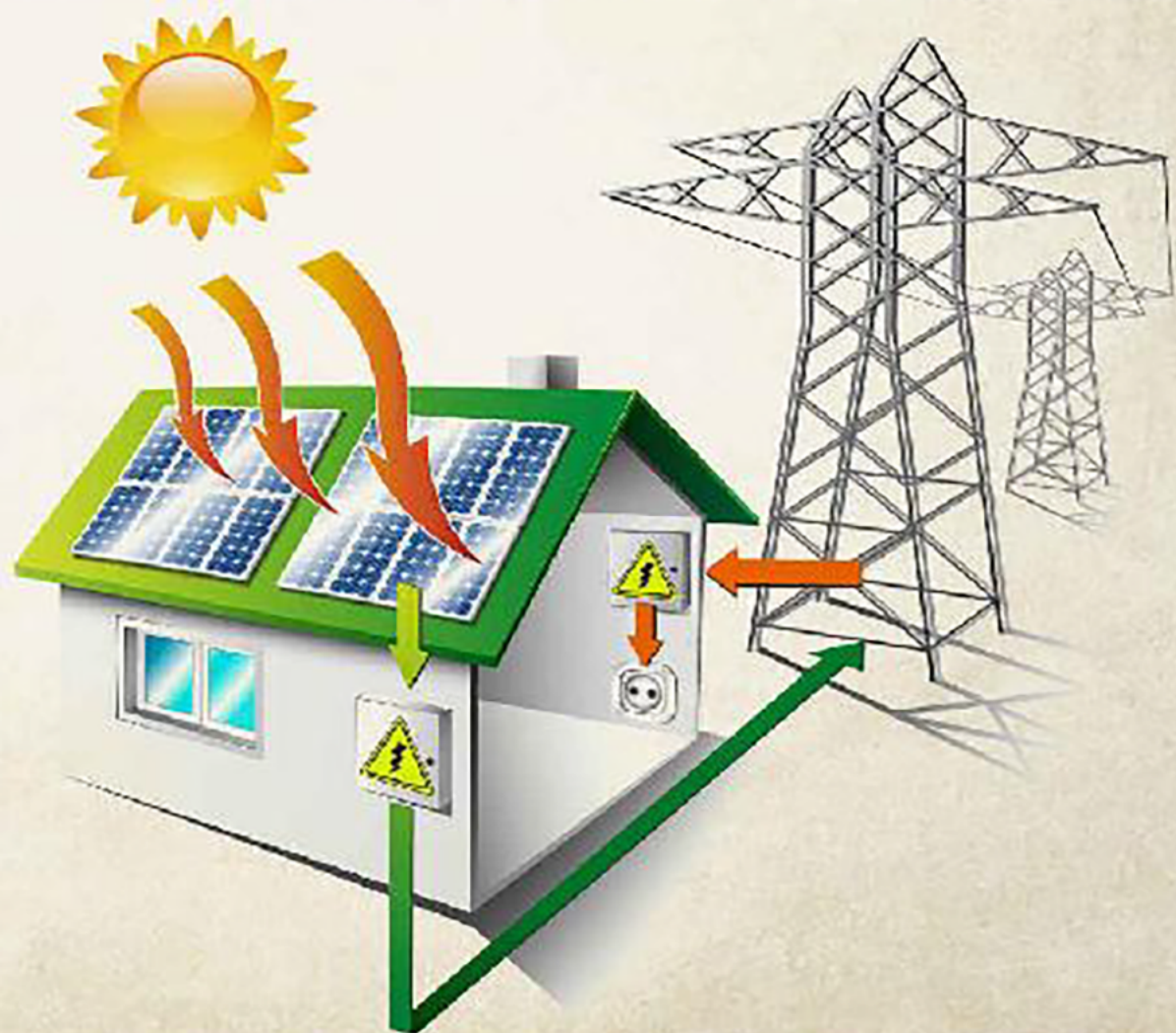


# SOLAR POWER

## — DIY HANDBOOK —

SO, YOU WANT TO CONNECT YOUR OFF-GRID  
SOLAR PANEL TO A 12 VOLTS BATTERY?



BAIANO REEVES

# **Solar Power DIY Handbook.**

So, You Want To Connect Your Off-Grid  
Solar Panel to a 12 Volts Battery?

Baiano Reeves

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# Introduction

I want to thank you and congratulate you for downloading the book, "Solar Power DIY Handbook: How to Connect Your Off-Grid Solar Panel to a 12Volts Battery".

This book has actionable information on how to connect your off-grid solar panel to a 12 volts battery.

To the person who has little experience in solar technology, installing a solar panel, as well as knowing the right components to use may appear to be especially daunting. The truth, however, is that it is relatively simple to install your solar panel and connect it to your battery.

What is more; once you have successfully done it once, it is a lot like learning how to ride a bicycle- you never forget, or have to relearn the process again. If you are thinking about installing a solar panel for your home or office, this book is especially handy, as it takes you through the whole process from start to finish.

This book gives you explicit instruction on solar technology. It explains all you ever need to know about solar power as well as solar panel installation. By the end of this book, you would be able to look at solar panel installation as a relatively simple process, with the prospect of a little fun involved. Let's begin.

Thanks again for downloading this book. I hope you enjoy it!

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## Testimonials:

“This book was written as a guide for solar and clean energy enthusiasts to navigate this novel technology and make informed decisions on incorporating this technology to save money and energy at home, and in other leisurely activities such as travelling(boats and RVs).”

Dave Litcum, Michigan

“I loved it because it demystifies solar energy by breaking down concepts into bite size pieces. I finally got 2 panels setup successfully on my RV”

Tracy L,Florida

I read this book and walked away with at least the confidence of holding an intelligent cocktail conversation and also felt brave enough to tackle that secret desire I always had of being a survivalist who goes off-grid and free myself from the trappings of today's society. I now have my home grid-tied to Solar Panels and it saves me a bit of money monthly.

Jeffrey Hall, Atlanta

Let's start with the basics, i.e., building an understanding of solar power, so you know what your task is.

# Chapter 1: What Should You Know About Solar Power?

To keep the information as relevant to the book title as possible, rather than attack solar power information on a wholesale sort of manner, we will focus on the material that you most need to know, if you are preparing to install a solar panel on your roof. This chapter's title may well have said, "Here is what you need to know about solar technology if you are ready to put up a solar panel." Stakes are high here. However: this could well be the most critical chapter in the entire book. Look at it this way: say you want to buy a car. If you are a first-time buyer, it is natural that the process would seem daunting. However, the truth is that there are very many people who have bought cars and if you want, you can have them "spot" you with automobile information when you go shopping. Putting up solar panels on your roof may cost just as much as walking into a car shop and buying a new car. However, in comparison, there are far fewer people who can say they have owned a "solar system." Here is another thing; the stakes are far higher. After all, the thing is going on the roof of your house. It is not as simple as saying, "Well, if I make some mistake or other, I will know better next time." Thus, before you make the jump and start installing your panel; before you make a leap and skip this chapter for the more technical stuff, read the contents of this chapter.

Ask yourself the following questions before you install solar panels.

## **#1: Is your roof even suitable to support the solar panels?**

Consider this one, first and foremost. If, for most of the day, the beautiful trees on your compound throw shade on your roof, the solar window may not be enough for ample solar energy collection. Sure enough, your panels would collect some, but will the little energy collected justify the money you put in for the full installation?

If your roof is not suitable, you do not have to give up on solar power. You could always look into shared solar energy or community solar. It may not indeed appeal to you, but this sort of approach allows you, along with multiple other consumers, to purchase a stake in some solar

installation. Of course, you would have to deal with a small bill at the end of the month.

