

## Overview

The GS-50+Preconfigured Kits are designed to be modular and expandable solar generators, capable of meeting a wide variety of power production needs. These kits can be as simple as a battery charger or expanded to provide enough power to continuously support a cabin.

Grape Solar understands that one size does not fit all when it comes to solar power and that power consumption tends to grow over time. With the GS-50+Preconfigured Kits you will be able to meet your power generation goals in a system that can cost-effectively grow with your changing needs.

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## System Sizing: Step 1 - Determine Consumption

To determine the total system size you must first calculate your consumption in Watt hours (Wh) per day.

### Lighting

If you have four 15W LED lights (actual wattage not equivalent wattage) that you plan on running for 8 hours per day, you would take the wattage of each bulb, multiply it by the number of bulbs and multiply that by the number of hours of run time per day.

$$4 \text{ bulbs} \times 15 \text{ W/bulb} \times 8 \text{ hours/day} = 480 \text{ Wh/day}$$

### Misc. Electronics

If you want a system to power your laptop for 6 hours per day plus a microwave oven for 10 minutes per day you would first need to determine the wattage of each device. This information can usually be found on the device or approximated with the help of an internet search. Let's assume that the laptop consumes 65W and the microwave oven consumes 800W. Multiply each device's wattage by its run time and add the two numbers together.

$$1 \text{ laptop} \times 65 \text{ W/laptop} \times 6 \text{ hours/day} = 390 \text{ Wh/day} \quad 1 \text{ oven} \times 800 \text{ W/oven} \times (10/60) \text{ hours/day} = 134 \text{ Wh/day} \quad 390 \text{ Wh/day} + 134 \text{ Wh/day} = 523 \text{ Wh/day}$$

### **Battery Charging**

If your plan is to keep a battery bank charged, first add up the Amp hour (Ah) capacity of all the batteries in your system, then multiply by the battery voltage to get watt-hours. The Ah capacity is usually shown on the side of the battery. For example, an RV with two 80Ah 12 volt batteries would have a 1920 Wh battery bank. Most batteries can only discharge 50% of their Wh capacity so only 50% of the total Wh rating needs to be fed to them to bring them to full charge. In this case that would be 1920 divided by two, equaling 960 Wh.

$$2 \text{ batteries/day} \times 80 \text{ Ah/battery} \times 0.50 \times 12 \text{ V} = 960 \text{ Wh/day}$$

### **Watts vs. Watt hours**

Keep in mind that Watts is an instantaneous power measurement, not to be confused with Watt hours, which is the actual energy consumption. Watts must be multiplied by estimated run time to determine energy consumption. A good analogy would be speed vs. distance. Watts are equivalent to speed, where as Watt hours would be the distance. In order to determine how many panels are needed you need to know the "distance."

## **System Sizing: Step 2 - Calculate Panel Count**

On an average day, a single 50W panel will produce about 150 Watt hours (Wh) of charge. This figure will vary depending on temperature, brightness and time of sun exposure. In the Summer production will be higher than in the Winter. On bright sunny days the output will be higher than on cloudy days.

$$\text{A single 50W panel will have an average daily production of:} \\ 150 \text{ Watt hours (Wh)} = 0.15 \text{ kilo Watt hours (kWh)} = 12.5 \text{ Amp hours (Ah)}$$

After determining your consumption in step one, divide that number by the production of a single panel:

### **Lighting example:**

Four 15W LEDs for 4 hours per day

$$240 \text{ Wh} / 150 \text{ Wh/panel} = 1.6 \text{ panels} = 2 \text{ panels}$$

### **Misc. Electronics example:**

One 65W laptop for 5 hours and one 800W microwave for 10 minutes, per day

$$458 \text{ Wh} / 150 \text{ Wh/panel} = 3.05 \text{ panels} = 3 \text{ panels}$$

**Battery Charging example:**

One 80Ah battery per day

$$480 \text{ Wh} / 150 \text{ Wh/panel} = 3.2 \text{ panels} = 4 \text{ panels}$$

**Area Specific Production:**

More accurate panel production estimates can be made by using an online program that takes into account the local climate, latitude, tilt angle and bearing of the panel.

