MINI-COURSE + HANDBOOK:

How to Size, Setup & Maintain Your Own Off-Grid Solar Power System

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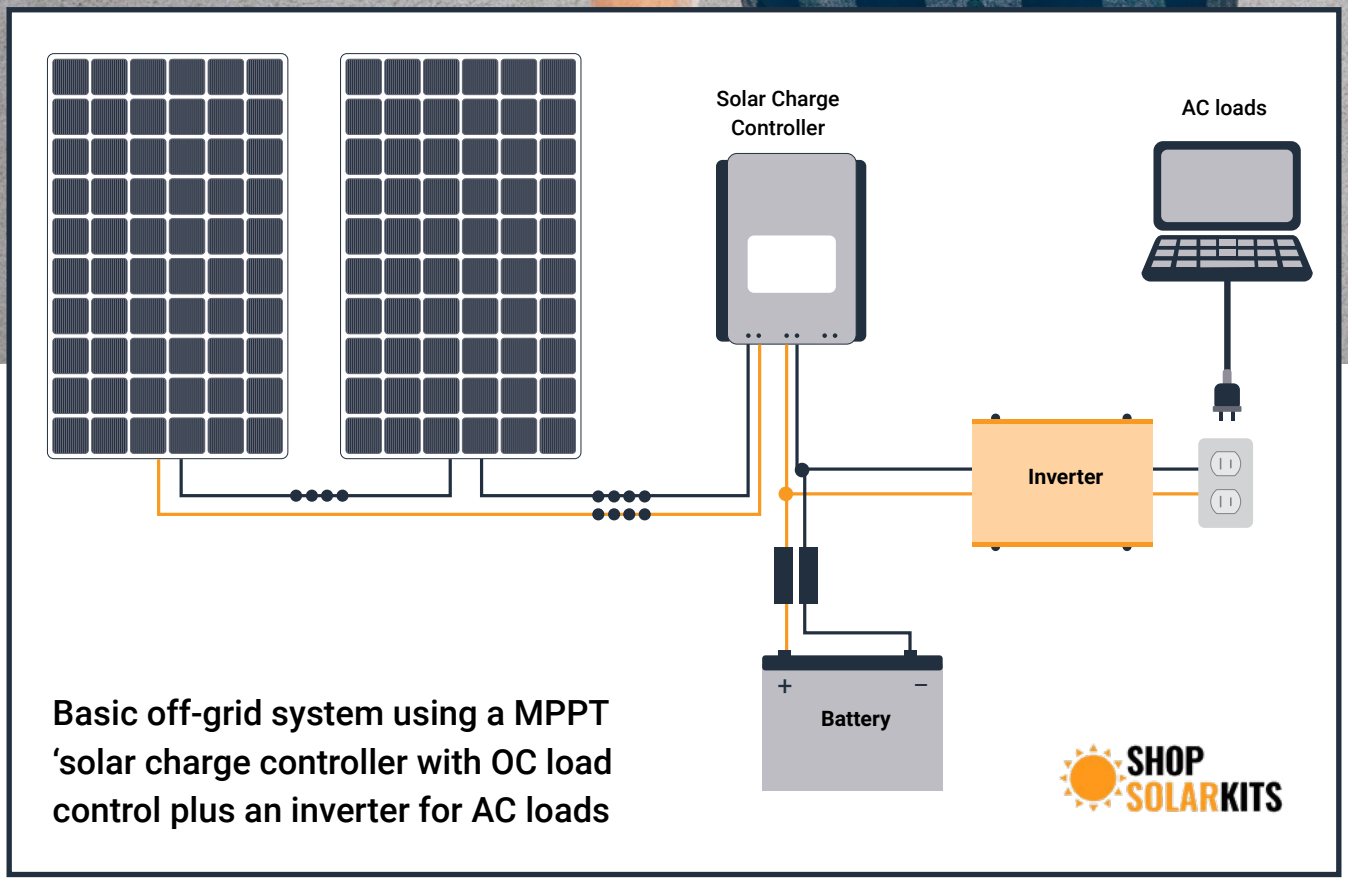


Basic off-grid system using a MPPT 'solar charge controller with OC load control plus an inverter for AC loads

SHOP SOLARKITS

MODULE 1

Overview & Introduction

Off-grid solar power systems are hard to understand. The electrical terminology can leave you feeling clueless and have you questioning your intelligence. (Trust me, I was right there not long ago.) Amps, volts, watts, watt-hours, amp hours, split phase, 120/240 inverter, battery, pure sine wave, monocrystalline - the list of electrical jargon goes on. Figuring out how to **size the perfect solar power system for your needs can actually be super frustrating**.

