



# SOLAR STIK™

## SOLAR STIK™ SOLAR SCHOOL

Solar energy is a great source of electrical power. However, every application does not always fit solar energy. This section helps the novice learn a little about solar power, and figure out if you have an application suitable for a Solar Stik™.

This SOLAR SCHOOL section gives the reader a basic understanding of a "closed" DC (not connected to the grid) electrical system. A closed system is one that incorporates a method of producing power, a method of storing power, and appliances that use the stored power.

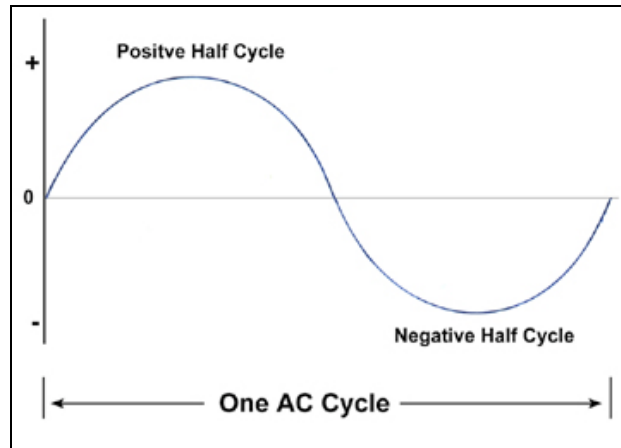
It is critical to have a balance between all the working components of a closed electrical system. Striking a "balance" means knowing the total power consumption, generation, and storage requirements for successful appliance operation.

The following principles will be covered:

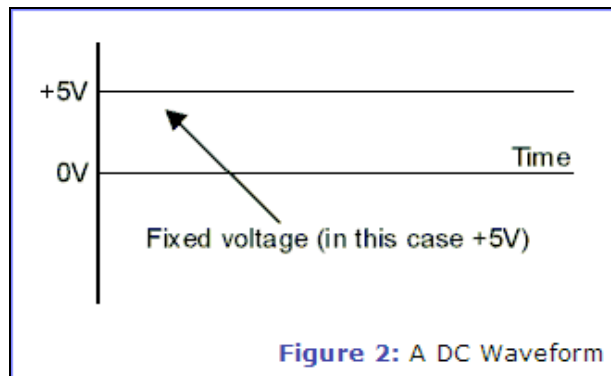
1. Find the power requirements (Watts) for each individual appliance (load).
2. Determine how long each load runs in a 24 hour cycle.
3. Add up the power consumption of all electrical loads for a 24-hour period.
4. Determine how much power is needed to replace energy taken from the batteries.
5. Install a solar/wind charging system that meets or exceeds the total load requirements.

## THE BASIC ELECTRICAL SYSTEM

The first thing we will cover is a little about basic electrical systems. There are 2 commonly used types of electricity:



AC (sine wave alternating current - fig. 1)



DC (direct current - fig. 2)

Both of these types of electricity are measured in Voltage. Most small DC systems use 12 Volts (12VDC), and most AC systems use 120 Volts (120VAC).

To determine which type of system you are using is whether energy is supplied from a battery bank, or from a commercial power line or gasoline generator. Any time primary energy source is a battery, then that is a DC system. DC systems are commonly found in motorhomes, sailboats, powerboats, cars, and campers. A Solar Stik™ produces 12 Volts of DC energy (12VDC), so if your power comes from a battery, then you may be a good candidate to use Solar.

Next, let's dive a little deeper into the specifics of a DC system. A "load" is anything that consumes energy in your electrical system. All electrical systems are built around the amount of energy that the loads will require. There are three factors that combine to successfully supply energy to the load.

"Voltage" or "VOLTS" is the force that "pushes" the electricity through the wire... the higher the Voltage, then the higher the force of the "push".

Current is the rate of electricity flow through a wire, and is measured in "AMPS".

The power that is consumed by the appliance is measured "WATTS".

## DETERMINING THE ELECTRICAL CHARACTERISTICS OF A DC ELECTRICAL SYSTEM - VOLTS, AMPS, & WATTS

Imagine that you own a camper and you need to build a DC electrical system for it. Your camper will have two loads in its electrical system, a 12 Volt DC refrigerator, and a 12 Volt DC light, with each one consuming different amounts of energy. (As we discussed, "consumed energy" is measured in Watts. You will see that a "Watt" is represented by the letter "P" [for "power"] in our electrical formulas).

