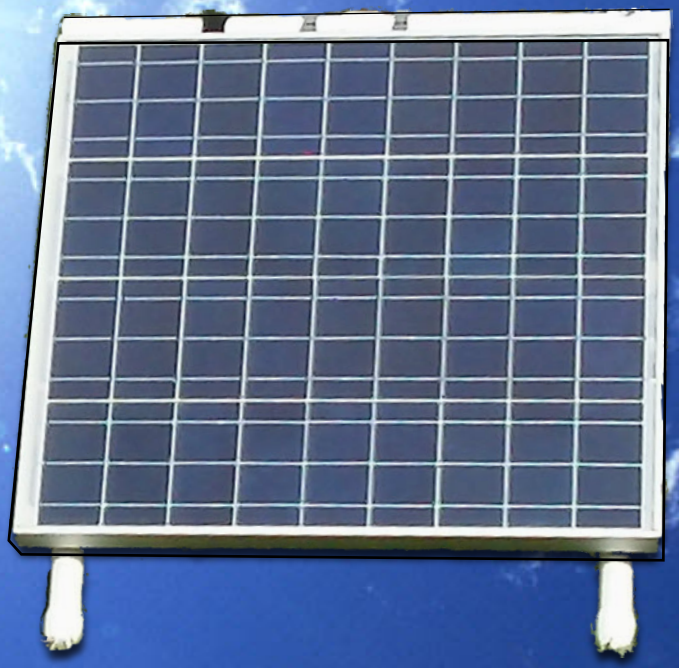
Build Your Own

SOLAR GENERATOR



- 45 Watt Solar Panel
- High Quality Charge Controller
- Indestructible PVC Frame
- Plug-n-Play Power

Portable Power: A must for Farmer Market Vendors needing a reliable, mobile power source. Great for a Tailgate Party or the Campsite to power appliances such as a blender, 12 volt cooler, coffee maker, or portable fridge.

Home Office: Start taking the home office off the grid. Power laptop or tablet computers. Or charge your smart phone overnight. Power other electronics such as a television or video game machine.

Emergency Power: Never be left in the dark! Power when you need it the most. Choose the right Power Pack for lights or the entertainment center when the grid fails. Or power a full size refrigerator. Perfect for 'deep preparedness'.

By John L. Prim © 2013

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This DIY Portable Solar Generator Plan is Donation Ware.

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http://www.zdcore.com/donate.html
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This Free Plan is Available at
http://www.zdcore.com/patently-absurd.html

1 Important Notice

Warning

NEC
Section 690-18
Prevent Panel Power Production

This is extremely important for one reason - **electricity can kill you** - look at the table below.

SAFETY REMINDER

Wear protective gear, including:
- Safety Glasses
- Ear plugs / muffs

When using power tools:
- Take off jewelry
- Avoid loose clothing
- Tool guards in place
- Secure work piece when possible
- Beware of trip hazards

When you connect the solar panel to the mounting frame, take every precaution to prevent electric shock.

The panel can produce some power even with indoor light as an energy source.

The solar panel cords have covered connectors making it almost impossible to *accidentally* cross the negative to positive terminal.

Always **disconnect** or **cover** the panel when working on a solar generator.

No Light = No Power

ELECTRIC HAZARD

Body Reaction	AC	DC
Tingle	1 milliamp	6 milliamp
Shock Can Move - Reflex	2 milliamp	9 milliamp
Severe Can't Let Go - Burns Stop Breathing	20 milliamp	90 milliamp
Heart Attack Probable Death	100 milliamp	500 milliamp
Heart Stops Death Occurs in Minutes	> 1 amp	> 1 amp

Safety is Always First

FIVE POWER TOOL RULES

1. Keep tools in good condition with regular maintenance.
2. Use the right tool for the job.
3. Examine tool for damage before use. DO NOT USE DAMAGED TOOLS!
4. Operate tools according to the manufacturers' instructions.
5. Properly use the right personal protective equipment.

WORKBENCH

- Keep clean and free of clutter
- Area free of slip & trip hazards
- Good lighting equals good work

PERSONAL PROTECTION

- Safety glasses
- Hearing protection
- Proper gloves (when needed)
- Dust mask and/or
- Adequate ventilation

POWER TOOLS

- Take off jewelry
- Avoid loose clothing
- Tool guards in place
- Secure work piece when possible

ELECTRICAL

- Do not overload outlets
- Turn off tools not in use
- Extension cords in good condition
- De-energize power when wiring

2 Introduction

Super Storm

Climate change is here.

And the resulting super storms are leaving millions without power. And without homes.

While a few will continue to deny climate change reality, and some others may argue climate change didn't cause Super Storm Sandy, the hard truth is climate change made the storm much, much worse.

How?

Sea levels rise. Because of global warming, Sandy slammed a **greater volume of seawater** at the coast. In depth, this amounts to about 8 more inches of water. It may not, at first glance, seem like much. But such meager inches turned the super storm's surge into a super flood.

Is this the new "normal"? For the foreseeable future, this is the new normal. And each and every one of us should be more prepared for these storms, super sized by global warming.

We should also take a longer view and mitigate climate change before it becomes much, much worse. We have the technology to do this. The real question is whether we have the will to widely harness and use such technology.

And we must answer this question here and now, for time is not on our side.

Solar Power

> **Photovoltaics** (**PV**) - *a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect. Photovoltaic power generation employs solar panels composed of a number of solar cells containing a photovoltaic material.* (**Wikipedia**)

Solar power is the solution for both disaster preparedness and for reducing the threats of climate change far into the future. And even small solar can make a large difference for a brighter tomorrow.

Up to 15% of electricity in an American home is consumed by electronic devices, from televisions and computers to constantly charging one's cell phone.

A portable solar generator with regular daily use can result in a 15% reduction in one's electric bill.

Looking at the table to the right, the total yearly consumption of electronic devices is 516 Kilowatt hours.

Let's compare that number.

A coal fired plant at 40% efficiency uses about 700 pounds of coal to power a 100 watt light bulb for one year.

100 Watts x 10 = 1 Kilowatt
700 pounds x 10 = 7,000 pounds
7,000 pounds x 516 Kilowatts = 3,612,000 lbs

3,612,000 lbs = 1,806 tons of coal

Average Home Yearly Consumption

Device	Kilowatt Hours
Desktop Computer	255
Laptop Computer	83
LCD TV (<40")	77
Power Tool	37
Hand-Held Vacuum	29
Cordless Phone	26
MP3 Player	6
Cell Phone	3
Source:	ACEEE

The average American homeowner uses 1,806 tons of coal per year to power just the electronic devices listed. That's a lot of coal. It's also a lot of pollution contributing to global warming.

A ton of coal pollutes about 2.5 tons of carbon dioxide or more, depending on the grade of the coal.

1,806 x 2.5 = 4,514 tons of CO_2 released into the atmosphere every year.

Now multiply that by millions upon millions of homes. All this, just for some electronic devices.

There's a better way to produce this energy. Portable solar generators can power our most used electronic devices. It reduces the electric bill, lowers air pollution, and slows climate change. It prevents storms from becoming much, much worse. And when the storms do come, we're ready.

And it's not about preparing for "doomsday." It's about preparing for a solar powered world. We have the technology. Let's build and use it.

