteries in solar applications. They can disintegrate and/or explode. ("Solar Power 101 : Batteries", Backwoods Home Magazine, May/June 2004)
16. Do not replace one battery at a time. Remove bad batteries and have a smaller battery bank until the entire bank can be replaced.
17. Get a hydrometer. It costs about \$10. An hydrometer allows you to test each cell in your batteries. If a battery has bad cells it should be removed from the battery bank.
18. Put one teaspoon of Epson salts in each cell of new lead acid batteries.

19. This is the most important aspect of battery care! Check the voltage of the battery bank daily. The best time to check the battery bank is early in the morning before the sun hits the panels and before any energy is used. Your goal is not to go below 80% of full charge, or 12.46 volts. The batteries will last much longer if only the top 20% is used.

% of Charge	Voltage	Specific Gravity
100	12.70	1.265
90	12.58	1.249
80	12.46	1.233
70	12.36	1.218
60	12.28	1.204
50	12.20	1.190
40	12.12	1.176
30	12.04	1.162
20	11.98	1.148
10	11.94	1.134
0	11.90	1.120

These readings are correct at 75° Fahrenheit.
Back Home Magazine, issue 56, p. 14

Batteries are the heart of your power system. They may demand your attention occasionally, but your relationship with them need not be a struggle. With proper installation, a little understanding, and some simple maintenance, your batteries will live long and healthy lives.

The Generator

What it does

Creates electricity using a fuel-driven engine attached to a generator.

What it costs

Depending on size, from a few hundred to several thousand dollars.

Advantages

- ⊗ Adds great flexibility to a small photovoltaic system. The photovoltaic system can be smaller and less expensive with the addition of a generator.
- ⊗ Can be used to power tools during the construction of the homestead.
- ⊗ Can be used to charge the battery bank during cloudy weather.

Disadvantages

- ⊗ Fuel must be purchased and stored. Gasoline must be rotated regularly; it will last only a few months.
- ⊗ Noisy and stinky.
- ⊗ Must be carefully maintained.

Notes

Smaller gas-powered generators typically run at 3600 RPMS.

Larger diesel generators typically run at 1800 RPMS.

Good quality diesel generators can be run constantly and can last for years.

Small, gas-powered generators can be used intermittently - that is, a few hours at a time.

Sizing the generator

A generator that is too large will not work at capacity and will not last.

A generator that is too small will shut down under too great a load and will wear out prematurely.

Suggestion: If you need a small generator most of the time, buy a small generator and rent a larger one when you need it.

Safety alert

Generators create carbon monoxide and must not be used indoors.

The Generator...continued

Operating Tips

- 1) To extend the life of a new unit do the following: Run the new unit for one hour, then drain the oil and replace with new oil. This will remove any metal shavings created during manufacturing. You may further extend engine life by using synthetic oil. If you use synthetic oil continue to change the oil at intervals suggested by the manufacturer. You may be surprised at how often oil changes are needed! Generators "throw" some oil, that is, some oil is used during operation. Check the oil before starting the generator, **every time!**
- 2) When you start the generator give it a few moments to "smooth out" before sending power to your charger or appliances. Spikes and dips in voltage can occur when the generator is first started and when it is shut down.
- 3) Keep the generator tuned up and running smoothly. A poorly running generator can damage your charger and appliances.
- 4) Disconnect charger or appliances from the generator before you shut it down. Don't allow the generator to run out of gas while it is connected to a charger or appliances.
- 5) Generators tend to vibrate when running. This makes nuts, bolts and screws loosen. When you change the oil, remember to tighten all nuts, bolts and screws.
- 6) Inverter Generators. (2009) Honda, Yamaha and Robin offer new models with built-in, high quality inverters. These units are expensive, but produce high quality electricity for sensitive electronic gear.

The Converter/Charger

What it does

Changes 115-120 volt alternating current to 12 volt direct current, which can be used to charge the battery bank.

What it costs

Depending on size from \$100 to several hundred dollars.

General information

A converter is coupled with a generator. The converter must be sized according to the size of the battery bank. The generator must be sized according to the size of the converter.

EXAMPLE: You calculate that a thirty amp converter will be large enough to charge your battery bank. A 3500 watt generator will be needed to power the thirty amp converter.

The Voltmeter

What it does

Meters the voltage of the battery bank.

What it costs

For a digital unit, approximately \$10 - \$100. An analog unit with bouncing arrows is worthless.

Why it is important

For long battery life, just the top 20% of the battery should be used. In order to determine the battery's stage of charge, a voltmeter is used. The voltmeter should be checked daily, in the morning, before the sun hits the photovoltaic panels and before the batteries are discharged by use.

NOTE: The voltmeter I use now is a BCM-12 LED meter. The cost was \$42. At a glance you will always know exactly what is happening to your batteries. (2009)

The Inverter

What it does

Changes direct current (DC) to alternating current (AC). Some inverters also double as battery chargers.

What it cost

Depending on size and quality, \$100 to several \$1000.

Why it is important

The inverter allows the use of standard AC products. Smaller wire can be used when using AC as opposed to DC.

Important information

Certain AC products will not work with inverter power, i.e., certain printers, certain computers, some stereo gear, some battery chargers for power tools, ceiling fans, etc. Call manufacturers with questions before you purchase or ask others who live off-the-grid.