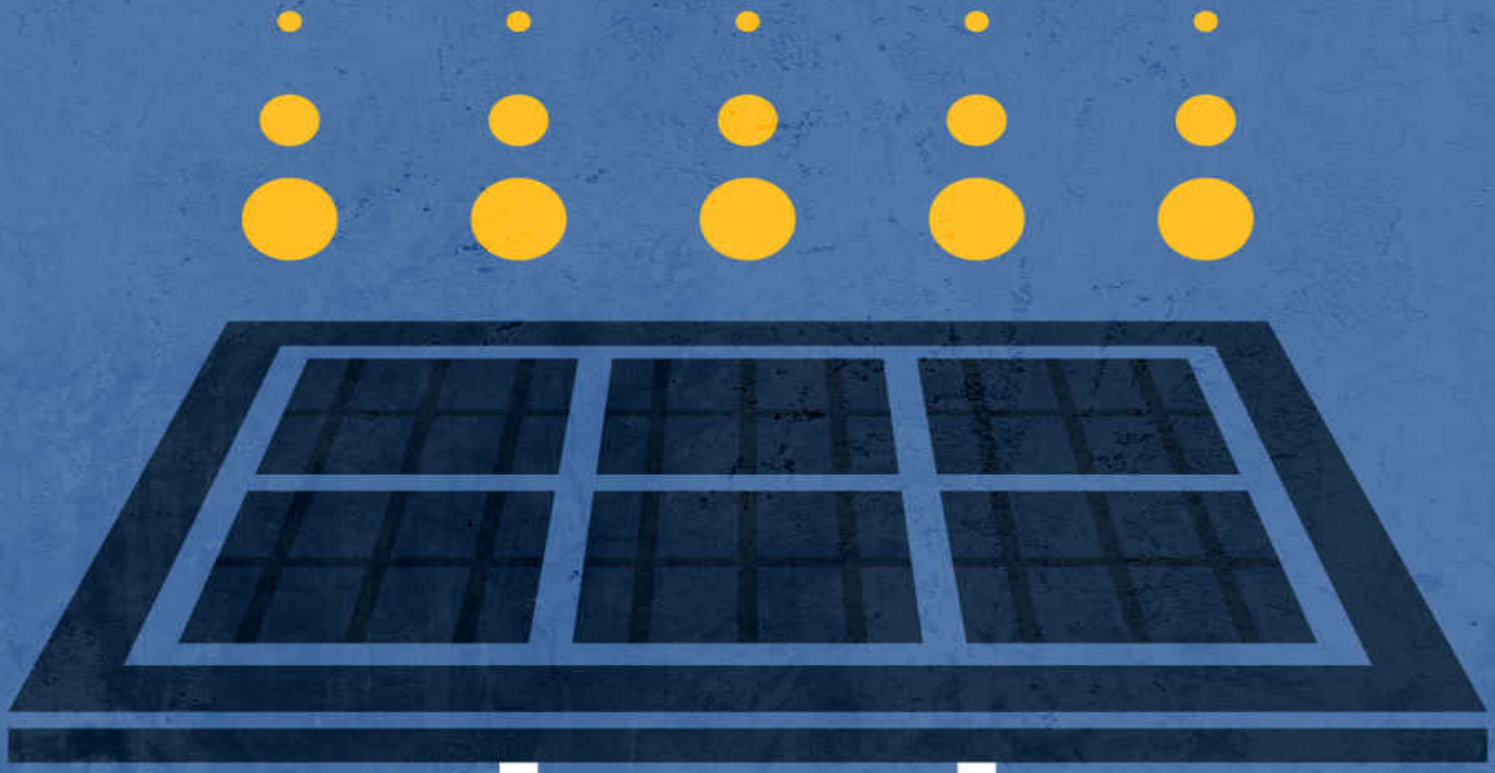
NICK JACOBSEN



OFF GRID SOLAR POWER

+SIMPLIFIED—

The DIY Guide to Install a Mobile Solar Power System in RV's, Vans, Cabins, Boats and Tiny Homes.

OFF-GRID SOLAR POWER SIMPLIFIED

THE DIY GUIDE TO INSTALL A MOBILE SOLAR POWER SYSTEM IN RV'S, VANS, CABINS, BOATS, AND TINY HOMES

NICK JACOBSEN

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INTRODUCTION

This book is about how to get off the grid. For some, it's simple electrical independence. Getting off the electrical grid. For others, it's much more complete than that. This book is going to take you from simply getting off the electrical grid to full independence from ANY sort of grid or outside service. I'm going to take you from simple electrical independence to *full* independence from almost anyone or anything.

Solar energy is, quite simply, the energy that comes from and is collected by the sun and is the primary source of energy on the whole planet. It is a type of energy that runs on flow, not on stock, and therefore its continuous use does not diminish its availability in any way.

The subject of Solar Power is as wide as it is deep. It covers technical, electrical, structural, and aesthetics. From the bolstering of your roof truss to the wiring of the system and the ventilation of the batteries, the installation of the solar power system in your home may sound overwhelming and daunting, but it is quite straightforward.

Only a couple of wires are involved in installing an off-grid solar system, so if you're a DIY person, you can do this! Seeing those complex solar equipment and tools could steal anyone's confidence, but then, this book will show you how simple setting up an off-grid solar system is. I have decided to look at the basic components of the off-grid solar system, and so, together, we can deal with the nervousness that comes with installing an off-grid solar system yourself.

This book will also cover several other aspects, like choosing the right type of batteries to use and maintenance of your solar system. Apart from setting up your solar system, you will also learn how to calculate the amount of load your home device draws and how to calculate the battery's capacity for an amount of load. Once you have successfully set up an off-grid solar system once, it's a lot like you learning how to ride a bicycle as you never forget or have to relearn the process again.

In this book, we will talk a lot about the electricity generated by solar energy and its uses, but we will deal with both concepts of solar electricity and passive solar, as both are useful for different types of projects and circumstances.

Let's explore this exciting topic in detail.

Chapter 1: Off-grid

An off-grid solar system is a renewable energy power system designed to provide energy and power to a remote location that is not connected to an electrical grid. An off-grid system enables you to generate electricity. The main components of an off-grid solar system are solar panels, inverter, controller, and battery. Solar panels are the highest cost, and you will need at least 5 of them. The battery is the most important part of the system because it stores the energy generated by the solar panels.

The sun is a great source of energy if you are living far enough away from the main grid or simply if you want to get independence from the main grid. With this option, you'll need to install solar panels that convert a sunbeam into electricity. The cost of this comes down from what they used to cost.

This is where off-grid solar systems get a little tricky. If you want to get off-grid completely, then you need to keep in mind that the sun isn't shining every day of the year. This means you'll need a rainy-day backup option. Sometimes a generator can be an option, but this still makes you reliant on fuel, and it can be a less than desirable option. A better choice may be to have a more reliable battery bank. No matter what you choose, make sure you factor in the additional cost for setting up this backup system.

Considerations When Setting Up Your Off-grid System

Figure Out Just How Much Power You Need

Okay, arrange a Kazakh excursion without seeing what number of miles you to get that, and by expansion, what amount of gas you need? It is somewhat rash, is it not? You can't just announce that you would put resources into 4 sun-based boards and two batteries and expectation that it is all you require. Recall that everything gets fueled by your framework. See precisely how much force you need. You can allude to this asset, this asset, and this asset for help on the best way to decide your home force prerequisites.

Calculate the Number of Batteries That you Need

When you know how much force you need, it is important to sort out the number of batteries needed to store this force.

Do you have to just store power for two days, all things considered, or might you want to have enough force put away for 4 days and past?

Do you have an additional wellspring of intensity, state, a turbine, or generator that offers vigorous help when the sun doesn't appear?

Will your batteries be put away in a warmed room, or will they be in a virus room?

The colder the battery extra space, the bigger your battery bank should be. If your place of habitation has temperatures that plunge beneath the point of solidification, you need 3 batteries for each two that your companion in a radiant area employments.

Calculate the Number of Panels That you Need

Accept your area just as seasons into thought. It is great to know how much force you require, yet it is similarly essential to realize how much sun is

accessible to reap. Utilize the direct outcome imaginable for your specific area. Along these lines, you are in no peril of ever running out of intensity.

You can allude to: **https://us.sunpower.com/how-many-solar-panels-do-you-need-panel-size-and-output-factors**

this asset **https://www.solarreviews.com/blog/how-many-solar-panels-do-i-need-to-run-my-house**,

and this asset **https://home.howstuffworks.com/green-living/question418.htm** to decide the number of sun-oriented boards you need.

Select a Solar Charge Controller and Inverter

This book has just covered both the sun-powered charge regulator and inverter. To have your framework as effective and ideal as could reasonably be expected, it is important to have both. You can allude to this asset and this asset to decide the sun-oriented charge regulator to buy. Concerning the inverter, you can allude to this asset and this asset.

Sun Exposure

Solar power systems rely on plenty of light for the household to receive sufficient energy. Even the smallest area of shade on the panels can reduce the quantity of solar energy that you can receive at any particular time. Therefore, you need to assess any obstructions that could be in the way of the solar panels receiving maximum light. If you have not yet built your remote home, you can position it in a location with minimal obstructions.

Loads List

Once you have determined which energy-efficient appliances that you will use on a daily or weekly basis, you can proceed to create a loads list. A loads list is a list of all the electrical appliances that will be powered by your solar power system and measurement (in Watts) of the amount of power each device uses, how many hours during the day the device will be on, and whether it has a start-up surge similar to a fridge or a good pump. At the end of your list, you will determine the total amount of power that your appliances will use per hour every day. This list is crucial when you are ready to construct the off-grid solar power system because the total load will determine the number of solar panels required, the number of batteries, and the size of the inverter.

Calculating Your Energy Consumption

Sizing requirements of solar panels change according to the energy consumption you desire. Here are all the major applications where you need to calculate energy consumption and understand the required size of solar panels.

Once you have assessed the location and considered how much power your tiny home will require, it is time to complete the calculations that will help you purchase the correct quantity of solar power components. These calculations are not complicated; all you need is basic math literacy and a willingness to learn. I will break down each calculation in the simplest form so you can follow this manual with ease. Let’s begin.

Analyze the Load and Give an Estimate of the Daily Usage

As discussed, determining how much power you need is a crucial step that cannot be overlooked or given a rough estimate. To avoid this step would be the same as driving toward a foreign destination without any map or

coordinates. Important questions that you will need to answer at this stage are: What are you powering, and how long do you need to power it? You also need to plan for worst-case scenarios, particularly weather conditions in your environment. For instance, during winter, the sky may be cloudy for weeks at a time, and you will need a solar power system that is large enough to provide power throughout these months.

Some people will try to do guesswork when it is time to decide on how much power an appliance requires. This is a dangerous exercise because your guess may be incorrect, leaving you with a system too small to power your entire home. Another mistake I see a lot is when people estimate the amount of power needed by considering the home's square footage. Once again, this is a dangerous exercise because, within the same square footage, two cabins may be using different amounts of power (one cabin may be using an electric stove and a water heater while the other one is using a fridge, electric oven, air conditioning system, and an electric dishwasher).

Most electrical machines, appliances, and equipment will have a power label on them. Take time to look for this label because it contains all the valuable information you will need to calculate how much solar power you need. Some labels will list the watts, amps, and others will add the voltage range. If you find that the voltage listed is DC instead of AC, you multiply the DC volts by the amps to receive a number in Watts. Other times the voltage listed will be a range; for instance, it might read 150 to 250 volts. In this case, you would use the voltage number that is generally used in your particular area.

Below are the first two formulas to calculate Watts and "daily W hours":

Volts X Amps = Watts

Watts X (hours the device is on per day) = Daily W hours

You will also find that some loads are not active; however, when they are on, they have a very high surge (this would be loads such as refrigerators, pumps, or heater fans). This makes it challenging to determine how many Watt-hours the load uses in total throughout the day. If you find yourself in this predicament, I would suggest that you find the Energy Star label on the device or appliance; this label should provide you with the average annual kilowatt (kWh) used. Thereafter, take the kWh and divide it by the number of days in a year to get the kilowatt per day. Below is a photo of the power label on my washing machine with an annual kilowatt value. Let's use this formula below to help calculate the kilowatt-hour per day:

KWh per year/365 days = kWh per day

192/365 = 0.53kWh per day

Calculate the Capacity of the Battery Bank

This step involves calculating how big our battery bank should be. The first order of business is to select the voltage of the battery bank. Most off-grid battery banks are usually set at 12V, 24V, or 48V. To determine the voltage, consider a few things. Firstly, the voltage size will be determined based on how large your load is. Generally speaking, you can always remember this rule: the higher the output wattage, the higher the DC input (voltage) needs to be. Alternatively, you can look at the size of the power inverter (which converts DC to AC) and determine the voltage using the size of the inverter. For instance, if you are using a 2000W inverter (perhaps the load is not too large), it will most likely use 24V if you have purchased a 7000W inverter, and it will most likely require 48V.

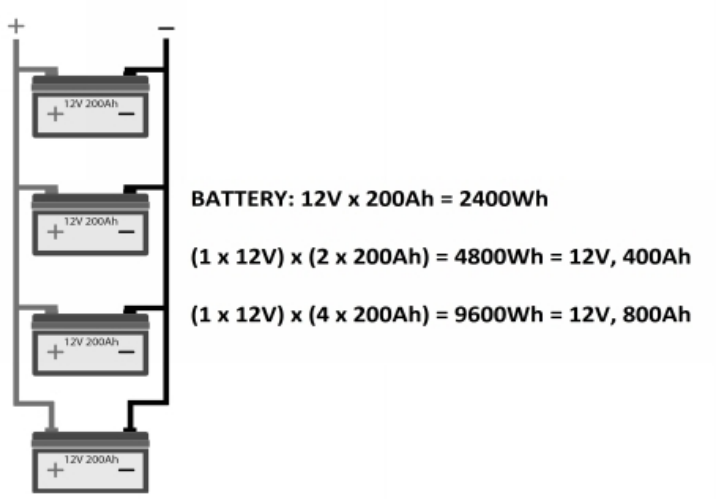
You need to also consider the type of battery that you will purchase to make the system as efficient as possible. Lead batteries are a popular choice for most off-grid solar power homes. When choosing a lead battery, you can either pick the flooded or sealed lead batteries. Flooded lead batteries are quite demanding in that they will need regular maintenance, involving adding water and assessing the gravity (sg) levels. On the other hand, sealed lead batteries will require less maintenance; they do not release a lot of gas and can be safely positioned in an unvented room (however, not airtight). Flood lead batteries cost less than a sealed lead battery and have a longer life span, regardless of the amount of maintenance involved in taking good care of them.

The second type of battery available in the market is a saltwater battery, a fairly new non-toxic technology. One of the main features of this battery is that it can be discharged down to “100% empty” without harming the battery. This allows you to consume as much power as possible from the

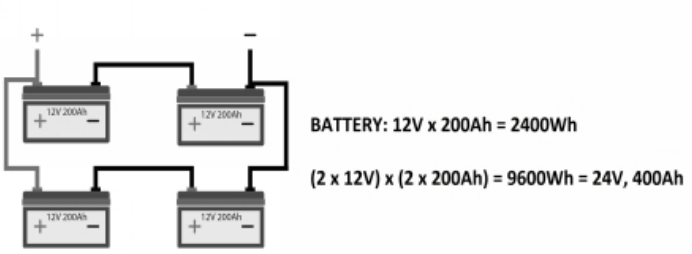
battery, thereby requiring fewer batteries for the battery bank. Indeed, this amazing benefit comes with a higher price tag than the lead batteries, but you will reduce high costs by using fewer batteries in the battery bank.

Lastly, you can also consider using lithium batteries, which can be significantly discharged while also maintaining a long-life span. The only limitation to using lithium batteries is that they are sensitive to being 100% emptied, and most of the time, you will have to replace them after one small incident. Therefore, when you use these kinds of batteries, you must create a battery management system that will monitor the proper charging and discharging of the battery. The cost of a lithium battery is higher than other available batteries in the market. Nonetheless, these prices should drop shortly.

Assuming that the total load that you would need to power is 4800Wh (information from our load list) and you wanted to create a parallel circuit, you would only need two batteries connected parallel to each other. However, if you need 9600Wh capacity, keep the design and add two more batteries, resulting in a four-battery bank. Below is an illustration to show you the design of a parallel battery bank. Please notice how the amp-hour changes and the voltage stays the same in both calculations:



However, you may not want to have so many strings in the circuit, so you need to tweak the design a bit. Instead of placing all the batteries in parallel, wire them using parallel strings of two in series (instead of one long one). Below is the illustration of how the battery bank design would look like. Please notice how the voltage and the Ah increase as you combine both parallel and series circuits:



The day of autonomy refers to the amount of time (usually in days) that the solar power system can operate using battery power alone before you can use the generator. You can look at the amount of power you use daily or weekly to see how large the battery bank needs to last on days or weeks where there is no sunlight. Nevertheless, you need to remember that the more days you plan on using the battery alone, the larger and more expensive the battery bank will be. However, you do not want to

underestimate the number of days either because you will unnecessarily strain the batteries (this will ultimately reduce the battery life span). After the days of autonomy are over, you can kick start the generator to charge the battery bank.

Calculate the Solar Panel Array Wattage

Make a few considerations when you decide on the number of solar panels needed for the solar power system. Firstly, you can look at an insolation map to show the peak sun hours in your geographical location. This can help determine whether you will manage with only a few solar panels because your area is always full of sun or whether you need to invest in a large number of solar panels because you don't receive a lot of sun throughout the year. When choosing the number of panels for the solar array, always plan for the worst—in most cases, the worst-case scenario is always winter.

