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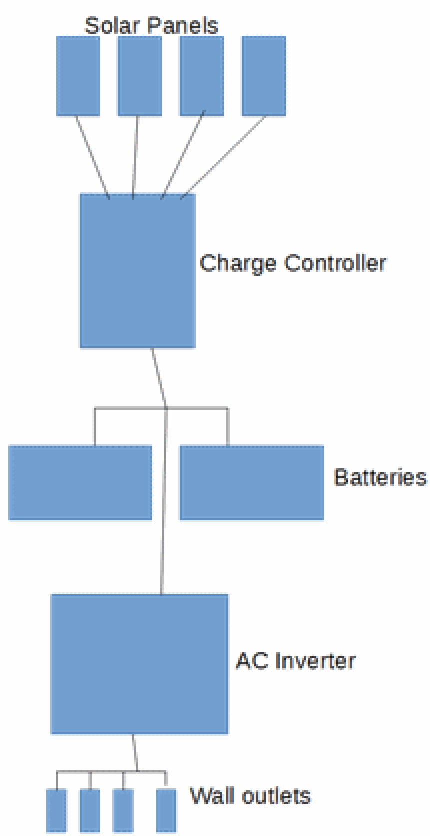
**So you want to learn about solar. Good, this is a good place to start. How does a solar system work? Simple, it's a battery running a box called an Inverter that makes the power you use every day in your house. That power is called AC power and that's what's available in each one of your wall sockets in your house or RV. When you plug a TV or cell charger into the wall socket, you're plugging it into AC power coming from your grid or electric company. In a solar system, a box called an Inverter stands in for the power company's power and makes the AC power from the batteries it's hooked up to. AC stands for "Alternating Current" and in America the wall outlet voltage is 120 volts.**
**So as you can see, the solar system is really a battery powered system running an Inverter. The solar panels are there to charge the batteries. Let me say that again, "The solar panels are there to charge the batteries".**

**Next you have another box called a "Charge Controller" that goes between your solar panels and the batteries. The Charge controller is there to make sure you don't over-charge your batteries. Without the charge controller, the solar panels would over-charge your batteries and ruin them or worse, cause a fire in rare situations.**

**I realize this might sound a little confusing but once you think about it and look at the figure below, it will start to make more sense on how a solar system is operating.**

**Once you get the basic idea of how the system works it will be easier to make decisions about how to order one or build one.**

**More detail on the next page.**




Basic Solar System

# Basics of a solar power system

**You have four (4) major components or pieces of the system.**

1. **Solar Panels**
2. **Charge Controller**
3. **Batteries**
4. **Inverter for AC power**

**1. You have your solar panels. These determine how much power you get from the sun each day. It is important to put up enough panels to ensure a full charge in full, bright sunlight each day when your batteries are only half charged or 50% charged as a bare minimum. This ensures you will be able to fully charge your system in two days of full sun if your batteries are completely discharged. Hopefully you won't completely discharge your batteries as this shortens their life. An example would be if you have 1000 watts of solar panels, then your batteries should not store more than 10 times that amount or 10,000 watts. This represents 1000 watts times 5 hours of sunlight per day for a total of 5,000 watts, enough to fully charge the batteries over 2 full days. This is adjustable.**

**Before we continue, there is a concept which you must grasp if you're going to understand Solar Power……**

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**<u>I cannot stress this enough… Because we are talking about a power system, that is, a system that makes, and delivers POWER, You need to know how Power Is Measured…</u>**

**I'll do my best to explain this in simple, easy to understand terms.**

**Power is measured in Watts. What is a Watt? It's a measurement just like a teaspoon is used to measure sugar or whatever. A watt is made up of something called amps and volts. It's actually a product of them multiplied together but we're not interested in that much detail. All you need to know for now is that the watt is how power, electrical power, is measured. You power company uses this same unit (watts) to bill you when you're connected to the grid. In fact, if you get an electric bill, it will say on it somewhere how many watts you used in the previous month you were billed. Look for a statement, usually in a box that has a number with the word "kw" or "kwh" beside it. That term "kw" stands for**

KiloWatt which means “kilo” or thousand and watt, the better meaning is kilowatt which means one thousand watts so 1 kw= 1000 watts.  The power company bills you for these kilowatts by the hour. Hence a term “kwh” which means “kilowatt hours”.  So your bill may read 130 kwh which means 130 kilowatt hours or in simple terms 130 thousand watts for one hour.  Obviously you didn’t use it all in an hour, it was for the whole month.  So if you divide that number by 30 days you get an average use of power per day.  In this case, 130 / 30 = 4.33 kwh per day. That’s 4.33 kilowatt hours per day.  How much energy is that?  It’s 4 thousand and 330 watts of power for the day or 4.33 kilowatts of power used in a day.