Dare to Compare

Solar Mak Technology

Harbor Freight Tools

iPower Station '45'

Solar Power:	45 Watts
Power Pack	**Hand Carry**
Battery:	18 Ah
Inverter:	400 / 800 Watts
AC Outlet:	2
DC Socket:	2
USB Port:	1
Jumper Cables:	Yes
Air Compressor:	Yes

Thunderbolt '45'

Solar Power:	45 Watts
Power Pack	**No**
Battery:	No
Inverter:	No
AC Outlet:	No
DC Socket:	2
USB Port:	1
Jumper Cables:	No
Air Compressor:	No

The iPower Station 45 solar panel is higher quality and more efficient than the Thunderbolt 45 amorphous panels. With the iPower Station, one is getting more power in a ready and rugged mobile package.

Current pricing for the Thunderbolt Kit is about $200.00. The DIY iPower Solar Generator in this manual is about $210.00. Adding a portable power pack brings the price for the iPower Station 45 to $310.00.

The US 30% Federal Solar Tax credit can be applied to the iPower Station 45, as long as it's limited to providing power for home use. One can have a high quality solar power station for as little as $200.00, after the tax credit.

Ready and reliable. Unmatched price to performance. Made for the Middle Class.
Only iPower Station delivers power where and when you need it most.

3 Solar Generator

Component Sources

	Array	Price Each	Amount	Subtotal
	45 Watt Solar Panel - ULS		1	
	4 Amp Charge Controller - ULS		1	
	12 Volt Power Cord - RS		1	
	Red Electric Tape - HF		1	

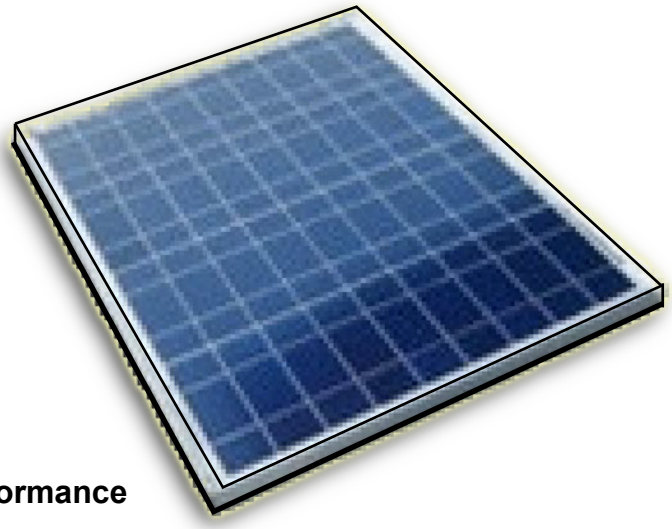
	Battery Pack	Price Each	Amount	Subtotal
	5 in 1 Power Pack - HF		1	

	PVC Frame	Price Each	Amount	Subtotal
	1 inch (Number 6 - 10') Pipe - SB		1	
	Slip Tee - SB		3	
	End Cap - SB		2	
	45* Elbow - SB		2	
	Screw Tab Cap - SB		1	

	Miscellaneous	Price Each	Amount	Subtotal
	Mounting Clamps - Local		6	
	Lock Pin - HF		1	
	Self Drilling Screw - HF		Set	
	Nuts, Bolts, and Washers - HF		Set	
			TOTAL:	

Instructions: Print this page. Click on the blue link for supplier pricing. Write the price of each, then calculate total cost. Place a single mark in the blue box from the lower left corner to the upper right corner when an item is ordered. Place another mark from the upper left corner to the lower right corner when the item is received.

Solar Panel



Efficiency vs. Real Performance

Due to the manufacturing process, Mono panels are black and Poly panels are blue. Monocrystalline panels are, technically, more efficient than Polycrystalline panels.

How does that translate to real world performance? Let's compare the amp rating output of a 45 watt solar panel:

- Mono panel produces 2.6 amps
- Poly panel produces 2.5 amps

In this case, the Mono produces a tenth of an amp more than the Poly panel. But a Mono panel can cost two to three times more than a Poly panel.

Under real world conditions, the Poly panel offers a better price to performance. For a portable solar generator, a Poly panel is a much better return on investment.

In other words, one's portable solar generator will pay for itself much, much faster while delivering almost the same performance as a Mono panel.

Current price for a 45 watt Poly solar panel is about $100.00.

NEC
Section 690 - 8

As a safety precaution because a panel can occasionally produce more than its rated output, an additional multiplying factor of 125% is used.

We'll look at this more closely as we go over the solar generator build.

Panel Specifications	
Type:	Polycrystalline
Weight:	11 lbs
Module Size:	22" x 26" x 1.38"
Total Watts:	45 Watts
Max Volts:	17 Volts
Max Power:	2.5 Amps
Temp Range:	-40 to +185 (F)
Tolerance:	5%
Junction:	IP-65
Source:	UL Solar

Charge Controller

MPPT vs PWM

Multi Point Power Tracking (MPPT) is claimed to increase solar power production up to 30% compared to Pulse Width Modulation. But there's a number of catches:

- As the solar panel heats up, MPPT drops off and is comparable to PWM.
- Under the best real world conditions, MPPT increases production about 20%.
- MPPT is much more expensive than PWM.

Looking at the output of a 45 watt panel, production is increased about half an amp per sun hour. Keep in mind, such increase only occurs when the solar panel is operating in a cooler climate (winter season).

For portable solar generators, PWM offers the best price to performance.

Not all PWM controllers are equal. We highly recommend Specialty Concepts patent Automatic Sequencing Charger for the following reasons:

- Over 30 years experience.
- Indirect lightening protection built in.
- Robust field reliability rate of 99.89%.
- Terminal block for easy wire connection.
- Reverse leak protection - no night time losses.
- Easy read LED power production indicator.
- 10 year warranty.
- Made in USA.

Current price for the ASC 12 volt / 4 Amp controller is about $40.00.

Charger Specifications	
Type:	Patent PWM
UL 1714:	Yes
FM approved:	Yes
CSA approved:	Yes
Efficiency:	99%
Solid State:	Yes
Weather proof:	Yes
Auto shut off:	Yes
Rating:	12 Volts / 4 Amp
Source:	UL Solar

PVC Components

The PVC Frame

The solar panel, charge controller, and power cord are permanently mounted to the PVC frame. PVC is chosen over an aluminum / metal frame because it's rust proof, lightweight, and extremely easy to handle. Unlike a metal frame, a PVC frame can last as long as the solar panel, producing power for 40 years or more. Other benefits include:

- Electrically non-conductive (safety feature).
- Resistant to fracturing due to its elasticity (low maintenance).
- Resistant to salt, chemicals, and corrosive soils (long lasting).
- Good stiffness, making it strong for heavy duty use (low maintenance).
- Easy to recycle, making it better for the environment (reduce pollution and reuse).

Our biggest reasons for choosing PVC centers around how we use the solar generator daily in real life. It must be:

1. Easy to carry.
2. Fast and easy to set up.
3. Safe to use, with no pinch points.
4. Easy to close and store when not in use.
5. Folds flat as one unit, so nothing is misplaced.

The frame took the most time for us to design and test. Keeping it straight and simple means paying attention to the details that matter most.

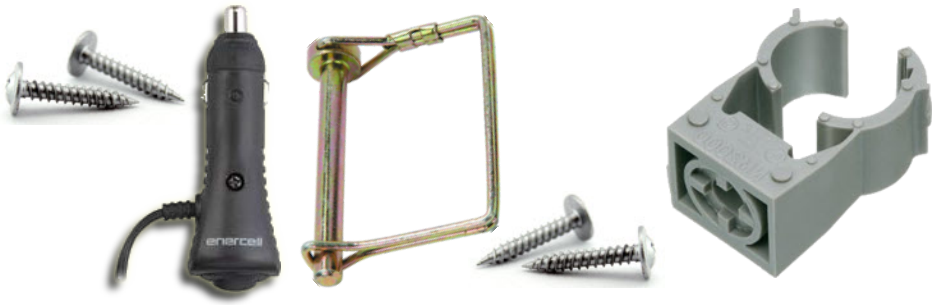
It's the easiest to use portable solar generator, made for the middle class.

