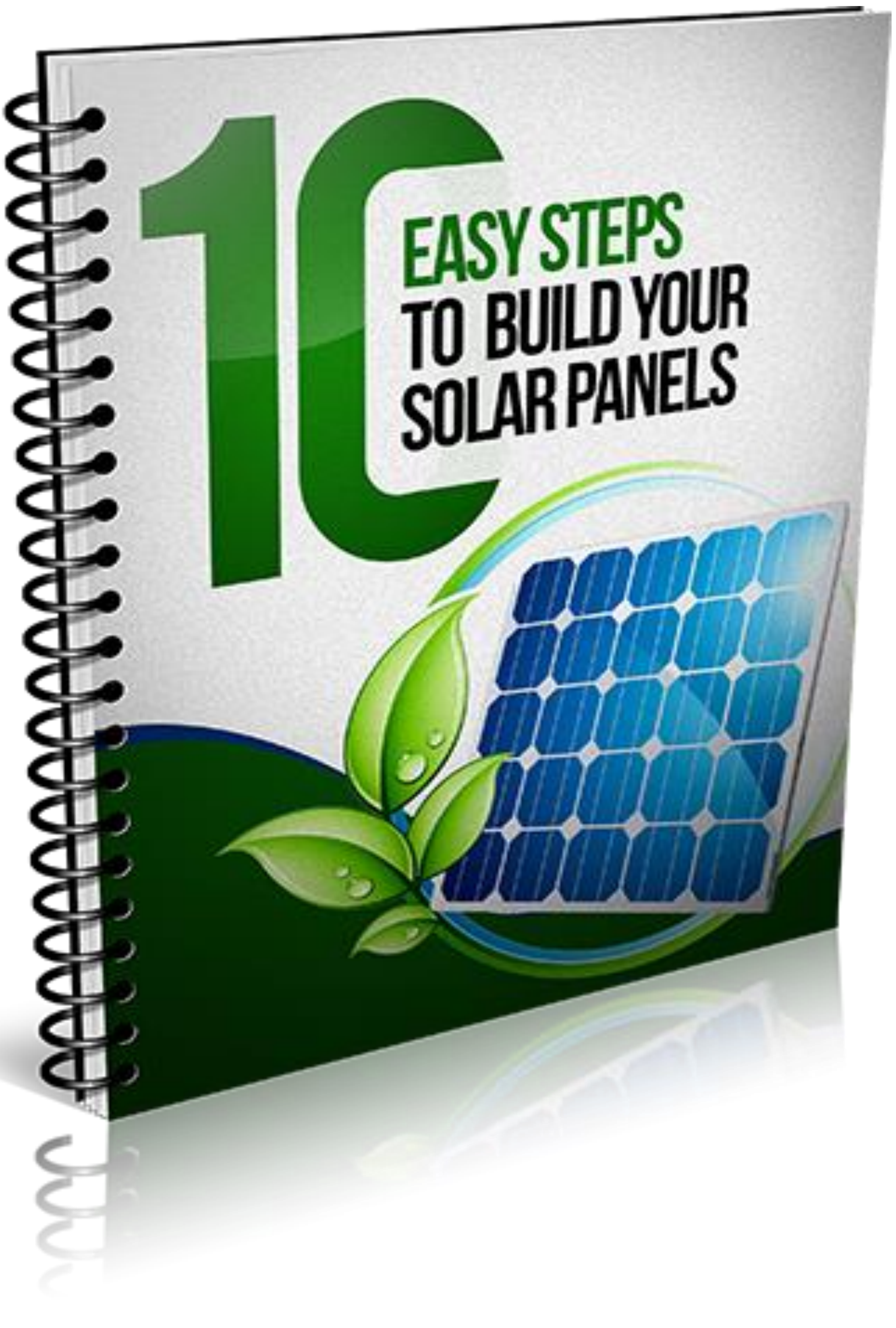
10
EASY STEPS
TO BUILD YOUR
SOLAR PANELS

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Produce your own energy using solar Photovoltaic (PV)

Plug into the sun for FREE energy! Become energy independent, reduce your utility bills, protect yourself against blackouts and reduce environmental pollution!