If your roof is all right for panel installation, make sure that it is strong enough. Consider renovation if the roof's shape is not as good as it should be. If you have to conduct revisions on your roof a few years down the line, it would cost you money to have the solar panels disconnected, and then set up again.

Do not forget to read any homeowners association "covenant" as well. Some of these prohibit such additions as solar panels to rooftops. It is, for the most part, an aesthetics thing, but you would have to abide by it nonetheless.

## **#2: Can you say you have done all you can to maximize efficiency?**

Put simply, the solar energy amount that you intend to produce would depend on the energy you use. It makes all the sense in the world to trim your energy use as much as you can. Perform an energy audit at your home, install as many energy efficiency upgrades as you can and then think about drawing up those solar energy blueprints you are so itchy to draw up.

## **#3: Which solar kind makes the most sense?**

There are two dominant solar energy technologies to choose from: photovoltaic technology, which employs cell arrays to convert sunlight to electricity, and thermal technology, which uses sunlight to heat up water, even air, for use inside.

If you have known your home to use lots of energy, especially for heating, or you live in the sort of place that comes with high heating fuel bill, meaning an investment in solar thermal technology could save you much money going forward. However, there is a reason why you perhaps did not know there were two solar energy technologies: very few people ever have solar thermal technology installed in their homes. This information deficit means that you may have a much harder time installing this technology. If you decide to go for a qualified installer, then you may end up throwing a lot of dollars at him, or her.



#### **#4: How will you be able to connect to the grid?**

Details tend to vary going by where you live. Still, any time you connect with a utility, there is more than a few logistics to wade through. Is there a fee to be paid? How long will it take you and yours to get hooked up to the grid? Once you do get accredited, how will you get credited for the power you are generating? When will this happen?

If you have no idea what those last two sentences allude to, they are referring to net metering. Utilities are supposed to reimburse solar at about the same rate they charge electricity users. Before you start beaming, understand that this particular area is rife with political shenanigans. Look at the state of Nevada, for instance, which has policies in place that reimburses peanut amounts, making it difficult to recoup installation costs. No matter which part of the US you live, you get refunded for sure if you connect to the grid: however don't get your hopes up too much.

#### **#5: If you employ the services of an installer, can you trust him or her?**

The issue of trustworthiness, in all honesty, applies every time you have professionals or other come into your home. However, when you consider that solar tends to combine home improvement logistics with electrical risks, you need to be a lot more careful here. Insist on credentials and make sure they are valid. As a smart man once said, "What sense does it make to hire an electrician who has never done actual electrical work?"

Having answers to the questions above in mind, now you can begin getting a bit technical with solar power installation. Let's start by learning the fundamentals of electric circuits because it is the core of installing solar power.

# Chapter 2: Fundamentals Of Electric Circuits

This chapter guides you through the fundamentals of an electric circuit:

## #1: The resistor

As their name suggests, resistors "resist" electric current. The resistor controls the currents and voltages in the circuit so that the entire circuit runs smoothly.

Here is a simple illustration: Supposing you have a Light Emitting Diode (LED) that you want to turn on using a 9-volt battery. If you connect the battery directly to the LED, current then flows through the LED. In fact, way more current than the LED can hold flows through it. The LED gets burnt out. On the other hand, a resistor, put in series with your LED controls the current flowing through, so that the LED does not burn out.

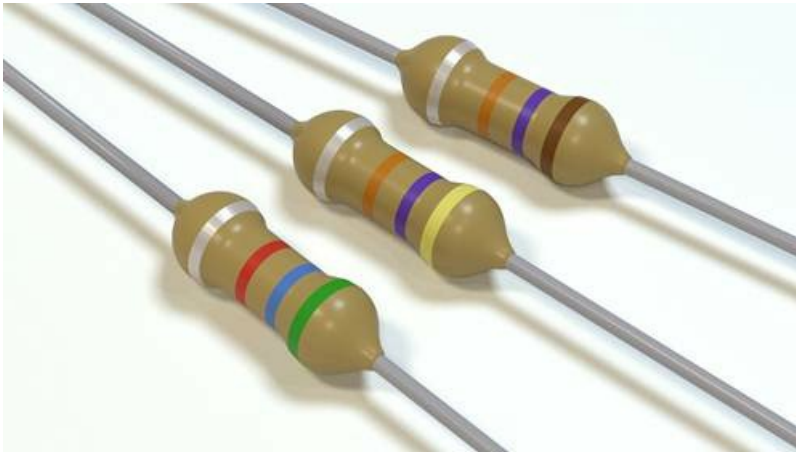


Diagram of 3 types of resistors

## #2: Capacitor

To correctly understand the capacitor, think of it as a battery that has insufficient capacity. In simpler terms, this is an over-glorified battery, so to speak, that gets charged and discharged in the same way a battery is. The capacitor's work is to introduce a "time delay" in your circuit. A

capacitor is most commonly employed to remove electrical "noise." In other words, it ensures that the circuit voltage is as stable as possible.



Diagram of a capacitor

### #3: Light Emitting Diode (LED)

An LED is a component "with the capacity to give light. An LED is vital in that it gives you feedback from your circuit. For example, if your circuit indeed has power running, the LED lights up to show this. You can also use the LED to add to the aesthetics of your circuit by lighting it up, but this is not a necessary use.



Diagram of three LEDs(Light Emitting Diodes)

### #4: The transistor

The transistor may well be the most difficult electric circuit component to comprehend. To help you understand it better, think of it as a switch that is controlled by an electrical signal. If you run, say, 0.7 volts between the emitter and the base, this "switch" is turned on. However, rather than have just 2 states, ON and OFF, this switch also has the "a bit on" option, by controlling current that runs through its base.

Just a bit of current running through the base provides current amplified to 100 times (this is dependent on the transistor you are using). It is this effect that is used to construct amplifiers.



Diagram of a transistor

## **#5: Inductor**

The inductor is somewhat weird. The inductor is a coil of wire, and you can quickly make one by making several loops on some wire. At times, the inductor is wound around a metal core. Inductors act as filters in the circuit.



Diagram of an Inductor

## **#6: Integrated circuit (IC)**

The IC comprises multiple electronic components but all it is at the end of the day is an electronic circuit that is so compressed that it can fit inside a small chip.

The IC could play any role: it could be a microprocessor, an amplifier, a USB to serial converter... it could well be anything! The IC plays whatever role it has been installed to play in your electrical circuit.



### Diagram of an Integrated Circuit

Your understanding of the different terms we have discussed above helps you understand much of what will be discussed later on. Next, let us understand how solar panels work so that you install the whole system with knowledge; not just following steps.

# Chapter 3: Mechanisms Of Solar Panels

It helps to understand how solar panels work, even as you seek to install one. While the solar panel appears to be something mystic- an assemblage of sophisticated technologies, it is pretty simple. Once you understand the concept of solar cells and how they work, you well along your way to understanding the solar panel's workings. However, first, let us lay some ground before attacking the solar cell subject. How much energy can we realistically get from the sun?

Here is some technical information that, while not being too vital in the general scheme of things, gives you some perspective on just how much energy the sun has to offer. Every square meter of the earth's surface gets up to 164 watts of energy from the sun. Look at it this way: you could set up a very potent table lamp (say, a 150-watt lamp) on every square meter and pretty much illuminate all of the earth using solar power. This is quite impressive, is it not? However, if this looks a little too fancy to digest, then consider this other example: if just 1% of the Sahara desert were to be covered with solar panels, the solar energy produced would be sufficient to power the entire world. What I am saying is simple; there is an awful lot of the sun's energy to go around!