The simulator can be found here: <http://rredc.nrel.gov/solar/calculators/PVWATTS/version1>

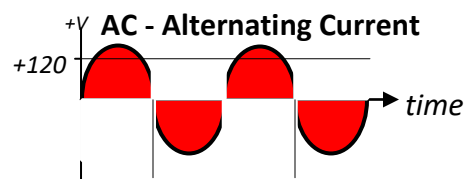
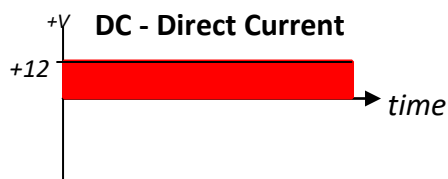
1. Click on your State
2. Click on the city nearest to your location
3. Change the DC rating from 4.0 to .05 (to simulate a single 50W panel)
4. Change the tilt angle to whatever your panel is tilted at (ideal is equal to your latitude)
5. Confirm that your azimuth is correct (180 degrees, facing South, is optimal)
6. Click "Calculate"

A new page will show a "Results" box. The middle column "AC energy" will show your panel output broken down yearly and monthly in Kilowatt-hours (divide this by 1000 to get watt-hours). For example, the total kWh for one year of 50-watt panel production in zip code 97402 is 60 kWh. The average daily production would be approx. 164 watt-hours.

$$106,794 \text{ Wh/yr} / 365 \text{ days/yr} = 292 \text{ Wh/day}$$

### System Sizing: Step 3 - Inverter Sizing

The solar panels put out DC power that is fed through a charge controller onto a battery bank. If you have an application that requires AC power you will need an inverter to take that power off of the battery and turn it into 120V AC.



When selecting an inverter it is important to know the total Wattage of your load. In Step 1 we determined the Watt Hour consumption, but for inverter sizing we can go back to just using Watts, and ignore the time factor.

The GS-50+KIT has two options for inverters, a light XPower 450 modified sine and a heavy PROwatt SW 2000 pure sine. Because of the modular design of this kit, other inverters may be used as long as they are compatible with the voltage of the battery bank.

**Lighting example:**

Three 60W incandescent light bulbs

$$3 \text{ Bulbs} \times 60 \text{ W/bulb} = 180 \text{ W} \quad \text{Use the XPower 450}$$

**Misc. Electronics example:**

One 65W laptop for 6 hours and one 800W microwave for 10 minutes, per day

$$\begin{aligned} 1 \text{ laptop} \times 65 \text{ W/laptop} &= 65 \text{ W} && \text{Use the XPower 450} \\ 1 \text{ microwave} \times 800 \text{ W/microwave} &= 800 \text{ W} && \text{Use the PROwatt SW 2000} \\ \text{Together} &= 65 \text{ W} + 800 \text{ W} = 865 \text{ W} && \text{Use the PROwatt SW 2000} \end{aligned}$$

**Battery**

**Charging example:**

Two 80Ah batteries per day

**No AC required - No inverter needed**

**Pure Sine vs. Modified Sine**

The XPower 450 inverter option uses what is called a modified sine wave. This means that the output of the inverter looks more like a stair step pattern than the smooth wave shown in the diagram above. Modified Sine is fine for charging small devices but if you plan to use anything that has an AC motor you will need the PROwatt SW 2000 inverter with pure sine output. Also, some stereos and musical equipment may emit an unwanted “hum” when powered by a modified sine inverter. LED lights generally require pure sine wave inverters.

## **System Sizing: Step 4 - Battery Bank Sizing**

The GS-50+ Preconfigured Kits do not come with batteries, but will work with most deep cycle batteries. A deep cycle battery is designed to be charged and discharged regularly, unlike standard car batteries that are meant to hold a somewhat constant charge. Deep cycle batteries come in many forms including lead acid, sealed AGM and Lithium Ion. A typical deep cycle battery can discharge about 50% of it's Amp hour (Ah) capacity.