This guide will provide all the useful information about the ever-evolving world of solar photovoltaic, or PV for short. In essence, we will be examining how we have learned to take the sun's energy and convert that into electricity.

The sun has an enormous amount of energy, evident by the sunburns we have all put ourselves through. Humans have learned to passively harness this energy for thousands of years, using the sun's rays to warm their homes or dry their food and clothing. Not until the latter part of the 19th century, however, did we discover how to convert those powerful rays of sunlight into usable energy in the form of direct current electricity.

This important breakthrough will be discussed, with the various types of solar cells that have been developed and the pros and cons of each.

The main components of a solar electric system will be identified and discussed, and, finally, we will discuss the steps towards constructing your own solar PV panel to harness the sun's full potential.

Types of Solar Cells and Calculating Power

The sun's rays are comprised of many tiny photons of light. These photons, while technically without matter, do possess energy. These little balls of energy multiplied many times over strike the surface of the solar panel and cause the necessary commotion to knock the electron free in the solar cell.

Solar cells are typically made up of high grade silicon as the semiconductor, but this alone is not sufficient to create an efficient enough solar cell. However, if a doping agent is introduced, commonly boron and phosphorus, it causes an unbalanced chemical structure, with a surplus of electrons in the silicon-phosphorus layer on the front surface of the cells.

This creates a negative charge and is referred to as the N-layer. Boron is often added to the back layer of the cells, creating a silicon-boron mixture that has a positive charge and can easily accept extra electrons, often referred to as the P-layer.

In between the two is a positive/negative junction, or P/N junction. This middle junction between the other two layers has a neutral charge and will only allow the flow of electrons in one direction; from the P-layer to the N-layer.

Inherently, electrons like to move from negative to positive charges, and the only pathway for the electrons to return to the P-layer from the N-layer is through the conductor, which offers them very little resistance and allows them to flow out of the surface of the solar cell.
It then returns to the solar cell through the completed circuit into the Player.

By taking this flow of electrons, or electricity, and attaching a load to its circuit you make the electrons do work and have usable, renewable energy.
When each photon hits the cell it carries enough energy from the sun with it to excite one electron in the cell into the movement that creates the electricity. That is where the importance of the sun comes in.

Without an outside energy source, the circuit would not flow. However, when there is enough sunlight, the electrons from the P-layer leave their unbalanced atom and leave holes behind, which are easily filled by new electrons returning from their work in the circuit. This process happens until the sun sets for the day and they lay in wait for a new day.

A blocking diode on the positive lead prevents any current from the cells at night and draining the batteries. You can wire the solar cells together to form a solar panel. When solar panels are wired together they form a solar array.

Solar cells are typically comprised of three solid types: monocrystalline, polycrystalline or amorphous cells. While many different materials are used to make the solar cells, the most common element used for the mono- and polycrystalline cells is silicon. Silicon, while the second most abundant element on the

Earth's crust, must be of the highest grade to be used in solar cell production.

It must be cleaned of any impurities and superheated to form the ingots that are then thinly cut into the crystalline solar cells. Amorphous or thin film cells are comprised of many different elements, commonly cadmium, telluride, or indium, among others. These cells are typically applied to a flexible substrate such as aluminum, certain plastics or even glass by evermore technically advanced methods.

Of the three, monocrystalline cells are the most efficient, while polycrystalline cells are a close second.
Amorphous cells, while considerably less efficient tend to cost only a fraction of what the crystalline cells do. The crystalline cells comprise the panels that are typically used in residential installation. Because they are so much more efficient that the amorphous cells you do not need as much roof or ground space to provide enough energy to offset a typical home's usage.

However, due to amorphous panels' low costs they tend to be preferred for many commercial applications, since space is not an issue in many cases.

When you know both the voltage and amperage of a solar cell you can multiply them together to find its rating in watts. Completed solar panels are rated in watts, so it's important to understand this formula.

Knowing just two parts of the formula, you can also derive the third component. For example, understanding the basic formula V (volts) x A (amps) = W (watts) allows us to derive the amps from a 100 watt 18 volt panel.