On top of that, most people who understand this type of stuff love using big fancy words and seem to want to make you feel even dumber than you already do. At least, that was my experience early on.

I had no prior electrical experience when first getting into the industry half a decade ago. So I felt the same overwhelming frustration you might be feeling right now. And it took me over two years to even begin wrapping my head around the fundamentals (and that's working with and selling solar kits every day).

After speaking with thousands of customers and selling over 30,000 off-grid solar kits, it made sense to create a simple handbook, taking everything I learned about sizing off-grid solar power systems over the past half-decade and helping you do it yourself.

You can quickly sum up off-grid solar power into a handful of math equations and the understanding of a few basic principles. I promise not to use big fancy words or to dive into the scientific backgrounds of each piece of an off-grid solar power system.

Instead, we'll use a few simple analogies, a handful of math equations, and some pictures and diagrams we've drawn for other customers over the years to have you **sizing the perfect solar power system for your needs in less than an hour!**

MODULE 2

Foundational Analogies

To simplify things, we'll explain two analogies born out of thousands of phone calls with customers trying to help them understand how off-grid solar works and to answer questions like, why do I even need a battery bank!?

The Bathtub Analogy, Explained:

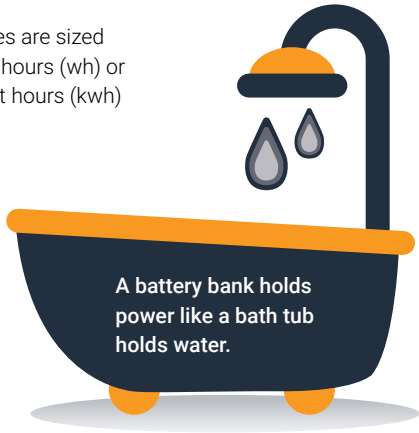
One way to think about how off-grid power works is the bathtub analogy. Your bathtub holds water just like your battery bank holds power.

The only way to get water into your bathtub is to turn on the faucets or the shower. Think of the solar panels on your off-grid power system the same way. Solar panels are the only way to fill it up (other than a backup fuel generator).

Your solar panels will act like the shower head that is going to dump the power into your battery bank. More panels = more water flowing into your batteries.

Solar panel arrays are sized in watts (W) or kilowatts (KW)

Batteries are sized in watt hours (wh) or kilowatt hours (kwh)



The sun only shines effectively for about six hours every day, so your solar panels have a limited time to collect power, or, in the bathtub analogy, your tub only has six hours to collect water. Between 5 and 6 pm every night, the water flow into your tub stops, and you can only use what you collected during the day.

Every evening, you use the water in your tub as carefully as possible to ensure there is enough left for the morning. And every evening, you must use the power you collected throughout the day carefully, so there is enough left in the morning to power your appliances until the sun comes up and begins filling your battery again.

In an ideal world, your solar panel array is large enough to fill or overflow your tub by 2 or 3 pm every day. If it is, you have more than enough to create your own sort of "peak," allowing you to use a ton of excess power that would otherwise go to waste in the atmosphere.