However, this energy cannot be directly used. It has to be converted to electricity.

## **Understanding solar cells**

A solar cell is a device that traps sunlight and directly converts it to electricity. A solar cell is about the size of your palm. Its shape resembles that of an octagon, and its color is bluish-black, which is why all solar panels tend to have the same bluish-black tint to them.



Diagram of a solar cell

On its own, a solar cell is not much use; you could not derive enough electricity from it. Solar cells are usually bundled together to form larger electrical units known as solar modules. These modules are themselves bundled together to form even larger electrical units that the world refers to as solar panels. At times, they are "chopped" into portable chips so they can power small-sized electronics, such as pocket watches and calculators.

## **Comparing the solar cell to a battery cell**

Like is the case with the battery cell, a solar cell in your solar panel was designed so that its primary function is to generate electricity. However, whereas the battery cell derives its electricity from chemicals, the solar cell captures sunlight, which it converts to electricity. Some people insist on referring to the solar cell as a photovoltaic cell given that they use sunlight (the Greek word for light is 'photo.' As for the "voltaic" bit, it refers to Alessandro Volta, the legendary Italian electrical scientist.)

## **The way of the solar cell**

Think of light as being comprised of small-sized particles called photons. With this in mind, a light beam is akin to a brightly colored fire "hose" that shoots trillions of photons toward the Earth. When you place a solar cell into the beam's path, it traps these photons and proceeds to convert them from a flow of photons to a flow of electrons. In short, it converts them to electrical current flow.

Each cell generates a few volts, so the panel's job is to bring together all



the electricity produced by the individual cells so that the current produced is large enough as to be useful. Most solar cells consist of silicon slices. When sunlight hits a solar cell, the energy it carries then "blasts" electrons contained in the silicon. These electrons are directed through an electric circuit and power gadgets that use electricity to run.

What you have read up to this point is a very simplified illustration. Let us take a closer inspection on the subject:

## **How are solar cells constructed?**

We said that solar cells comprise of silicon. Silicon is a semiconductor: it does not typically conduct electricity, but under unique circumstances, it can.

A solar cell is essentially a two-layer silicon sandwich, where the silicon is specially treated to allow electricity indeed to flow through it uniquely. The lower silicon layer is treated so that it has "slightly too few number of electrons." The upper layer is treated oppositely however so that it has slightly "too many electrons."

When you place a layer of the latter on a sheet of the former, a wall forms at the junction. No electrons can pass this barrier. However, this ceases to be the case when light shines on this silicon sandwich. As the photons, or light particles, enter the silicon sandwich, they "give up" the energy they carry to the silicon atoms. This incoming energy blasts electrons out of the lower layer so that they leap across the barrier to the top layer and then flow out and around the electrical circuit. The more light shone, the higher the number of electrons that are knocked off, and the larger the current derived. Scientists like to refer to this phenomenon as the photoelectric effect.

## **How efficient are solar cells?**

If you attended grade school science lessons, you are familiar with the scientific claim that it is impossible to create energy. You can only convert energy from one form to the other. Thus, a solar cell cannot put out any more power than it gets from the sun. Even more importantly, it is impossible for the solar cell to give out just as much energy as it gets from the sun; a fair amount of it gets lost in transition. In practice, solar cells are only able to convert 10-20% of the energy they receive from the

sun. A single junction solar cell, however, has a maximum efficiency of around 30%. So before you get intimidated by the "single junction" tag, this sort of cell is the typical cell in your solar panel.

Now that you know how solar panels work and understand the different terms you may come across in the book, let's look at batteries.

# Chapter 4: Choosing Batteries: Lead Acid or Lithium?

## What is the superior battery type?

So very many off-grid energy systems have dead lead acid batteries around the US that a documentary covering all of them would run for years before exhausting them all. Moreover, it is difficult to blame the door of the lead-acid batteries: they are designed to work for a few years, which is what they do before fading and losing their charge depth. Lithium-ion batteries, on the other hand, while considerably more complicated than their lead counterparts, have some notable advantages. There is no argument that lithium batteries are superior. Let us examine exactly why this is so:



Lithium versus Lead Battery

## Lithium-ion battery

**Advantage #1:** The size and weight of the lithium battery are superior

Lithium batteries are a lot smaller than a lead battery. In fact, lithium batteries are only a third the size and weight of the typical lead battery. The charge capacity is similar to that of the lead battery, something made possible by the lithium battery's superior energy density. The higher energy density improves deployment and installation to a considerable

degree.

**Advantage #2:** The resilience level of Lithium is better than Lead

As you may well know, all batteries may be quickly and extensively damaged when excessively discharged. The same is the case when the battery is stored at extreme temperatures. However, the lead battery is a lot less tolerating of this roughhousing and is inevitably damaged when repeatedly discharged too quickly. If the lead battery is discharged below half its State of Charge (SOC) or discharged faster than C/8A (C8 rating means the battery is completely discharged over a period of 8 hours), it loses potential cycles.

Compare this to the lithium battery: it could be discharged to up to 80% of its SOC and at a high C/2 rate (C/2 rating means the battery gets wholly discharged over a period of 2 hours), and there is no long-term damage to show for it. If you have no plans to keep changing batteries every few years while having to be super careful with them, the lithium battery is the ideal option.

**Advantage #3:** The lifecycle is superior

Let us talk battery prices. It is no secret that the lithium battery costs you a lot more dollars than the lead battery. With time, this will change, and the lithium battery will cost a lot less (projections say that in a few years, prices will drop below \$400 per kWh). As is the case with many things, a lower price for a particular product (Lead battery) compared to another (Lithium battery) does not always make it cheaper. Some wise fellow once said "cheap is expensive": this is what we are alluding to.

Look at it this way: a lead battery, while costing less, will require lots of maintenance and you will surely have to replace it after some time. A lithium battery, while costing more, requires minimal maintenance; it is a lot more tolerant to rough treatment and has a lifespan equaling that of, say, 3-4 lead batteries.

## **What do you do at this stage?**

The lithium battery is undoubtedly the better battery. Still, the lead battery has served the world for nearly two centuries, so it cannot be vilified. If money is a problem, start out with the lead battery, while

looking to move to the lithium battery in the future.

Now that you know about batteries, solar panels and other valuable information that you need to get started, let's talk about wires and the fuse box that you need for the installation.

# Chapter 5: How To Choose Your Wire And Fuse Box

## #1: Choosing the ideal wire for your electric circuit

It makes much sense to insist on using the ideal wire for your circuit. You could go the cheap route and use the lowest price wire you can find, but it is very likely that is not the correct wire for you, and the circuit would experience unnecessary hitches and electrical noise.

A quality wire is almost always stranded metal, as opposed to being solid metal. Moreover, a tin-plated copper wire is ideal. The ideal wire insulation rating sits at 105 C; anything lower decreases the wire's current carrying capacity.

## #2: Choosing the perfect fuse and fuse box for your circuit

There are several factors to consider when choosing your fuse and fuse box, like the overall size of the wire in your circuit. Here are a few pointers to help you settle on the right fuse:

## #3 Choosing the Ideal Fuse Amperage

Here are 3 methods to take to select the correct fuse amperage:

3 a) **You could calculate the maximum fuse amperage;** this is reliant on the total length of wire in your electric circuit. Maximum fuse amperage, while cutting down on nuisance blows, offers your wire significantly less protection.

3 b) **Alternatively, calculate the minimum fuse amperage.** You do this by multiplying the wire amperage rating by 125%. For instance,  $80A \times 125\% = 100A$ . The minimum fuse amperage provides higher wire protection, but this may be at the cost of experiencing nuisance blows.