V x A = W or W/V=A

100w / 18v = 5.55 amps that the panel will deliver

Once you know the voltage and amperage of your solar cells you can begin to wire them together to form the solar panel. The solar cells are wired together with conductors, commonly tab ribbon. This allows us to take the single solar cell and pair it with similar cells to create a solar panel with customizable power outputs.

There are two ways to connect the cells together. The first is in a series connection, where the positive electrode from the cell is connected to the negative electrode of the next cell. The second way is with a parallel connection. This circuit takes the positive electrodes from the cells and connects it to the positive electrodes from the adjacent cell.

It is important to note that when you wire two cells together in series you add the voltage and the current remains constant, while when you wire two cells together in parallel you add the current and the voltage remains constant.

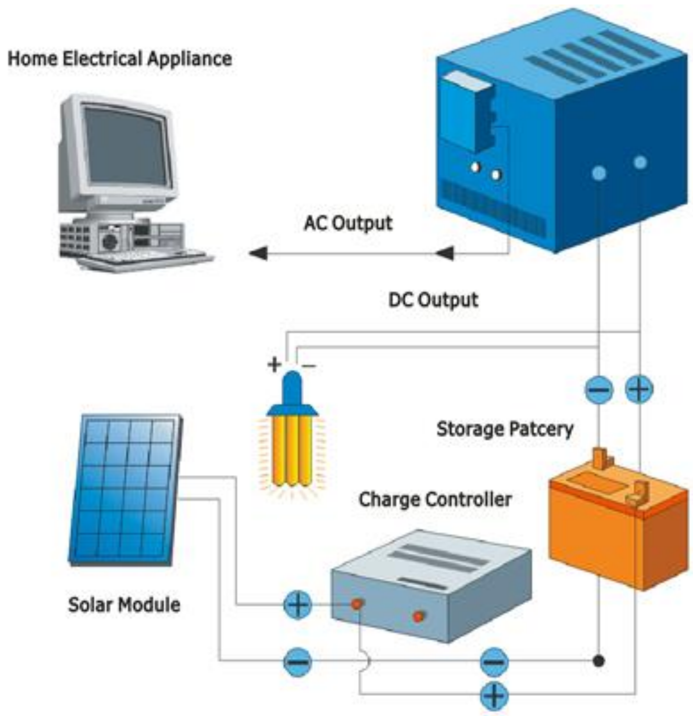
System Components

There are three main types of solar electric systems: off-grid, grid-tied or grid-tied with battery back-up. Off grid systems typically use batteries as their form of energy storage and have been around for many decades. Grid-tied systems have only gained popularity in recent years, as utility, state and federal incentives have made the solar system much more cost competitive with its dirty rivals: the fossil fuels.

These grid-tied systems use the utility grid (the network of wires and cables that span every city and town in the US) to store their energy, sending excess energy into the grid during the day and pulling from it at night. A good resource to check to see what incentives are available in your state is www.dsireusa.org.

Every solar system, no matter which type, will always start at the solar panel. This is where the energy starts, and from there it must enter some conductor to reach its destination. This conductor is typically an insulated copper wire. The amount of energy and the distance of the wire will determine what size wire to use.

In an off-grid application, the energy from the sun typically flows through these components:



From the solar panel the current flows into a charge controller. This unit is in essence a regulator of energy. It is a customizable unit that regulates the flow of energy to the battery and determines how much energy is being pulled from the batteries at nighttime or in cloudy weather. Depending on the size of the solar array you may spend anywhere from under $100 to a couple hundred dollars for your charge controller(s).

Controllers are available in a variety of sizes and appearances. The batteries are a crucial component of your off-grid system. This is what will be powering your appliances when the sun goes down or behind clouds. Most batteries now are lead-acid batteries, although as more funding is being put into the R &D of batteries the chemistry is constantly evolving and becoming more efficient.

Batteries are also available in unsealed and sealed types. The unsealed types are much more common due to their lower cost. However, they do require weekly maintenance to keep their electrolyte levels above the plates inside the battery. The sealed batteries come at a premium, but do not require the maintenance, since the electrolyte is usually in a gel substance.