Does that make sense?  If it doesn’t, please read it again and have someone help you understand this term because your solar system is going to supply you with watts and in most cases, a few thousand watts for a day’s use.  And you need to understand how much power you’re using to determine if you have a big enough system to meet your needs.  So understanding this kilowatt thing is extremely important unless you don’t care if the lights go out….

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Hopefully you have some understanding of power and how it’s measured now. This information will tell you all kinds of things about your solar system.  So let’s get started.

2.  As mentioned above, you need solar panels to charge your batteries.  But first, the power from the solar panels *must* go thru a charge controller. Why ? Because the charge controller monitors the batteries and makes sure they get fully charged but not over-charged.  Without this important piece of equipment, you batteries will be destroyed or worse.  Without the controller, you could have a fire or explosion depending on battery type.  And depending on how big your solar panel array is, you might even need more than one charge controller to handle the power being put into the batteries.

Charge controller types:<br>
There are two (2) basic types of charge controllers.<br>
One is called a “pwm” type and the other is called a “mppt” type.

Pwm type controllers are much cheaper usually as they are not as efficient as the other type of controller.  What does that mean ?  It means the pwm type controllers are not able to use all of the energy coming from your solar panels. And it’s important in most cases that you get every last watt of power from your solar panels as possible.  Those panels cost money and you don’t want to throw away your money on wasted power if you can help it.  If you’re on a limited tight budget, a pwm controller may be all you can afford.  That’s OK, just be aware that

**there is a better option out there.**

**The Mppt charge controller is the most efficient and utilizes almost all the energy that your solar panels can develop.  It's typically 10 to 20 % more efficient than the pwm type controllers.  But it costs more too.  And don't be fooled by the people selling so called mppt controllers for the same price as a pwm type, it's a scam.  Mppt controllers are a lot more complex that the pwm type so if you can afford it, buy the mppt type.  Look for reputable brands. Some are over-priced but that's in another book.**

**3.  Batteries: There a several types of batteries being used in solar systems today. In days past, the lead acid battery was all that was available.  It was proven and powerful.  And Heavy.  And short lived if not kept charged properly, and maintenance was always an issue as they used water up when being used and charged.**

**<u>The single most important thing about a battery is it's lifespan.</u>  How long does it last ?  Battery life is usually rated in cycles.  What's a cycle ?  A "cycle" is a discharge and recharge one time, so when you use a battery, you run it down or discharge it.  Then you charge it back up and that's one cycle.**

**<u>The amount of cycles a battery can withstand is directly related to MUCH you discharge it.</u>  That is, how much did you run the battery down.  If you only used the battery a little bit, it might only be discharged 10 or 15% percent.  This light discharging will make the battery last Much Longer than running it all the way down.  *Running a battery all the way down will shorten the life of almost Any Battery.*  But it will almost ruin a lead acid battery.  Haven't you ever noticed that if you run your car battery down to a point where it's dead, even if you charge it back up it's never the same again and it doesn't last long after that.  That's why lead acid batteries are not a good choice for solar power.**

**Typical Cycle Life of various batteries:**
**Lead Acid: 200-500**
**AGM Lead: 200-800+**
**Lithium iron phosphate: 4000-15000**

**Of course there are several different lithium batteries, some made with manganese, others with cobalt and others along with straight lithium.  Lithium is excellent when it comes to storing power and lifespan, but certain types are fire hazards and that's why the Lithium Iron phosphate type were developed.  They are much safer that other type lithium batteries.  Still, precautions should always be taken to ensure safety.**

**So as you can see, Lithium Iron Phosphate aka LifePO4 is the preferred type to get when setting up a solar system. Cost is 3 times as much but life is up to 30 times as great as lead acid. And you can run them all the way down without killing them like lead acid.**

**If there is any way, buy Lithium Iron phosphate batteries for your solar system.. Avoid other types if possible. Note that battery technology is changing rapidly and newer safer types are promised in the future. But at the time of this writing LifePO4 is the way to go.**

**4. Inverters: Since this is a beginners manual I will not go into the fine detail about inverter as such but give an overview of what they do and what to look for. As the diagram above shows, the inverter supplies the AC power from your batteries to your house or building. Inverters run on 12 volts, 24 volts, and 48 volts with a few odd ducks thrown in to the mix. Some of the newer inverters run on much higher voltage batteries but those are commercial systems not covered here.**

**Safety: Inverters produce the same voltage that your wall socket has and can kill you if you're not careful. Wiring to inverters can get hot and cause a fire if not designed and installed with big enough wire. A protection device between the inverter and batteries is called for, along with fuses on the inverter output to the house wiring for safety.**