You should also plan for unexpected inefficiencies, such as the possibility of the solar panels being placed in an area with obstructions, the soiling of the panels, or having the voltage drop due to the wiring. When the solar panels do not work at their optimum level, you could lose as much as 1/3 of the solar power from the panels. For instance, in a 100W rated solar panel, you could potentially receive only 67W if the system had any inefficiencies, and the usable power would be significantly reduced.

Another factor that may contribute to the efficiency of the panels is the type of solar panels you decide to use. There are two basic types of PV solar panels in the market, namely monocrystalline and polycrystalline solar panels. Monocrystalline panels consist of uniform cells with a high-efficiency rating of up to 20%. These panels are readily available on the

market, and they are the most reliable type of solar cell, having a reputation for lasting between 25 and 50 years.

Polycrystalline panels consist of non-uniform cells and, as such, have a lower efficiency rating of about 10 to 15%. The lower efficiency of each panel means that you need to install a lot more to get the right amount of power. Nevertheless, polycrystalline panels are a lot more affordable than monocrystalline panels, providing a sweet cost incentive for those seeking to reduce the total cost of installing their solar power system.

To calculate the minimum watts needed in the array of solar panels, you can perform a simple calculation: start with the daily watt-hours and divide the number by your location's worst-case peak sun hours (during winter). Then take this new number and divide it by the system efficiency of 67% (calculated using the 67W from the example above). Below is an example of how your calculation should look:

Our daily watt-hours: 2192Wh

Our peak sun hour: 2.8 (see insolation map for your area)

2192Wh/2.8/0.67 = 1168W

Once you have calculated how many watts of total panels the system requires, make sure that the number of panels you intend to purchase can be wired either using a parallel or series design. Furthermore, your responsibility is to ensure that the nominal voltage of the solar panels either matches or is higher than the voltage of the battery bank.

Select a Charge Controller

There are two types of charge controllers which you have the liberty to use as part of our solar power system. The two controller technologies are

known as PWM and MPPT. The PWM charge controller works by making a connection from the solar array directly to the battery bank. When there is a continuous active charge from the solar array to the battery bank, the array's output voltage is pulled down or lowered to the battery voltage. The more the battery charges, the higher the voltage of the battery increases, thereby increasing the total voltage output of the solar panel simultaneously. Make sure to match the nominal voltage of the solar panels with the voltage from the battery bank. A 12V panel is required to charge a 12V battery, and a 48V panel must be used to charge a 48V battery and so forth.

MPPT controllers, on the other hand, will measure the Vmp (voltage at maximum power) of the solar array and convert the high PV voltage into a lower battery voltage. When this voltage is lowered to match the battery bank voltage, the current is effectively raised, and you end up receiving far more available power from the solar panels. Due to this technology, MPPT charge controllers are usually more expensive than PWM controllers; however, they are significantly more efficient than the latter.

SPECIFY THE SIZE OF THE INVERTER

When deciding on the size of an inverter, remember the function that it is created to serve. The inverter's purpose is to convert the direct current (DC) from the battery bank into an alternative current (AC) that can be used to power the house load.

The DC voltage must be changed into a sine wave curve that travels above and below 0 volts to do this. When inverters were first invented, the most appropriate way to do this was to make the voltage rise straight up and come straight down, creating what looked like a chopped signal. This chopped up and down signal is referred to as a Modified Sine Wave. One of the benefits of using a Modified Sine Wave inverter is that it is useful when

building simple systems or powering old electrical appliances built using older technologies. This type of inverter would not be suitable for powering electronic equipment, audio, rechargeable batteries, or digital clocks.

Now that the charge controller has charged your battery bank, the off-grid solar inverter can convert the 12VDC, 24VDC, or 48VDC battery bank into an AC voltage. The AC output will largely depend on your specific needs; however, in North America, you can make use of a 120V single phase, 240V split phase, 480V 3-phase, and so forth. Once again, it will depend on how you wire the output of your inverter, the type of inverter that you will purchase, and determining what your house loads require.

It is also good to remember that an off-grid inverter is not able to feed excess power back to the main utility grid; however, it can connect to the main utility grid and use it as a battery charger. For instance, those who live in a houseboat or RV can connect to shore power and use the main grid to charge their battery bank when their solar panels do not provide sufficient power. However, the AC connection will remain one-directional, meaning that it will only take from the grid and not give any power back.

Lastly, you will need to insert breakers into our solar power system to protect from excessive currents and short circuits. There are five main areas where you can place breakers in the system: between the solar panels and the charge controller, in the solar combiner box as well as in the DC load center, between the charge controller and the battery bank, between the battery bank and the inverter, and lastly between the inverter and the AC loads.

Sizing Needs

Electronic Devices

When finding sizing needs for electronic devices, focus on the following factors:

The energy required by the device

First of all, you need to know the energy required to run your device for a specified period. Most devices provide power usage in watts. You need to multiply this given value by the number of hours you desire to use your device every day. This will inform you about the daily energy required to use your electric device.

Energy generated by a particular solar panel

The next thing to calculate is the energy generation capacity of a solar panel. Here, you will also have to see the power in watts. This is the energy that your device will receive via solar panels; however, it comes down to the time of sunlight exposure, too, so keep that in mind. Now, multiply the power generation capacity of solar panels and match it with the batteries you have.

Finally, you can include weather conditions according to the time of year and match them with your energy consumption requirements. This will provide you a precise number related to power, which you can incorporate when selecting a solar panel size.

RVs and Campers

Solar energy is the ultimate solution for campers and RVs. They provide necessary energy consumption to ensure power to your lights and other devices; however, there are multiple factors you should always remember when calculating energy consumption and the size of solar panels for camping purposes.

The Output Provided by a Solar Panel

Become aware of the output that your solar panel can offer for your RV. This will help you know the energy budget, as well as the time associated with energy availability.

Geographic Location

You will have to take your geographical location into account, too, as campers keep on changing locations. You need to calculate energy availability according to the sunlight availability in locations where you plan to go.

Devices you Have in Your RV

Air conditioners, lights, and many other devices require different power. On average, you can obtain a solar kit for your RV that offers 380-watt power to run general devices; however, the size will increase depending on what kind of devices you have in your RV. Similarly, you also have to care about the potential period for which you desire to use your devices in the RV.

Apart from that, make sure you include battery capacity in amp-hours to understand consumption. Large loads require a higher storage capacity to run smoothly.

Now, you can take the amp-hour of a battery and multiply it with the solar power capacity according to the time of sunlight, and then match it with the energy required to run your RV devices for a particular period every day. When these two numbers match, you will find the perfect size of panels for your needs.

BOATS

Boats are a little complicated regarding solar energy consumption calculation. You naturally start with power consumption calculation here as

well; however, there are unique factors associated with this calculation.

Solar Panel Size for Topped-off Batteries

With regards to the energy consumption required when you are not using your boat, some people don’t need any energy when a boat is not in use; however, others have pump, lights, or alarm systems that require energy. Some boats can also contain refrigerators or other equipment that require excess energy consumption. You have to incorporate all these factors associated with your energy consumption.

If you need energy just for auto-discharge of batteries, then you can go with small panels of 5-watt size for every battery you have. Make sure you choose the right type of batteries that offer the necessary storage.

Solar Panel Size for the Bilge Pump and Other Minor Permanent Loads

In case your boat requires permanent energy consumption, you need to upgrade your solar panel size; however, it will depend on the size of your boat too. The vessel size, cockpit, and deck size will help you choose an approximate size, such as 10W, 20W, or a higher power size.

You can multiply the amp-hour of the battery with the sunlight period, and then you can choose a complementing size that offers the necessary energy to your permanent loads. For instance, if a 20W panel receives sunlight for about 5 to 6 hours every week, you can get proper energy for 120Ah batteries.

Solar Panel Size for Equipment That Needs High Energy

If your boat has a refrigerator or any other energy-expensive equipment, you need to upgrade your solar panel size. Here, you need to care about the

energy efficiency of the equipment. Old equipment requires a higher amount of power in your boat, and you need to make sure that solar panel size can compensate for the energy required to run those devices in your boat.

Solar Panel Size When you are Away From Land

If you use your boat for long hours away from land, you need to ensure you can consume enough energy and have it available. Calculate the energy requirements of your boat's essentials and then calculate the hours for which you need energy daily. That is how you will find a clear solar panel size and battery storage requirement for your boat.

HOUSE

Reducing your carbon footprint, improving energy efficiency, and saving money are all possible with solar panel installation in your home; however, it all comes down to how you calculate energy consumption.

You will require peak sunlight hours, household energy necessity on an hourly basis, and the wattage of each panel. Multiply the hours with energy requirement and divide it with the wattage of one panel. This way, you will find the number of solar panels required in your home. You can choose a low or high wattage panel ranging from 150W to 370W. These are average power wattage that works for households. You will require between 18 to 40 panels to generate about 10,000 to 11,000 kWh every year. All these calculations will depend on the following factors:

Current kWh Consumption in Your Household

Look at the electricity bills you are paying for the last few months. This illustrates a better concept of energy consumption in your home. Divide the

value provided in the bill with 30 to get the daily energy requirement. Multiplying this per day consumption with 365 will give you the energy consumption for the whole year. On average, a medium-sized home requires about 200 kWh every month.

A Size That Suits Your Home Design

Apart from the numbers, the size of the panels matters too. For that, you need to give a close look at your roof location. It is all about achieving the desired output with maximum sunlight exposure. A limited area in your roof will restrict your ability to get larger sizes; however, you can compensate by choosing higher efficiency panels in small sizes.

For residential purposes, you can find approximately 60 inches by 40 inches; however, the sizes differ depending on the manufacturer you choose.

BUSINESS

For businesses, energy efficiency and availability are essential, and the calculation of power consumption and sizes matters the most.

A small or medium business can use up to 25,000 kWh of energy on an annual basis. This much energy consumption requires correctly-sized panels in suitable numbers, but the energy consumption increases with the size of your business, and you need to understand the current business size and potential growth in the coming future as well. This way, you can find the potential energy consumption for your business.

On average, you can obtain 250 watts of power from your solar panel; however, it is essential to get an accurate energy generation value to multiply and find the number of panels you will require. The size of the

panel and the location will also impact this calculation, so keep that in mind too.

Most calculations depend on the peak sunlight you obtain in your business location. Mostly, these ranges from 4 to 6 hours on an average day, so make sure you calculate the peak sunlight availability and then define your panel size requirement accordingly.

It is essential to understand real-world scenarios when calculating energy consumption. On paper, you can obtain average calculations, but the real values are achievable when you record real-world situations along with the variables such as clouds, shades, period, reduced performance of batteries, and others. Always include a few extra panels in the desired size to compensate for those variables. This way, you can avoid an unnecessary struggle when you need solar energy. Choose quality panels and balance them with the numbers that can comfortably provide your required energy. That is the right and the most efficient way of calculating panel requirements. Make sure you use the right methods of installation.

Tips When Building an Off-Grid Solar System

Do Not Go Above 100 Amps

There are so many dangers and problems that could arise when you use an extremely high electrical current. A simple mistake made in a highly charged system can be deadly or lead to a property fire. For safety reasons, most solar charge controllers will instill a maximum of 80 amps, and you will also find that deep cycle solar batteries avoid providing a high current. It should be reassuring that your system components are regulated; however, it is your responsibility to be cautious in how you use and wire the components.

Use the Highest Voltage

It is common to find many people opting for a 12-volt system because they believe it will be strong enough to power their entire set-up. However, in reality, when using 12 volts, you can experience a lot of voltage drops. Voltage drop refers to the decrease of electrical power along the path of a current, which flows in an electrical circuit. Solar batteries don't usually provide a high current, and inverters have a specific voltage range they will operate within. Therefore, when the battery bank voltage drops too low, the inverter will simply shut down. The solution to this problem would be to increase the system voltage either from 12V−24V or 24V−48V.

Purchase the Largest Wires That you Can Afford

Another way to reduce the risk of voltage drop is to purchase the largest and fattest wires that money can buy. This is because heavier wires carry less resistance than smaller and thinner wires. Furthermore, having heavier and larger wires allows you to carry greater loads or upgrade your system in the future. This will enable you to plan and avoid purchasing or replacing more wires a year or two down the line (unexpected costs are not fun).

Overbuild, Don't Underbuild Your System

There are so many parts, considerations, and processes to account for when constructing an off-grid solar power system. The accuracy in determining how much power you need in your homes is crucial in building a functional system. It is so easy to miss a calculation or overlook certain figures, which ultimately results in an underperforming system. Therefore, I would recommend you add at least 20 to 30% more solar panels and batteries than what you had already calculated to give your system room to expand if needs be.

Wash Your Panels Regularly

Our solar panels are exposed to a lot of dirt, dust, bird poop, leaves, or pollen, and this—if not frequently removed—can decrease the power output of the solar panels. A rain shower will not do a great job of cleaning the panels for you; you need to personally wash them now and then. To wash panels, take a non-abrasive brush and warm soap water and gently clean and dry panels throughout the year.

Benefits of Off the Grid Living

People who have chosen off the grid living style a few years ago would tell you that this new lifestyle of theirs has outweighed all those new comforts that city life had offered. Also, you will enjoy long-term benefits such as the low amount of power outages, lesser energy expenses, better environmental knowledge, and lesser dependence on naturally occurring fuels. If you are planning to choose this natural style of lifestyle, then you must know its array of benefits in detail.

Lower Energy Costs

When there are no power bills to pay every month, you will be saving hundreds of hard-earned money. You can install both solar thermal panels and wind generators to make use of solar energy and wind energy when there is no sun or wind. Apart from saving money on power bills, you need not be worried about the power outages as you can make use of wind power on rainy or wintry seasons and vice versa.

No Power Problems

No matter when you have a storm with lightning or heavy snowfall, the power of your non-grid home will remain intact. As you will have BP solar

panels and wind turbines to provide you with natural power, you can get hot water and lighting in your home. It also indicates that your loved ones will stay warm during the chilly days, and your work or productivity will not be disturbed.

Enhanced Environmental Knowledge

When you have alternative systems for energy, you can update your knowledge in the best manner by learning various ways that can help in achieving hands-on education about the environment. You will be learning about the patterns of solar energy and the changes occurring in the weather. You will know how to stay warm with solar energy during the winters and use wind energy to keep you cool at night. You can do your laundry on a hot day that lets you hang it dry using the natural energy of the sun. You will also know more ways to conserve the natural energy to use it at a later time.

Lowers the Dependence Levels on Fossil Fuels

When you choose the off-grid living style, you need not depend on the power firms to get energy. It also indicates that you need be worried about the rising rates of power. Also, you will lower the carbon footprint as you will only utilize green and renewable energy for your homes. When you compare this power with the emissions of fossil fuels when burnt, the fossil fuels have higher levels of pollution and have high levels of carbon emissions.

Off-Grid Living Basic Requisites

Living life off the grid, for most people, is a choice to conserve energy and live in a natural environment. Off-grid living, no doubt, requires some

initial preparation and investment. If you wish to start living without any dependency on electricity, here is a guide to help you achieve this;

- **Choose the right place to live:** If you plan to harness the natural resources of wind, water, and solar power to produce electricity, you will need a suitable location where these resources are bountiful and accessible. Off the grid living first requires an off-grid home, i.e., a location which is sunny and windy.
- **Stock up on initial investment:** Such a lifestyle often requires you to invest in a home that utilizes independent energy resources or builds an energy-efficient house for yourself. All these require considerable investment and planning.
- **Stay in an off-grid society:** If you wish to stay off-grid and cannot find land that provides an abundant supply of wind, solar, and water power to harness, then you can always choose any one of the pre-constructed communities that follow a self-dependent lifestyle.
- **Install septic tank:** To stay completely off the grid, secure land that provides you with the facility of drawing water from the well. Install a septic tank to carry out this endeavor. All these are essential for effective wastewater management.
- **Invest in an energy-efficient plan:** A lucrative and efficient way to start out living off the grid is by doing some initial bit of planning. Invest in custom-made plans that involve the production of up to 10,000 kWh of electricity every year. You can also opt for solar panels, hydro energy, and other modes of electricity storage.
- **Invest in storage devices like generators:** To be able to store the renewable energy that you harness, you will need to install

backup systems, like propane generators. Stock up on funds to invest in such systems and clean up storage space for them.

- **Drill a household well:** To live off the grid, you will have to utilize natural resources of water such as rain and even harness groundwater. For this, you may need to drill a household well or buy cisterns for the collection of rainwater in case you grow crops on your land.
- **Opt for solar kits:** The real way to cut down on energy consumption and live off the grid completely is by installing solar thermal panels for your home or commercial spaces. Whether used singly or in combination with electric supply, they greatly reduce your energy bills.
- **Begin composting:** Living away from the grid also means providing a garbage service for your home. By composting or recycling, you can remove the majority of household waste and take the rest to your local dump.
- **Limit overall electric consumption:** If your livelihood itself relies upon electronics, then there a couple of things you may need to do to reduce overall consumption. Install energy backups such as generators and limit the use of unwanted electric appliances at home, like dryers, microwaves, and video game consoles.

Living off the grid is a wise lifestyle choice, one that is likely to bear fruit in future generations when enormous energy issues challenge the world. Living off the grid is not only energy-efficient and futuristic but also proves to be a great money-saver in the long run.

Grounding or Earthling Your Off-Grid Solar System

Grounding or earthling is when electrical charges from your P.V. system are discharged into the ground/earth. It is a protective measure when working with anything related to electricity.