For either battery you will want to keep them away from any potential heat or fire sources. A shed or a well vented room in your home will work best. Try to avoid temperature extremes for your battery bank, as this will affect the performance negatively.

The charge controller can be programmed to stop flow from the batteries when they reach a certain depth of discharge (DOD). The DOD is typically no less than 50% of the battery's capacity. The further you discharge a battery on a regular basis the shorter the life span of a battery will be. For solar applications you will want to use deep cycle batteries. Wired together, they form a battery bank.

These may look very similar to car batteries but are only similar in appearance and greatly differ in their requirements. Car batteries are meant to be fully discharged and then rapidly recharged. Solar deep cycle batteries are slowly charged throughout the day and then discharged slowly at night. Their energy input will vary throughout the day and the discharge will be sporadic at night, too.

A car battery used for a solar application would not be expected to last even one year, while a well maintained deep-cycle battery can be expected to last 6 years or more, depending on the depth of discharge level you have set and how often you keep the electrolyte levels maintained.

If you are using just direct current (DC) loads you will not need an inverter and can just charge the loads from the battery, assuming the voltages match up. However, the cost and availability of DC appliances remains an impediment to the solely DC home.

Alternating current (AC) appliances dominate the home appliance landscape and require an inverter to change the DC current from the solar array to AC current for your refrigerator, TV, lights, etc. You should expect to spend around $0.50/watt or more depending on the size of the inverter needed. Typically, all but the largest residential solar systems will work fine on one inverter.

Inverters, like the charge controllers, will vary in shape and size depending upon the inverter's output rating and manufacturer.

You may be able to save some money on larger systems by purchasing an inverter that has a charge controller inside its circuitry.

Check the spec sheets to determine this. Many of the larger manufacturers of inverters have solar string sizing programs available for free on their website, so you may want to reference this to determine what size inverter to use. The inverter's input voltage window is the main determination to determine how many panels you can wire together in a series string, which is why they are often called string inverters.

You can get by with an inverter that is rated below the name plate rating of the array. For example, a solar array with a name plate rating of 3,300 watts (3.3 kilowatts) will work just fine with a 3,000 watt inverter, since you will typically lose up to 20% of the output from the panels from many factors. Among them, voltage losses in the wires, panel mismatch, dirt or pollen on the panels and the DC to AC inversion.

Disconnect switches are often times built into the inverters, but many municipalities require a separate disconnect switch for either the DC side or the AC side, or both. If you are planning on getting your system inspected by a licensed inspector or are going to connect your system to the grid check with your local laws to determine which disconnects you will need to install. The National Electrical Code (NEC) book, too, has set laws on mounting the equipment, such as how high off the ground, distance from batteries and other components, etc.

Disconnect switches, depending on how many strings of panels you are creating may need to have an integrated fuse. These disconnects can be purchased at a local electrical supply or hardware store.

If you are constructing a small array, you may get away with just one battery, a small charge controller and a low wattage inverter, like the kind you can plug into your car adaptor. You can plug many AC electronics or even appliances directly into the inverter, so long as the inverter is rated to handle the load requirements.

For larger systems, you should opt to run the inverter AC wires directly into your homes breaker panel with breaker slots allotted for the inverter. A master electrician's services should be sought for this step.

To make sure your breaker panel can handle the backfed current take the busbar rating found on the inside cover, multiply it by 1.2 and then subtract your main breaker size. The max continuous output current of the inverter multiplied by 1.25 (depending on which NEC Code year you reference) must be below this number.

For example, a 200 A breaker panel (standard in most new construction) with a 200 A main breaker will allow for 40 A to be backfed (200 x 1.2 – 200 = 40 A). You can typically fit up to about 7000 watts on a 200 A breaker panel since the max continuous output of a 7,000 watt inverter is usually close to 32 A. The max continuous output of the inverter is found in the spec sheet or by contacting the manufacturer.

Grid-tied systems substitute the utility grid for the batteries. Most homes that are connected to the grid opt for this service. If going this route, you will want your utility provider to install a net meter for you.