And it's also what makes it so insanely great.

Current pricing for a single 10 foot length of size 6 PVC pipe and all the fittings for the frame is about $30.00.

PVC Specifications	
Type:	Furniture Grade
Size:	6
Outer Diameter:	1.315"
Inner Bore:	1"
UV Resistant:	Yes
Slip Tee:	3 total
End Cap:	2 total
45* Elbow:	2 total
Screw Tab Cap:	1 total
Source:	Simplified Building

Other Components



Power Cord

The Enercell 12VDC power adapter plug w/ switch comes with a 10 Amp fuse built in and 18 gauge cord.

Power Cord Specifications	
Rating:	12 Volts / 10 Amps
Source:	Radio Shack

Lock Pin

This locks the legs of the solar generator in place when in use. Also increases stability in higher wind conditions.

Lock Pin Specifications	
Length:	3 inches
Source:	Harbor Freight

Self Drill Screws

Self drilling screws permanently connect PVC fittings to the pipe for the solar generator frame.

Self Drill Screws	
Length:	Various
Source:	Harbor Freight

Nuts, Bolts and Washers

Permanently secures the Mounting clamps to the solar panel and charge controller. Flat / lock washers are also necessary.

Nuts, Bolts, and Washers	
Length:	Various
Source:	Harbor Freight

Mounting Clamps (QuickLatch Pipe Hanger)

These mount the solar panel and charge controller to the frame with snap in place ease. Source from a local electric supply or hardware store. A total of six are needed. More info:

Mounting Clamps	
Manufacturer:	Arlington
Source:	**Local Store**

Manufacturer: Arlington UPC: 54518
Part Number: MM2025 Size: 1”

Last but not least, we’ll also need electric tape.

Current pricing for all the remaining components comes to a total of about $40.00.

Build It

Balance of System

Balance of system (BOS) usually refers to all the components that make up a photovoltaic system except for the panels. This normally includes the inverter, batteries, racks, mounts, wiring, and switches.

We've taken a slightly different approach in defining balance of system. Instead, we've focused on balance of generation for the best price to performance.

A portable solar power generator is made up of all the components mentioned above, including a solar panel, controller, and necessary wiring.

Balance of generation includes design cost, land, site preparation, installation, operation and maintenance costs. Let's briefly examine each one:

- Design Cost

This is an open source solar generator design. Design cost is kept to an affordable level with contributions from many, many people. As an Open Product Sponsor, a small fee is provided to the solar generator project. In other words, your design cost is already covered!

- Installation

Installation is mainly labor cost. It varies depending on the size of the system and number of components involved. In this case, you're saving on labor cost because you're building the solar power generator.

- Land / Site Preparation

The best benefit of portable solar power is there is no land / site preparation. All one has to do is point it at the sun to produce power. It's easy to use power when and where you need it most.

- Operation / Maintenance

The solar generators is "plug and play," making it very easy to operate. There is some maintenance involved. It should be regularly inspected once in the spring and once in the fall.

Overall, this solar generator provides the best price to performance in its class.

1. Set Up

Organize one's work space. Wear protective equipment and follow safe work practices.

- Workbench

A workbench can be a fold out table or a sheet of plywood secured to 2 sawhorses. Make sure there is ample space to move and work.

- Tools

To the right is listed the tools required to build the solar generator. A **tape measure** is also needed. Notice a drill driver is the only power tool. Almost all these tools can be found in a **tool kit**, making it easier to organize, carry, and store.

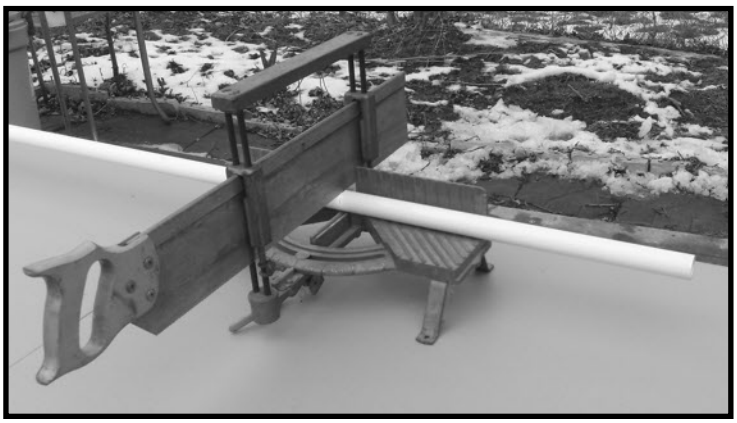
- Supply Boxes

One way to make the work easier is to organize components into supply boxes. In this way, parts are easily found. Completed assemblies can be stored until they're installed on the solar generator.

Always plan your work and take your time building the solar generator.

Tools Needed	
1	Miter Box Saw
2	Screwdriver Set
3	Drill Bit Set
4	Needle Nose Pliers
5	Electrician Pliers
6	Wire Strippers
7	Drill Driver

2. PVC Cut List



Miter saw steadies work piece for cutting

- Prepare

Set up the miter saw and gather all your PVC parts together. Print out the mounting frame diagram and use it as a guide.

Store the other tools / supply boxes under the workbench. Keeping your work bench uncluttered helps to focus one's attention on the work at hand.

All cuts are straight, not mitered. The miter box helps steady the work and saw for a straight, true, and clean cut.

- Cut List

The PVC pipe is cut into four pieces. One for the pivot, one for the cross bar, and two for the mount. Lengths are as follows:

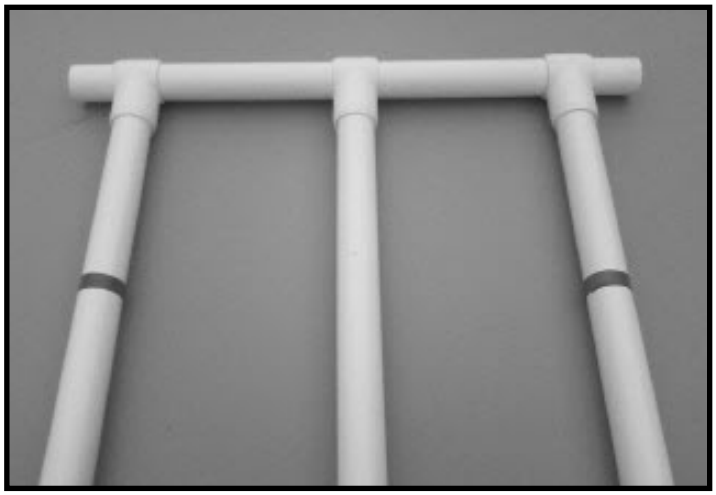
Pivot Leg: 17 ¼ ”

Cross Bar: 20 ¼”

Mounting Legs: 23 ¾”

Use a paper towel to wipe off excess shavings from the PVC pipe after each cut.

Mounting legs identified by red electric tape



Legs, Slip Tees, and Cross Bar

- Lay Out Parts

Once cuts are complete, put away the miter saw under the workbench.

Pull all the PVC parts out of the supply box and double check all the pieces are on hand.

Place the drill driver, a 3/32 drill bit, and self drilling screws on the workbench.

We can now begin assembly of the mounting frame.

3. PVC Frame Assembly

- Dry Fit

Dry fit the PVC frame assembly together before any permanent attachment with the screws.

This ensures each piece is in the right place. And if it isn't, then it can be easily detached and put in the right place.