3 c) **Choose the fuse amperage that falls near the midpoint of the**

**maximum and minimum fuse amperages.** Midrange values provide you with the best possible balance. While the wire protection is not as excellent as it is with minimum fuse amperage, you do not have to deal with constant nuisance blows. Along similar lines, while nuisance blows are not entirely off the table, you get better wire protection compared to maximum fuse amperage. Now we have to choose a Fuse housing.

## #4 Fuse Box

Consider environmental factors: Fuse boxes that come with insulation covers are great for protecting the fuse from accidental shorting. If you live in a humid place and especially one where there are inflammable vapors present, it is best to have a fuse box that comes with ignition protection. Accumulated flammable vapors could well take out your fuse and the electric circuit. Ingress protection (IP is an equipment rating of the resistance to penetration by water or chemicals) on the fuse box protects your fuse from wash down, spray and even humidity.

Choose between a block or in-line fuse holder.



Block fuse box



In-line fuse box

### **Fuse block diagram**

Your choice depends on your particular situation:

- a) Fuse blocks mount easily on solid surfaces and have the capacity to hold multiple fuses
- b) In-line fuse holders are compact, and they are ideal as low-amperage fuse holders

Next, let's talk about switches.



# Chapter 6: Types Of Switches

An electrical switch is any device that interrupts electron flow in a circuit. Switches are, in nature, binary devices. A switch is either entirely on (closed) or completely off (open). This chapter explores several switch types with illustrations explaining them.

## #1: Toggle switch

The toggle switch is actuated by a lever that angles in "one of two or even more positions." The common light switches in your house are examples of toggle switches. Most toggle switches come to rest in any of the lever positions in their array. Think about your light switches: One you switch on, the switch comes to rest at the "ON" position until you turn it off, at which point it rests at the "OFF" position. Some toggle switches have an inbuilt spring mechanism that returns the lever to a default "normal" position.



Diagram of toggle switch

## #2: Pushbutton switch

Pushbutton switches are two-position and activated with a button, which is pressed and released. Most pushbutton switches have a spring mechanism built in them that returns the button to the un-pressed, "out"

position, at least for momentary operation. There are pushbutton switches that latch on or off, in alternate fashion, for every push. Others stay in the "in" position until the button gets pulled back.



Push button switch

### #3: Selector switch

These switches get actuated via a rotary knob or a lever, to select one position out of two or more positions. Like is the case with the toggle switch, the selector switch may rest on any of the positions in the switch's array, or have an in-built spring system that allows for momentary operation.



Diagram of selector switch

### #4: Joystick switch

The joystick switch has a lever that is free for motion in more than one axis. Think about the analog button in a joystick, where you get to rotate it in multiple directions without restriction. The flexibility is not quite at

that level here, but it gives you an idea. One or more than one switch contact mechanism out of several gets actuated, and this is dependent on the direction that the lever is pushed. At times, this is dependent on how FAR the lever gets pushed. We are not ruling this switch type out entirely, but it is unlikely that the joystick switch would be a fixture in your electric circuit: these switches are mainly used to drive crane or robots



Diagram of Joystick Switch

#### **#5: Level actuator limit switch**

These limit switches resemble rugged toggle or selector switches closely, and they come with a fitted lever that is in turn pushed by a machine part. Frequently, the lever is tipped with a small-sized roller bearing, so that it may not get worn off with prolonged usage.



Level actuator Switch

#### **#6: Proximity switch**

These switches are designed so they "sense" the approach of a metallic machine part. This sensing is made possible by making it sensitive to a magnetic field or a high-frequency electromagnetic field induced by the machine part. A simple proximity switch uses a magnet that actuates

(cause to operate) a "sealed-switch mechanism" every time the machine part gets close.



Proximity Switch

### #7: Speed switch

This switch type senses the shaft rotary speed, and they do this either by a mechanism that senses centrifugal weight or by non-contact shaft motion detection. This detection could be magnetic or optical.



Diagram of a speed switch

## #8: Pressure switch

Liquid or gas pressure may be used to activate a switch mechanism. The gas or liquid pressure is usually applied to a diaphragm, piston or bellows, and is then converted from its pressure form to mechanical force. The mechanical force is then used to actuate the switch mechanism.



## #9: Temperature switch

Think of the bimetallic strip, an inexpensive temperature sensing mechanism. It comprises two metals joined in back-to-back fashion to form a thin strip. Each of the two metals has a different thermal expansion rate. When the strip is either heated or cooled, the differing thermal expansion rates causes the metal strip to bend. This bending effect may then be employed to activate a switch mechanism. Some of the more advanced switches, though still relatively simplistic in all honesty, employ a brass bulb filled with gas or liquid, with a small tube linking this bulb to a pressure-sensing switch. When the bulb is heated, the liquid within the bulb expands. The expansion generates a pressure increase, which actuates the mechanism of the switch.



Diagram of Temperature switch.

Next, lets tackle inverters and charge controllers.

# Chapter 7: Inverters And Charge Controllers

This chapter examines both the inverter and the charge controller, and seek to make a verdict on which is the better option for you. Both the charge controller and the inverter perform a similar role as they sit between the solar system and the rest of the grid, but they go about their work in markedly different ways.

## a) The solar inverter: What is it?

The solar inverter works to convert solar power to 240 volt AC directly. To put it simply, with an inverter, when the sun is shining outside, and the solar panel is picking up its energy, you can use the power produced in your house directly from the panels without having to cycle your batteries. To charge your batteries, you need to pair the battery up with a battery inverter that is compatible. This battery-battery inverter pairing is referred to as AC coupling, seeing as the link is with AC electricity in this scheme.



Diagram showing inverter

## b) The charge controller: what is it?

The charge controller works to take DC solar power produced from the solar panels and directs it to the batteries for charging. The primary function of the charge controller is to regulate the power that gets to the battery, so as not to overcharge them and risk damaging them. This regulatory function is why some people refer to them as regulators.

The power thus stays in DC format all the way from the solar panels to

your batteries. It only goes through 240 volt AC conversion when the time to use it in your house is high. This conversion is made possible via the battery inverter we discussed above. This conversion coupling is called DC coupling, seeing as the DC solar panels get coupled with the DC charge controller, with the ultimate goal of charging up the batteries.



Charge Controller

**c) Where does the difference lie?**

The difference is that while the solar inverter is AC coupled, the charge controller is DC coupled.

Which one presents the better option?

There are many reasons as to why anyone would prefer to opt for one and not the other and the argument can be made that it is healthy to have both options in your system.

Here is the thing though- DC coupled systems tend to be more cost-effective, and significantly so, for small, domestic standalone systems. AC coupled systems boast of the same cost-effectiveness when it comes to larger systems. If your solar system is small-sized and only powers your house, consider the former. However, if you intend to have a more extensive domestic system, the latter is the better option.



# Chapter 8: Batteries Without The Solar Panel

Let us take the solar panel away for a bit and focus on the battery itself, minus the panel and incoming charge:

Let us begin at the beginning: a 12-volt battery is... not a 12-volt battery. The 12-volt tag is merely a nominal and convenient term that is used to distinguish one battery type from another. A 12-volt battery that gets fully charged and then allowed to sit or "rest" for several hours, even days, with absolutely no load drawn from it and no charge going into it even out its charge and measures around 12.6 volts between its terminals.

If your battery, under the conditions outlined above, measures a flat 12 volts, then you are the owner of an almost depleted battery that would not serve you very long or very well either. In fact, if the battery resting voltage is at 12.0 or 12.1, the battery only has a maximum of 25% of useful energy remaining. This sort of battery is either almost dead or is intensely recycled to the point where it cannot go through the same treatment again for many more times without getting dead.