This meter records the flow of electricity in both directions, essentially crediting your account for sending excess electricity into the grid.

When the sun is out and your panels are producing more electricity than your home needs, your meter will spin backwards. When the sun goes down and the lights come on you begin to pull electricity from the grid and your meter spins forwards again. Most states have now adopted net metering for renewable energy systems. If you don’t get a net meter your old meter may actually charge you for energy consumed and energy produced!

It is important to note that when you lose power from the grid, you won’t be able to use the power from your solar array. This is a safety feature built into the inverters so that if you have a utility lineman working on the power lines in your front yard they can be confident there is no current in the lines. If your array were in the backyard feeding the grid and he was working in the front he would run the chance of having a bad electric shock.

A small percentage of homeowners opt for a grid-tied solar system with battery backup. This is more common in places with an unreliable utility connection like very remote areas or places with inclimate weather. Aside from the extra maintenance and introducing more toxic chemicals into your home and the environment, you could pay up to 50% more on the total cost of an installed system by adding battery backup. There are inverters out there that have grid-tied/battery backup capabilities, but you may need two inverters for this option.

Having a crucial load subpanel is a good option for when the power goes down and you are drawing from the batteries. This isolates some of your electric loads on a separate breaker panel so that you won't pull down the battery's storage too fast by running unnecessary loads.

The Best Location for PV Panels

The biggest factor when determining the location is access to the sun. The way the panels are wired together, it is very important that your panels will get at least 6 hours of unobstructed sun per day. This 'solar window' is typically from 9 am to 6pm, but may adjust to earlier or later in the day depending on the orientation of the panels. The optimal pitch for the panels is equal to your latitude, although in many locations with cloudy winters, it may be optimal to subtract about 15 degrees from your latitude for optimal pitch. A solar pathfinder or a Solmetric sun eye are two popular options for determining the site's sun potential.

They are useful tools that will show what shade issues you will have with a particular spot at all times of the year and even what time of the day. Shade is to be avoided at all costs since the cells and panels are mainly wired in series, and shading even one cell of a panel can wipe out a portion of the entire array.

National Renewable Energy Laboratories (NREL) has developed a very useful online resource to determine the potential output of your array. The program is called PVWatts and is free to use online. It can be found online at: http://www.nrel.gov/rredc/pvwatts/. Simply input your array size in kilowatts, the orientation and angle of your panel and your zip code and the program will give you your estimated kilowatt hour (kWh) output for each month of the year.

If you cannot mount the panel to your roof, another consideration for site selection is to keep the array as close to your home as reasonably possible, since long wire runs will have higher power losses and will require thicker wires, increasing the cost of your system and requiring longer trenches.

The Building Process

Currently, the limiting factor for widespread adoption of solar is the initial cost of the completed solar system. While a typical solar system will consist of many components, the solar panels often comprise more than 50% of the entire cost. This accounts for thousands of dollars even in most residential cases.

Solar panels, when made yourself can be done for fractions of the cost of what is available commercially, and can ultimately save you a lot of money, whether you opt for building a small 60 watt solar system or for wiring several panels together and creating a larger system.

Even with no experience and limited access to tools anyone can learn how to build a fully functional PV panel and can begin producing energy from the sun in just a few hours. For the purpose of this DIY panel we will be dealing with crystalline cells and the following is a basic guideline in what steps to take, which methods to employ and which tools to use to.

Materials Needed

Solar Cells

Connecting Wire

Wood or Other Panel Material

Panel Cover (plexiglass)

Solder

Clear Silicone Caulk

Stainless Steel Screws

UV Protected Paint / Prime

Tools Needed

Saw

Caulk Gun

Screwdriver

Knife

Protective eye wear

Soldering gun

Flux Pen

Paint brush

Multimeter

Gloves

STEP 1: Measure your Solar Cells

Solar cells are measured by their power in watts. To obtain a cell's wattage you must first know how many volts, again represented by V, and amps, represented by A, the cell has. Amps are commonly measured in current, represented by I.