First, lay out the three legs and attach a slip tee to the top of each one. Then slide the cross bar through the slip tees. Attach each end cap to the ends of the cross bar.

The center pivot leg is shorter than the outer mounting legs. The outer mounting legs are the same length.

Firmly press all fittings into place, making sure they're in all the way.

Now measure the distance on the cross bar from outside end to end. It should be about 20 ½".

Last, attach the feet to the legs.

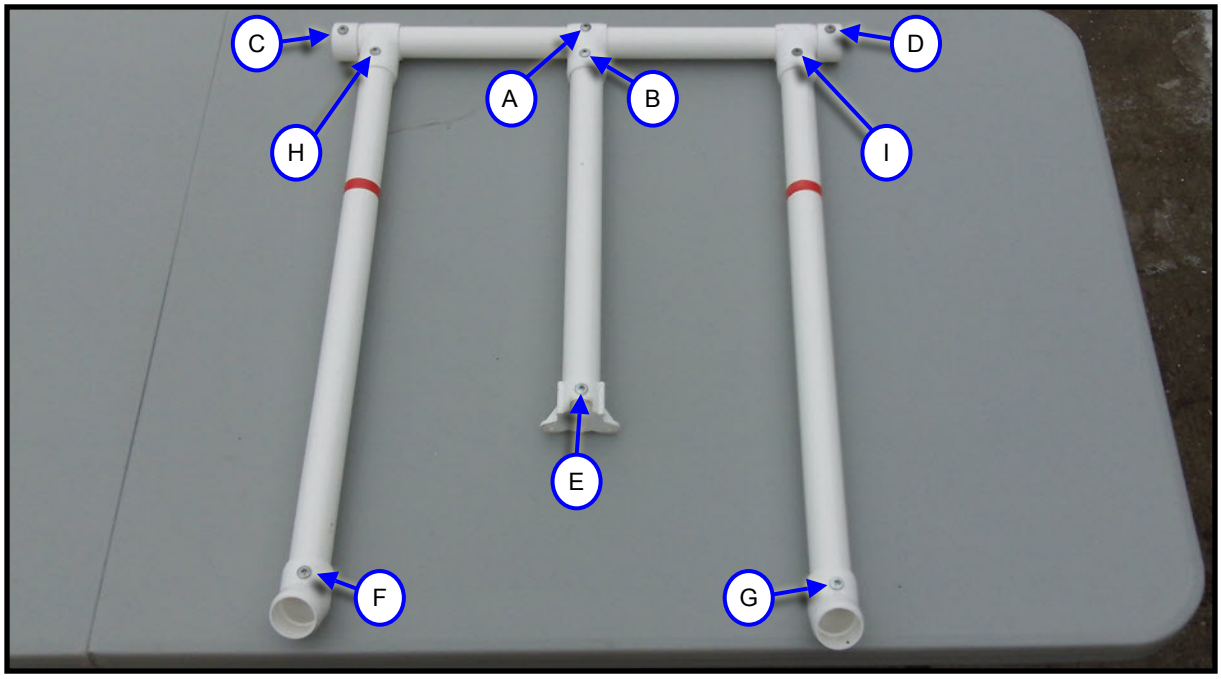
The screw tab cap is attached to the bottom of the center pivot leg.

The 45* elbows are attached to the bottom of the outer mounting legs.

Check that the mounting frame is level. Set it up as shown in the picture, making sure all the feet are even and level with the ground. Adjust them until they are level and true.

Checking Frame Fit

- Ready Fasteners



Pay Careful Attention to the Fastener Points!

- Permanent PVC Attachment

Take your time screwing the pieces together. Drilling in the wrong place will result in the frame failing to fold open properly. Pay close attention for drilling in the right spot.

1. Lay the mounting frame flat on the workbench. The feet on the outer mounting legs should be pointing upward.

2. Set up the drill driver with a 3/32" drill bit. Use the tape measure to center the pivot leg on the cross bar. The center should be about 10¼" from the outer edge of either end cap.

3. Then drill one hole **[A]** through the slip tee and into the center bar. Then drill another hole **[B]** through the slip tee and into the pivot leg. Use the screwdriver to insert a self drilling screw into each hole.

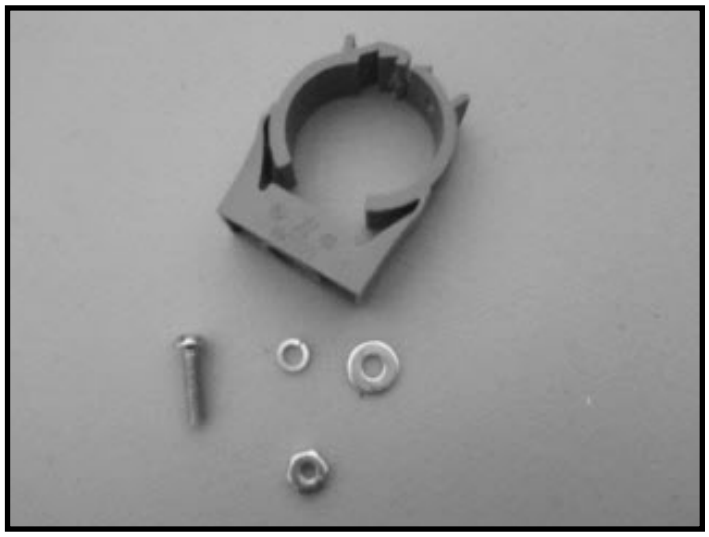
4. Next, drill a hole through each end cap and into the cross bar. Use the screwdriver to insert a self drilling screw into hole **[C]** and **[D]**.

5. Repeat the procedure for the feet. Drill a hole through the tab cap and into the pivot leg **[E]**. Then drill a hole through each elbow into the mounting legs **[F]** and **[G]**. Use the screwdriver to insert a self drilling screw into each of the holes.

6. **Important!** For the last step, drill a hole through the two remaining slip tees **[H]** and **[I]** and into the mounting legs only. **Do Not Drill Holes Into The Cross Bar.** The outer mounting leg slip tees act as a hinge on the cross bar so the solar generator can easily fold open and closed. Use the screwdriver to insert a self drilling screw into each of the holes.

7. Mounting frame assembly is complete. Set it aside next to your workbench. Remove the solar panel from the box. Put it face down on cardboard (reuse a piece of the box) on top of the workbench.

4. Solar Panel Attachment



- Clamp Assembly

The solar panel should be lying face down on the workbench. You'll need a screwdriver and pliers. Thread should be quarter 20. Take out four each of the following:

- ¾ " long bolt
- nut
- lock washer
- flat washer

The bolt assemblies are for securing each QuickLatch pipe hanger to the panel.

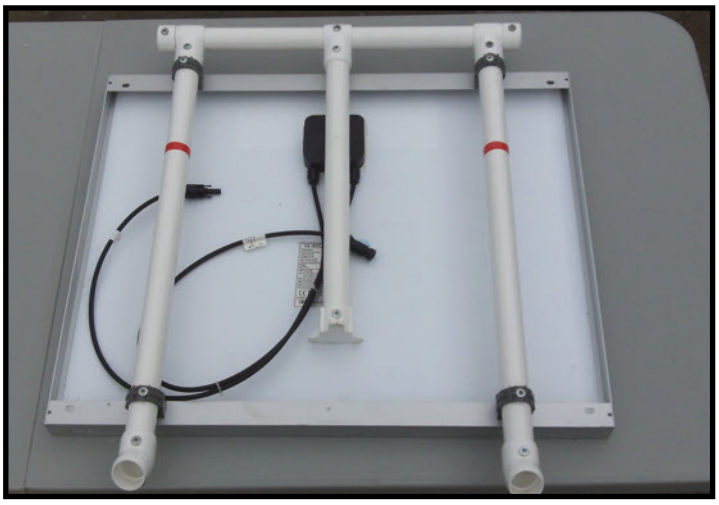
- Clamp Attachment

About a third of the way in from each side of the solar panel are four holes.