Your 12-volt battery supplies useful energy in a particular voltage window: from 14+ volts after you have thoroughly recharged it, down to 10.5 or so volts in use or under load (this is when the TV pictures start to creep toward the center of the screen, and the lights go dim.) Below 10.5 volts, there is not much usefulness in the battery.

No 12-volt battery in the world will be able to stay at 14+ volts for more than a few seconds unless you have hooked it up to the solar panel. Also, while we have said that the useful limit is 10.5 volts, you are merely asking for trouble if you consistently allow your battery levels to fall below 12.5 volts. If the resting voltage reaches 12.1, you have a deep discharged one cycle, and the battery's life only gets shorter. Here is a tip for you: If you have some friends who have picked up RV experience or especially own RVs, ask them everything you would like to know about battery usage. They are, more often than not, significant resources for battery knowledge seeing as they depend on batteries to watch TV and have light at night.

Water your batteries AFTER charging, unless the plates had been exposed before charging. If the plates are exposed, ensure around 1/8 height of water covers the plates.

Check the water level after charging and ensure that it is  $\frac{1}{4}$  below the fill tube bottom in the cell cover. Moreover, you should not just top up with water from any place: it means a lot to your battery that the water you top it up with is distilled and does not exceed 200TDS (TDS stands for total dissolved solids.)

The image below gives a summary of what some of the different items we have discussed above do.

### **Battery State of Charge**

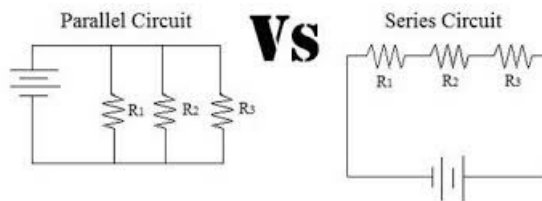
<b>Voltage</b>	<b>State of Charge</b>
12.6+	100%
12.5	90%
12.42	80%
12.32	70%
12.20	60%
12.06	50%
11.9	40%
11.75	30%
11.58	20%
11.31	10%
10.5	0%

Next, we will discuss how to split several devices in a single circuit.

# Chapter 9: How To Split Several Devices In A Single Circuit

This chapter primarily teaches you how to set up a parallel circuit. Let us have a bit of preamble to this: when connecting electrical devices to a circuit, there are 2 ways you can go about it:

1: Hook them all up into a series circuit, where the current flows from one device to the next or



2: Connect them in a parallel circuit where the current flows via several different paths, with each one having its circuit.

There are multiple reasons why a parallel circuit is a better option to a series circuit, but the leading ones have to be these: a parallel circuit is not susceptible to overloading as a series circuit is, and if one device malfunctions in a parallel circuit, flow of electricity does not stop, unlike a series circuit.

For ease of understanding, this chapter will not illustrate how to hook up your solar connection to various devices in your house; instead, it shows you how to hook up several simple devices in a simple circuit. This way, you can quickly understand how to set up a parallel circuit, and transfer this knowledge when setting up your home circuit.

Let us explore how to set up a parallel circuit, with multiple devices split in a single circuit:

## **Step #1: Gather the primary components of your parallel circuit**

You only need a few things to complete this simple project. You need a power source, naturally, two loads (loads are the items that use

electricity), conducting material (wires) and a switch.

Use a 12-volt battery as your power source.

Use some copper wire as your conducting material. If anything, an insulated copper wire is easy to find. The wire is cut into several pieces. Try and have at least 35 inches of wire to work with.

For your load, light bulbs will do.

A switch is not much work to find. Any hardware store will have some.

### **Step #2: Prepare your wires**

Cut your 35-40 inch wire into five pieces. Each piece should be around 6 to 8 inches.

Remove around 1.5 cm of insulation from both ends of the pieces. Use wire strippers or scissors for this. You could still attempt to "skin" the wire ends using your fingernails, or burn the insulation off as many people do, but you risk damaging the wire.

### **Step #3: Connect your first light bulb to your battery**

Connecting this should be easy enough: Attach a wire to the positive battery terminal and wrap the other end around the left side of one light bulb.

### **Step #4: Start to connect the switch to the battery**

Take a separate wire switch and then connect it to the negative battery terminal. Proceed to take the other wire end and hook it up to the switch.

### **Step #5: Connect your switch to your first light bulb**

Take yet another wire piece; first, connect it to the switch and then wrap it around the right side of your light bulb.

### **Step #6: Connect to your 2nd light bulb.**

Take your 4th wire piece and then wind it around the left light bulb side, then wrap the other wire end around the 2nd light bulb's left side.

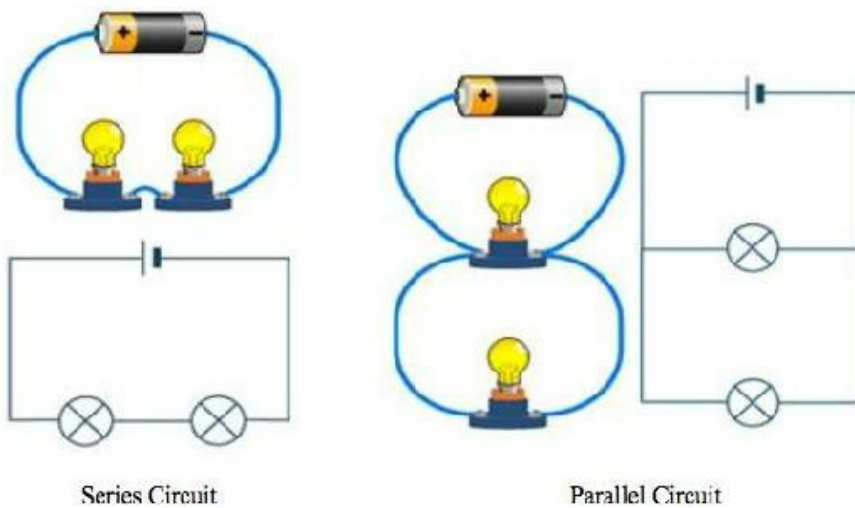
### Step #7: Complete your circuit

You should have at least one remaining wire piece. Wrap this wire around the right side of your first light bulb and then take the other end and wrap it around the right side of your second light bulb.

### Step #8: Turn on your switch

This is elementary stuff: turn your switch on: both light bulbs should get turned on.

The above is a simple circuit with simplistic devices in it. However, by and large, parallel connections take up this format.



Series Circuit

Parallel Circuit

Simplistic series and parallel circuit diagram

Now that you know how to split different devices in a single circuit, next, we should focus on the placement and direction of your solar panel.

# Chapter 10: Placement And Direction Of Panel

You could be adept at everything related to solar panel installation and put up a most capable solar system in your compound. However, if you mess up the panel placement, you would only have a limited amount of sunlight hitting your panel and only succeed in making things unnecessarily difficult for yourself.

## **What is the best direction for your solar panel to face?**

There is a general rule here: if you reside in the US, or just about anywhere else in the Northern Hemisphere, you want your panels to face true south. True south enables your solar panels to pick up the maximum amount of sunlight, helping you generate more electricity and in so doing, save money on those pesky electricity bills.

## **What is the difference between true south and "regular" south?**

When you look at your compass, the south direction it points to is the magnetic south. It is not the true south.

## **What is the difference?**

The compass points to the Earth's geomagnetic field's south. If you did grade school geography, you likely know that the Earth's inner core is fluid. The nickel and iron components of this fluid outer core pull the compass needle a little way from the true south.