As we discussed before, to determine its watts, represented, by W, you multiply the volts by the amps. This formula can be expressed as V x A = W. If the voltage and amperage are unknown, you can measure it with a multimeter that will take both current readings up to at least 10 amps and voltage reading of up to 600 volts.

Take your measurements in full, constant sun. You can hold the cell perpendicular to the sun and contact the multimeters negative and positive leads to the negative and positive electrodes on the cell, or may opt to construct a solar tester using a highly conductive backing, such as a copper plate. This will provide a steady place to rest the cells for measurement and will only require you to touch the positive lead from the multimeter to the metal backing instead of the cell itself.

A solar cell will have a voltage right around ½ or .5 volts, but may read as high as .6 volts in direct sun, while its current rating will vary dependant in its size. For example, a 3 x 6 solar cell may read .5 volts and 4 amps under full sun. If you were to cut that cell up into four equal pieces, you will have four cells that each still read .5 volts, but now each one has just 1 amp. Be very careful in your handling and measuring of the cells, as they are extremely thin and very fragile.

Measure all of your cells to make sure that you are only going to be using the best cells for your solar panel. Less desirable cells should be put aside with the broken cells for future projects that don't require very much power.

This is an important step, especially if buying blemished, broken or used cells off of the internet since if just one cell has a low current rating it will bring down the current of the rest of the cells it is wired in series with.

Remember, when wiring in series the voltages add, but the current remains the same, and will only be as strong as its weakest link. Measuring the current is more important than measuring the voltage, since each cell will be close to .5 volts even with blemishes or chips.

Going back to the previous example with the 3 x 6 cell cut into four pieces we will now see just how customizable a solar panel can be. The solar cell started with a rating of .5 volts at 4 amps. By cutting it into quarters we have 4 cells of .5 volts and 1 amp.

Now, if we were to wire these cells together in series we will have a string of cells with 2 volts (.5 volts x 4) and 1 amp. If we were to wire these cells together in parallel, we would have a string of cells with .5 volts and 4 amps. The same concept applies to wiring panels together.

STEP 2: Establish how much power you need

If you are trying to charge a 12 volt battery it is advisable that you build a 16-18 volt panel. To build an 18 V panel (as we are to do) you need 36 cells in series. This is determined because 36 cells in series at .5 V each will give us 18 V (36 cells x .5V = 18V). The amperage will be the same as the rating of just one solar cell, in this example, 3.5 amps, since they are all wired in series.

If you desire higher amperage you can wire two strings of 36 cells together in parallel to double the amperage in a given panel to have an 18V 7A panel, or you can simply wire two 18v 3.5 A panels together in parallel to achieve the same purpose. Keep in mind size and weight limitations, not to mention breakability when determining the power output of your panel.

STEP 3: Solar Panel Dimensions

This is done by some simple math. First, take the dimensions of your individual solar cells, in our case 3” x 6”. There are two main panels layouts that you may wish to work with. The first and the one we will outline are 4 rows of 9 cells wired together. The other option is to use 3 rows of 12 cells.

Working with the example of the 4 rows of 9 cells, we need to determine the width and length of the panel. If each cell is 3” x 6” and there are 4 cells wide we will need at least 24” (6” x 4 = 24”). Typically you will want to allow at least ¼” in between the rows, so add ¾” to the width (¼” x 3 = ¾”). Then add an inch on the right and left sides and you are left with 24 ¾”. We’ll round this up to 25”.

Do the same math to determine the height. (9 cells high x 3” each) + (8 spaces in between the cells X ¼”) + (3” – allow more spaces along the tops and bottoms of the panel for wiring the individual strings of cells together) = 32”. That leaves us with 25” x 32”. This is the dimension necessary for the substrate that you will be attaching the solar cells to with liquid silicon.

To determine the panel backing size you take the substrate dimensions and add the width of the side wall pieces of wood. The side wall pieces of wood can be as little as 1” wide or less, just make sure that they are sturdy. They are used to attach to the panel backing along the edges to allow for a cavity in between the edges for the cells and substrate to secure into.