If you need a battery to store 1200Wh of charge you first need to convert the 1200Wh to Ah by dividing it by 12V (the voltage of a battery) to get 100Ah. Since the battery can only discharge 50% of it's capacity, you must divide the 100Ah by 50% to get 200Ah. A 200Ah battery bank will store 1200Wh of usable power.

$$1200 \text{ Wh} / 12 \text{ V} = 100 \text{ Ah} \quad 100 \text{ Ah} / 0.50 = 200 \text{ Ah battery bank}$$

### Lighting example:

Four 15W LEDs for 8 hours per day, one day back-up

$$480 \text{ Wh} / 12 \text{ V} = 40 \text{ Ah} \quad (40 \text{ Ah} / 0.50) \times 1 \text{ day} = 80 \text{ Ah battery bank}$$

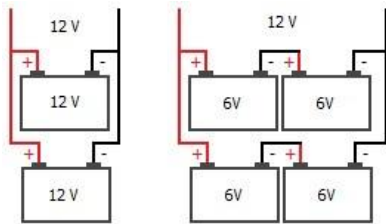
### Misc. Electronics example:

One 65W laptop for 6 hours and one 800W microwave for 10 minutes, one week back-up

$$523 \text{ Wh} / 12 \text{ V} = 44 \text{ Ah} \\ (44 \text{ Ah} / 0.50) \times 7 \text{ days} = 616 \text{ Ah battery bank}$$

### Battery Connections:

Multiple batteries can be connected to each other to increase the Amp Hour storage capacity of your system. Since the charge controller and inverters in the GS-50+KIT are designed for 12V systems it is important that multiple 12V batteries are connected in parallel and if your system incorporates 6V batteries they should be connected in series pairs.



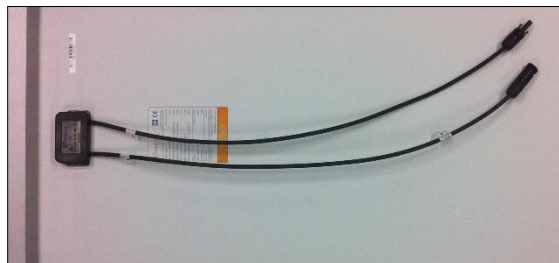
### Battery Life:

Batteries have a limited life. A battery that is discharged 50% every day will not last as long as a battery that is only discharged 20% every day. Consider this when designing your system, adding “too many” batteries will not adversely affect the electrical performance of your kit but it will increase the life of all the batteries in the system.