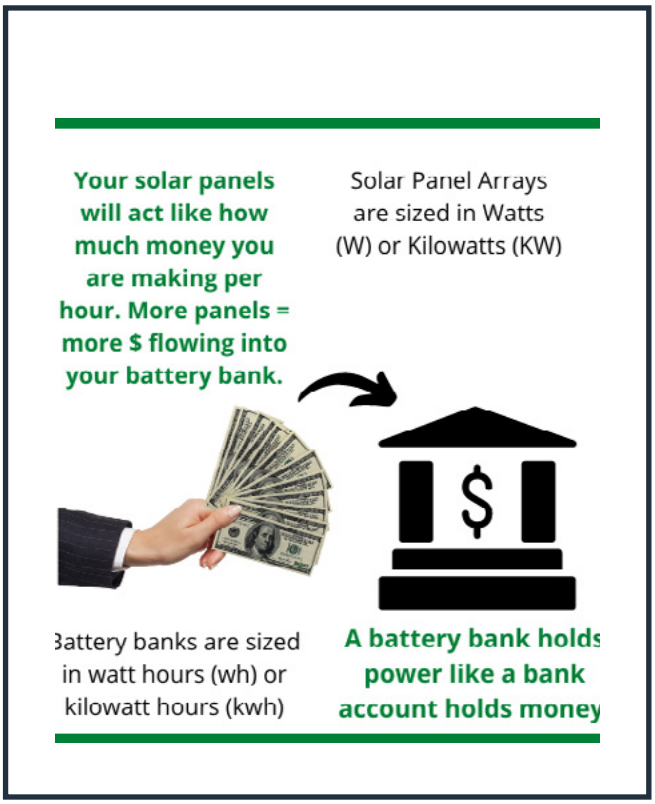
The more money you spend, the bigger the tub you get for storing water. If you have a small budget, you could get something the size of a bathtub, but if you're willing to spend more, you can get a hot tub or swimming pool. The bigger the tub you get, the bigger the faucets you need to fill it during the day.

The same logic applies if you're thinking about custom solar power systems or solar generator kits.

The Bank Account Analogy, Explained:

You can also think about your off-grid battery bank like a bank account. It holds money, just like your battery bank holds power.

The only way to get cash into your bank account is to deposit money you've earned, and the only ways to get power into your battery bank are your solar panels or a backup fuel generator.



Again, your solar panels only have six good hours a day to generate the cash to fill your bank account. So the more solar panels you have, the more money you make per hour.

Between 5 and 6 pm every night, the money flow into your bank account stops, and you have to use what you collected during the day to get through the evening and into the next morning. And every evening, you have to carefully use the power you banked so that you have enough left in the morning to run your appliances until the sun comes back up and starts driving power back into your system.

In an ideal world, you want a big enough solar panel array that your bank account is full or overflowing by 2 to 3 pm each day, giving you more than enough cash to spend.

Again, the same logic applies when considering large, custom solar power systems or solar generator kits.

MODULE 3

Sizing Equations

Using the seven steps below, you can get an almost perfect estimate for the size of the off-grid solar power system you need.

Sizing a solar kit comes down to understanding and calculating three main numbers:

1. Battery Bank Size
2. Solar Array Size
3. Inverter Size

Using the equations below and the information in our handbook, you should be able to dial-in these three numbers for yourself within the next 20 to 30 minutes.

Grab a pen and paper, and follow along:

1. Amps x Volts = Watts

You need to know this equation to get the **WATT DRAW** (measured hourly) of each appliance you want to run. Most of your appliances list their amps and/or volts on them. If it only lists the amps and the appliance plugs into a standard wall outlet, it's 120V.

Your dryer, oven, well pump, etc., are typically the only 240V appliances in a home, and you can tell because of the big weird plug.

2. Total Average Hourly Load in Watts (TAHL)

To find the TAHL, take all of the appliances you want to run off solar and add up their hourly watt draw.

We typically only include things that run for more than five minutes at a time. Appliances like your microwave, toaster, and hair dryer do not run long enough to factor into the equation since we want an average continuous hourly load/watt draw.

Why? **We are trying to get an average hourly load overnight when we're not producing solar power and are simply running off of stored battery power.**

You have no incoming power after the sun goes down, so you need to ensure you're not going to drain your battery two or three hours after the sun sets.

Here's an example. Say we're going t o run a fridge, freezer, lights, wifi modem, fans, and TV, charge phones, use the microwave and toaster occasionally, and run a well pump and air conditioner at times, both rather large, i.e., a 15,000 BTU air conditioner.