There is a formula to determine the power characteristics of an electrical system, and it is as follows: VOLTAGE, multiplied by AMPS, equals POWER ( $V \times A = P$ ). To the seasoned electrician, this formula is known as "Ohm's Law".

Variations of this formula can be used to determine all three values:

$$V \times A = P$$

$$V = P / A$$

$$A = P / V$$

Let's say that your 12 Volt DC light bulb consumes 25 Watts of power, and you need to know how much current (AMPS) it will draw.

We need to use the following formula:

AMPS equals WATTS divided by VOLTAGE ( $A = P / V$ ). Inserting the values that we know, we then have  $A = 25 / 12$ , and solving the equation we have  $A = 2.1$  Amps consumed by a 25 Watt light bulb in a 12 Volt system.

Pretty easy, right? Good!

Now let's look at the refrigerator. Every electrical appliance has a data plate or tag on it that tells you what type and how much power is necessary to operate the appliance. If no data plate is present, then the manufacturer's literature will have it in its pages. Depending on the manufacturer, you may be reading the operating energy requirement in Watts or Amps.

If you know the voltage (V) you can use either value (Watts or Amps) to determine the other.

For example, if the Power consumption rating is given on the data plate is "60 Watts", then plug in the system Voltage and to determine the current (AMPS) value.

$P / V = A$ , or in this case,  $60 / 12 = 5$ ... so the refrigerator draws 5 Amps.

Now let's figure out the total of Amperage draw for the camper's DC system. Simply add the values of the Amp ratings of all of the loads together. The total Amp draw for the light and the refrigerator is 7.1 Amps!

## THE "HEART" OF ANY DC SYSTEM... THE BATTERY

Now that we have the total load for the system, we need to learn how it relates to your battery or batteries (battery bank). Batteries store energy, and often have ratings that correspond the amount of energy they can store, known as the "Battery Capacity". This is expressed as "Amp-hours".

It important to have the proper battery capacity for many reasons:

- \* Proper capacity should be able to supply total power required by the loads in your particular system
- \* Proper capacity should conform to the recharging capabilities. A Solar Stik™ will recharge 12 Volt batteries at a specific daily rate.
- \* Proper battery capacity ensures that there is enough energy to power your loads between charges.

AMP-HOURS - if the battery label reads 125 Amp-hour reserve, then it means that it can provide 25 Amps continuously for 5 hours ( $25 \text{ amps} \times 5 \text{ hours}$ ) and at the end of 5 hours, the battery would be considered "discharged" and out of service until charged.

If you were to look at a deep-cycle battery, you will probably find a label that rates the battery capacity in AMP-HOURS. This relates to how many Amps can flow from the battery to the load, in the amount of time it takes to consider the battery as "discharged".

WATT-HOURS - Like "Amp-hours", a "Watt-hour" is power consumed over a certain amount of time. If you have the battery ratings for Voltage and Amp-Hours (AH), you can also determine the WATT-HOURS (WH) that are stored in the battery. ( $V \times AH =$

WH). For example, a 100 Amp Hour battery at 12 VDC can supply up to 1200 Watt Hours of energy.

## DAILY POWER REQUIREMENTS: AMP-HOURS & KILOWATT-HOURS

Let's back up for a minute. We figured that the camper refrigerator and light total current draw was 7.1 Amps when they were both operating, but you may not use the light all the time, or the refrigerator may only actually operate for a total of 20 minutes during an hour.

To get an accurate picture of your system's daily requirements, you will need to get the sum total of 'hours per day' of refrigeration and light operation time.

Let's say that you added it all up and estimated that the total Amp draw from the batteries was 7.1 amps for 8 hours in a 24 hour period. This means that you are consuming about 57 Amp-hours per day, right? ( $7.1 \text{ Amps} \times 8 \text{ hours} = 56.8 \text{ Amp-hours}$ )

In the same manner, the Watt-hours can also be calculated. If the refrigerator and light consume a total of 85 Watts and operate for a total of 8 hours daily, then the total Watt-hours consumed in a 24-hour period would be 680 Watt-hours.