Keep in mind that the height of the panel walls must be tall enough to allow the substrate and attached cells to safely sit in the cavity and still allow the panel cover to fit into place without contacting the solar cells. Next, add an extra inch onto the width and height of the substrate to ensure the substrate will fit within panel walls. We’ll call this our insurance inch.

This leaves us with 25” + 2” (2 x 1” side walls) + 2” (insurance inches) = 29” and 32” + 2” + 2” = 36”. We’re left with 29” x 36”. This is your panel backing dimensions.

It is important to note that this is the *minimum* size for your panel. If you find a precut piece a little larger you can work with it, just add more spaces in between the cells or along the edges. The important part is that the side walls are cut to length to match the panel backing and that the cell substrate will be large enough to secure all of the cells to, but small enough to fit within the cavity created by the construction of the panel backing and side walls. Do the same for a panel comprised of 3 rows of 12 cells but make adjustments as necessary.

STEP 4: Construct the Panel Frame

There are several different materials you can use to construct your solar panel frame. We use wood for our example because it is easy to work with and readily available at low or no cost. You can use a variety of materials to construct your panel frame but the other popular DIY materials are aluminum and preformed plastics.

This step is where you'll want to throw on your safety goggles and cut the wood pieces to the predetermined lengths. Cut the panel backing to the predetermined size. Sanding the edges after the cuts will make handling that much easier in the future. Take the thin pieces of wood that you will be using for the side walls and cut down to match the size of the panel backing.

Next, cut your substrate that you'll be attaching the cells to at the predetermined dimensions. Glue, nail or screw down the side walls to the panel backing. I like to secure the panel walls down the panel backing with wood glue for a temporary fix, just until we're ready to screw down the panel cover.

It is after this step that you'll want to put a good 3 coats of UV protected paint/primer on the wood surfaces. You may also paint the individual pieces before they are secured together; just make sure that the wood is fully covered by the paint – this is more for longevity of the panel than aesthetics.

Lighter colors are favorable, as darker colors will absorb more sunlight and will make the solar panel hotter. Solar cells, as with many other electronics, perform better at lower temperatures. Before you attach the cells to the substrate in step #6 make sure that the substrate will indeed fit within the panel side walls.

STEP 5: Solder Cells Together

This is the fun part. If you have pre-tabbed cells (the ones with the thin tab ribbon coming off of the face) you will only have to solder the cells together at the back, or negative side. If untabbed, apply solder to the tab ribbon and connect the tab ribbon to the front electrodes that run from the lower portion of the cell all the way to the upper portion.

Typically you will have to do this twice for each cell as you will have two electrode strips. Allow enough tab ribbon lead to come off of the cell to attach it to the back side of the next cell in series, roughly twice the height of your cell. Crimp the tab ribbon leads just above the cell so that you will have some flexibility between cells. This serves two purposes.

The first is to allow to cells to move with the substrate as it expands and contracts with the weather fluctuations without putting too much strain on the solder connections. The second is to provide some leeway after you have soldered the cells together to align the cells in a straight row and provide uniform spacing.

Once you have done this to all of your cells flip them over so that the backs are facing up. Solder the remaining tab ribbon to the back electrode so that they are wired in series. In the example we are using, you'll want to do this for 9 cells to complete the substring. Even though you will have some room to move the cells independent of one another due to the crimping done before hand, try to keep the cells wired in a straight row and evenly spaced so that they will fit on the substrate as you have measured earlier.

The last step here is to solder a little length of tab ribbon to the negative side of the first cell in each string, so that the completed strings will have leads coming from both ends.

STEP 6: Attach Cells to Substrate

What we'll need to do first is lay down the completed strings on the substrate and position all 4 strings where they will be when the panel is finished. Take a fine point pen and mark the four corners of each string so that you will easily be able to lay them back in place later. Flip each string over one at a time and apply a little bit of silicon caulk to the backs of each cell.

Once each cell has a tiny bit of caulk on its backside flip them back over and lay them down on the substrate according to the lines you have just drawn. Make sure to rotate your strings when laying them on the substrate. For example, your positive leads, when coming off of the bottom of one string should be adjacent to the negative leads coming off next string.