The Difference Between Grounding and Earthling

If you are grounding your solar system, you are using a current-carrying conductor for the process, whereas, for the earth, you will use a non-current carrying conductor.

The main reason for grounding or earthling your solar system is to transfer the lethal roaming charges around your off-grid P.V. system to the ground to ensure safety to both the user and the equipment. Grounding or earthling your solar equipment might seem unnecessary as your system already comes with fuses and disconnects.

However, there is still some equipment that you should ground. For instance, your solar panel consecrates a large amount of electricity, so

grounding your solar panel is reasonable. However, you can decide to ground whatever part of your solar system.

Here's How to Ground Your Solar Panel

For grounding your outdoor solar panel, you have to use the thick copper wire that can handle the enormous electric current.

1. Drive your grounding rod deep into the earth. (You can dig a hole or any other means necessary.)
2. Make sure your rod is at least six inches above the ground.

3. Next, get your copper wire ready.
4. Use a clamp to attach it to your grounding rod.
5. After that, attach the other end of your copper wire to your pole mounting system.
6. Around your grounding screw on your solar panel, unscrew it and attach the copper wire to it. After, screw it back to hold it firmly in place.
7. Attach your wire to the pole by using a zip-tie or black tape.
8. You are done grounding your solar panel, and you and your other solar equipment are now safe from spikes of electricity.

Mistakes to Avoid

Incorrect Solar System Sizing

Incorrect sizing of a solar power system is the most common mistake to make. Most of the time, it is due to mental shortcuts and basing the power requirements on factors that do not accurately represent how much power is used. For instance, you may look at your last utility bill and conclude that you use X amount of power when, in reality, this amount fluctuates throughout the seasons. There are many other factors that you must consider when deciding on power usage, such as changing climate temperatures, the positioning of panels, panel efficiency, and so much more.

Leasing Your System

Solar power systems are only a sound investment if you own the system. Leasing a solar system presents many disadvantages. Firstly, the region offers tax incentives for installing solar systems in homes; by leasing your system, you would not receive these incentives (they would go toward the real owner). Secondly, leasing may seem more affordable on a month-to-

month basis; however, you will pay an excessive amount of interest. It would also tie you into contracts that directly oppose your lifestyle of being self-sufficient. Therefore, I would suggest that you purchase your system and give yourself the peace of mind that you deserve.

Not Thinking Ahead

When many decide on building an off-grid solar power system, they make the mistake of calculating how they use power in their homes now and fail to think about how the power will be used in future homes. It would be an expensive endeavor to have to expand your system later in life because of unforeseen life circumstances.

Overlooking the Warranty Terms

Within the solar industry, it is believed that the length of a product's warranty is directly related to the manufacturer's confidence in their product. In other words, this means when the warranty is short, it is assumed that the product is of low quality and results in poor performance. Adopt this same mentality when purchasing solar products and aim to purchase products with the longest amount of protection. Understand what the warranty entails and what services it covers. Please do not be fooled by performance warranties which will provide the general lifespan of a product throughout the industry. Seek a manufacturer's warranty which will usually last for about 10 years.

Using Sun-tracking Systems

Many individuals believe that using sun-tracking systems will assist them in increasing the quantity of energy that their solar panel array produces. However, in reality, purchasing a sun tracking system may be just an extra expense on the ever-growing list. This is because you are better off

purchasing more panels for your system and being proactive about your need for more energy production instead of the passive route of purchasing a tracker (which may or may not help “track” more sunlight). Moreover, sun-tracking systems are prone to system failures, so don’t expect it to last as long as your installed solar panels.

Deciding not to Purchase a Battery Monitor

Battery monitors are extremely useful devices that provide much-needed information about the status and health of the battery bank. This device helps maintain the bank by detecting issues presented in the off-grid solar power system or current levels of power available. This information is particularly useful to those individuals who are still learning more about solar power and need as much support in understanding their solar power system. Additionally, the battery monitor will measure and keep track of the total amp hours accumulated in the system, which subsequently allows you to monitor a household’s energy usage.

Not Investing in a Backup Generator

Generators may seem like an unnecessary expense when setting up an off-grid solar power system; however, they form an indispensable part of the system, especially when you have decided to go completely off the grid. One of the major reasons why one decides to go off-grid is having the freedom to power their homes in the manner that they desire. However, you cannot control unpredictable weather conditions, but you can plan for that time. Your generator will be a lifesaver during worst-case scenarios, which can happen at any time. You cannot generalize when planning your off-grid solar power system and believe that the climate will always remain the same and neutral.

Not Staying Up to Date with New Technology

The solar power industry is still fairly new, and as a result, there are always new updates and products released in the market. This is good news for you because it means you are always presented with opportunities to make the solar power system more efficient. It also means that it is becoming more affordable to own a solar system because of the demand for solar products. Keeping up-to-date with new technologies will help you purchase more efficient components, creating an overall efficient solar power system. It will also expose you to more environmentally-friendly alternatives to building a solar power system which will reduce your overall carbon footprint.

Setting Up Equipment and Wiring the Off-grid System

1. First, we place batteries
2. Connect the solar charge controller to batteries
3. Solar panels to charge controller
4. Where to put the batteries
5. We will idealistically require a place:
6. Insulated from large temperature fluctuation.
7. Where the battery can be secured (with a strap) so that it does not tip over (if it is a vehicle).
8. A dry place that is protected from moisture.
9. Ventilation if you don’t use a sealed battery.
10. A compartment should be somewhere in the middle of a vehicle between the front and back parts of the vehicle (where is located center of gravity of a vehicle).

One other important safety tip: To reduce the likelihood of your batteries' terminals coming into contact with any other substance and potentially setting off a fire, you can wrap the positive terminals with a large, flat piece of rubber or at least insulating tape. Rubber doesn't conduct electricity, and it is very good at isolating sparks and such. So, keep this in mind just as a safety precaution.

What About the Charge Controller?

The charge controller is a small piece of hardware that doesn't weigh very much. So, you can easily mount this on the wall. Preferably, you could mount it about chest-high. That way, you can easily see it and read it.

Think of the placement for your thermostat. You can place it on that high. Also, you want to keep your charge controller close to the entire setup. That way, you can check in on your solar power system once in a while, minimize power losses for wires, and make sure that everything is set up the way it is supposed to be set up.

I would not advise you to locate your charge controller inside the house while your entire setup is in the basement. The reason for this is that if you have the charge controller inside the house while the setup is elsewhere, then you won't be taking a look at the system as often. By having the charge controller near the hardware, you will be forcing yourself to take a look at your system every time you check the charge controller.

So, the solar charge controllers should be mounted close to the batteries, typically somewhere on a wall. A charge controller has cooling fins for convective ventilation. So, make sure that under and above a charge controller is some space for this.

How to mount? Just use some screws or mounting tape if your charge controller is lightweight but not recommended.

Where to Place Inverter?

The inverter has to be placed close to the battery bank so that it has minimum power losses for wires. Typically, you can mount an inverter on a wall.

Choosing Wires

The efficiency of the system largely depends on the wires (material that the conductor is made from and thickness) you have used in the system. The copper conductor has high conductivity.

Gage size is the overall thickness of the wire. Wire gage size for solar power systems ranges from the thinnest 14 gauge to the thickest 0/4-gauge wire.

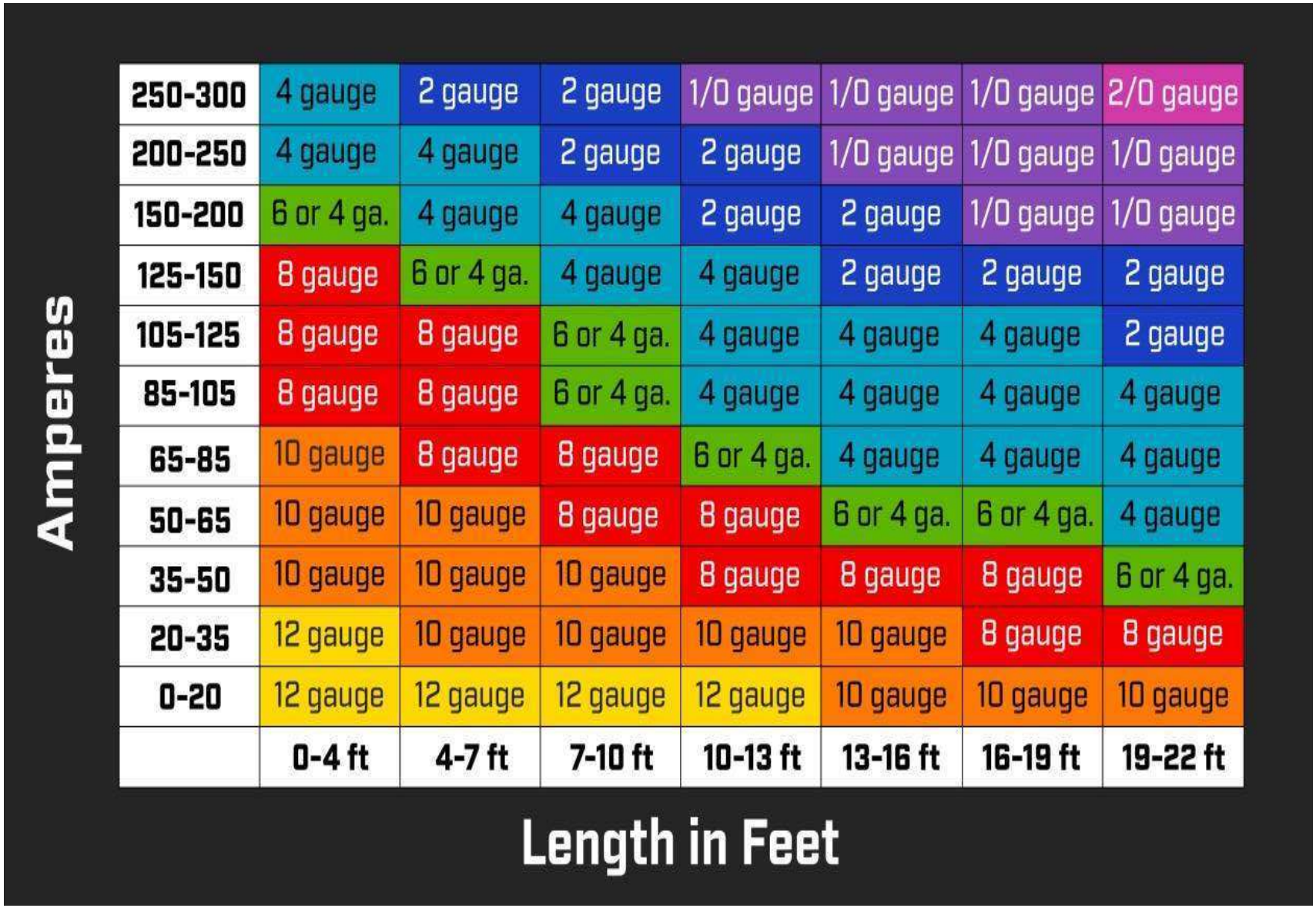
The thickness of the wire dependent on the length of the wire and amp load that the wire should carry; If you choose smaller wires that are required, you can cause overheating, which can lead to fire and huge power losses in the system. If you chose the wrong wire, even a fuse would not save you.

Recommendations

- Always choose a little bit thicker wire than required if it is possible;
- For wiring solar panels, use a solar hook up wire (UV (ultraviolet) resistant);
- For long distances use thicker wire to conduct current efficiently;
- If you don’t want to use thick wires (copper) because they are very expensive or because they can’t find one, then you can increase the

voltage for that wire just by connecting elements of the system (batteries or solar panels) in series.

- Wire size recommendations:
- If you wire 12-volt panels:
- 10-gauge wire if the length is less than 25 feet; 8-gauge wire if the length is more than 25 feet; If you connect 2 12-volt solar panels in series, you will have 24 volts total, now you can use 12- or 10-gauge wires.
- Wiring a solar charge controller (amps) and battery bank:
- 20 amps–12 gauge 30 amps–10 gauge 40 amps–8 gauge 60 amps–6 gauge 80 amps–4 gauge.
- Choosing wire for wiring an inverter and battery bank:
- The inverter carries a big current and requires very thick wire. If you don’t want to look for wires and installing fuse and connectors. You can buy an inverter wiring kit online with an already installed fuse.
- 1000-watt inverter – 4-gauge wire 2000-watt inverter – 0-gauge wire 2500-watt inverter – 2/0-gauge wire 3000-watt inverter – 4/0-gauge wire *For running appliances you can use 12 gauge or 10-gauge wire* safely; 12-volt wire gauge chart Source qualitymobilevideo.com


Amperes
250-300 4 gauge 2 gauge 2 gauge 1/0 gauge 1/0 gauge 1/0 gauge 2/0 gauge
200-250 4 gauge 4 gauge 2 gauge 2 gauge 1/0 gauge 1/0 gauge 1/0 gauge
150-200 6 or 4 ga. 4 gauge 4 gauge 2 gauge 2 gauge 1/0 gauge 1/0 gauge
125-150 8 gauge 6 or 4 ga. 4 gauge 4 gauge 2 gauge 2 gauge 2 gauge
105-125 8 gauge 8 gauge 6 or 4 ga. 4 gauge 4 gauge 4 gauge 2 gauge
85-105 8 gauge 8 gauge 6 or 4 ga. 4 gauge 4 gauge 4 gauge 4 gauge
65-85 10 gauge 8 gauge 8 gauge 6 or 4 ga. 4 gauge 4 gauge 4 gauge
50-65 10 gauge 10 gauge 8 gauge 8 gauge 6 or 4 ga. 6 or 4 ga. 4 gauge
35-50 10 gauge 10 gauge 10 gauge 8 gauge 8 gauge 8 gauge 6 or 4 ga.
20-35 12 gauge 10 gauge 10 gauge 10 gauge 10 gauge 8 gauge 8 gauge
0-20 12 gauge 12 gauge 12 gauge 12 gauge 10 gauge 10 gauge 10 gauge
0-4 ft 4-7 ft 7-10 ft 10-13 ft 13-16 ft 16-19 ft 19-22 ft
Length in Feet

Connecting a Solar Charge Controller to the Battery Bank

We have to connect the solar charge controller to the battery bank first because there is a risk that you will damage the solar charge controller (electronic) if it connects solar panels first.

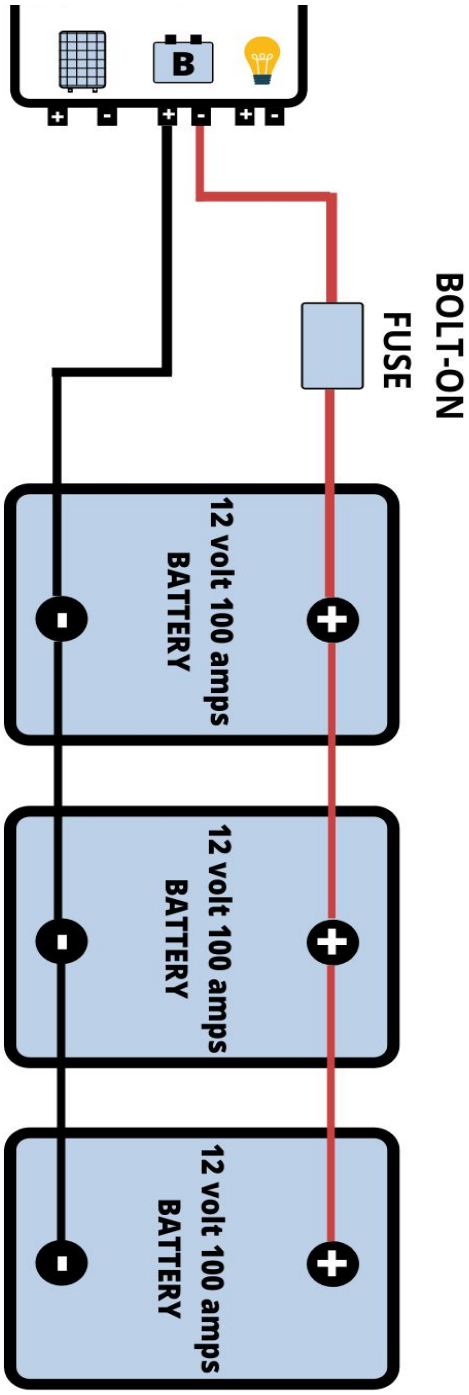
We should wire a solar charge controller and batteries and after the solar charge controller and solar panels.

First, we connect a wire to the negative terminal of the battery then to a negative terminal of the solar charge controller (should be marked as a battery). For this, we have to strip one end of the wire and attach a crimp connector that will be connected to the negative terminal of the battery, after this another end of the wire we have to strip and connect to the solar charge controller (by using a screwdriver or Allen wrench).