**That being said, smaller systems have inverters that are so small as not to need much in the way of extra fuses and protection devices. This is because smaller inverters have internal fusing and do not generate thousands of watts of power. Small models only produce 500 to 1000 watts of power and usually have internal fuses and protection built-in. However, units in the 2000 watt class and larger should be installed and used with caution as these power levels are enough to cause harm and fires. You should ALWAYS use some sort of disconnect device between the batteries and inverter whether it be a switch or fuse. Failure to include these safety devices can lead to serious injury, fires, or death. Even a small 100 watt inverter can generate enough power to stop your heart if you get electrocuted by it. Always be Careful !!**

**Inverters are sold as 2 (two) basic types: Modified sine wave, and Pure Sine wave.**

**Modified sine wave types are advertised as usable almost anywhere but the truth is a little different. Some small transformer devices like a shaver charger and small electronic devices will overheat with a modified sine wave inverter. You may not even notice it getting hot, but it can create a fire. Yes, modified sine**

wave inverters are much cheaper and the reason they are is because they are much simpler in design and parts. Running large appliances' like an electric heater or hot plate will be fine on this type of inverter. Many microwave's work on them as well with no problem. But a computer or television may not work well and even be damaged by these type's of inverters. Better to spend the extra money and get pure sine wave type inverters and that way you don't have to worry about plugging anything into them and causing damage.

The pure sine wave inverters produce the same type of power the grid/power company does. So it's not an issue to plug anything you want into them as long as you don't overload them.

Pure sine wave inverters cost 3 or more times as much as a modified sine wave type so don't be fooled by low prices on a claimed pure sine wave inverter.

Another thing to note is many of the lower power inverters that are cheap, don't say what type of inverter they are. If this is the case, you can be sure it's NOT A PURE SINE WAVE. ALL Inverter manufacturers TELL YOU if theirs is a Pure Sine Wave type. So when you see a low priced on and it doesn't say what type it is, you can be sure it's a modified sine wave type.

----------------------------How to size your system---------------------------

Up until now we've talked about the basic's of how a solar system works. But how do you get an idea of how big a system do you need? It's fairly basic, you calculate how much power your using if you can, and make decisions on what you want to run and size the system from there. Here's and example taken from a real world user:

This person heats with wood so no bill for heating, and cooks with a microwave and induction cooker to save energy. Cooling in the summer is provided by a window air conditioner and a fan. A refrigerator and WiFi system run 24/7 along with a few lights and stereo or computer. And there are other odds and ends that need power to charge the cell phone or run a computer. This person installed a power meter to measure the total power used on a daily basis. Available from Amazon for $ 25. The meter shows 3.3 to 4.2 kw of power use per day. Standard design practice is for the batteries to supply power for 3 days without recharging in case of storms. This person is covered if they limit their power usage to the lower number above of 3.3 kw per day. Times 3 days this is 9.9 kw hours of use so they need a 10 kw battery bank or said another way, they need enough batteries to supply the 9.9 kw which would give them 3 days of operating without any sun at all. Since batteries come in more or less even numbers of power based upon amperage of the battery times it's voltage, this come out to the kwh

**the battery can deliver. The 200 amp hour batteries they have operate at 12.8 volts (nominal) for a total of 2560 watts per battery or rounded off to 2.5 kw per battery. So 4 of these batteries in parallel will provide the 10 kw or kwh they need for 3 days of no sun use. Now that we've determined the correct size for the batteries, we now calculate the size of the solar panels needed to fully charge these batteries from zero in 2 days. Based upon 5 hours of full sunlight per day, we can take our 10 kw battery and divide it by the number of hours in 2 full days which is 10 hours. 5 hours per day times 2 = 10 hours. So a 10 kw battery bank needs a 1 kw array of solar power. 10 kw/10 hrs. = 1kw. If we wanted to fully charge the battery in one day we would need a 2 kw solar panel array as 2kw x 5 hrs= 10 kw… Do you see how this works out? Look at the numbers again and it will make sense. This person actually has a 2.2 kw solar array which will indeed fully charge those batteries in a single good day of sunlight. Please note in this example, the losses of the solar system have been ignored. There are losses in any electrical system including solar systems. I have not gone into losses as this is a beginners manual. There is more detail in other manuals offered. Although I offer these manuals for free, they are not free for me to make and I ask for donations of any amount if you can on the download page. They are free because I know some of you cannot afford much and live on fixed incomes so this is my hope to be of some use for all.**

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**I hope this booklet has been a help to you in your search for information about solar systems. Please use the contact page to let me know if you have questions or you find a type-o somewhere.**

**Thanks for your supplies,**

**Tom Brent**

**R35Solar.com**