Put on a latex glove (or something similar) to avoid depositing any fingerprints or greases onto the surface on the cell and then gently push down in the center of the cell where the caulk was applied to leave each cell firmly attached to the substrate. Allow sufficient time to dry.

STEP 7: Finish Wiring and Secure Substrate to Panel

Now that you have your finished substrate it's time to wire the 4 individual strings together. The two strings on the ends should have a negative and positive lead coming off of the cells. These will be your "homeruns" or the wires that will come out the back of the panel.

Take the opposite end of the first string from the home run wire end and straighten out the tab ribbons that come off of the cell. Do this to the adjacent string as well. Taking a piece of copper wire or bus ribbon connect the leads off of the cells by first bending the leads over the copper wire or bus ribbon to make a good electrical connection.

Then take a little bit of solder and cover any exposed copper wire and ensure that the connection will not fail. Do this to the opposite end of the second and third strings and finally to the leads coming off of the third and fourth strings on the same end of the substrate as your first connection.

You have now wired all 36 cells in series and are ready to make the homerun connections. Lay the substrate within the panel walls. If it appears that the side walls will not shade the outmost cells during the early mornings and late evenings (before 9am or after 3pm is acceptable if oriented at true south). Screw the substrate to the panel backing. Taking some copper wire, attach the positive and negatives leads that come off of the two remaining cells. In our case these should be on the top of the panel on opposite ends. Bend the leads over the wire ends as done before and then solder into place.

Use enough wire to easily go from the cells leads and out the back of the panel with enough extra sticking out the back to easily work with; at least six inches but more is better – you can always cut it back later. Attach a blocking diode to the positive homerun wire so that current will not flow out of the batteries at night and into the panel, effectively draining out the power you've spent all day storing. Drill a hole in the top middle of the substrate for your homeruns to exit the panel.

STEP 8: Attach Clear Cover

Now that you have all of your cells wired together and attached to the finished panel you are ready to attach the panel cover. Before you do seal in the cells, however, make sure that you have given a day or so for the silicon to completely cure. Off gassing from the silicon will leave a haze on the inner cover if you jump the gun on this step.

For the cover, plexiglass is a very inexpensive option, and you can easily cut it to match the panel dimension. Tempered glass can be substituted here if you have found something with the correct dimensions, but remember that once glass has been tempered you cannot cut it. Regular glass is also an option, but the fragility of it is a concern. Hail and debris that would bounce off of the plexiglass or tempered glass could easily break the normal glass.

Whatever cover you use, make sure that it is UV protected otherwise you'll see yellowing and will lose efficiency. Attach the cover to the panel. With the case of the plexiglass or normal glass you can drill a pilot hole and then use stainless steel screws, making sure to hand turn the last couple of threads to avoid shattering the cover. Stay as far away from the glass edges as possible.

STEP 9: Seal with Clear Silicone Caulk

Now that your panel is completely assembled, take your silicon caulk sealant and apply liberally to the outer edges of the panel. Seal all gaps and holes between the cover, the panel walls and the backing. You have the option of sealing the inner edge of the panel backing and walls, too, but this must be done before the substrate is in place. While not necessary, this extra sealant will prevent more moisture protection, but again make sure the sealant has dried before affixing the panel cover.

STEP 10: Test your Solar Panel

Now that you panel is complete its time to test it out! Going out into full sun, take your panel and orient it so that it is as perpendicular to the sun's rays as possible. This will give you the highest readings and, thus, the biggest sense of accomplishment.

Take your multimeter and attach the negative lead to the negative homerun and the same with the positive lead. Take the voltage and current readings. You should see at least 18 volts from your 36 cells, although it is quite possible that you will see a little more. As the cells heat up in the solar panel throughout the day under the sun you can expect to see this number dip.

Next, change the setting on the multimeter to get the current reading. You should see a current reading similar to what each individual cell was rated at. Multiply your voltage rating by your current rating and you have your panel's power in watts. Now you're done and can congratulate yourself on producing your own clean electricity for years to come right in your backyard!