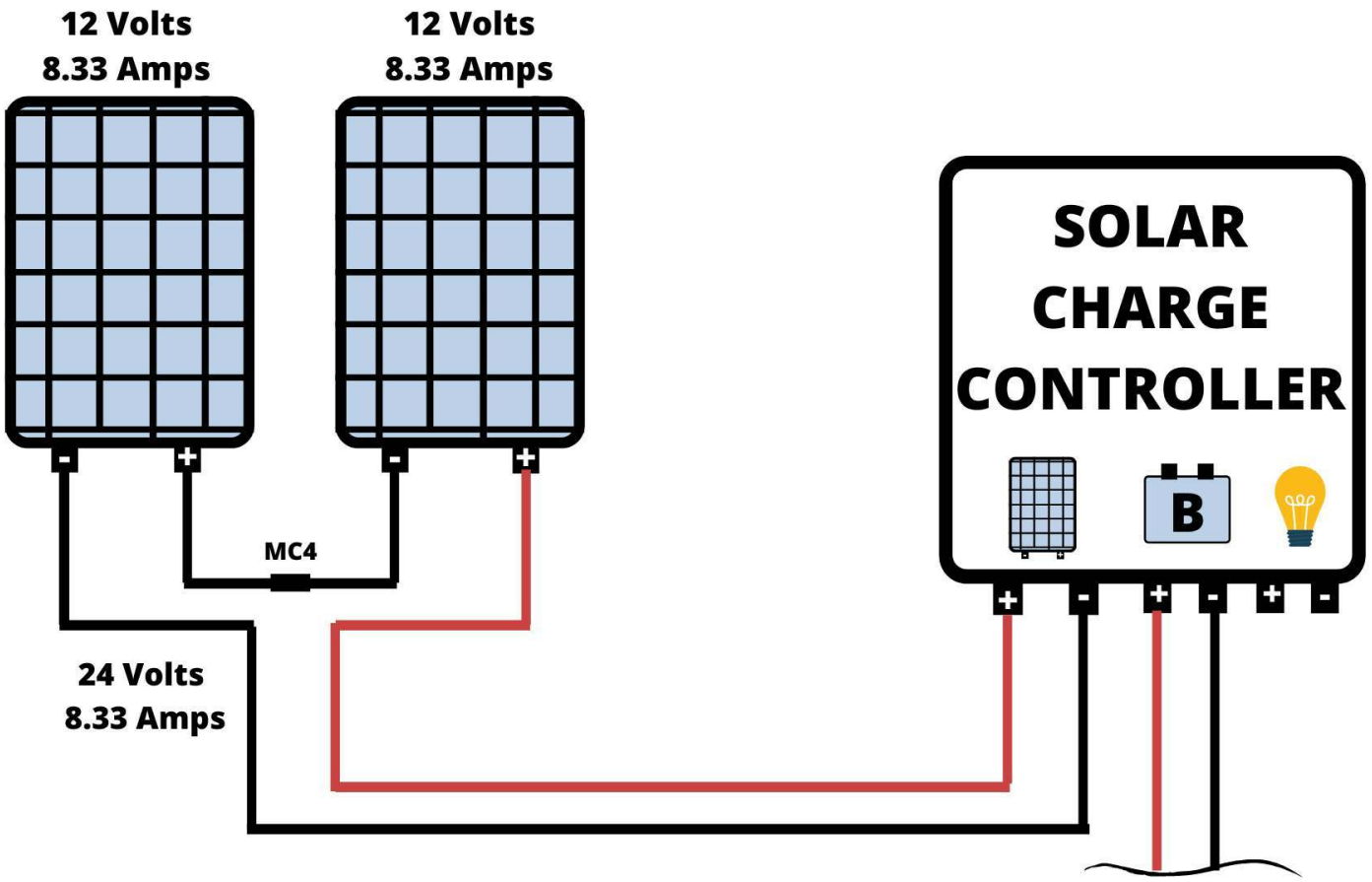
Then, strip and insert a wire to the positive terminal of the solar charge controller and run the wire to the battery bank and attach it to the battery bank fuse by using a crimp connector.

If you have made everything right—you will see a green light on the solar charge controller showing that the batteries are connected.

After this, we can start wiring solar panels and connect them to the solar charge controller.



Connecting Solar Panels to a Solar Charge Controller


12 Volts
8.33 Amps
12 Volts
8.33 Amps
SOLAR
CHARGE
CONTROLLER
B
MC4
24 Volts
8.33 Amps

For this, we have to pass wires through the roof. In most cases, you have to drill 2 holes into the roof and later seal the holes with caulk.

A lot of people use “a cable entry gland” and self-leveling sealant to make it look good and seal holes in the roof.

Before connecting the solar panel array to the solar charge controller when you connected a lot of panels in series, check if the voltage isn’t higher than the maximum voltage of the solar charge controller to not burn it. To measure the voltage of the solar array by using a multimeter, and also would be great to check the polarity of wires.

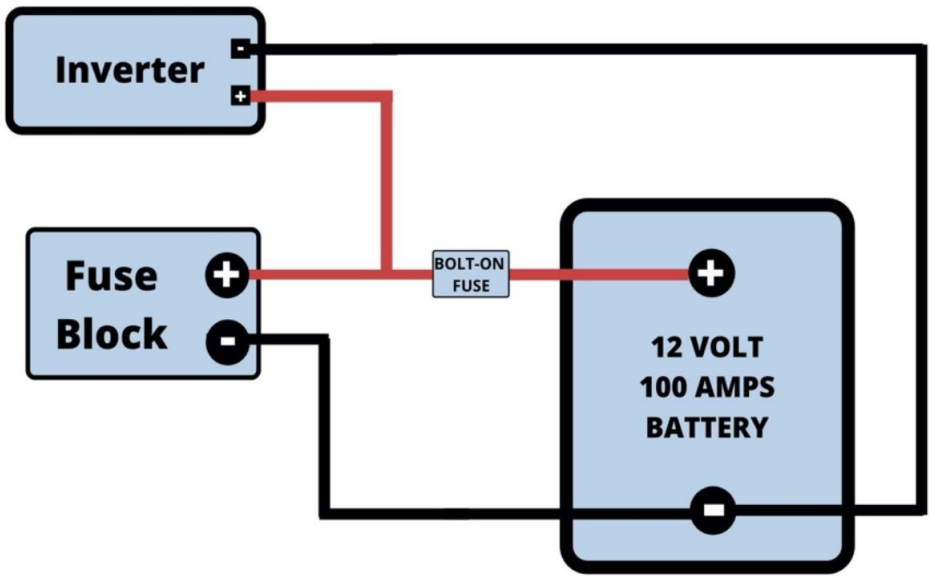
All MC4 connectors should be located on the roof.

How to connect wires in the solar charge controller?

Read the manual of your solar charge controller. Positive wire to positive sign “+” on solar charge controller, negative “-” to negative. When everything is made right, you will see a green light that shows that solar panels are connected and charging batteries.

Connecting Inverter

The inverter will supply 120 volts (if you live in the USA) or 220-240-volts if you live in Europe (Germany and France - 230 volts).



Connect the inverter to the battery bank directly using an inverter wiring kit (that might come with an inverter, or buy it separately), or choose the wire thickness the way I described above. Bolt positive cable to the bolt-on fuse, and after this connect the negative cable. Usually, the negative terminal (the wire that will be connected last) will spark when you connect the inverter,

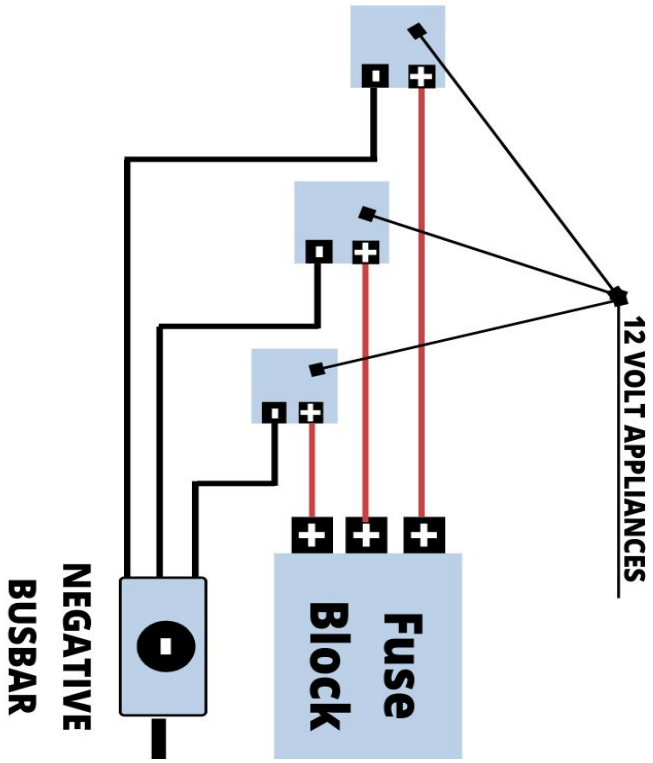
and it is normal. Now you can start the inverter and run the AC appliances by using the inverter.

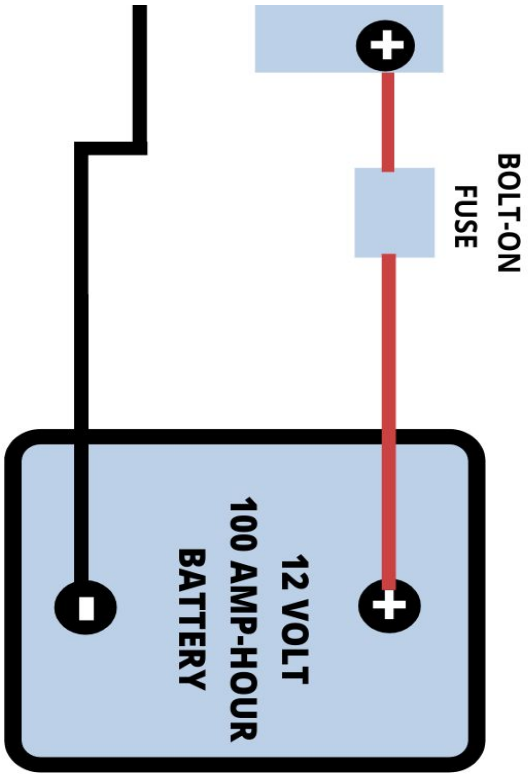
CONNECTING THE FUSE BLOCK

The fuse block will supply 12-volt DC appliances. If you will have a higher voltage battery bank (24, 48 volts) then you will have to buy the converter to get 12-volt power, as I said before.

We require a 2-to-8-gauge wire, to see what is recommended for your fuse block, read the manual. Or chose the cable base on the maximum current (amps) that the fuse block will have to provide.

Mount your fuse block close to the batteries. A fuse block has a positive and negative terminal which we need to connect to the battery bank.





How to connect a battery monitor and why we need one?

Increase the life of the battery (by charging it to 50 or at least 70% for a lead-acid battery, and 20 – 50% for lithium batteries).

We can estimate the health of the battery, simply knowing how much power a battery is storing and estimate how long the battery will last.

We need one to know how much power we have drawn out of the batteries and figure out a true state of charge.

One of the most popular and best battery monitors is the shunt. There are also battery monitors that have a hole sensor.

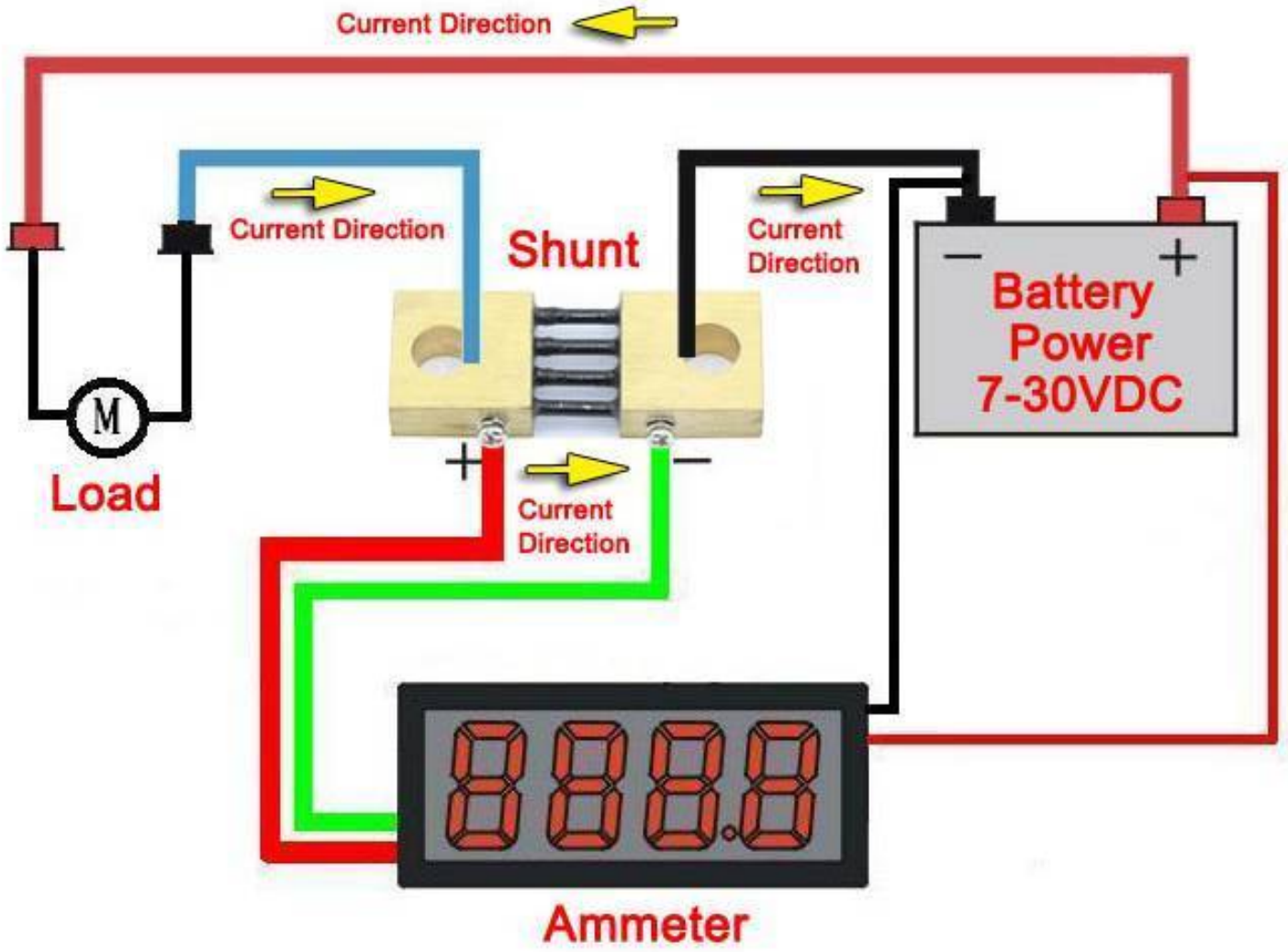
Most battery monitors are showing the battery capacity, the voltage of the battery, amps, what-hours, watts, and more. More expensive battery monitors can show volts, amps that are going in and out of the battery.

Most battery monitors provide instructions and a wiring diagram for the battery monitor so that you couldn’t mess it up.

A shunt has a post on each side and two screws in the middle. The battery monitor will be connected to those 2 screws, and the monitor showing the current that goes through this shunt.

Depending on where you wire your shunt, this will determine what a shunt will measure. If you want to measure how much power your solar panels are producing (voltage, amps) then connect the shunt before the solar charge controller.

Wire Connection

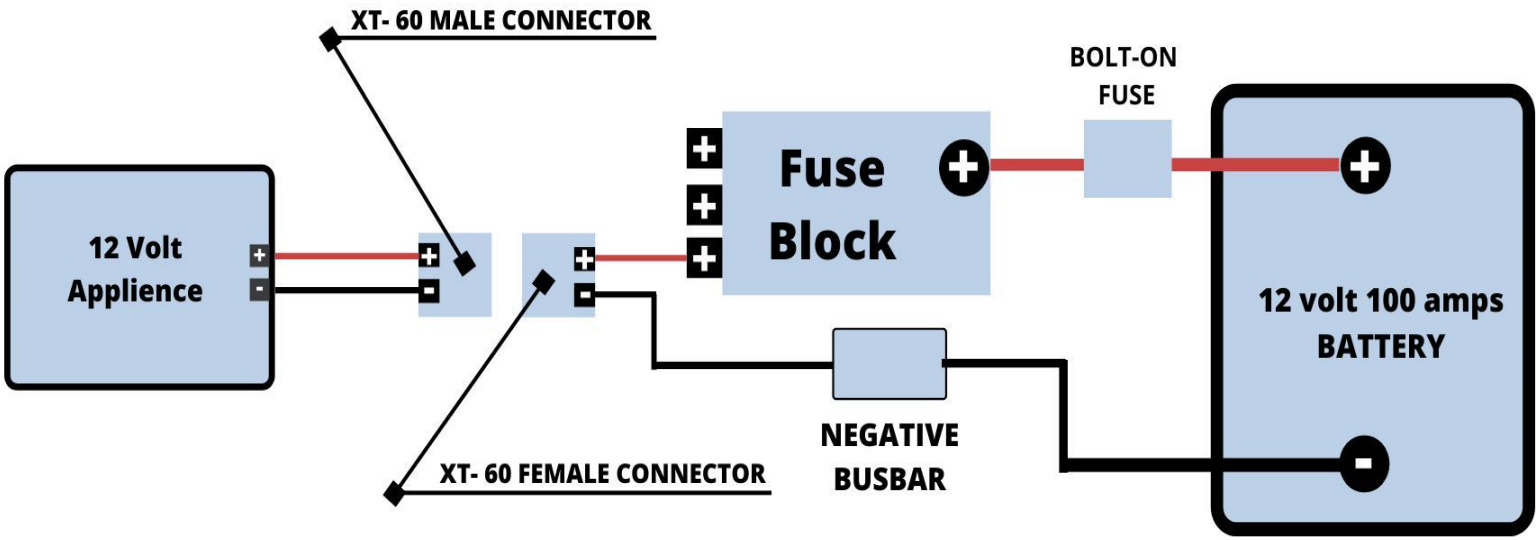


How to connect a DC 12-volt appliance?

You can wire appliances to male-type plug connectors (XT-60 or Anderson Power pole). For this, you will have to hardwire a female-type connector to the fuse block. We can use appliances when we want. Or you can hardwire appliances directly to the fuse block.