Over each hole, line up a QuickLatch along the panel's lip. Line up and drop a bolt through the QuickLatch and panel hole.

Then add to the underside of the lip a flat washer, lock washer, and nut.

Last, use the pliers to hold the nut while using the screwdriver to tighten the bolt. This secures the QuickLatch in place.



- Snap In Mounting Frame

Take the frame and insert each mounting leg into the QuickLatches, two per leg.

Firmly press down on the leg near each QuickLatch. You should hear a couple of clicks as each QuickLatch snaps closed.

Last, drill a hole in each QuickLatch into the mounting leg. Then use the screwdriver to insert a self drilling screw in each hole.

The solar panel is now firmly attached to the frame. The solar generator is 75% complete.

Solar Wiring

NEC
National Electrical Code

Here is where we slightly depart from the NEC but still meet its intent.

In stationary solar generators, a combiner box brings together all the leads from each solar panel.

Inside that box, all positive wires are connected to a bus bar, and all negative wires are connected to a separate bus bar. This combines all the power coming from the panels at the bus bar.

A single positive and negative wire is then attached to each bus bar leading to the positive and negative terminal on the charge controller.

The combiner box can also be fused for overcurrent protection to prevent component damage and fire.

These combiner boxes are designed for stationary applications, not portable ones. They're too expensive and bulky to be used in a portable solar generator.

To meet our need for a safe portable solar generator, we'll use a **DC fuse** from the auto, marine, and recreation vehicle (RV) industries.

Glass tube fuses are standard and affordable. And it's proven technology.

We'll need to replace the 10 amp fuse in the 12 volt power cord with a **5 amp fuse**.

The benefits of using a glass tube fuse include:

- Affordable
- Meets intent of the NEC
- Small and easy to install
- Provides overcurrent protection
- Available at most auto parts stores

Even with all these benefits, this fuse isn't approved by the NEC for residential (stationary) use.

It's possible the NEC could be updated to allow for use in low voltage applications, such as a portable solar generator. But it's unlikely.

The NEC's main focus is safe wiring practices regarding high voltages in both residential and commercial applications.

Regardless, it's still a good standard to follow to develop good work practices.

The portable solar generator meets that intent by providing overcurrent protection between the solar charge controller and the power pack.

Glass Tube Fuse

Note: A wire amp rating should always be equal or greater than the fuse rating.

It ensures the fuse blows in the case of a prolonged power surge malfunction.

It prevents wires catching fire and stops damage to other components in the circuit.

5. Charge Controller Wiring

- Attach Pipe Clamps

Thread should be quarter 20. Take out two each of the following:

- ¼" bolt
- lock washer
- nut

Line up the QuickLatch on the back edge of the charge controller. Drop the bolt through the hole and secure them together with the needle nose pliers and screwdriver.

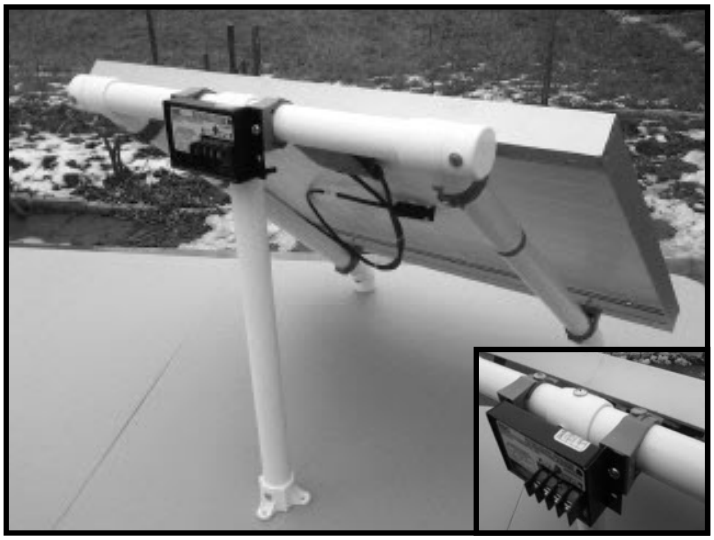
- Snap To Solar Generator

Take the controller and insert it over the center pivot leg on the cross bar.

Firmly press the controller against the cross bar. You should hear a couple of clicks as each QuickLatch snaps closed.

Last, drill a hole in on top of each QuickLatch and Pivot Tee into the cross bar. Use the screwdriver to insert a self drilling screw in each hole.

The controller is now firmly attached to the frame.

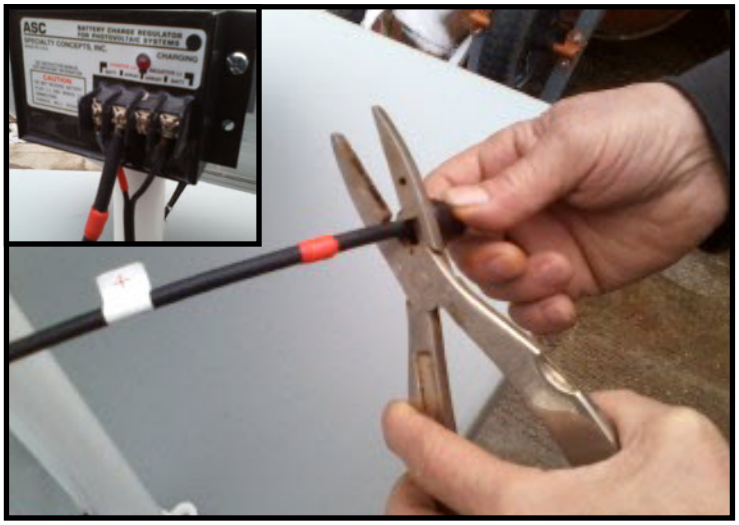


- Attach Power Cord

Carefully pull the negative and positive lead apart about 3 inches. The positive lead has a small (+) tag on it. Wrap some red electric tape around the positive cord (near the cord split) for easier identification.

Using the wire stripper to expose about 1 inch of wire on each lead. Twist each wire and fold it in half - this ensures a good contact on the controller. On the controller bus bar, use a screwdriver to secure the negative lead to the negative terminal marked "battery." Repeat for the positive lead to the positive "battery" terminal.

6. Solar Panel Wiring and Lock Pin



- Positive Cable Attachment

Using the electrician pliers/cutter, cut off the connector and strip the wire back about ¼ inch. Wrap some red electric tape around the positive cable for easier identification.

On the controller bus bar, use a screwdriver to secure the positive wire lead to the positive terminal marked “pv.”

Lightly tug on the cable to ensure it’s firmly attached to the positive pv terminal on the charge controller.

- Negative Cable Attachment

Using the electrician pliers/cutter, cut off the connector and strip the wire back about ¼ inch.

On the controller bus bar, use a screwdriver to secure the negative wire lead to the negative terminal marked “pv.”

Lightly tug on the cable to ensure it’s firmly attached to the negative pv terminal.

Notice the LED indicator lights up - showing the solar panel is producing power.

- Lock Pin

Fold open and set the solar generator on a flat surface.

Using the drill driver and a 5/16” bit, carefully drill a hole completely through the right mounting leg and slip tee.

Wipe off PVC shavings and insert the lock pin.

The iPower Solar Generator is complete.