Important Notes on Finding Your Total Average Hourly Load (TAHL) in Watts:

- Most appliances rate their max load, so it's best to Google "appliance average load in watts" for a more accurate number. The average draw is usually much lower than what is on the appliance. For example, the label on a fridge may read 800W, but it may only draw 100W on average, a BIG difference.

- Use Appendix A for more help and a worksheet on coming up with your average hourly load in watts.
- This number is the foundation for sizing your entire solar system, so you must get a good feel for an average here. We typically see anywhere from 100-500W/hour as the average watt draw range, even for larger off-grid homes.

3. Sizing Your Battery Bank = TAHL * Target Battery Run Time in Hours

Sticking with the example above, we'll go with a total average hourly load in watts (TAHL) of 450W and say we want to run this all night long with no problems.

So, we'll use 20 hours at the target run time, which should get us from the 5 to 6 pm period when the sun is no longer hot enough until about 8 to 9 am when the sun is back up, shining on your panels and filling your battery again.

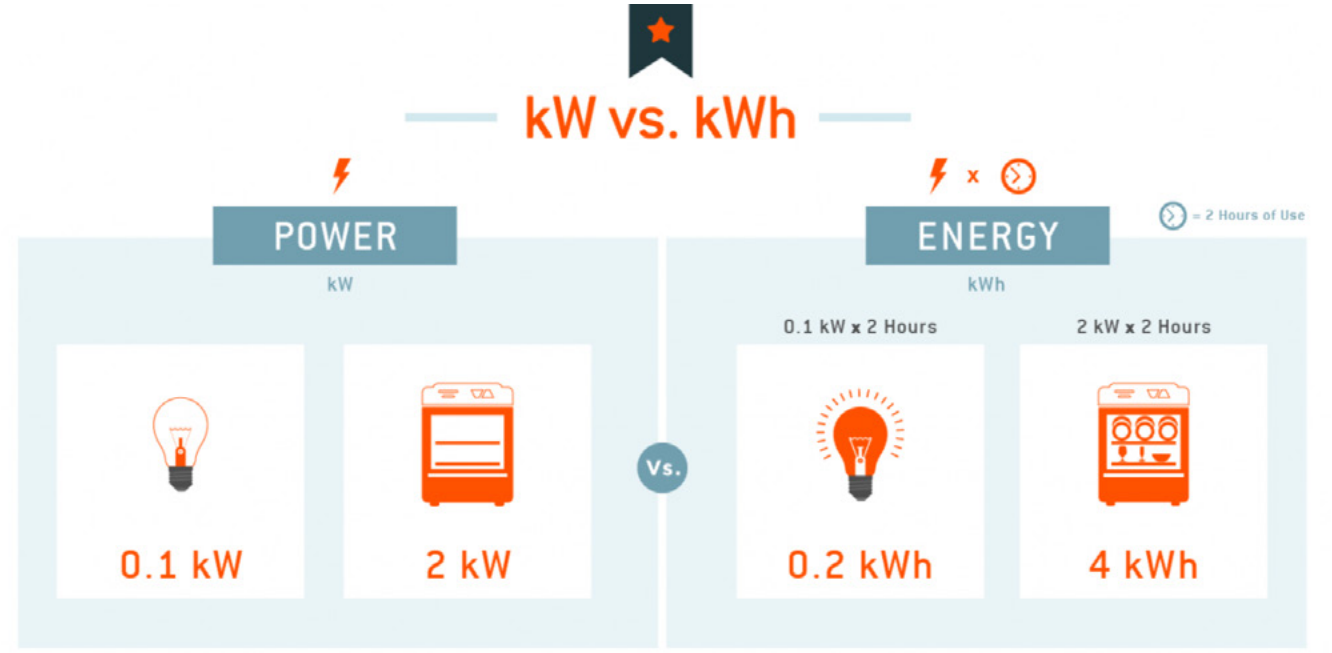
In this case, 450W x 20 hours = 9,000wH or 9kWh

So, you'd need a 9,000wH battery bank to handle a 450W continuous load for 20 hours.