XT-60 connectors:

Source of the image - *www.batteryspace.com*


XT- 60 MALE CONNECTOR
BOLT-ON
FUSE
Fuse
Block
12 Volt
Applience
12 volt 100 amps
BATTERY
NEGATIVE
BUSBAR
XT- 60 FEMALE CONNECTOR

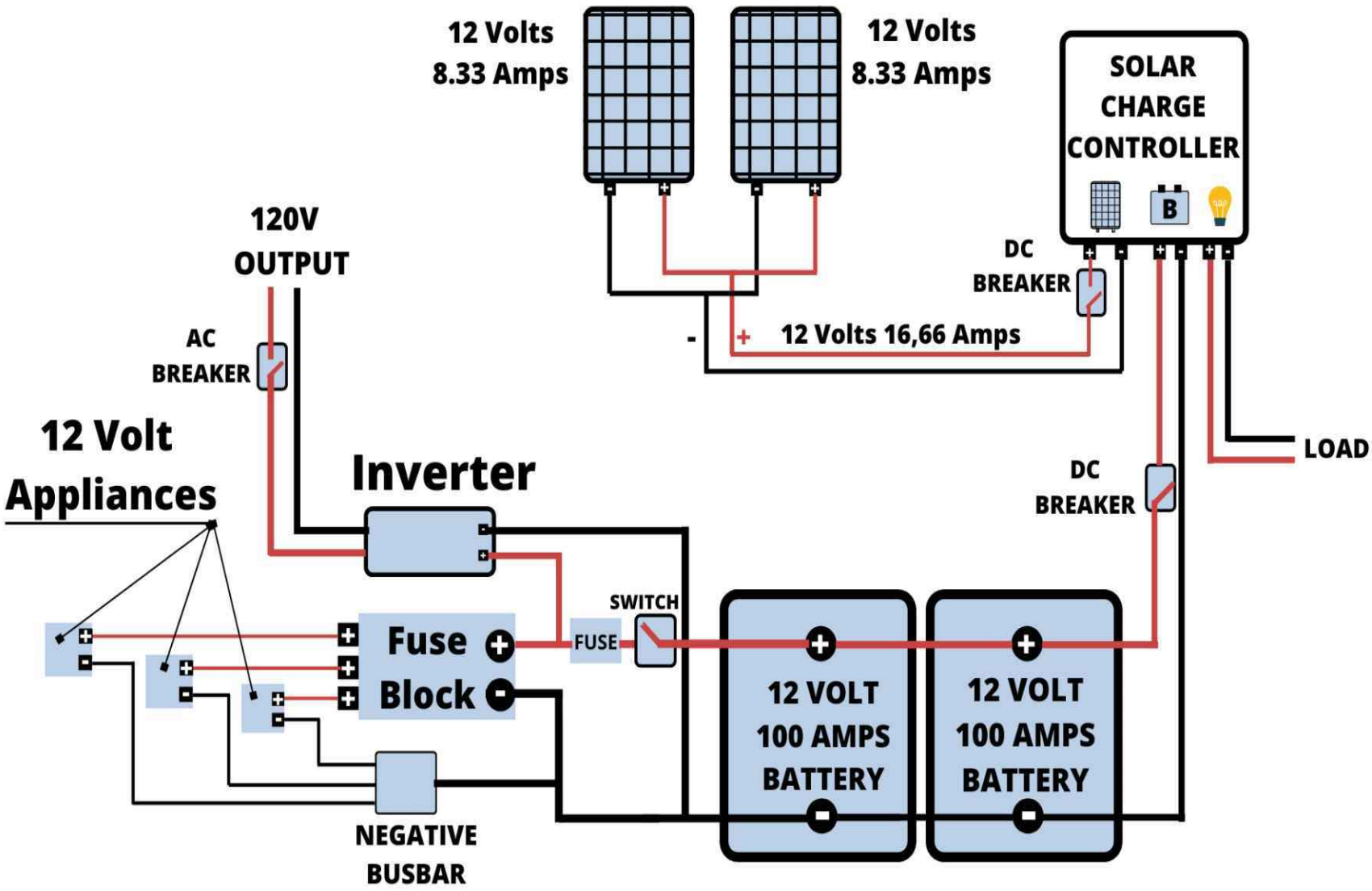
Always make sure that you are using a proper gauge wire and fuse when connecting 12-volt appliances. Also, only use a 12-volt appliance, not a smaller one, because otherwise, you will damage an appliance.

XT-60 connectors are designed to power up to 60 amps of appliances.

You can’t use XT-60 with large appliances. For larger appliances, you have to use an Anderson Power pole connector.

To use an XT-60 connector, you will need a soldering experience. Recommend to watch some videos online to see and learn to solder and experiment a little bit before soldering connectors.

This is what your final wiring diagram should look like:


12 Volts
8.33 Amps
12 Volts
8.33 Amps
SOLAR
CHARGE
CONTROLLER
B
120V
OUTPUT
DC
BREAKER
AC
BREAKER
-
+
12 Volts 16,66 Amps
LOAD
12 Volt
Appliances
Inverter
DC
BREAKER
SWITCH
FUSE
Fuse
Block
12 VOLT
100 AMPS
BATTERY
12 VOLT
100 AMPS
BATTERY
NEGATIVE
BUSBAR

Things to keep in mind when installing and running the system

- Make sure that the voltage is balanced between batteries and panels. To avoid having to do some extra math, you can purchase batteries that have the same voltage as the panels. That way, you can hook them up on a parallel connection.
- If possible, get an MPPT charge controller. This is the most efficient type of controller. If you cannot spring for one, the PWM charge controller will do a good job.
- Use a pure sine wave inverter whenever possible. This is the best kind of inverter as it simulates the AC wave very closely.
- It is always a good idea to keep your equipped rose off the ground. This is especially true if you plan to set it up in your basement.
- Monitor your system regularly. Once a week seems to be a good timeframe to do this in. That way, you can keep a close eye but not become obsessed with it.
- Whenever possible, spend a few bucks to get the best-rated equipment. If you are on a tight budget, you can pick less sophisticated equipment that is made by a recognized manufacturer.

Chapter 2: On-grid

Designing Of On Grid Solar Energy System

With the increasing development of technologies in the field of solar energy, more and more people have started to build solar energy systems. Among the different types of systems mounted around the world, the most commonly used is the on-grid solar power system.

What is On-grid Solar?

The solar systems can be categorized according to their grid connectivity into 3 different groups. These are 0n-grid, off-grid, and hybrid solar systems (the combination of both on-grid and off-grid). An on-grid solar energy system is a system for generating solar energy in which it is connected to the utility grid. The electricity that the system generates is sent to the grid where the various devices work. Excessive power returns to the grid at any time.

The on-grid solar system is much more appealing than the off-grid system. Solar power is only generated when the grid is available. The electrical source will be cut off in the case of a power outage. There is also a need to focus on backups such as DG sets for emergency power supply. The power shut down happens, mainly for safety and technological purposes.

How Does On-grid Solar Power System Work?

The system operates in two ways—the supply of electricity will flow from the grid to which it is connected to the home of the user and from the home of the user to the grid. This feature makes the on-grid solar system

inexpensive and very useful. The solar panels are ‘tied’ to the grid, mounted on the user’s house. The solar panels convert sunlight to Direct Current (DC) electric power. This current is then transferred to an inverter. The solar inverter converts the DC to alternating current (AC) so that the electrical components are powered. This electricity is then redirected into the grid, where it is distributed for everyday use.

Furthermore, the grid-tied inverter controls the quantity and voltage of electricity supplied to the household, as all the power produced is generally more than a home demand or can accommodate. The net meter is an essential feature of the solar system. It is a tool capable of monitoring the electricity supplied to the grid and the electricity used. The outstanding is reported at the end of each month, and a bill is given to the customer. This ‘converted’ power source is then used by the homes via the central panel for the delivery of electricity.

Benefits of Grid-Tied Solar Energy System

Grid-tied solar systems are incredibly common because they guarantee the investment you make.

Once the solar is activated, you see savings on your immediate energy expenses and start generating electricity. This is why people buy a solar grid-tie network which the common reason is to reduce their utility bills. When the system is in service, the electricity it generates is free, so it needs little or no maintenance.

Zero Electricity Bills: Since the solar power system is connected to the grid, the user just needs to pay for the extra energy that he consumes. The monthly bill that is created defines if the customer has any payments to

make. Around the same time, though, if the user consumes less energy, the waste is pumped back into the system.

Passive income generation: With grid connectivity, the user will bill for the excess energy he’s generated. Not only does it reduce the energy costs, but it also takes advantage of the market save for the surplus power produced.

On-grid solar systems are the most energy effective and easy to install. These are suitable schemes for homes because it is easy to recover the costs paid by the extra electricity supplied to the grid.

Solar increases the worth and resale quality of a house-this solar premium takes place as long as you have electricity. Solar makes a home more appealing to prospective buyers, particularly if compared to an otherwise similar home. In case you want to sell your house in a competitive real estate market, this will make a huge difference.

Grid-tied systems are eligible for a federal income/investment tax deduction of 26% as well as an exemption from sales tax. It refers to the total installation bill—not just the equipment! And solar energy is a renewable power source. This effectively and easily reduces reliance on fossil fuels and helps to protect the atmosphere.

Chapter 3: Hybrid System

There is also a third option that combines the previous two systems. It is a grid-tied system but also maintains a battery backup like the off-grid system. The main difference is that the battery backup can be smaller and cheaper. This means you can use both the sun and the local power grid without having to invest in the high cost of an entire setup.

The hybrid solar system has also created a need to have a new type of inverter. This allows you to control when you send energy to your devices, when you collect it to the battery bank and when you send power back to the utility grid. This means you have the flexibility to take advantage of electricity rates throughout different hours of the day. You'll be able to use the grid when it's cheapest and send extra power to the grid when you can get the most return.

Determining which of these three options are best for you will depend on several factors, including the following:

- Budget
- Local weather
- Distance to grid hookup
- Amount and type of payback from the power company

Perhaps one of the better things to think about when making your decision is exactly how much money you save with solar panels. In the long run, you'll be able to save a lot of money with solar panels. Simply look at your utility bills and check local rates to see how much you can save. Keep the following in mind:

In recent years, the cost of installing solar panels has become cheaper, and the cost of energy hasn't been going down recently.

You'll be able to enjoy a significant tax dedication. The federal solar tax credit allows you a 30% tax break on the cost of installation. Whether you live off-grid or on-grid, these tax credits will apply to you.

Solar panels last a long time and don't require a lot of maintenance or replacement.

Solar provides the chance for a less polluted environment while saving you money in a variety of ways.

Using the Sun to Save Money

If you want to save money when using a solar-powered system, then there are some additional things to consider. The first is a thermal water heating system. This is similar to the solar panel, but rather than turning the solar rays into electrical power, they trap and use them to produce heat. The heat is transferred to the water tank, where you can use it to have hot water for your entire RV. This will also help save you money on the cost of heating water.

There is also a passive solar design, which is very simple. This is where you use parts of your RV to either heat or cool using the suns' rays instead of electricity wattage. You won't need a lot of investment or even a lot of mechanical parts. Some common examples of this type include the following:

- Windows - If you have them strategically placed and easily opened, then you can provide the right temperature for your RV

- Thermal Chimney - This causes heat to rise so that air can move and cool your RV.
- Thermal Mass - The various parts of your RV or big water containers can stockpile heat for use for longer periods. Think of heated flooring.

Another thing you may want to consider is the cost of going solar with an off-grid system. The simplest answer to this is about $10,000 to $15,000 for a complete solar panel system. Getting a battery backup system is usually an additional $5,000 to $7,000. However, this cost is often paid off quickly as you get a good return on your investment.

If solar systems don’t seem like the right option where you live or if you aren’t interested in setting up a solar system, then you’ll need to consider other power systems. Let’s look at two other options you can consider.

Wind Systems

Another way to get power to your off-grid RV with sustainable natural resources is wind energy. It is another clean and dependable power generation method. With this system, you use wind turbines, essentially propellers that are powered through the wind to produce kinetic energy. These propellers are connected to a drive shaft and gearbox, which in turn send energy to a generator. The generator takes in DC energy and converts it over to AC power. As with solar energy, it is important to note that there are times when the wind turbines won’t be generating consistent energy. This is when you will need a charge controller to power and charge a battery. The battery can then be used to power your home with AC power.

Chapter 4: Solar Power

What is Solar Power?

We hear about solar power in increasing frequency these days, and that is because of two core reasons. The first is the environmental impact of nonrenewable energy production, and the fear of the depletion of that source of energy has expedited the development of alternative power generation technologies. This leads to the second reason, which is the precipitous fall in costs associated with the deployment of distributed solar-generated power.

The key factor that we must distinguish when it comes to understanding any kind of power generation technology is that power is not just influenced by the generation of it, but also the distribution of it. Right now, the power ecosystem is characterized by centralized generation (regardless of the method of generation) that is then fed to a nationwide grid and transported over long distances. This has a two-pronged effect. The first is that it needs huge capital investment to expand or maintain this grid. The second is that there are significant inefficiencies at play here.

You have to generate a significantly higher amount of electricity to support the needs of a community when you need to transport that energy over wires because a large amount is wasted in transmission. Look at it this way; if water pipes were naturally porous (this is hypothetical to drive a point), then you would lose more water the longer the pipe distance (traveling from the source to use). So, you would lose less water if the source of water were two doors away compared to how much you would lose if the source was two towns away. Because at each length of pipe the water travels, part of it

seeps out of the pipe. Because of this, the water plant has to process more water to overcome the loss of this water. Processing water is expensive.

Now think about this same thing in electricity terms. The power generation company has to generate more electricity than is being used because it has to transmit that electricity over inefficient cables over long distances.

Since there are two factors at play here, there are two ways to reduce the burgeoning power generation cost and the environmental cost that the old way imposes on us. The first is to convert the methods of generating electricity. This is the kind of thing that Elon Musk has invested in (SolarCity—a company owned by Musk's cousins).

The idea behind this is to have a farm of solar panels and then connect that power generation ability to the existing grid so that the power can be transmitted to the end-user.

The second method of doing this is to distribute the solar generation ability and allow each end user to generate what he needs when he needs it, and then push what he doesn't use back to the grid so that others can use it. This is the personal solar generation capability.

In this book, we will be focusing on this personal generation capability and how to go about literally getting off the grid by doing that.

How Does It Work?

ENERGY

In physical sciences, energy is measured as the capacity to do work. It has to be produced, stored, transmitted, and spent on useful work. The two main types of energy are potential (stored) and kinetic (work). Chemical, mechanical, gravitational, and nuclear power are stored as potential energies, while electricity, heat, motion, and sound are kinetic energies that carry out useful work.

Power is defined as the rate of work execution or amount of energy spent in unit time (seconds, minutes, and hours, etc.). Electricity is a specific type of energy, and it has many sources; they include hydropower (water and dams), nonrenewable sources (burning coal), and thermonuclear (radioactive reactions) energy. Some alternative sources of power are

windmills (air), biomass (burning wood), tidal power (ocean waves), and solar panels (sunlight).

Energy is measured in a unit known as joules. 1 Joule is equivalent to 1 watt per second. Power companies measure electricity consumption in a kilowatt-hour (kWh). 1 kWh is equivalent to 3.6×106 J (3600 kJ or 3.6 MJ). Electricity usage is also calculated in units of kilowatt-hours per year (kWh/yr).

How Do Solar Panel Systems Work?

The solar panel company installs the power system using insulated wiring. Every modern home has the main power supply from the grid. The panel system is set up, and the electrical cables connect various components to form a circuit. Electricity is electron charges running through this circuitry. Electricity powers multiple appliances without any interruption. Batteries, inverters, and generators assure a glitch-free 24-7-power supply.

Let us look at how the solar panel system functions to generate sufficient power:

- First, light from the sun directly strikes the PV panels on the roof.
- Panels are made up of individual solar cells (interconnected for specific voltages).
- Solar cells capture this sunlight and convert it into direct current (DC).
- Electrical circuits (wires and controllers) carry this DC into large-sized batteries.
- This stored solar energy is converted from DC into AC by an inverter.
- The wires or circuits from the inverter enter the home’s main lines.

- They supply solar power (in converted form—AC) to bulbs, TVs, fridges, *etc.*
- The generated and stored energy is measured in volts and amps.
- Home appliances are rated in watts, watt-hour, amps, and amp-hour.
- Energy or power that is stored/generated, or spent in an hour is a useful measure.

Two Kinds of Solar Power

As the name suggests, solar power is the power that comes from our sun. It is rather simple, and it can be broken down into two. The first is the use of the photons that the sun releases, and the second is to use the heat that the sun releases. They are not the same. To prove this to yourself, think about it this way. You know those tinted glass sheets that you stick on windows. Remember how it does two things. It reduces the light that comes in, but more importantly, it cuts out the heat. That's because it allows the photons of a certain frequency in but filters the heat out. So, from here, we know that there are at least two components to sunlight (there are more, but that is outside the scope of this book).

The first kind of energy that you get from the sun is the photon that carries light, and when you place a photovoltaic sheet in its path, the photon that hits it releases the electron in the sheet. That electron then flows to wherever you want it to along the cables that are attached. In that form, you get direct conversion of energy from the sun.

The second is the heat that the sun emits. This is a kind of energy too, but it is a little different from flowing electrons (which we call electricity). Solar panels that extract heat use that heat to raise the temperature of the water, and that hot water is run through radiators and water tanks for showers.