7. Plug and Play

Operating your portable solar generator is easy. As long as a power pack has a 12 volt outlet, then it can be solar charged by the iPower Solar Generator.

The LED on the 12 volt plug is always lit no matter if the switch is in the “on” or “off” position. It’s an easy visual indication the fuse inside is good. If the LED isn’t lit on the plug, then the fuse has probably blown and needs replacing.

Insert the 12 volt plug into the 12 volt socket of the power pack, then switch the plug into the “on” position. If the battery is low, then the LED on the charge controller will light up, showing that it’s recharging the battery.

As the battery reaches full charge, the charge controller LED will begin flashing on and off. Once the battery is fully charged, then the LED will go out. Turn the plug switch to the “off” position and remove the plug from the power pack’s 12 volt socket.

To store the iPower Generator, pull the lock pin from the frame. Wrap the power cord into a loop and hang it from the lock pin. Then attach the lock pin around the cross bar near the charge controller. Fold closed for storage or travel.

The iPower Solar Generator is a “set it and forget it” device. When a power pack needs recharging, fold open the generator. Aim it at the sun, lock pin the cross bar, plug it in and switch it on. That’s it!

It’s completely “plug and play.” Sets up in less than a minute. It’s power when and where you need it the most.

4 Power Packs

5 in 1 Power Pack

This is the very first power pack we used with our solar generators. And it's still one of the best. We've powered everything from laptop computers to blenders.

The power pack can be fully charged in 3 to 6 hours with a 45 watt solar generator.

It's much faster than charging from a home outlet, which can take up to 48 hours or more.

Solar charging a power pack is always faster because there are no power conversion losses.

And best of all, solar energy is free.

Power Pack Specifications	
Type:	Hand Carry
DC Outlets:	2
AC Outlets:	2
Inverter:	400 / 800 Watts
Air Compressor:	260 psi
Jumper Cables:	Yes
Battery:	18 Ah
Source:	Harbor Freight

Other Packs

There are hundreds of **Power Packs** that are easily charged with an iPower Solar Generator.

They come in many different shapes, sizes, colors, batteries, and power inverters.

The minimum requirement for any of these power packs is a 12 volt socket so it can be quickly and easily charged with one's portable solar generator.

If you're looking to have emergency back up power to run a full size refrigerator during longer utility outages, then an iPower Pro is the way to go.

Our iPower Station Pro is more versatile, with a larger solar generator and bigger storage battery when utility outages last more than a few hours.

It's important to carefully look over a power pack's specifications, then choose the one best matching your energy requirements.

Electricity Basics

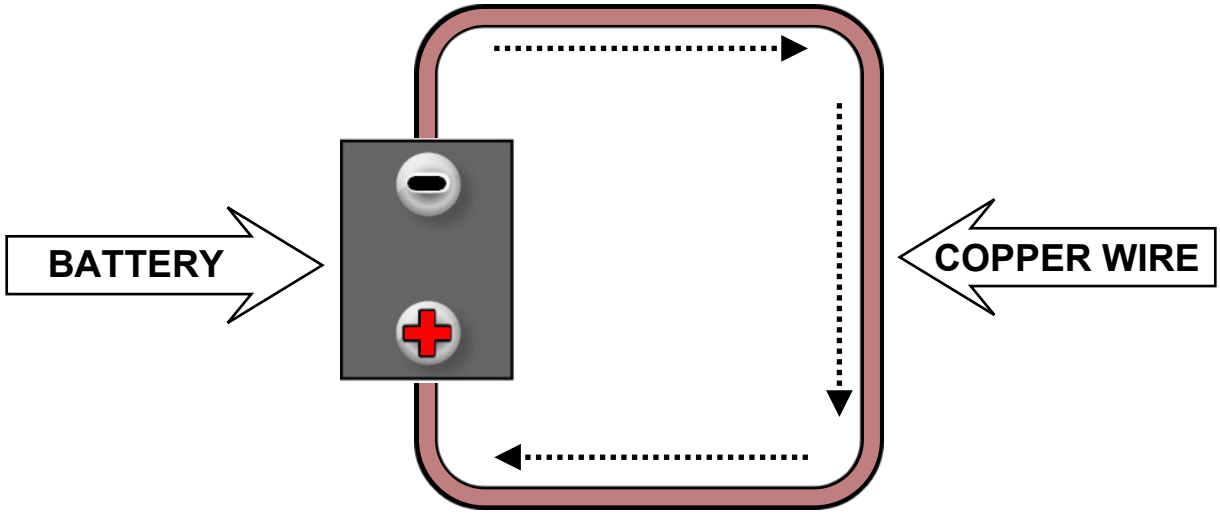


FIG 1: Flow of Electrons

Ohm's Law

Voltage is the difference in electrical charge between two points. There must be more electrons at one point and fewer at the other point to maintain voltage.

Electrons carry a negative charge. When a wire is connected between the two points, electrons flow from the negative to the positive terminal.

Remember that Current is the electron flow in a **conductor**, such as copper wire.

Insulators are used to safely contain electricity. Plastic is an insulator, because it has high resistance to electron movement.

Resistance is measured in **Ohms**. The relationship between voltage, current and resistance is explained by Ohm's law.

OHM'S LAW: E = I x R

E = Voltage
I = Amps
R = Ohms

If the value of any two is known, then the third can be calculated.

To make it easier to remember these relationships, one can use Ohm's Triangle:

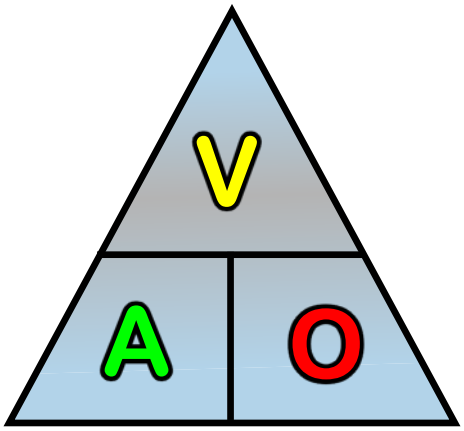


FIG 2: Ohm's Triangle

E is the electromotive force (potential difference) which is moving electrons through the wire. It's measured in **Volts**.

I is the intensity of electron flow (current) moving through the wire. It's measured in **Amps**.

R is resistance of electron flow in the wire. It's measured in **Ohms**.

Using Ohm's Law:

1) Current is directly proportional to voltage. If voltage goes up, so does current. Or if voltage goes down, so does current.

2) Current is inversely proportional to resistance. If resistance increases, then current decreases. And if resistance decreases, then current increases.

By covering the **V**, the triangle shows:

Voltage = Amps x Ohms

By covering the **A**, the triangle shows:

Amps = Volts / Ohms

By covering the **O**, the triangle shows:

Ohms = Volts / Amps

Loads

A copper wire can be thought of as a pipe which electrons flow through.

In the same way, a battery can be thought of as a tank with a pump. It maintains a constant voltage (or "pump pressure") no matter if current is flowing or not.

A load is a main circuit resistance. It can be thought of as a valve.

FYI

Conventional current flow is shown from positive to negative because Ben Franklin thought current flowed this way.

Electrons actually move from negative to positive.

When electrons move through this "valve," voltage is lost because of the resistance of the load. Figure 3 shows all the voltage is lost to the load.