If you employ a solar installer, he or she determines the true south by computing your site's magnetic declination. You can also determine your true south by waiting until noontime, then stepping out of the house and having a look at the shadows cast. Shadows from vertically positioned objects, with your example, while standing, run north-south.

## **If your roof does not face south, where do you install your panels?**

Suppose your roof faces east-west? Well, if you go ahead and install your panels, you would have to live with less light reaching your panels. You

have a few options, however:

You can increase the solar collection area, either by shopping for more panels or increasing the collector area.

You may also use racks that orient your panels southward. About these racks: the thing is that they add to installation costs, most times to the point of inefficiency. Racks are rarely if ever, used in the installation.

You can mount your panels in another area that is not your roof. There are some who opt to mount their panels on, say, a southward facing wall. If your yard has ample space, you can install your panels on the ground. This latter method makes maintenance easy. You can even place your ground panels on trackers which adjusts your panels' orientation throughout the year, maximizing their collection of sunlight.

### **What about the angular perspective?**

There is something called the "ideal solar panel tilt." This angle is calculated based on the latitude of the site. A simple rule that you can follow in the US is to multiply the latitude by 0.76, and then add 3.1 degrees.

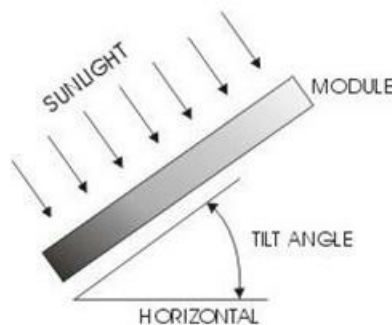


Illustration showing angular tilt

Let me take the discussion a little further by talking about sourcing for premade or building the solar power systems from scratch.

# Chapter 11: Sourcing- Buy Premade Or Built

The DIY solar panel kit is appealing as far as costs go. Moreover, in truth, many people have found a lot of success and joy from DIY solar panel kits. However, before you overlook premade solar panels and go full DIY, read this chapter carefully, then make your decision.

## **What do you get in DIY solar panel kits?**

The truth is that it is scarce for a solar panel DIY kit to include all the parts that are necessary for full installation. You will need to make an extra trip to the shop for wires, breakers, conduit fittings, AC/DC disconnects, sub panel and junction boxes. The deficiencies do not stop here: the parts that you find in your kit rarely ever boast of the same efficiency levels as those found in pre-built panels. This book does not mean to slight any regions, but the truth is that the bulk of DIY parts are, in some capacity or other, sourced from China. Make of that what you will. Efficiency levels, it follows, are mediocre and underwhelming. Moreover, if you believe that efficiency is something that you can overlook, think hard: the better the panel efficiency, the more likely it is that your electric bills get lighter. Also, with low-efficiency panels, well, the only way to fight the efficiency problems is to stack as many of them on your roof as is possible. Do you have that much roof at your disposal?

The efficiency issue

Efficiency carries on from the previous chapter. Efficiency will almost always be conveyed as a percentage. By efficiency, we mean the sunlight amount that your panel can convert to electricity. The higher your efficiency is, the higher the watt output. If you use a Costco or Grape Solar DIY panel the efficiency rarely ever cracks 15%, with an output of 235 watts. Calling this underwhelming is an understatement. By comparison, a solar panel pre-built by SunPower has an efficiency of 21%, with a watt output of 345 watts. What this translates to is that for every 22 solar DIY panels, you only need 15 SunPower panels to provide the same wattage. As panels age and take a consistent beating by rain and sun, corrosion eventually sets in. Corrosion affects efficiency levels, and



over time, your panels become less productive. Prebuilt panels hold up far better, concerning aging, in comparison to DIY panels.

### **Upfront solar panel cost versus lifetime value**

It is time to consider cost versus value. These days, the dominant solar power companies out there will not only handle shipping issues, but they also provide personnel to install the panels for you. You will have a warranty to prop you up, a superior product on your rooftop and all round assurance that your product will hold up and do so well.

DIY solar panels call for you to hire an installer or install it yourself. You may also need to stack more panels on your roof to produce enough electricity. Both of these require money or time. The upfront costs may seem sweet with DIY kits, but the installation costs and maintenance headaches mean that you would not be saving up on much, compared to buying premade panels. It is best to purchase premade panels from reputable companies: you would be grateful for this decision 5 years down the line.

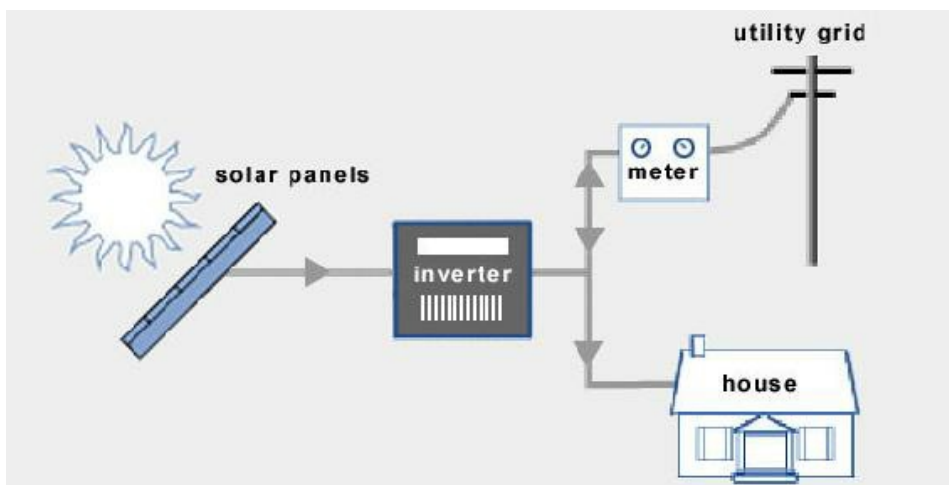
With what we have discussed in mind, let's now move on to talking about grid tie solar.

## Chapter 12: Grid Tie Solar

This chapter examines how a grid-tied system works. As far as your solar connection goes, you have the option of either getting hooked up to the grid, in this case having a grid-tied system or going full Kaczynski mode and having it off-grid.

### What is a grid-tied system?

There is nothing complicated about this one: this is merely a solar system that is hooked up to the electrical grid. Therefore, you can use electricity from your solar panels as well as that from the electrical grid. If you cannot afford to have as many solar panels as are required to run everything in your home even after doing a usage efficiency evaluation, then having a grid-tied system is ideal. So if anything, winter would not have to bring a scowl on your face, seeing as so many days have little to no sunlight available.



### Connecting your house to the grid

For starters, it is necessary to be familiar with all your local interconnection laws. Interconnection laws are those laws that are in place about renewable energy systems, such as solar power systems, and their connection to the electrical grid. To get your system hooked up to the grid, it is necessary to file interconnection applications as well as

metering applications.

## **The benefits that come with a grid-tied system**

### **A grid-tied system gives you several advantages over an off-grid system:**

**Reliability:** Solar power systems are not perfect power systems. There are days when efficiency is reduced, or when the weather is so bad that your electrical appliances may well be running on fumes. An off-grid system is likely to run out of power, leaving you in the dark. This is not so for a grid-tied system. If your solar system is not providing sufficient power, power gets pulled from the electrical grid. The grid is your back up, in case of power failure.

**Costs:** For you to function at optimal levels, off-grid systems require you to install specialized equipment. This equipment often gets expensive fast. It is also simple math that less equipment means fewer costs directed toward equipment purchase. Such is usually the case with most grid-tied systems. Not only will battery costs not be your concern, but you would not have to deal with such issues as battery maintenance and deep cycling.