These are closed systems and can be used during the day but need to be supplemented with another heat source during the night. We will get to that as the book unfolds, but for now, the point that we are trying to make is that you should look at solar power as two distinct types—electron generation for electricity and heat capture for temperature modulation.

Benefits of Solar Power

Solar power provides many advantages that make it an ideal energy source. Many households are slowly switching over to renewable energy sources, and using the rays from the sun can certainly lead to this cleaner energy surge, as well. All life forms on Earth rely on the power of the sun in some way, shape, or form. Much more can be done to harness its unlimited power. The following are some of the benefits of solar power.

Clean and Renewable

It is 100% clean and renewable. It reduces the reliance on dangerous fossil fuels that have unnecessary health and environmental consequences. If we are to continue using oil, coal, and gas at a higher rate, our air, water, and soil will continue to be damaged, resulting in the loss of many species over several decades. It is estimated that more species can become extinct from fossil fuels between the years 2000 and 2065 than in all the previous years of existence combined.

Freedom to Control Electricity

Many households experience power outages regularly. This includes developed countries, especially during natural disasters. The electrical grids in the U.S. are over 100 years old and are not built to handle the increased population size and extreme weather events. To upgrade the electrical grids,

it will cost each state billions of dollars, and the fees will be passed onto the customers.

Save Money

The cost of home energy expenses is constantly going up and won't be slowing down anytime soon. Solar offers year-round efficiency and savings. Even during cloudy days, the sun still emits rays. So, don't believe that you will go without power when you can't see the sun. This could reduce your monthly energy bill down to zero. Eliminating those expensive electrical bills alone makes this investment worth it.

Creating Your Solar Panel

Now when you know how a solar panel generator works, creating one for yourself would be a piece of cake. Don't think of it as a complex structure. You would need some basic tools to put the entire system together. Before you begin, start collecting the following things:

Solar panels can be easily bought from an online store as well. They come in different sizes and shapes so that you can pick the one that suits your power needs.

- Charge controller
- Inverter
- Wires
- Deep cycle battery
- Connectors

When you have collected all the essential things, let's learn how to put it all together by following these easy steps:

Start by connecting the battery and the inverter. This will make sure that the extra amount of power produced by your panel would get stored in the battery.

While connecting these two components, follow the same drill of connecting the negative end of the wire to the battery's negative pole and then connecting it to the positive one.

Furthermore, complete the circuit by connecting the charge controller to the negative end of the battery. Now, connect it to the solar panel as well. This will help you regulate the amount of energy produced.

Similarly, follow the same routine while connecting the positive end of the panel (before connecting it to the negative part).

After connecting everything properly, leave your panel out to absorb the rays of the sun. Ideally, one should keep it on the roof. Make sure that it is exposed to the maximum amount of sunlight.

Let it charge. The indicator will let you know the amount of energy produced. When it is over 50%, connect your devices to the battery (or inverter). Ideally, you can simply use it to substitute the main power line of your house. Use it wisely and keep checking the amount of power produced while using it.

That's it! By following these simple steps, you would be able to generate an adequate amount of power for yourself and your home. Solar power is one of the most widely used and cost-efficient sources of alternative energy. It is slowly making its way into every major city and town. There are already more than 650 thousand houses in America that rely on solar energy as their primary source of power.

If you stay at a place that gets enough amount of sunlight, then you should not hesitate from using solar power as well. Take this crucial step and create a mini solar plant for yourself as well. It would be a significant step toward a fulfilling future.

Now when you know how to install a solar power system, move to our next chapter and try some other kinds of alternative power sources as well.

What Solar Power Systems Consist of?

There are quite a few solar power systems that you can use to collect solar energy, but here in this chapter, we will run a basic overview of the main components that most consist of. Here are a few examples.

Solar Panels

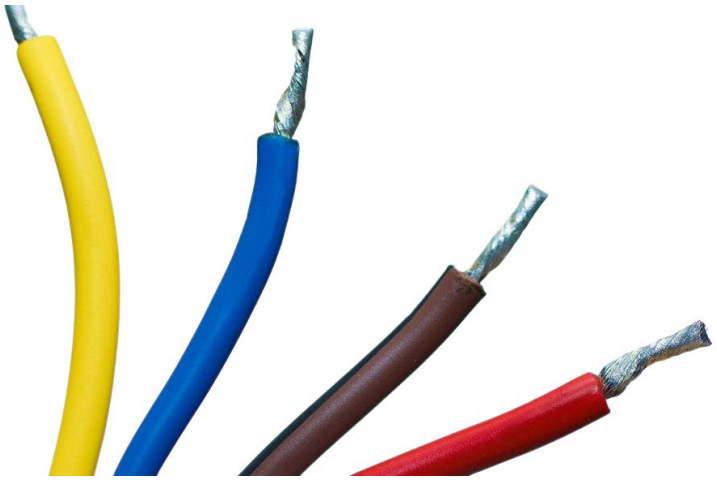
The solar panel itself is the framework or housing that solar cells go into. They are usually composed of light wood or aluminum materials, shaped into a rectangle. For our tutorial in this book, we are going to use a ½ inch

thick piece of plywood with a raised lip of about 1-inch thickness on its outer edges. This lip will serve to hold the solar cells in place on the panel.

Solar Cells

Arguably the most important aspect of the entire solar system, solar cells are the component that absorbs direct sunlight. You can buy these cells at stores or online. But just a word of caution—if you plan on buying these cells new, you are liable to pay a pretty penny for them. But solar cells purchased used or slightly blemished, on the other hand, can be bought for literally just a few bucks apiece. Fortunately, there are used solar cell stores, sites, and distributors popping up all over the place.

DC Wiring



Once your solar panel and solar cells are in place, you are going to have to think about the kind of DC wiring you are going to install. For the most part, DC wiring is pretty simplistic and straightforward, and just about anyone could do it. All you need is a power drill, a set of sunlight-resistant solar panel wiring, and a special device called a “blocking diode” that will keep the battery your panels will be connected to from becoming drained during periods of inactivity.

Deep Cycle Batteries

Deep cycle batteries are the storage units for all the solar energy that you collect directly from the sun. These batteries work as your solar bank so that even on the gloomiest, most overcast of days, you can tap into it for the energy you stored up when the sun was shining brightly overhead. These batteries were made with storage of power in mind, holding onto energy for long periods and then deeply discharge that energy when you need it, sending it right over to whatever device or apparatus you need to power.

DC/AC Inverter

As mentioned earlier in this book, solar power is collected as a direct (DC) current. To power your AC (alternating current) driven devices, therefore, you will need to run it through an inverter. The inverter will multiple your DC creating 120 AC volts for every 12 DC volts. These kinds of inverters are easily recognizable due to their “cigarette lighter” port and their 120-volt socket.

Mounting Equipment

The mounting equipment for your solar system is the intractable foundation on which you place your solar panels; this is the component that allows solar panels to stay on roofs and other structures for several years without disturbance. The mounting equipment grants the whole system balance and stability.

UTILITY METER

Some would say that having a utility meter is optional, but I would say that it is mandatory. If you want to know exactly how much power you are expanding and producing regularly. You can get your hands on cheap utility meters at most hardware stores, or you could purchase them online.

GENERATOR

Although the whole purpose of having a fully operational mobile solar power system is to be free from other sources of energy, you still would be wise to have a backup generator on hand. Even if you almost all of your power from your solar power system, there be certain instances in which a backup generator would be useful. If, for example, you find yourself going through several overcast days without enough sunlight, the generator could temporarily step in to fill that gap.

How Does Light Become Electricity?

Traveling negatively charged particles, known as electrons, is the key to electricity. These electrons or ions have a small amount of negative charge. The circuitry is installed to facilitate the smooth movement of ions. Scientific principles or laws are applied while setting up the wiring. The flow is controlled through an on-off mechanism of switches.

These switches, plug or socket points, and regulators are made of insulating materials. The copper wiring is usually hidden from the naked eye. The electric/electronic components like charge controller, inverter, battery, etc.,

are put in protective enclosures. Ventilated plastic boxes or wooden cabinets/shelves are customarily used. Conversion of photons or light energy into electrical energy is not possible without this complicated installation.

Energy Conversion

Humans apply observation skills and intelligence to understand natural phenomena. Science and energy studies have progressed very far in recent centuries. As a result, we convert various forms of energy into one another for our benefit. They include:

- *Automobiles* - Petrol or diesel powers the car. Chemical energy changes into kinetic or mechanical energy (using a battery—electrical energy).
- *Steam Engines* - Conversion of coal or chemical energy into thermal/heat energy. Heat is converted into mechanical energy in turbines to move trains.
- *TV* - Electrical energy is converted into sound and light energy.

In this manner, a large number of energy conversions happen daily. Human progress and civilization have sped up due to energy utilization; however, rampant energy consumption has affected the global climate. Natural or alternative energy sources like sunlight and wind are considered healthier. Advanced scientific research and engineering precision led to the development of PV panels. Nanotechnology breakthroughs are leading to more and more efficient solar power systems.

Selection of Suitable Solar Power System

Inexperienced homeowners fail to decide for or against solar power. They do not fully understand the technical aspects of applications. Also, they

worry about costs and maintenance needs. Select the ideal PV system for your home using these instructions:

- **Your Energy Needs -** Calculate your energy needs without fail. You have to know the wattage per hour of spending in the house. Select the suitable panels that are marked with power output values. Match the wattage to the total number of panels and their correct sizes. For example, laptops need at least 25W to deliver a trickle charge.
- **Panels And Space -** If a 120W panel is enormous for your area, choose two 60W panels. The width, thickness, length, material, and power ratings are all necessary.
- **Big or Small Budget -** Efficient panels are costly, while rigid panels are cheaper (per W) as compared to flexible, folding models. Negotiate a deal with the company, and compute the total cost, including cables, junction boxes, packaging, manuals, *etc.*
- **Any Accessories -** Mounting racks, brackets, or frames are necessary parts. Pole and angled mounts are expensive. Some PV systems are offered with in-built cabling and plug-and-play connectors.
- **Type Of Installation –** Low-weight folding panels are flexible and transportable. These are more suited for traveling lifestyles. The non-portable, fixed installations are for housing property, sheds, and garages.

Quick Calculations

- In 4 hours of temperate sunshine, a 10W panel can assure up to 40W of power.

- However, the same 10W panel can yield about 10W of solar power in the winter season.
- The daytime sunshine has to be up to 6 hours for efficient power generation.
- Household appliances have wattage labels, and you know the number of hours of use.
- Add up the daily watt-hour requirements for the TV, fan, bulb, etc., to get a total.
- Calculate for one season (summer) the total energy needs also in wattage.
- Also, find the right battery, panel size, and charge controller for your energy needs.

Matching Needs and Solutions

Homeowners do not have identical or similar energy needs. Different people have different lifestyles and habits. The number of family members is different, and outsiders cannot predict power consumption. Yes, electricity bills from the company are useful in knowing the energy needs; however, some residents are responsible, and they save energy through responsible behavior.

Others are not particular about energy conservation, and they are quite wasteful. Solar power has been unveiled in the marketplace for this reason. The natural energy source or sun has abundant light for everyone’s needs, but consumers have to make good use of this valuable solution. They have to match their energy needs with solar panel design or layout.

Chapter 5: Solar Panels

What are Solar Panels?

Solar panels transform solar energy into useful human energy, heat, or electricity. Although similar on the outside, there are different solar panel technologies. The source of energy is always the same solar energy, but some panels are useful for heating domestic water while others for the production of electricity.

Solar panels incorporate individual solar cells. Semiconductor materials like silicon fabricate these cells. The cells are connected to generate the desired power output or voltage. The batteries are rated in amps (current) in full sunlight. Volts have to be multiplied by amps to find out the watts.

The DC generated in the 12 volts range is stored in a battery. An inverter can directly convert it into AC. In this arrangement, the homeowner can plug into a 120 volts socket for power usage. Alternatively, the battery size has to be chosen by the energy demands of a house. Customers usually opt for the right battery, charge controller, and inverter for the best performance.

Solar cells are very fragile; therefore, one should handle them with care. The solar company delivers panels with frames and glass covering. Some fixtures also have plexiglass coverings to lower the costs. Glass is more efficient, mainly if the sunlight is warm and welcoming. Cells are connected in a panel in -ve, +ve series with polarized terminals. A standard solar panel layout relies on 3-inch X 6-inch solar cells.

The assembled panels are enclosed in frames and covered in glass. These parts are shifted to the roof and installed with the necessary wiring. The panels are arranged in a continuous array without any gaps whatsoever. The wires also connect the battery, controller, and inverter. After completing the set-up, the electrician usually tests the installation. He uses a digital meter or voltmeter to check output power.

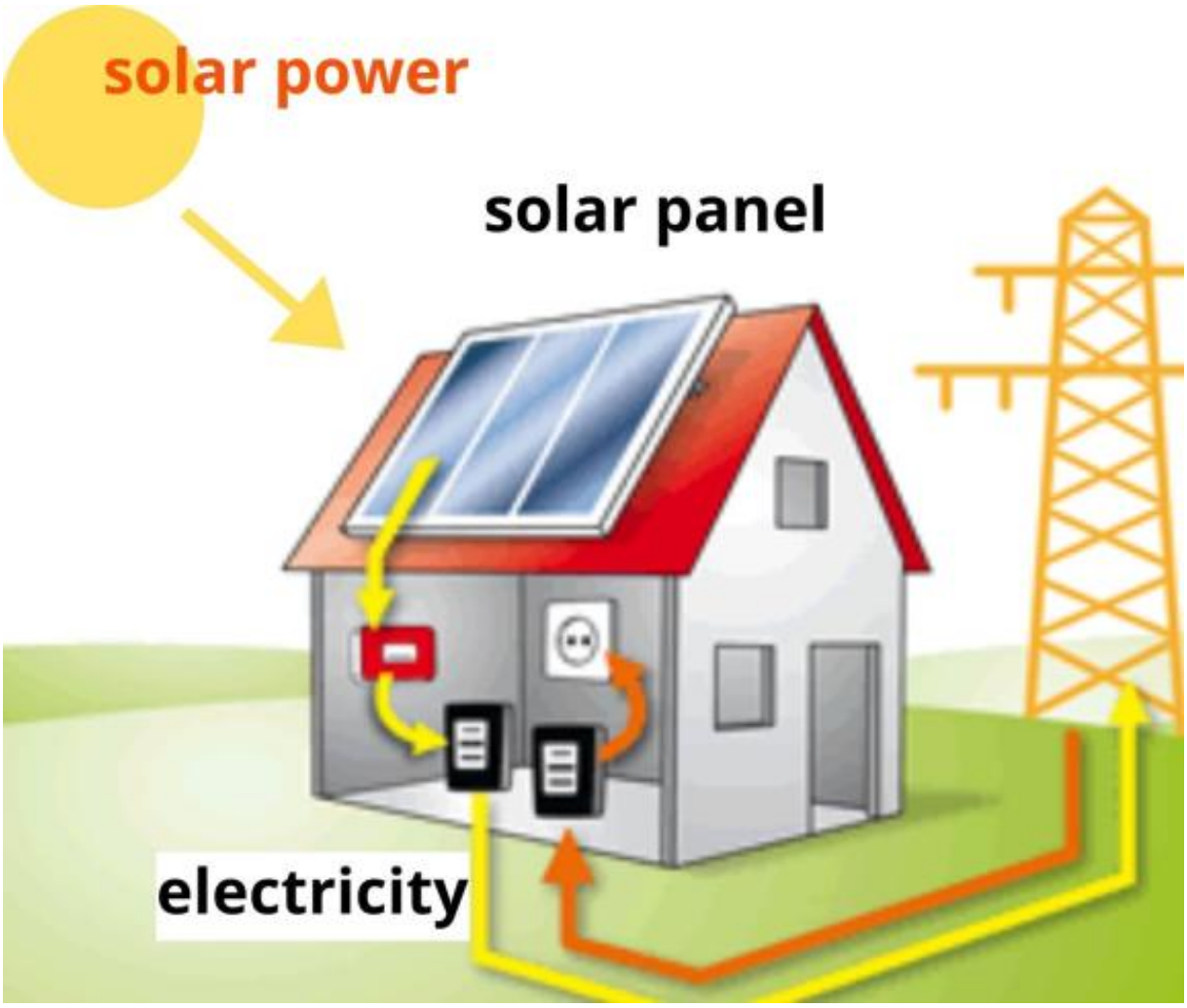
The panels have to capture the right amount of high-quality sunlight directly, so they are positioned angularly to receive the light. If panels are not angled correctly, the rays are not received well; therefore, it reduces the efficiency, and the voltmeter shows the low voltage. The best panels in direct sunlight can assure up to 18 volts of power output any day.

Panels and battery connect to the charge controller at the terminal points. The wiring is insulated to protect against overload or short circuit; hence, this ensures that a fuse will blow in case of an emergency or unexpected fluctuations. Otherwise, the wires get overheated and melt or start a fire. Finally, the inverter is also connected to supply AC power inside the house. Once the whole power system is installed fully, the usage of appliances becomes safe.