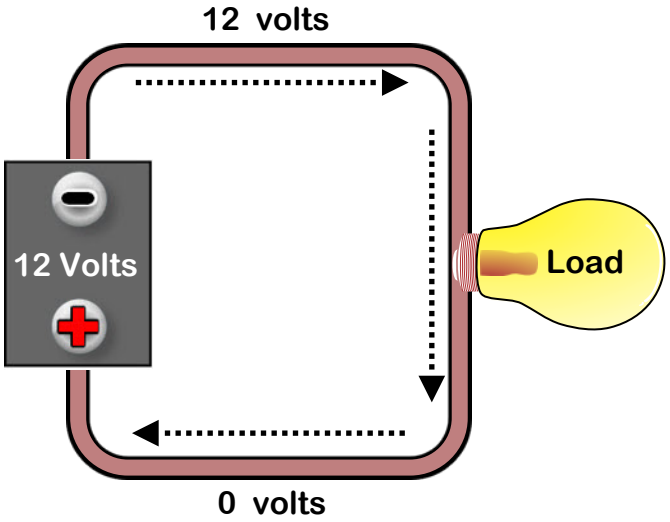


FIG 3: Voltage Drop

This is known as a voltage drop. It's where the resistance of a load in a circuit causes a voltage loss equal to the source voltage.

Power

Power is the rate of energy conversion.

For practical purposes, the rate at which an electrical charge is produced or consumed can be found two ways.

One way is to determine Amp hours (**Ah**), and the other way is to determine Watt hours (**Wh**). We'll explore each.

Amp Hours

To find Amp hours, multiply Amps by hours. The storage capacity of a deep cycle battery is expressed in Amp hours. For most batteries, the standard means to compare this capacity is by using a 20 hour rate.

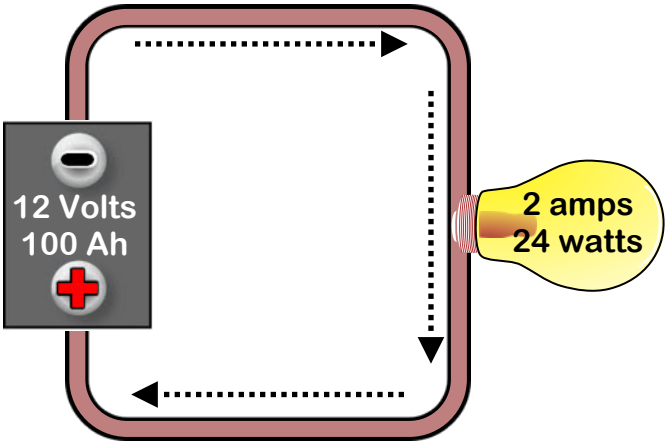


FIG 4: Amp Hours

Looking at Figure 4, the battery's capacity is 100 Amp hours. A battery's capacity decreases as the load increases. This battery can maintain a 5 amp load for 20 hours before being completely discharged.

Tip: Never discharge a battery more than 50%, as it shortens the life of the battery.

The light bulb has a resistance of 6 Ohms. It consumes 2 amps of power. Over 20 hours, the load will consume 40 Amp hours of power.

The battery shouldn't be discharged more than half its capacity. The light bulb consumes less than 50 Ah.

In general, it's a safe load for the battery on this circuit.

Watt Hours

To find watts, multiply volts by amps. Looking at Figure 4, we can find the wattage of the light bulb: 12 Volts x 2 Amps = 24 Watts.

To determine watt hours, multiply watts by hours: 24 Watts x 20 Hours = 480 Watt hours.

A more common unit is kilowatt hours, which is 1000 watts multiplied by time. Utility companies use kilowatt hours to determine what to charge customers on their electric bill. If the light bulb is on almost 42 hours, then it consumes 1 Kwh.

Which One to Use?

In general, which measure to use is determined by the application and the load size.

For example, most electronic circuits use milliamps (thousandths of an amp). The electronic circuits in your smart phone use milliamps.

Individual appliances, from coffee makers and vacuum cleaners to refrigerators and televisions, use amps.

Kilowatts are used as an easier means to compare the consumption of combined appliance loads. It's used by electric utilities to help them better match their production and obtain a standard price rate.

With portable solar generators, we're mainly concerned with individual appliance use, so we'll focus on amps and Amp hours. Looking at Figure 4 again, we can plug the numbers into Ohm's triangle.

6 Ohms = 12 Volts / 2 Amps

2 Amps = 12 volts / 6 Ohms

12 Volts = 2 Amps x 6 Ohms

We've determined that the light bulb uses 24 Watts, or 2 Amps. It consumes 40 Ah in 20 hours.

24 Watts = 2 Amps x 12 volts

2 Ah = 2 Amps x 1 hour

40 Ah = 2 Amps x 20 hours

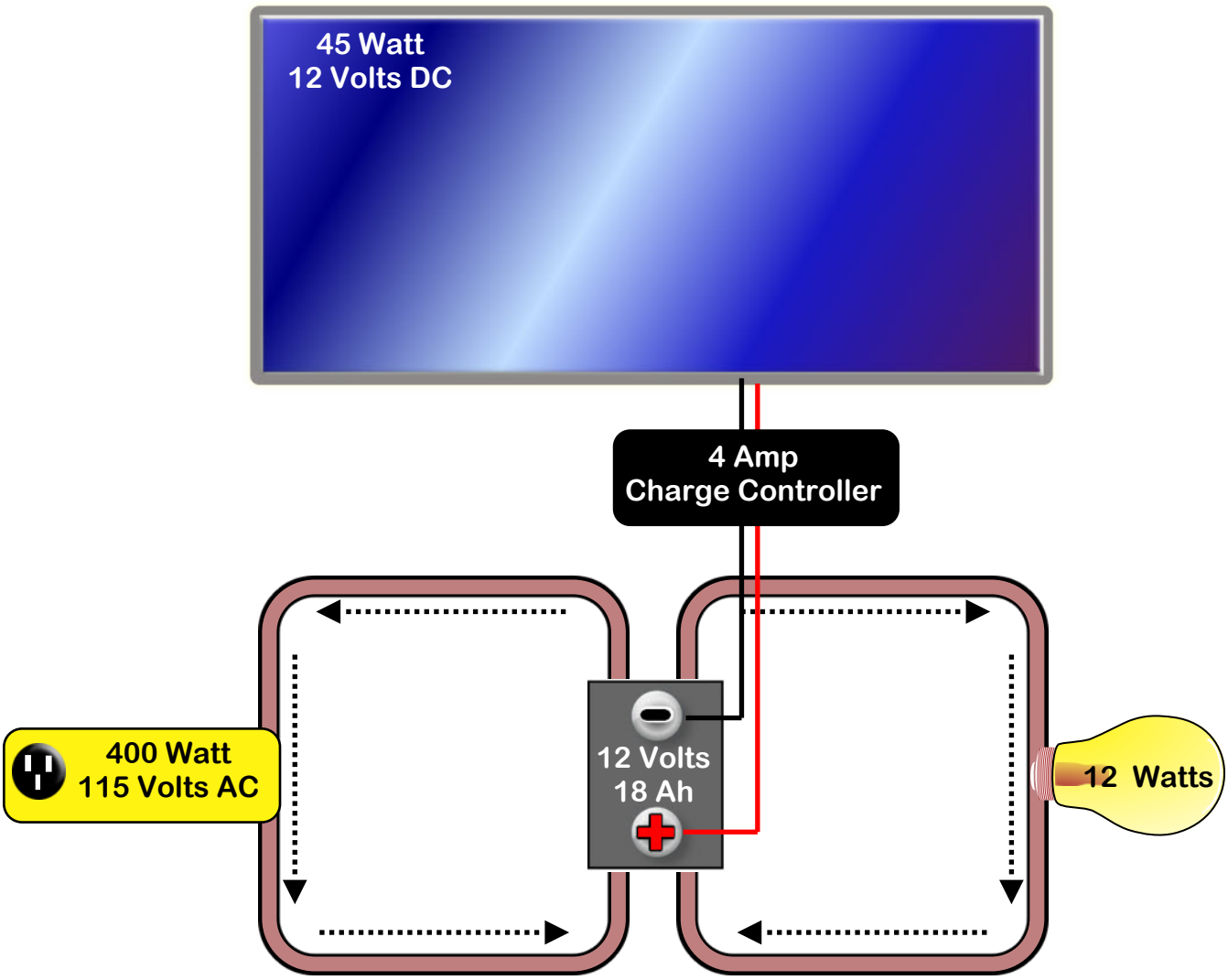


FIG 5: Portable Solar Generator Diagram

.DC & AC

Figure 5 is a diagram of a solar generator. Notice that most of the wiring is direct current.