## Connecting Panels in Parallel

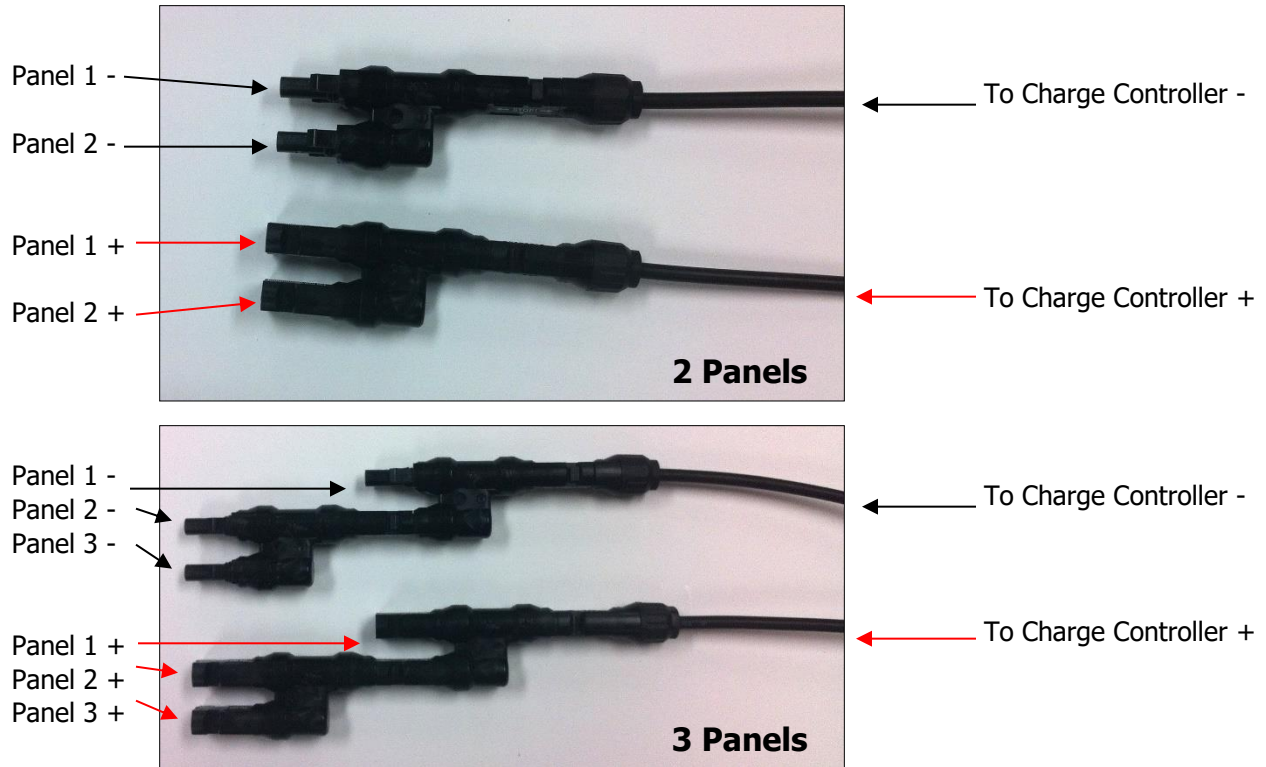
The solar panel comes with 900mm MC4 leads, one for positive + and the other for negative -. The connectors plug into the MC4 leads for the Charge Controller, or in multiple panel systems, plug into the MC4 T Branch connectors. Panels can be connected in parallel (+ to + and - to -), but never connect panels in series because this may result in a voltage that is too high for the charge controller. Below are some diagrams showing parallel connections:

Additional MC4 cables and connectors can be found in well stocked electrical supply warehouses or on Amazon.com using the keyword “MC4”.



Panel +

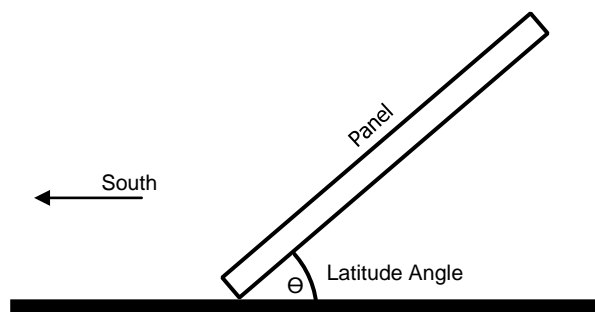
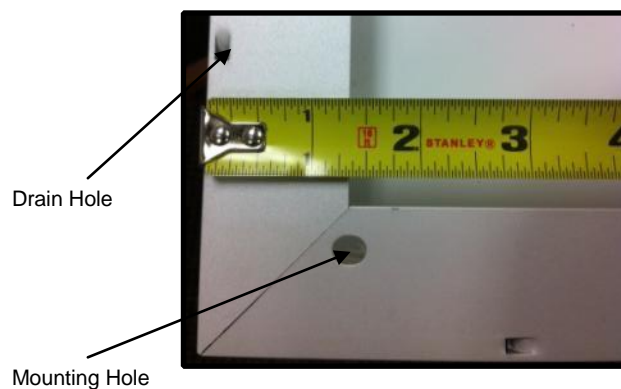
Panel -



## Mounting Hardware & Additional Accessories

### Mounting

Because of the wide variety of possible user applications, Grape Solar panels do not come standard with mounting hardware, but the panels come with sturdy aluminum frames that have mounting holes and can be mounted to a variety of structures and materials including wooden or metal frames.