The Types of Solar Panels

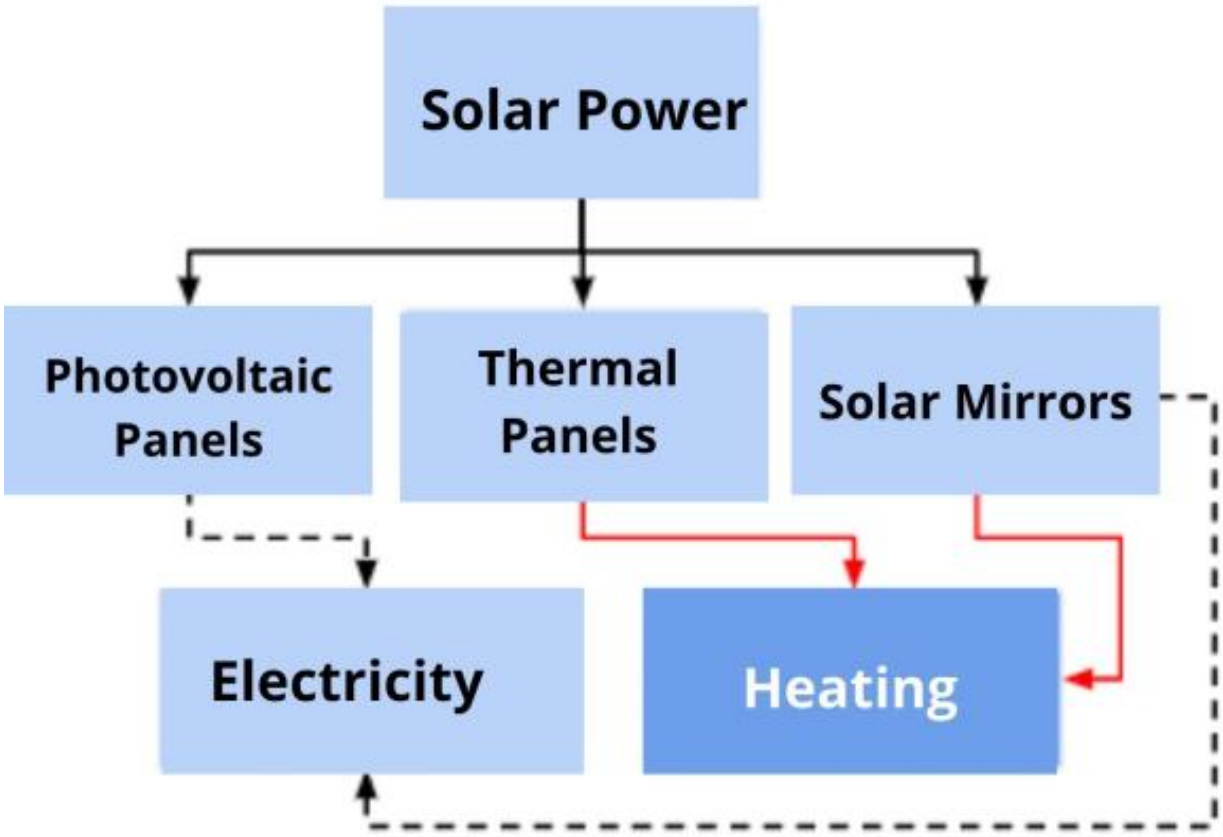
The main types of solar panels are the following:

Photovoltaic Solar Panels. These panels convert the sun's rays directly into electrical energy. The owner of the photovoltaic panels consumes self-produced electricity for domestic use or sells it to the national grid.



Solar Thermal Panels (Solar Collectors). They use the heat of the sun’s rays to heat domestic water and produce hot water for domestic use in the bathroom and kitchen (e.g. washing dishes, showering, etc.). They are an ecological substitute for the electric water heater and gas boiler.

CONCENTRATED SOLAR PANELS. This technology uses parabolic mirrors to reflect the sun’s rays and concentrate them in a single focal point that becomes particularly hot. This is the principle of Archimedes. The heat in the focal point can be used to heat a heat transfer fluid or a water tank, to cook food, or to generate steam and thus electricity.


Solar Power
Photovoltaic Panels
Thermal Panels
Solar Mirrors
Electricity
Heating

Chapter 6: RV's and Boats

You Can Live Off-Grid in an RV

This is perhaps one of the most important first questions to ask. When most people think about off-grid living, they are thinking of going into the rugged wilderness and building their place with materials from the land around them. However, there is also a way to live from an RV and still be completely off-grid. This doesn't mean that you can simply purchase an RV and go live wherever you want. There are still some extra steps you'll need to take to prepare the land and make your RV sustainable, but with these extra steps, you can live completely off-grid in an RV.

Many RVs are already suitable for dry camping, which means you can use them without needing hookups. Another term for this is boon docking. Typical RVs will have a water tank, a waste holding tank, and even a generator or battery for power. Nevertheless, an RV isn't always designed for those who want to live off the grid for an extended period. This means you'll need to make a few upgrades before living off the grid in an RV.

That's where this book is going to help you. We're going to see if off-grid living is right for you, and then we'll look into the best types of RVs for off-grid living and how you can make the necessary upgrades to live as long as you want in an RV.

Options for Off-grid Living in an RV

Once you know that living off-grid in an RV is right for you, and then you need to determine how far you want to take the concept. There are several options for living off-grid in an RV. Consider what your options are:

You can partially move off-grid for periods in your RV without having to give up too many comforts.

You can choose to buy a parcel of land and place your RV on it without hooking up any utilities.

You can also find free land where you can legally squat, such as BLM land, and go entirely off-grid.

You can also join a community of off-grid RV owners in places like Slab City in Arizona.

As you can see, living off-grid requires a unique lifestyle that isn't for everyone. You need to be willing to live in a way that is completely

different from normal living. You'll often be living off the beaten path and away from modern conveniences and civilization. You'll be on your own when it comes to dealing with health and other problems unless you choose to live in a communal setting. While you'll be living in an RV, you won't have many luxuries, and you will need to work hard each day just to maintain a basic lifestyle. If you think RV living off-grid is for you, then let's start looking at what you need to do to get started.

Self Sufficiency vs. Self-Contained

Once you are no longer reliant on an external provider for utilities, you are increasing your self-reliance. You are reliant only on yourself and the situation you create for yourself. The ability to live a mobile lifestyle is another option. When you can explore and get off-grid, then you can be self-contained and have a life-changing experience.

RVs have offered a self-contained lifestyle since the early 1900s. However, there is a difference between a self-sufficient RV and one that is self-contained. The difference is largely in taking all of the things you need to survive for a short period.

A self-contained RV is going to have all the things you need to get off-grid for some time, but this doesn't mean you can go off-grid completely or indefinitely. Once the batteries turn off, the lights will go out. Without a regenerative power source, off-grid living is limited. Self-sufficient RVs are completely different. A properly equipped RV in the right environment can stay off-grid for extended periods and potentially even indefinitely.

The key to true off-grid living is self-reliance and being able to be self-sufficient. These two things will make the off-grid timeframe as long as possible. So, the real question you need to ask yourself is how long you

want to stay off-grid? The answer to this will determine the type of RV you want to get.

You'll see advertisements for luxury travel trailers, and it is important to realize that the definition of the luxury concept for RVs is simply to have the best choices. It isn't about having the most expensive things or what is in demand. Rather, true RV luxury is about the ability to make the decision that is best for you and your living situation. For the off-grid lifestyle, this means not having to travel from space to space and find a location with utilities where it can be resupplied for a self-contained situation.

Time is another concept you want to consider since resupply can be a time-consuming endeavor if you are living on the grid. You need to find locations where you can restock and refill. It takes time to fill a gas tank, trade out propane tanks or recharge a battery system.

A high-end RV, first and foremost, needs to supply you with adequate power, both in stored battery power and in continuous resupply through solar panels and redundant backup power supplies. You should be able to run your AC and multiple high-powered appliances at the same time without issues. You should also have an opportunity to run audio/video systems and charge necessary electronics.

High-end RVs don't rely on generators as their primary source of energy. While generators can serve an important purpose, they certainly shouldn't be the main source of power. Generators shouldn't be run full time and are often prohibited or restricted to only an hour of run time in a day, especially at some places like National Parks. This can be very limiting if it is your primary off-grid power source.

Off-grid vs. Off-Road RVs

This is another important distinction to make when choosing an RV for off-grid living. When you think of off-road, you are thinking about living in the middle of nowhere on a rugged dirt road with off-road gear. If you're out in the middle of nowhere, then you're likely going to be off-grid, but off-grid can also be found in the middle of a city.

Perhaps one of the best uses of being off-grid is to park a high-end RV on a piece of property in town. Even if you are within city limits, you don't need to use connections. Off-grid provides you with greater flexibility when living your daily life. Off-grid living doesn't need to mean off-road living. However, if you are going to live in an RV within city limits, it is important to consider the legal issues involved before choosing to go this route. We'll discuss more on the legal issues of living off-grid in an RV shortly.

RVs and Solar Boats

To get as near carrying on with a sound life as an RV lover as could reasonably be expected, you should have power in the RV. The equivalent applies to boats. While a few unconventionality like to drag generators around in their RV, a great many people with sense to realize that sunlight-based boards are the best approach. However long the establishment is done capability, and you don't stop your RV in the shade constantly, sunlight-based boards give you all the force that you require. This part covers the most fundamental components, to the extent RV and sunlight-based boat boards go.

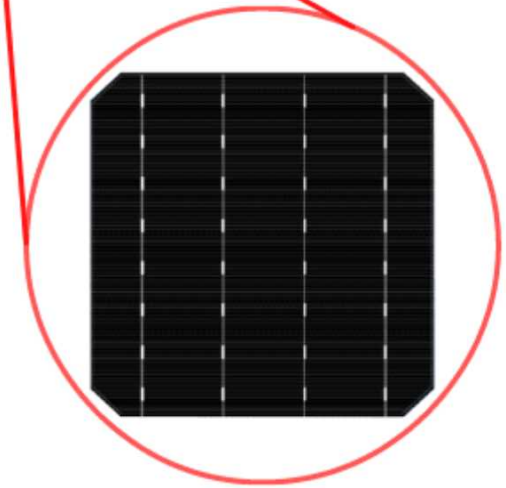
The different kinds of RV and boat solar panels:

There are 3-board types for you to browse on the off chance that you are the pleased proprietor of an RV or sunlight-based boat:

1. Mono-crystalline panel. These boards are produced using a solitary gem. The individual cell on this board is a skinny gem of silicon.
2. Polycrystalline. Sun-oriented boards have a few little estimated gems.
3. Amorphous. These boards are slim boards of film. The cells are made out of a meager silicon layer and fix to the sponsorship material.

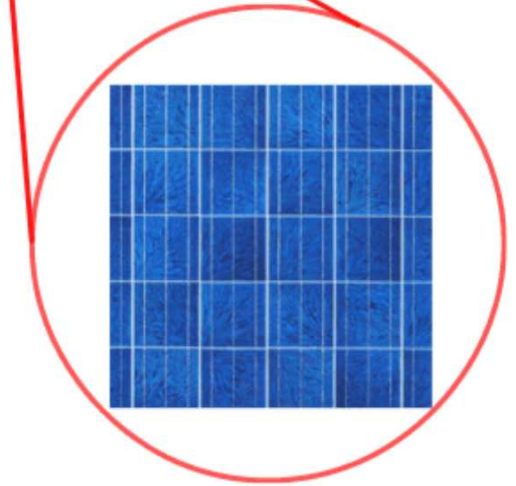
Mono

To make cells for monocrystalline panels, silicon is formed into bars and cut into wafers.



Poly

To make cells for polycrystalline panels, fragments of silicon are melted together to form the wafers.



Chapter 7: Tiny Homes and Cabins

DIY: Solar Power for Tiny Homes and Cabins

In their effort to minimize their dependence on materialistic possessions and free themselves from relying on the state for power, many homeowners will choose to live off-grid in remote homes located on the outskirts of the city. These smaller remote homes may be tiny versions of normal houses or cabins. Despite their size, these remote homes still require electricity for lighting, heating, bathing, and cooking. If you are an individual who is planning on building a tiny self-sufficient home or want to disconnect your home from your local utility grid, building your very own off-grid solar power system is the best solution for you. It will allow you to generate clean, renewable energy and power your home with as much electricity as you require (without paying costly bills each year to keep your lights on).

Some of the benefits that you will receive by building your own off-grid solar power system are similar to the benefits that many enjoy by shifting toward solar energy. In the long run, you will save money, produce clean energy that does not pollute the environment, and enjoy full control over your home's energy generation. In the future, when you decide to sell your tiny home, the presence of a solar power system will significantly increase the value of your property, allowing you to sell it for even more money.

Key Questions to Ask Before Building

When designing an off-grid solar power system for your tiny house or cabin, there are some important questions which you need to answer before

making any major decisions. These answers will help you curate your system depending on your specific electrical requirements for your home.

How Much Electricity Do You Intend on Generating?

Typically, tiny homes will use much less electricity than the amount used in larger homes. Nonetheless, each tiny home's load will be different due to how each household decides to live, the appliances that are used, and the number of people living within the home. To save a lot of money, you will want to generate as much electricity as possible. This means that it is good to have as many solar panels as you can afford.

Are you Installing a Roof-mounted System or a Ground-mounted System?

Decide where the system will be positioned before anything else. If you intend to mount the solar panels on the roof, it is important to check whether the roof receives an ample amount of sunlight. Also, if the roof is strong enough to hold and handle the weight of the solar panels without compromising its integrity, alternatively, you can choose to mount your solar panels on the ground. These ground-mounted systems will require extra racks as well as extra mounting equipment. Lastly, make sure your panels are slightly tilted to capture maximum sunlight.

How Many Batteries Will You Need?

Since you are using an off-grid solar power system, you will need to purchase a certain number of batteries to store excess solar power. The cells will form an indispensable part of the system because they will allow plenty of electricity during the night or when the weather conditions are not favorable for powering solar panels. If you are going to purchase batteries, consider storing them indoors as they are sensitive to extreme weather

fluctuations and can wear and degrade fairly easily when having to adjust between freezing and hot temperature regularly. Many suppliers will sell complete solar kits that include batteries that you can install in your home (this will remove the hassle of having to decide on the number of cells you have to buy).

Battery Capacity (Lithium Technology)

You will follow the same procedure as above. However, the values of efficiency and depth of discharge will be different as you can draw more from this type of battery, and it has a higher efficiency compared to lead-acid technology. Let us have a DoD of 90% and an efficiency of 90%. Remember that these are only hypothetical values and a bit conservative considering the developments in energy storage, especially on lithium-ion.

$$\text{Battery capacity} = \frac{\text{Energy Demand} \times \text{DoA}}{\text{system voltage} \times \text{DoD} \times \text{efficiency of storage}}$$

$$\text{Battery capacity} = \frac{3565 \times 2}{48 \times 0.9 \times 0.9} = 183 \text{ AH}$$

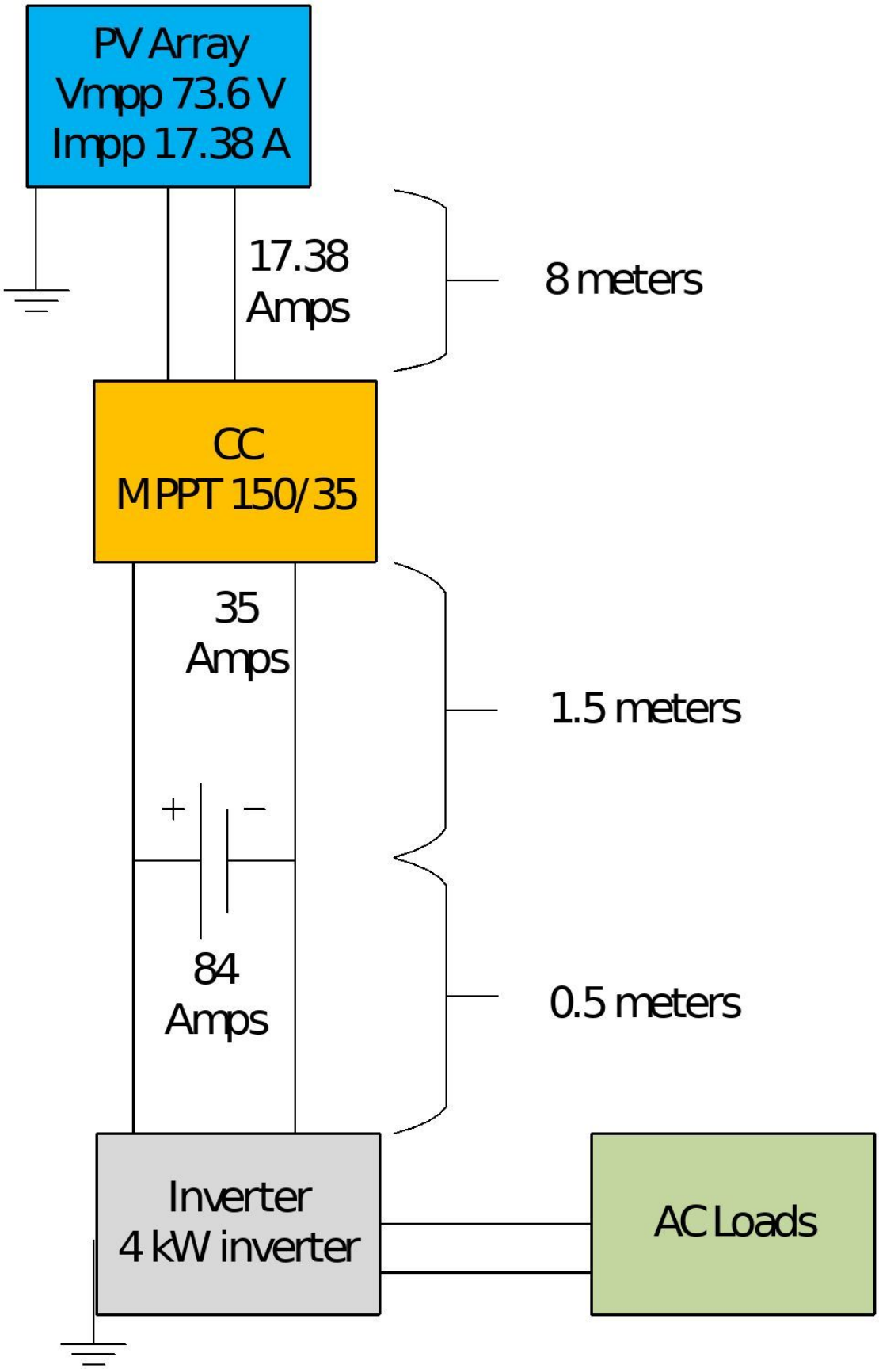
As you can see from the findings above, you will need about half the capacity of the lead-acid battery. Besides, you find that the lithium battery will serve you for a longer period compared to lead-acid. Again, kindly consult the appropriate datasheets to see the number of cycles you can achieve when regularly discharging the battery to a particular depth.