The A/C and well pump will come into play when sizing the inverter, but in this example, these aren't going to run all night long or for hours on end.

(Note: If you want to run the A/C all night long, most A/C units alone pull over 1,000W per hour. Over 8 hours, that's 8kWh just for the A/C unit.)

You can play with that 20-hour figure as it suits you. Some people really only use power during the day and then a light or two at night, so they use eight to ten hours as the figure. Other people want a ton of extra battery, so they use 40 to 50 hours as the multiplier. (We almost always use 18 to 20 hours as a good baseline multiplier.)



Difference between watt-hours and kilowatt hours *- Source: www.directenergyregulatedservices.com*

4. Understanding Watt Hours (wh) and Kilowatt Hours (kWh)

Power companies typically charge for electrical energy by the kilowatt-hour (kWh), which is equal to 1,000 watt-hours.

When there's an "h" on the end, this is a form of stored power. When there's no "h," it's just W or watts; this is a form of moving power (input or output).

Battery bank capacities use watt hours or kilowatt hours, which is how I typically think of them. (Forget amp hours and voltage for now.)

5. Sizing Your Solar Panel Array = Battery Bank Size in wH / Target Recharge time

Now that we know our approximate battery bank size in watt-hours, we need to figure out how much solar we need to recharge it. We typically want to use a target battery recharge rate of no more than six hours.

Why six hours? Because most of the US gets no more than six good hours of sunlight a day. So using a target of four hours is even more ideal; however, we need to factor in budget and space requirements.

Let's go back to the example above. If we have a 9,000wH battery and want to recharge it in six hours, we can find our solar panel array size by doing the following calculation:

9,000wh / 6 hours = 1,500W solar panel array

To speed up the recharge rate and ensure we're filling up even on cloudy days, do the following:

9,000wH / 4 hours = 2,250W solar panel array

I almost always like to use six hours as a good baseline. Once the recharge rates hit eight to ten hours, though, we need to consider adding more panels to get it down to around or under six hours; otherwise, you will not be putting enough juice into the batteries during the day.

6. Calculating Number of Solar Panels Needed = Array Size / Solar Panel Wattage

When picking actual panel wattage sizes, we find 200W and 370W panels are the most popular and the ideal physical size for most applications.

Once you go over 200W panels, you're into large-scale residential panels weighing 50 pounds each that you need to order in larger minimum-order quantities (usually eight). So if 200W panels do the trick, keep it simple and move to the next step!

When it comes to how many solar panels you need, it's also super simple math.

Using the above example:

1,500W/200W panel = 7.5 panels (Round up and get eight panels and get 1,600W to be safe.)

2,250W/370W panel = 6.08 panels (Six panels would do the trick.)

7. Calculating Inverter (Output) Size and Requirements = Find Your Biggest Load

Think of your inverter as what allows you to actually use the power stored in your batteries so that you can run what you want to run. Most inverters work as chargers, which means you can also use them to drive power into your batteries via an AC power source like a fuel generator or grid power from an outlet in your home.

Every appliance has a surge or a rush of power when it first starts, so we need to factor this in when sizing our inverter.

When sizing your inverter, think about what your biggest single load will be. On smaller systems, this might be a fridge compressor. On larger systems, it can be a well pump, dryer, air conditioner, heater, etc.

The four most popular inverter sizes are 1,000 to 2000W, 3,500 to 4000W, 6000W, and 12000W+.

So you can usually safely stay between one or the other once you know your biggest load and your average hourly load.

Based on what you're trying to run, you can more or less determine pretty quickly which inverter size range you need. If you need more than 2,000W, you jump to the 3,500 to 4,000W range.

Sticking with our example, we have an average hourly load of 450W and want to run some larger appliances like the well pump and A/C unit. I Googled "15,000 BTU AC unit watt draw and got 1,500W/hr," and the well pump is, let's say, 1 HP. Googling watt draw, we get 2,000W run, 4,000W surge.

So we could probably get away with a 3500W to 4000W inverter here since these will have the surge capacity to handle the surge of both appliances. Most inverters can do three times their continuous rating for 30 seconds.