For optimum energy production solar panels should be pointed in the direction of the sun to maximize the surface area that can receive light. Since the sun is a moving target, this is best approximated by pointing

the panel to the South (for those of us that live in the Northern hemisphere) at a tilt angle equal to your latitude.

For basic mounting application look for the Grape Solar Zippity Feet (see above) available on various retailers. If you plan to mount your panel to an RV, boat, or other vehicle Grape Solar Technical Support can recommend some quality products. Call Grape Solar Technical Support at **1-877-264-1014**.

### **Breakers and Fuses**

The GS-50+KIT is designed to include only the basic components needed for operation. In low voltage photovoltaic systems the likelihood of a power surge damaging your equipment is nearly nonexistent, therefore breakers and fuses are not included. But, that doesn't mean that correctly sized breakers and fuses will harm the performance of your system. Breakers or fuses can be added between the panels and the charge controller (5A per 50 watt panel), between the charge controller and the battery bank (generally 60A) and between the battery and inverter (250A). Suggestions regarding breakers and fuses are also available in your charge controller or inverter manual.

### **Grounding**

Grape Solar off-grid panels have grounding holes on the panel frame. Please refer to the Safety and Installation Manual included with the panel. We recommend 12 gauge wire for grounding. Inverters and charge controllers should be grounded according to the manufacturer's instructions.

## **Common Questions**

### **How many batteries will I need to go with my panels?**

Batteries have to do with how much power storage your system needs regardless of how much generation capacity you have. You can have 10kW of solar panels charging a 36Ah battery or you could have one 50W panel charging 1200Ah of batteries. The panel just affects how quickly the battery can be charged. If the battery bank is fully charged the charge controller will prevent over charging.

### **What inverters will work with my panels?**

In an off-grid, battery backup system, the inverter is connected to a battery bank and the panels feed power onto the battery bank through a charge controller. Since the inverter isn't directly connected to the panels, you can use any size inverter you want as long as it is compatible with your battery bank and the devices you plan to power. You can have 10kW of solar panels in the same system as a 450W inverter or you could have one 50W panel in the same system as a 7kW inverter. The size of the inverter just limits the size of the devices that your system can power, which affects how quickly the battery bank is drained. Inverter size has nothing to do with panel count.

### **Are these 12V or 24V panels?**

Panel voltage varies depending on temperature and brightness and load. The typical operating voltage of these panels is 17.5V. If the panel was exactly 12V there wouldn't be a large enough differential between the panels and the battery for current to flow from the panel to the battery. If you find panels advertised as "12V" they likely aren't actually 12V panels. If they were 12V panels you wouldn't want them for charging 12V batteries because they wouldn't work. The charge controller changes the output of the panel from the 17.5V to around 13.5V that would be fed onto the battery.

**If the charge controller is lowering the voltage, am I losing power?**

Power equals voltage multiplied by current (amps). When the charge controller lowers the voltage it increases the current, like a transformer.

**My equipment is connected correctly but I'm barely getting any current, why?**

Check the voltage of your battery bank. If it is over 13V the charge controller may be reducing the flow to prevent over charging the battery. This means your system is working perfectly. If the battery voltage is low, the battery may be damaged. If the problem persists, contact Grape Solar customer support.

**Do I need to reset my charge controller?**

Consult the owner's manual for the charge controller before pressing the reset button on the unit. Do NOT attempt to equalize sealed batteries.

**Can this system run my pump or motor?**

Contact Grape Solar ([support@grapesolar.com](mailto:support@grapesolar.com)) with complete specifications (startup and continuous electrical draw), run times, your location, and whether or not you need the system to run year round.

**For any other questions you may have, email [support@grapesolar.com](mailto:support@grapesolar.com)**