**Net metering:** There would be days when your system produces way more electricity than you could use. With a grid-tied system, you are in a position to feed this excess electricity to the grid. Enter the net metering concept: net metering is a billing system that compensates you for supplying your power to the grid. Since most grid-tied systems are net metered, the power meter then tracks the "power exchanges" between your home and the grid. With excess power production and the feeding of this excess power to the grid, the power meter, rather than spin forward, spins backward. The result is some credit that you can either pocket or use to handle future power-based payments.

Also, if you do not want to go through the headache of paying the utility company, you could go off grid. Let's discuss that next.

# Chapter 13: Off-Grid Solar Survivalists

This chapter covers the necessary steps to set up your off-grid system. In truth, the bulk of these steps feature even when installing a grid-tied system. However, you have to be a lot more vigilant with an off-grid system. In case of malfunctioning, you would not have the handy backup that is the electrical grid. So if you set up your system poorly, well, you then have to suffer in silence for a long time.

**Here are the necessary steps when setting up your off-grid system:**

**Step #1:** Figure out just how much power you need

Would you plan a Kazakh road trip without understanding how many miles you to get that and by extension, how much gas you need? It is a bit foolhardy, is it not? You cannot only declare that you would invest in 4 solar panels and two batteries and hope that it is all you need. Remember that everything gets powered by your system. Understand exactly how much power you need. You can refer to this resource, this resource and this resource for help on how to determine your home power requirements.

**Step #2:** Calculate the number of batteries that you need.

Once you know how much power you need, it is necessary to figure out the number of batteries required to store this power.

Do you need to only store power for two days at most or would you like to have enough power stored for 4 days and beyond?

Do you have an extra source of power, say, a turbine or generator that provides robust support when the sun does not show up?

Will your batteries be stored in a heated room or will they be in a cold room?

The colder the battery storage room, the larger your battery bank ought to

be. If your place of residence has temperatures that dip below freezing point, you need 3 batteries for every two that your friend in a sunny location uses.

**Step #3:** Calculate the number of panels that you need.

Take your location as well as times of the year into consideration. It is well and good to know how much power you require but it is just as important to know how much sun is available to harvest. Use the worst case scenario for your particular location. This way, you are in no danger of ever running out of power. You can refer to (<https://us.sunpower.com/blog/how-many-solar-panels-do-you-need-panel-size-and-output-factors/>), this resource (<https://solarpowerrocks.com/square-feet-solar-roof/>), and this resource (<https://home.howstuffworks.com/green-living/question418.htm>) to determine how many solar panels you need.

**Step #4:** Select a solar charge controller and inverter

This book has already covered both the solar charge controller and inverter. To have your system as efficient and optimal as possible, it is necessary to have both. You can refer to this resource and this resource to determine the solar charge controller to purchase. As for the inverter, you can refer to this resource and this resource.

**Step #5:** Consider the system balance

This final step is more like several final steps that you need to take:

Do you have the best possible fuse and fuse box? There is no room for gambling with an off-grid system. This book has already covered the fuse and fuse box issue.

How are you going to mount your panels? Will you have them on a rooftop or the ground? Will you do it yourself or will you have somebody else to do it for you?

What wire size will you need?

Answers to these question dictate what things you need to have (logistical stuff), how much more research you need to do and much more. However, as I already stated, sometimes it is best to work with

professionals especially for intricate electrical work; you do not want to void your warranty by doing something stupid when trying to make connections by yourself.

Note: Much of what we have discussed up to this point should help you to set up an off-grid solar power system. As I already stated, it is often best to work with professionals (I already gave my reasons). As such, to ensure you do not void your warranty and experience different other problems with solar panel installation, it is best to involve a professional, even if for consulting purposes only.

The other thing we will address is powering your RV or boat using solar.

# Chapter 14: RVs And Solar Boats

To get as close to living a healthy life as an RV enthusiast as possible, you will need to have electricity in the RV. The same applies to boats. While some eccentrics like to lug generators around in their RV, most people with sense know that solar panels are the way to go. As long as the installation is done competently and you do not park your RV in the shade all the time, solar panels give you all the power that you need. This chapter covers the most necessary elements, as far as RV and solar boat panels go.

## **The different kinds of RV and boat solar panels:**

There are 3-panel types for you to choose from if you are the proud owner of an RV or solar boat:

### **#1: Mono-crystalline panel**

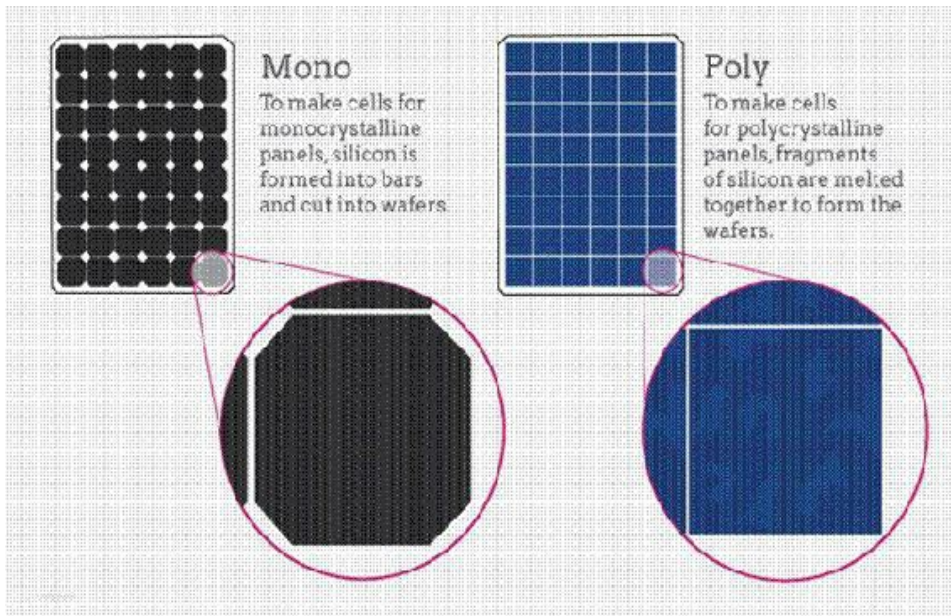
These panels are made from a single crystal. The individual cell in this panel is a wafer-thin crystal of silicon.

### **#2: Poly-crystalline**

Solar panels have several small sized crystals.

### **#3: Amorphous**

These panels are thin panels of film. The cells are composed of a thin silicon layer and fix to the backing material.



## What is the best RV or boat panel for you?

The smart RV/boat owner looks upon his roof as though it were prime real estate deserving of only the best kind of panel for it. Moreover, there is more to this than the simple nature of that sentence suggests. Let us examine all 3 options:

Amorphous panels are your cheapest option, and the efficiency is impressive. The downside is that it is two times the size of the polycrystalline panel.

The mono-crystalline crystalline boasts impressive efficiency and has been said to produce more power in low light conditions than the other two panel types.

The poly-crystalline panel, by quite a margin, is the most popular panel. It is half as small as the amorphous panel, and while it does not pack the power punch that the mono-crystalline does, it only produces a little less power. If this book is to make a panel recommendation for you, the poly-crystalline panel is your best option if you want a near-perfect marriage of efficiency and size. However, this panel is more expensive.

## Flexible panels for the RV: What is the difference between flexible RV panels & rigid solar panels?



## **Flexible solar panels:**

This is the latest solar technology. Some people like to call them "thin film panels" which has to be okay considering that is precisely what you think of them once you lay your eyes on one.