This rule is not perfect, so check each inverter's specs before buying. I'd probably go with a 6,000W inverter to be safe and to ensure I'm sized for if my needs increase in the future.

Example Results

With this, we know you need a 4,000W+ inverter that can handle both 120/240V output. Go with something around 9,000wH (also known as 9kwh) with roughly 2,000W of solar so you can fully recharge your battery in one day.

If there's no system with a 4,000W inverter and 9,000wH battery, you may need to jump up to a 6,000W system to get the battery bank size you need, which is fine because it allows for room to grow into your system.

This math will give you your numbers, so you can be more confident and flexible while shopping for a solar kit.

The worst-case scenario from choosing a kit that is too small is that your battery dies way too soon into the night, or you do not collect enough juice in the panels to refill it during the day. In this case, you'd need a bigger battery and more panels.

If you undersize the inverter, it will constantly trip a breaker on you.

These reasons are why you want to be sure you buy an appropriately sized kit for your needs. I always tell customers that I've never had someone call us and say they have too much power.

In Conclusion: Sizing Your Solar Kit

Again, sizing your solar kit comes down to finding and understanding three main numbers:

1. Battery Bank Size
2. Solar Array Size
3. Inverter Size

Using the equations above and the information in our handbook, you should be able to dial in the perfect solar kit using the above math and equations.

BONUS: Answering the Most Common Question: How Long Would X Generator or Battery Run Y Appliance?

This question is probably the one we get asked the most, and it can be summarized using the following equation:

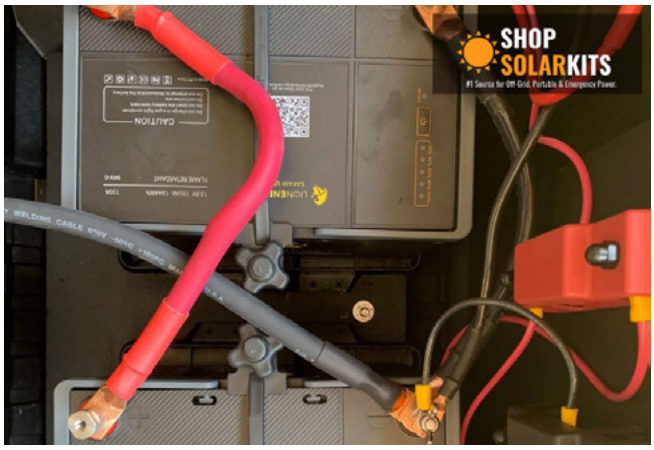
Battery bank size in watt hours (wh) / load of the appliance in watts (w)

So, for example, a solar power station with a 3,600wH battery would run a fridge pulling 100W for 36 hours (3,600/100W).

The same math applies if we're trying to figure out how long it would run a fridge, TV, and lights. Add it all together: 100 + 50 + 50 = 200W.

3,600wh / 200w = 18 hours

With this equation alone, you are ten times ahead of most people trying to figure out how off-grid solar works!



MODULE 4

Choosing the Perfect Solar Kit

Choosing a Solar Generator/Power Station vs. Stand Alone Solar System

Custom Solar Kits

Typically, custom solar kits allow for more customization. They are also more powerful, and you can expand them easily. However, they are more advanced to install and will almost always require a professional electrician to make final connections and ensure the system's safety.

Since these systems are more advanced, they are usually most popular for full-time off-grid living, advanced whole home backup power, or used to offset a home electric bill while providing grid independence if/when needed.

Solar Generator Kits (SoGen Kits)

Solar generator kits have come a long way since 2018 when we first started ShopSolarKits.com. The most significant thing to consider here is how portable and mobile you want or need the system to be. SoGen kits are much more portable and easy to install. And with the advancement of portable solar power stations and solar generator product lines, they are also extremely powerful and expandable.

While they are not as expandable as a custom solar system, they can be amazing options for emergency backup power, weekend getaways, mobile power solutions in food trucks, and other commercial applications.