Direct current is where the flow of electrons flow in only one direction. The battery polarity is always the same where one terminal is always negative and the other terminal is always positive. Think of it as a pump flowing in one direction.

Alternating current produces a voltage that reverses regularly. The polarity of the voltage alternates and the current changes direction. It has a very rapid cycle of increase, decrease, and reversal, creating a sine wave.

Alternating current can be produced electronically with an inverter, which converts DC to AC. The solar generator in this manual makes use of a power pack with an inverter for AC loads. Discover more about solar electricity at our SolarPedia.

Wattage Table

Below is a general list of the wattage of electronics, appliances, and tools.
Use it to match the power pack, battery, and inverter to your purposes.

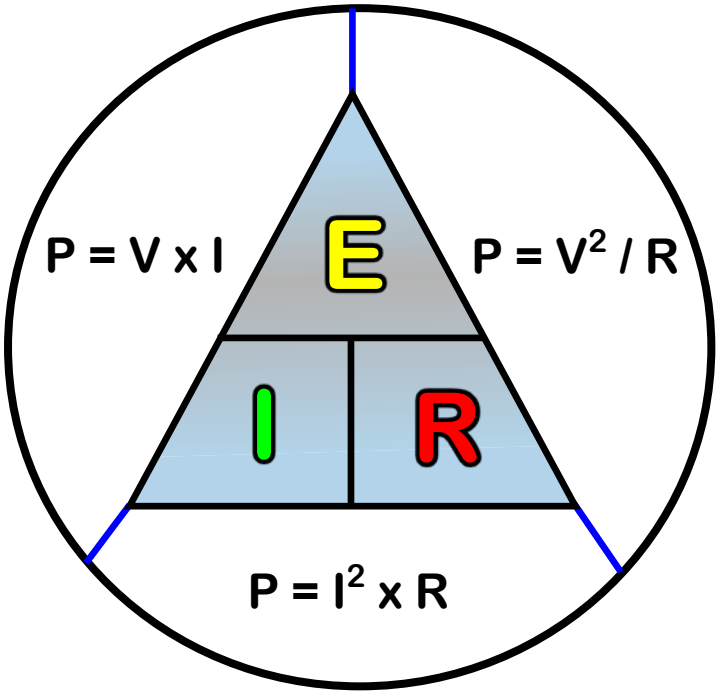
Electronics	Watts
Video Player	50-100
Clock Radio	50
Game Console	100
Satellite dish	40
Laptop/ Tablet	35 -100
Desktop Computer	200-400
Inkjet Printer	50-75
25" Color TV	300
19" Color TV	150
13" Color TV/ VCR	240
12" Black & White TV	40

Appliances	Watts
Coffee Pot	1200
Cappuccino Maker	1250
Blender	350
Hot Plate	1200
Frying Pan	1200
Toaster Oven	1200
Blow dryer	900 - 1500
Space Heater	1000-1500
Washing machine	950
Refrigerator/ Freezer	600
Freezer	500-800

Tools	Watts
Jig Saw	300
Table Saw	1800
6 1/2" circ. saw	1000
7 1/4" circ. saw	1200
8 1/4" circ. saw	1800
Disc Sander	1200
1/4" drill	250
3/8" drill	500
1/2" drill	750
Power Saw	500
Air Compressor	2000

Electric Math

Use the electric math formulas below to determine energy production, storage and loads.



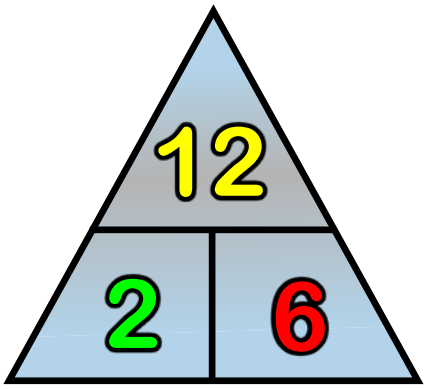
E = Volts

I = Amps

R = Ohms

P = Watts

If the value of any two are known, then one can find the other two. Examples:



P = V x I
24 watts = 12 volts x 2 amps
2 amps = 24 watts / 12 volts

P = I ² x R
24 watts = (2 x 2) x R
24 watts = 4 x R
R = 6 ohms

E = I x R
12 volts = 2 amps x 6 ohms

P = V ² / R
24 watts = (12 x 12) / R
R = 144 / 24
R = 6 ohms

The values inside Ohm's Triangle apply only to source voltage - whereas the formulas outside the triangle apply to both source and load voltage.

Maintenance Sheet

WARNING
TO PREVENT SHOCK AND DEATH
Before performing any maintenance:

- Ensure panels and wiring are dry
- Cover or disconnect solar panel

Monthly

Visually inspect solar generator for:

1. Loose or frayed wiring
2. Damage on panels and frame
3. Damage on battery / pack

If damage found, place out of service until repaired or replaced.

Inspection Notes:

	Jan	**Feb**	
	Mar	**Apr**	
	May	**Jun**	
	Jul	**Aug**	
	Sept	**Oct**	
	Nov	**Dec**	

Spring & Fall

Panel:

- Clean with paper towels using a mild and nonabrasive cleanser.

Battery:

- Inspect and maintain according to supplier's instructions.

Visually Inspect the Solar Generator

Check condition of panels, battery, controller, inverter, and frame:

- Loose frame hardware - including solar panel, controller, and frame
- Wires for any damage and weathering
- Panels for cracked glass or broken parts
- Corroded connectors between panels, controller, and power cord
- Any other condition that can affect safe operation

Troubleshooting

A number of things can result in the solar generator not operating. But thanks to the straight and simple design of the iPower Generator, these are easily remedied:

1. Check the lead connections on the charge controller. The wires may have come loose and need to be tightened.

2. Check the power cord for breaks or fraying. Sometimes, this can be repaired by butt splicing the cord back together. Or replace the whole cord.

3. Check the fuse in the power cord's 12 volt plug. It may be burned out and need replacing.

4. Check the contacts on the 12 volt plug. If they are rusted, then it can cause a poor connection for charging. Use a high grit sandpaper lightly to remove the rust.

Since the iPower Generator can be used with many different kinds of power packs, review the owner's manual for troubleshooting your power pack.

Quick Facts

1. In an emergency, the battery can be drained 100%, doubling the number of hours an appliance can operate.

2. Appliances can operate while the iPower Solar Generator is plugged into the power pack, conserving battery charge for use at night.

3. An external battery can be attached to the power pack with the integrated jumper cables, greatly expanding power reserve to run appliances for a much longer time.

4. DC appliances are more efficient than AC appliances, as power conversion loss is eliminated.

5. Solar charging a power pack is up to 12 times faster than charging from a home outlet. Solar charge the power pack in 3 to 4 hours rather than 3 to 4 days from a home outlet.