While labeled differently, the appliance energy requirements are exactly the same:

12 Volts multiplied by 56.8 Amp-hours = 681 Watt-hours ( $12 \times 56.8 = 681$ )

Finally, it is common to refer to power in terms of "Kilowatts". A "Kilowatt" of power equals 1000 Watts (Kilo = 1000). Using this term, 680 Watt-hours can be expressed as 0.68 Kilowatt-hours.

Now that we know how much energy we need to use on a daily basis, we need to determine how to replace the 57 Amp-hours or 0.68 Kilowatts of power that you consumed from the battery during one day.

Let's take a look at energy production of a two-panel Solar Stik™. According to the data plate on one 50 watt solar panel, it produces about 3 Amps at 18 Volts DC. Two panels produce 6 Amps. Therefore, the panels will need to produce 6 Amps for 10 hours (60 Amp-hours) to replace the energy used by your DC loads. This amount of energy will keep the battery (located in the Power Pak) fully charged and allow uninterrupted daily use of your refrigerator and light!

## THE SOLAR STIK™ AND THE BENEFITS OF MPPT CHARGE CONTROLS

The standard Solar Stik™ has two 50 Watt solar panels, giving us 100 total Watts of solar power. Solar panels are rated in Watts, but they create power, not consume it.

The solar panel's rated "Output Voltage" is about 18 Volts. Using our standard formula  $A = P / V$  (Amps = 100 / 18).

We find that the Solar Stik™ panels produce 5.8 Amps, or about 3 Amps per solar panel. On average, one can expect to be able to get 10 hours per day of direct sunlight, providing the user with about 60 Amp-hours of energy.

It is important to know that a Voltage greater than that of a battery Voltage is required to charge that battery. The higher Voltage is the "push" that enables the battery to be recharged. Charging Voltage must also be limited to prevent a battery from over charging or over heating. This is where "charge controllers" enter a solar system.

Also note that any conversion of one form of energy to another form of energy requires some power to perform the conversion.

Now that you know the Solar Stik™ Panels operate at 18 Volts, you may be thinking "...but my batteries are rated for 12 Volts". This is why we recommend (and provide) the use of an MPPT (Maximum Power Point Tracking) charge control. This charge control converts 18 Volts DC to about 14 Volts DC by using a small internal computer.

Allowing the solar panels to operate at their "Maximum Rated Voltage" instead of the "Battery Voltage" results in quicker recharge of your batteries. Let's perform the math to see the difference. First the MPPT math:

$$A = P / V$$

$$A = 100 / 14$$

$$A = 7.2$$

Using an MPPT charge control, the available current from the panels to the batteries is 7.2 Amps. This means that 86 Watts of power are being produced.

Non MPPT types of charge controllers force the solar panels to operate at the battery's Voltage as below:

$$A = P / V$$

$$A = 100 / 18$$

$$A = 5.5$$

In other words, the 5.5 Amps from the solar panels yields only 66 Watts of power to charge the battery.

In conclusion, an MPPT charge controller, increases the available current from the panels to the batteries from 5.5 Amps to 7.2 Amps... an increase of about 25%. This means faster and more complete charging of the battery.

There is always some energy loss in the transfer of the power generated at the panel to the batteries. This loss is greater for older systems that do not have MPPT technology. It is always better to use a MPPT charge controller with a solar or wind generator system.

## USING A DC TO AC POWER INVERTER

"What about using an inverter in my system to run a 120 Volt appliance? How much power will it draw?"

Let's say that you have a microwave oven that is rated at 600 cooking Watts. The manufacturer's plate indicates that it operates at 900 Watts. If we know the microwave uses 120VAC, then we can figure out the Amperage it requires to operate from an inverter. First, let us calculate the AC Amps required.

$$A = P / V$$

$$A = 900 / 120 = 7.5 \text{ Amps}$$

The microwave uses 7.5 Amps of AC (alternating current) from a 120V source.

An inverter powered from a DC system (battery) allows you to run AC appliances by converting 12VDC to 120VAC. Since an inverter consumes some power in the act of converting power, we must also take that into consideration.

To find out the current (Amps) from the battery (12V), use the following quick calculation:

AC Watts (inverter output) divided by 10 equals the DC input current (Amps).

$$900 / 10 = 90 \text{ amps.}$$

Using the example 900 Watt microwave oven powered by an inverter, then 90 DC Amps must be supplied by the battery.