### **Advantages**

They are light- exceptionally so, actually, and you can stack a lot of them on your boat or RV roof without being afraid that the C.O.G of your vehicle gets raised up too much.

You can install these panels directly on the RV roof, due to their thin and lightweight nature, which allows more streamlined form for your RV or boat. Also, the whole setup ends up looking very aesthetic indeed.

### **Disadvantages**

The paragraph above says that you can install them directly on your roof. If you do decide to install them directly on the RV roof, then you would have to walk on them at some point. The flexible solar panel manufacturers like to tell you that no harm will be done from walking on the solar panel but in truth, they will eventually develop tiny cracks that will affect the output and cut the panel lifespan.

These solar panels come with a 10-year warranty. Are you impressed? Well if you are, you really shouldn't be. Their counterparts come with 30-year warranties.

Heat buildup is always a factor with solar panels. The more space you have between the solar panel and the roof, the cooler the panels will stay. This will enable them to generate maximum power as conditions will be close to optimal. Flexible panels are fixed to your roof, and heat buildup will go right into the roof interior. During winter months, this can have a significant effect on power production. You may have to be content with less power production in the summer months.

Installation of your flexible panels will mean that you glue them to your roof. It is not so hard to glue them onto the roof, but you will have a difficult time taking them off the RV or boat roof once you decide to change vehicles.

Flexible panel

### **Rigid RV solar panels:**

These panels are hard, and they are usually fixed firmly. Their construction is one of the glass panes within an aluminum frame. They are far more conventional than their flexible counterparts.

#### **Advantages**

We will start with the most obvious one: these panels are far more durable. They can take multiple beatings that come with RV or boat travel. If you are looking to own your RV or solar boat for a long time, these will be ideal.

If you are the sort that is very conscious about the environment, silicon, the material the solar cells of these panels are made of, is more friendly to the environment and poses fewer problems when disposal/recycling time comes.

These panels have very impressive heat resistance. Moreover, just as we said, the more space there is between the panel and the roof, the cooler the panel can stay, maximizing power output.

#### **Disadvantages**

They weigh a whole lot more than the flexible ones

They do stick out above your roof and maybe an eyesore if you are into aesthetics.

At the end of the day, glass is breakable. The panels are made to withstand harsh climatic conditions, sure enough, but this fact still stands.

How many solar panels do you need for your RV?

Panels come in varied watt sizes. Depending on the size of your RV or boat space, if you cannot fit one big solar panel, you have the option of getting two panels with the same wattage. For example, if you have calculated that a 120-watt panel will well handle your power needs, you can get one 120 watt panel or two 60 watt panels.

# Chapter 15: Upcoming Solar Technologies

Solar technology made its cameo in 1905, and since then, there has been much evolution with regard to it. Today, there are a series of new developments that have filled the solar landscape with much promise. If the same innovative pace is maintained, much of the world will move to solar technology in the future. Solar technology, already clean and abundant, will present a package far too attractive to ignore or even downplay.

This chapter will look at some of the most recent solar technology developments. Some of the technology is a bit on the sophisticated side, but this book will do a job in presenting it in the most straightforward manner possible. However, first, a bit of preamble:

## **Solar cell technology advances**

Solar panel efficiency has long been the elephant in the room. Every time scientists converge in an attempt to make solar technology superior; you can bet your house that improvement of efficiency levels is their main bone of contention. A solar PV (Photo Voltaic) system comprises hundreds of solar cells. Sometimes, there are thousands of them. A typical solar cell only has a 15% efficiency level meaning that 85% of the sunlight that hits the cell goes to waste. Scientists are keen on making the light capture to conversion ratio more favorable- whichever way you read it, 15% is unimpressive.

### **#1: Light sensitive nanoparticles**

This one has its home in the University of Toronto. Recently, scientists at the University unearthed a light-sensitive nanoparticle, which they referred to as "colloidal quantum dot." If this technology is expounded on, the result will be a far more efficient solar capture material at a less expensive price, at least compared to the conventional solar panel. Light sensitive nanoparticles do not precisely constitute breakthrough technology so why is this here, considering that this particular University of Toronto project is still at the infancy stage? Well, nanoparticle tech breakthroughs of the past have always been trapped in the straitjacket of

being non-functional in the outdoors. This particular project has brought forth nanoparticles which can indeed work outdoors. Read the paragraph below to understand further:

The colloidal quantum dot, unlike other nanoparticles, does not bind to air (well, the binding is often with the oxygen part of air, if you like specifics). This quality allows for it to maintain stability outdoors and still do its job.

Scientists have already attempted to make some panels using this new technology, and since they are not ready to be commercialized yet, efficiency levels have been recorded at 8% more than the conventional panel.

## **#2: Gallium Arsenide**

A research team at the Imperial College, London, believes that they have come across the future of solar technology. They have discovered gallium arsenide; a material they firmly believe will multiply efficiency levels by up to 3 times. Solar cells made from this material have been christened the same "triple junction cells," and their bloated efficiency levels is as a result of chemical alterations that allow maximum sunlight capture an electric conversion.

## **Advances in energy storage**

Besides working on improving efficiency levels, scientists are also trying to figure out new ways to improve storage of solar energy. As things stand today, electricity tends to be a "use it or lose it" commodity, a phenomenon which is a little puzzling considering the technological advances today. Once your PV solar system produces it, your electricity is channeled to your appliances and the excess power goes to the grid: this power must either be used up... or lost. Also, since the sun does not shine 24 hours a day, the bulk of solar systems only meet the electrical demands of a part of the day. Sure enough, there are batteries, and this very book mentions the 12-volt battery often, but the truth is that even with recent battery developments, the battery is still a reasonably inefficient thing. It is also expensive, and the shelf life is short.

This is why scientists are working on new ways to store solar-generated electricity so that rather than having to be used when the sun is available;

it can be used on demand:

### **#1: Molten Salt Storage Technology (MSST)**

Novatec Solar, a solar company with an innovative edge, has recently proposed a system that looks to be very promising, as far as energy storage goes. The system uses molten salt storage tech. Inorganic salts are used to convert energy that is generated by the solar systems into solar thermal energy, but this time employing heat transfer fluid as opposed to oils, as some storage systems do.

The result is that solar plants can operate at far higher temperatures- up to 500 C- which would naturally lead to much higher power output. Solar storage costs would be significantly reduced with this technology, and the utility companies would finally be able to employ solar power plants as the base load plants, as opposed to giving them the usual auxiliary "top up" role.

### **#2: The solar panel that comes with an inbuilt battery**

The US Department of Energy stepped in to facilitate this one. Researchers at the Ohio State University have come out and said that they have come up with a battery that is up to 25% more efficient than anything that is on the market currently. It is also 25% cheaper than the usual battery on the market.

The secret to this cheap, albeit more efficient design, is that the battery is built into the solar panel, as opposed to being a different entity from the solar panel, as is the case with most setups today. By having the two come as one package, these scientists have determined that costs will be lowered by up to 25%, compared to what is available today.

# Conclusion

We have come to the end of the book. Thank you for reading and congratulations on reading until the end.

This book has done way more than teach you how to hook up your solar panel to your 12-volt battery. In truth, this book's primary objective was to illustrate that solar technology and solar panel installation is not as complicated as so many people make it. An installation professional will still likely put up a more refined setup than you are capable of but the truth, as this book outlines ever so candidly, is that you could very well install your system by yourself.

If you found the book valuable, can you recommend it to others? One way to do that is to post a review on Amazon. I also enjoyed writing this as my first book. I need the encouragement if I can be honest.

[Click here to leave a review for this book on Amazon!](#)

Thank you and good luck!

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