DC Cable Sizing

To determine the needed cable size, one needs to determine the location of each component and the amount of current flowing through each section.

For the inverter, consider the maximum output, which for our case, is a 4-kW inverter. We will need to consider the maximum current that can flow from the battery to the inverter to size the cable. This can be estimated by dividing the inverter power output by the system voltage. For the tiny house, the expected maximum current is (4000W/48V), which is approximately 84 Amps.

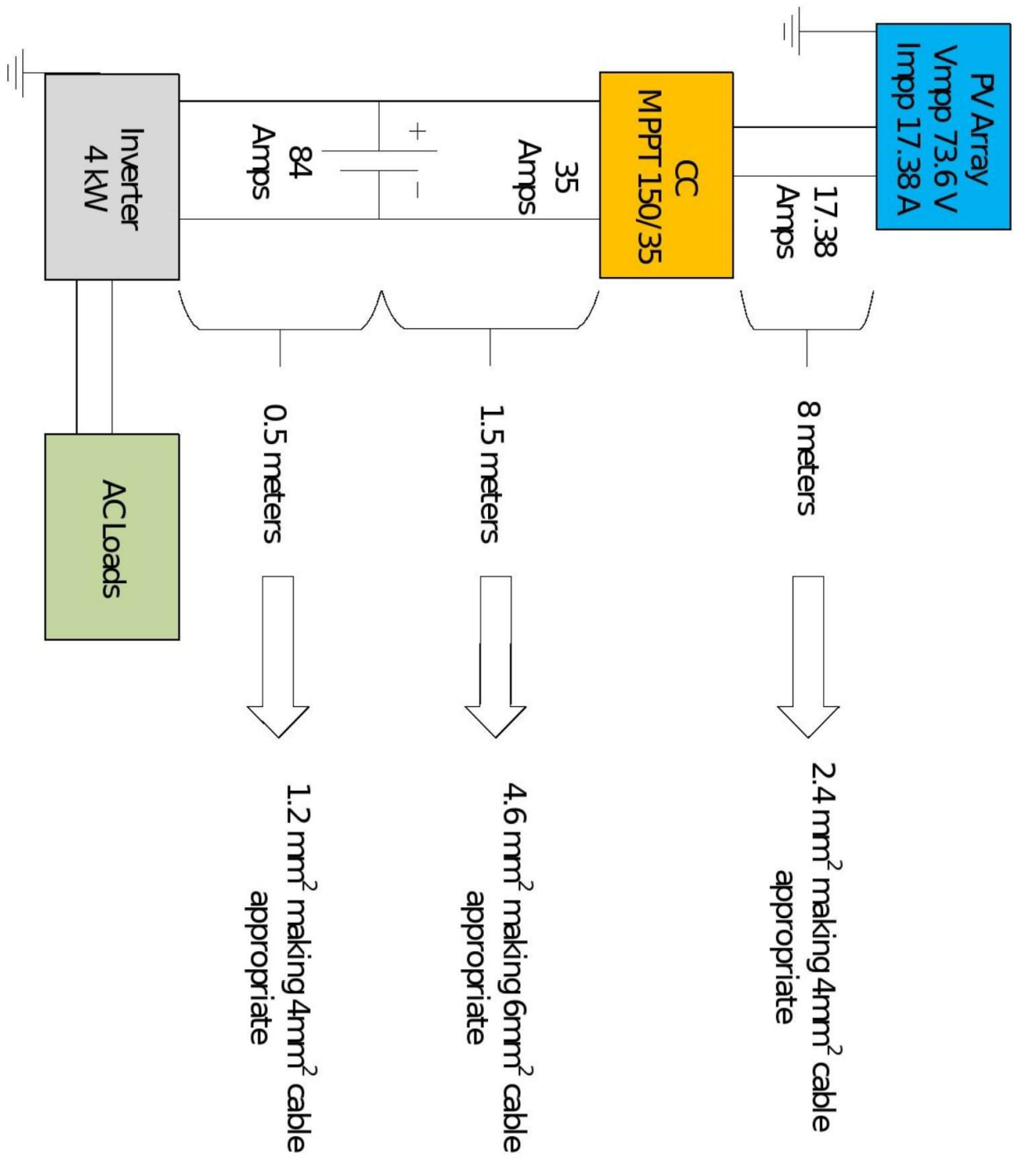
For this exercise, I will assume cable route lengths for the tiny house as indicated in the diagram below.


PV Array
Vmpp 73.6 V
Impp 17.38 A
17.38
Amps
8 meters
CC
MPPT 150/35
35
Amps
1.5 meters
+
−
84
Amps
0.5 meters
Inverter
4 kW inverter
AC Loads

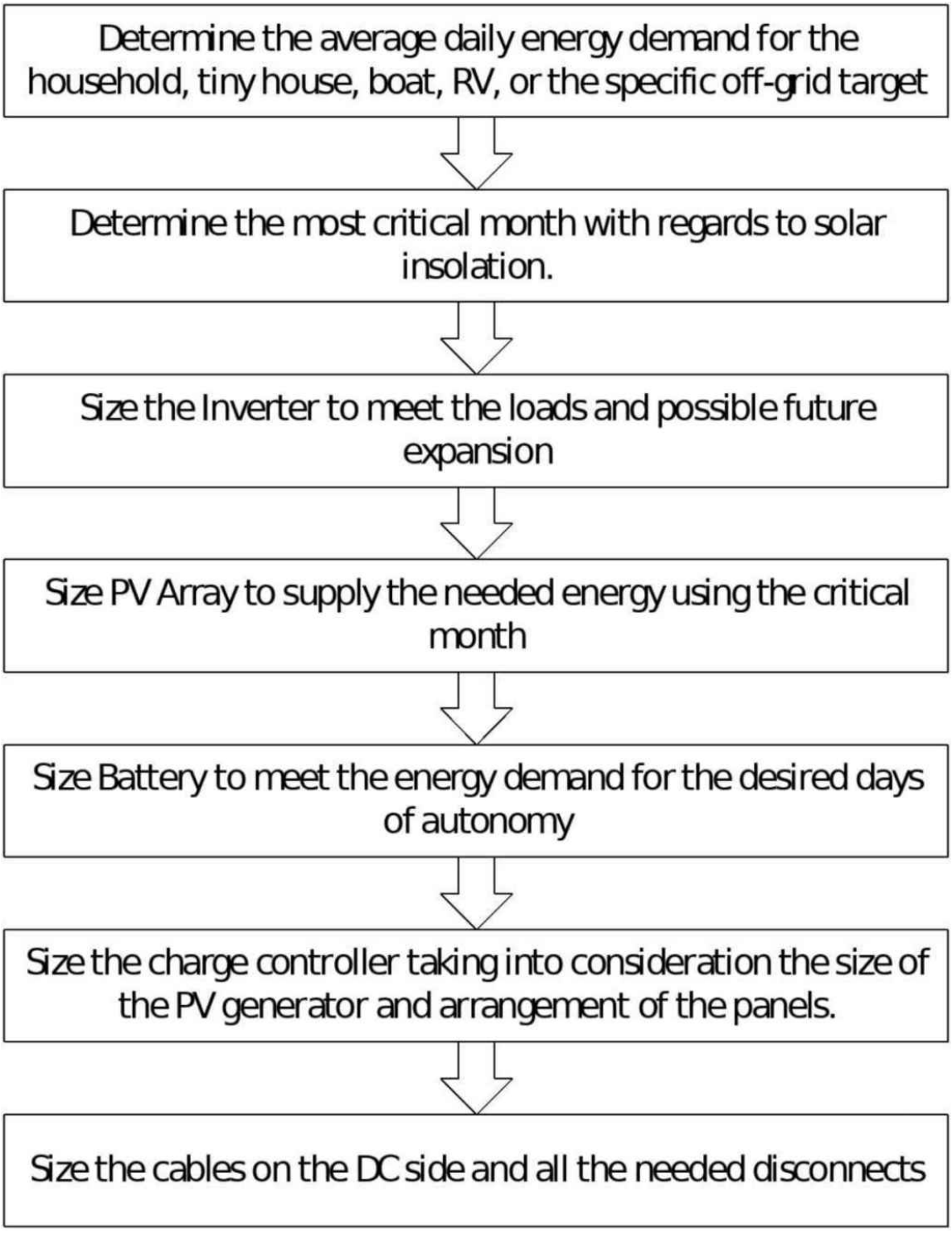
The formula used to determine the appropriate cable size is as shown below;

$$A = \frac{2 \times L \times I \times \rho}{\text{Voltage drop}}$$

The required cable lengths, using the estimated route length and the recommended voltage drop as shown in Table 1 for a 48-volt system.



SUMMARY PV SYSTEM SIZING



It is essential to note that energy demanded should be conducted for each month, especially when there is a significant variation in energy demand

across seasons or different months.

Chapter 8: Maintenance of the PV System

Cleaning

First of all, to ensure proper operation of the panels, they must be kept as clean as possible. Dust, dust, soil, external elements, such as leaves or birds' nests, can be the cause of the malfunction of the system. The dirt that is deposited can inhibit the absorption of sunlight and thus reduce the accumulation of energy. Seasonal cleaning of solar panels is always recommended.

Although rain can help to keep the panels clear, it is often not enough, and a more incisive intervention is needed, which may require the use of a specific detergent or suitable tools. It is best not to use a sponge that is too abrasive when cleaning, as this could damage and scratch the structure of the panels. Water, soap, and elbow oil are often sufficient to maintain the system at its best, but there are many kits on the market to make sure you use the right tools. Another important trick is to dry the modules well and avoid leaving halos, which can negatively affect the performance of the structure, although in a lesser way than dirt. To ensure the correct functioning of the system, it is always advisable to monitor the performance obtained. In this way, having the situation under control, we can immediately notice anomalies and faults.

The classic ordinary cleaning operations can sometimes not be easy at all. In case the solar panels are placed in places that are difficult to reach, as when they are placed on a roof, for example, you can use special telescopic tools that help in cleaning and reaching the most difficult points. Although the best solution, especially for those who have no time or who want to be

sure to have a job well done, is to turn to specialized companies. Usually, these companies take care of the maintenance of the system at 360 degrees, dedicating themselves not only to cleaning but also carrying out a visual check to detect any damage, monitor the performance of the system, and make sure it operates in complete efficiency.

Inverter Control

Inverters are the heart of every system. They are how solar energy is converted into electricity. Besides, they are responsible for monitoring the entire system and enable it to work at peak performance at all times. Usually, they have a 10-year warranty, and the monitoring, unless a fault occurs, should be done at the end of the 10 years. The inverters are overhauled by specialist personnel, who monitor their correct operation and ensure their efficiency.

Check Cabling and Electrical Connections

This control should also be entrusted to specialized personnel, who will periodically check that the whole system is working properly and that there are no faults or problems related to electrical connections.

Checking the Performance of Photovoltaic Modules

The control of the production of solar panels is a very useful tool to monitor the efficiency of the photovoltaic system. A drop in production can indicate problems, such as a failure or the presence of dirt. But the problem can be attributable to damage to one of the cells, which in this case will have to be replaced. A thermal chamber is often used to check the modules, which immediately detects faults and malfunctions.

Checking the Antifreeze Level

Checking the level of antifreeze, which helps prevent temperature changes during the winter months from damaging the photovoltaic modules, is also an important element to monitor. As we have seen, cold temperatures put stress on the system, which must be able to protect the cells from frost.

Summer Maintenance

Most homeowners love the summer because it is an extremely productive season for solar panels. Nonetheless, homeowners need to be mindful of the dust, pollen, or animal droppings that will land on the solar array every so often. You also cannot rely on summer rain showers to do the cleaning for you; they will not do a thorough cleaning the way you can. A simple rinse with warm soapy water and a non-abrasive brush should be enough to keep panels clean and efficient. Those individuals who live in areas where there is a lot of dust in the air during summer need to check on their panels regularly and simply rinse them off with a garden hose whenever necessary.

Fall Maintenance

Solar panels are durable enough to continue generating energy during the fall months. This, of course, is only possible when the panels are not covered in leaves, dust, or dirt. There is no way to keep the leaves away from interrupting the power system, even when there aren’t any huge trees near your home. Your greatest challenge during fall will be the autumn winds that carry debris and other vegetation in the air and offload them on panels and racking systems. Therefore, during the fall months, your task will be to remove the leaves that may obstruct the panel’s ability to receive full sunlight. To do this, you need equipment such as a ladder, rope, and a firm harness to help prop you onto the roof (if panels are mounted on the

ground, this process will be much easier). After that, use a soft brush to rake the leaves off the panels or use a leaf blower.

Winter Maintenance

Many homeowners fear that their solar panels will not produce much if any, electricity. While it may be challenging to receive full days of sunlight during winter, your solar panels will still absorb as much as they can take. There will be days (even when it is a half-day) where the sun will come out, and on these days, ensure there are no obstructions such as snow on panels which can sabotage power production. It may be a struggle to remove snow on the solar panels, especially in areas where there is a high chance of snowfall every week during the winter.

In cases like these, you will need to rely on the sun to melt the snow away within a day or two of it landing on the panels. However, for the snow to melt away, make sure to mount panels with at least a 15-degree tilt. Be cautious of ice build-up because it can compromise your roof's integrity, which will ultimately impact the structure of the solar power system. I do not recommend that individuals apply salt as a method of melting the snow because it could potentially damage the systems, causing the erosion of the racks and panels. By all means, try to remove as much ice as possible manually.

Spring Maintenance

I find that spring is the best time to do preventative maintenance work to expand the lifespan of your solar panels. In this time, you can focus on conducting an inspection of the installation, wiring, and the health of the inverter and battery bank to address any prevalent issues. The Solar America Board for Codes and Standards has compiled a list of things to

observe when conducting an annual solar power system inspection. These include, but are not limited to water leakage on the roof, roof drainage inefficiencies, and growth of plants near the panel installation area, corrosion on the racking system or electrical enclosures, signs of pest infestation, cracked glass on the panels, loose or missing bolts, and excessive wear on the inverter.

Conclusion

Thank you for reading this book. This book has done far more than show you how to connect your sunlight-based board to your 12-volt battery. In truth, this current book's essential target was to outline that sun-oriented innovation and sunlight-based board establishment isn't as confounded as countless individuals make it.

Solar energy is a renewable resource that harnesses the sun’s power to provide electricity to homes, businesses, and other uses. It can be used to do many things, like power lights and appliances or charge batteries. It is used in remote locations, in space, and even in underwater research stations.

The off-grid solar system is an electric power system that is not connected to the utility grid. These off-grid solar systems can be used for homes, buildings, cabins, farms, and remote areas where a utility grid isn't available. The main components of an off-grid solar system are the solar panels, inverter, controller, and battery.

The off-grid solar system is a type of solar power system that is disconnected from the electric grid. It relies on solar panels, a battery, and a charge controller. The charge controller protects the battery from overcharging and from being damaged by the sun. A solar system is a solar-powered energy system consisting of solar panels, an inverter, a controller, and a battery.

There are so many benefits of an off-grid solar system than the traditional grid-tie system. An off-grid system will be a better option for you as it will give you the freedom of power supply without any power cuts. When it

comes to choosing the components for your off-grid solar system, there are a lot of options out there to choose from. First, you want to choose your solar panels. There are many different types of solar panels to choose from, but the most common are monocrystalline and polycrystalline. A basic solar power system requires solar panels, batteries, and an inverter. If you're just starting, you can purchase a pre-packaged system that contains all the parts you need to get you started. The components are fairly simple and don't require a degree in engineering to understand how they work.

The solar power alternative is not only good for the environment, but it's also one of the best energy alternatives in this tough economy. The resources, manpower, and money involved in traditional energy creation can be used in other work.

Modern technology has made the solar system to be efficient as compared to the earlier technology, which limitations.

Despite continuous growth, solar power is still the most underutilized source of energy, and I believe that I can help change chant over time. If we all work together, we can create a solar world that reduces our energy bill and helps save the world. It will take a lot of time and effort.

The next step is to take the information provided in this book and start doing your research. If you like what you've read about solar power so far, then don't stop here because there is still a wealth of information to obtain. Start studying up what solar can offer you and set up a budget for a solar power system. Take all the steps to ensure the process is as smooth as possible. If you are ready to take the step into renewable energy, then do not wait any longer to get started. Shift over to solar and begin lowering and even eliminating your energy bill while also reducing your carbon footprint.

Nick Jacobsen

THANK YOU

First of all, thank you for purchasing **Off Grid Solar Power Simplified.**

I know you could have picked any number of books to read, but you chose this book, and for that, I am extremely grateful.

I hope that it added value and quality to your everyday life.

Books with reviews sell faster than a **Starbucks** brown coffee.

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I wish you all the best in your future success!

Nick Jacobsen