Please read the new SOLAR STIK™ INVERTER SCHOOL to get an in-depth understanding of inverters, the various types, and how to effectively choose one for your application.

## USING DC APPLIANCES IN A DC ELECTRICAL SYSTEM

When possible, it is recommended that you use a DC appliance in any application where the energy source is a battery. You will use less energy when compared to that used by an AC appliance powered by an inverter to perform the same function. Remember, there is approximately a 10 percent loss while using an inverter to produce the AC.

For example, a DC refrigerator may consume less power than an AC refrigerator will consume, but the result is the same... cold food storage. Dedicating some extra effort in finding DC appliances in place of traditional AC appliances when building your DC based system will prove extremely beneficial. The internet allows for easy product sourcing and comparison regarding DC appliances.

Some readily available DC appliances include:

Laptop computers, TV sets, sound systems, fans, coffee makers, blenders, refrigerators, water pumps, lights, communications equipment, handheld electronics, and rechargeable tools

Many of these items are used every day by people who have no idea that they are using a DC powered product. When purchasing an electrical appliance, remember to ask if a 12 Volt DC adapter is available for the product.

## A BRIEF OVERVIEW OF SOLAR PANELS

There are two commonly used types of rigid solar panels. These are Multi-crystalline and Mono-crystalline panel technologies. Both are excellent and efficient means of DC power production. The only differences are that the mono-crystalline usually have a slightly higher efficiency and the multi-crystalline usually are slightly cheaper to manufacture.

There are also Amorphous silicon solar panels and newer technologies emerging like CIGS (copper-indium-gallium-selenide). These types of panels are available in either rigid or flexible (rollable and/or foldable) configurations. The advantage of these technologies is that they are less expensive to produce, but less efficient and they require more surface area to achieve that same power production as their Mono/Multi-

crystalline counterparts. Also, Nanosolar technology is under development which will allow also irregular surfaces to produce power.

All solar panels work at their rated output in direct sunlight. So as the sun drops lower to the horizon in the late afternoon, most flat-mounted fixed solar panels gradually lose their power output. This means that a fixed mounted panel system works at rated capacity for about 3 to 4 hours per day (during "peak sunlight"), and summarily, are an inefficient means of power production.

To counter the inefficiencies of flat-mounted panels, it is usually necessary to install a larger solar panel array that maximizes the amount of power that can be produced during the daily period of "peak direct sunlight". Solar Stik™ panels are articulated and they are able to face the sun from dawn to dusk, maximizing solar panel power output. This ability enables a smaller array to produce the same amount of power as a larger fixed position array. More on flat solar panel arrays and the Solar Stik™ can be found in the Synopsis of the Solar Stik™.

For a detailed introduction on how solar panels generate electricity from sunlight, please visit the following: [science.howstuffworks.com](http://science.howstuffworks.com)

## IN SUMMARY

The Solar Stik™ is so versatile that it could be used as an "everyday" power generator for a wide spectrum of applications. Each Solar Stik™ can power applications that use up to 1 Kilowatt-Hour of power per day.

If one's daily power consumption is greater than what a single Solar Stik™ can generate in one day, it is possible to add power generating capability in a multitude of ways:

Multiple Solar Stiks™ can be "daisy-chained" or "tethered" together to create a larger power generating system. In the same manner, multiple Power Paks can be connected together to store the power.

A boat could have a wind generator or other solar panels added to it's deck, or an RV could have additional flat mounted solar panels placed on its roof. The methods and equipment for power production are numerous and usually easy to obtain.

There are many variations to the scenarios that we have presented... many requiring more greater understanding of electrical systems, but hopefully we have given you a basic understanding of solar energy and its use as a closed power system.

EDUCATIONAL MATERIALS AVAILABLE FOR DOWNLOAD FROM  
[WWW.SOLARSTIK.COM](http://WWW.SOLARSTIK.COM):

**INVERTER SCHOOL** – all about DC to AC inverters

**BATTERY SCHOOL** – all about lead-acid batteries

**A SYNOPSIS OF THE SOLAR STIK™** – how the Solar Stik™ works

**FREQUENTLY ASKED QUESTIONS** – all about the system & how it operates