Choosing Rigid or Folding Solar Panels

Whether you use rigid or folding solar panels comes down to personal preference. There's not much of a performance difference at all. Folding solar panels cost more because of the convenience of being able

to move them around and put them in the back of your car, for example.

Rigid solar panels are cheaper and typically last longer since they are simple rectangular panels designed to be outdoors, 24/7, mounted to a physical surface.

If you need to, you can also use rigid panels in a more portable fashion by leaning them against a fence, wall, or bricks in your yard.

Roof or Ground Mount for Solar Panels

Ground-mounted solar panels are the most popular option here at ShopSolarKits.com because you can usually get a better location for the array and point it perfectly at the sun all day.

Roof-mounted panels are "cleaner" since they're locked and loaded on the roof and feel more traditional. That said, maintenance and cleaning can be more complex when you have to climb all over your roof to do it. Maintenance and cleaning on a ground mount system are much easier since you can walk around it.

Usually, this isn't even a choice for people; it's more, "My roof won't work, so I'm ground mounting" or, "My roof is perfect, so I'm using that." Base it more on performance and the reality of the situation than your personal preference here.

MODULE 5

Setting Up & Installing a Solar Kit

Here, we look at a few of the main types of off-grid systems: home, mobile, and emergency backup.

Under each section, we discuss the significance of each system, followed by some key installation insights and application-specific tips for how to get your system up and running.

Off-Grid Home Solar Systems

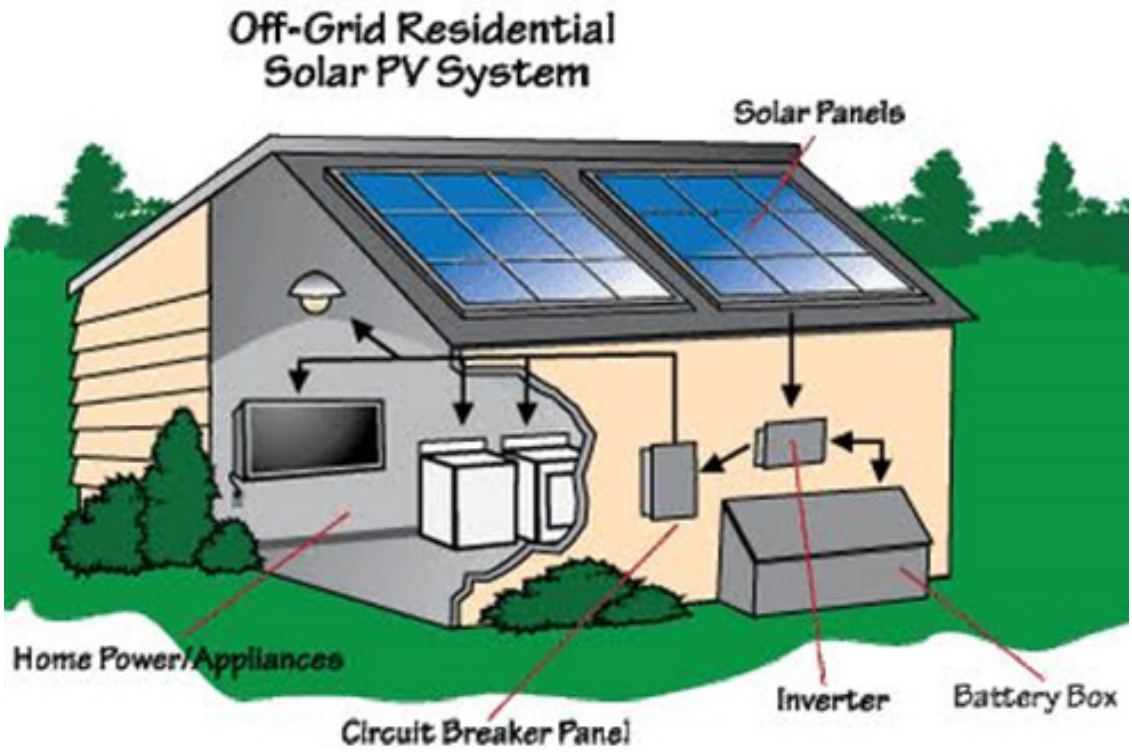
Home solar systems are arguably the most common type and a terrific way to ensure power during blackouts, reduce your electricity bill, or be ready for a devastating storm that might kill the grid and kick us back two centuries.

An advantage home systems have over most others is the availability of space. Unlike with mobile systems, you have ample room at home to install panels, inverters, and batteries, such as using part of your garage.

Home solar systems often allow the additional perk of connecting with the grid. Technically, systems installed over remote cabins or cottages are also home solar systems, regardless of whether there is a power grid. Let's move ahead and look at some installation insights.

Installation Insights

Here is a typical off-grid home solar system:

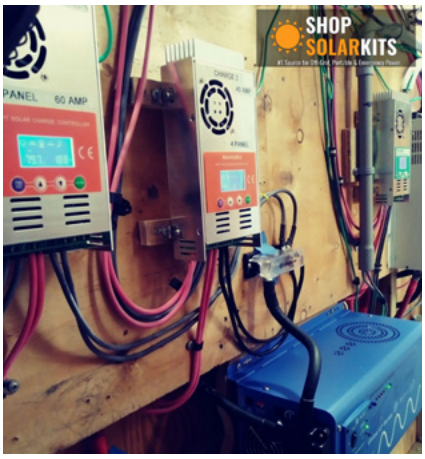


The above image is simply a pictorial representation of the wiring diagram we have seen previously in the book.

The image here illustrates a typical installation pattern, but there are ways to customize things to your needs. Let's look at a few ideas.

- Panel mounting:
  - The roof is often the best place for this, but you can also install the panels on the ground. This installation is useful when there isn't enough roof space or if most of it has a shadow, but there is sufficient space on the ground, such as in the backyard. An advantage here is the ease of cleaning.

- Other components:
  - As for the other components, since they don't have to collect sunlight, you can place them anywhere. Mounting the inverter and charge controller on a wall is a common practice.
  - If wall-mounting is not feasible, you can also get a ply sheet, drill some holes into it, and mount the inverter and controller on it, making the installation more robust and avoiding entangled or damaged wires or ports.
  - In any case, place your panels, batteries, charge controller, and inverter close to each other since longer cables tend to have more losses, especially DC cables.



- Optimization:
  - The most significant advantage of home solar systems compared to mobile applications is space availability. You can also optimize the space to minimize your solar power requirement. For example, you can set up a solar thermal unit instead of heating water or air using solar electricity.
  - Some people also prefer to use a diesel generator for occasional larger loads, saving money on panels and batteries. Generators are also an excellent addition for the rare event of a multi-day power outage. It does not make sense to spend more money on batteries for an event that may happen once every few years.

Portable & Mobile Solar Systems

Open any social media platform, and you will find a few people living what they call "van life." In a world that is so large, complex, and vividly beautiful, it makes sense that some people don't want to live in a single spot their whole lives. And it certainly makes sense to carry some sort of a home with you on long adventure trips to remote places.

A significant challenge when "living" in a vehicle is access to energy. Although the vehicle can power a few items through the battery, the van battery is powered with gasoline or diesel, which makes it an expensive way to use your laptops and refrigerator throughout the day. Additionally, vehicle batteries can only store a minimal amount of energy.

Enter portable solar power, a literal boon for van dwellers. DIY, off-grid mobile solar systems are a hit among RV enthusiasts. The same stands true for people spending a lot of time on boats or yachts or even living on them.

Installation Insights

- Maximum solar panels:
  - When installing a system on an RV or a boat, it is often better to just install as many panels as can fit on your vehicle since space is limited compared to, say, the roof of the house. You will probably not end up installing more panels than you need, so you can save time on some calculations.
  - Another reason is the unpredictability of sunlight based on where your vehicle is parked or facing. The angle of panels is also not as optimal throughout the day as on a home solar system. Panels with a similar rating will generate less power on an RV than on a house, making it even more critical to overdesign.

- Panel installation:
  - You can install solar panels on the roof by drilling holes to mount racks where you can mount the panels. You can use simple Z-style mounting brackets for the same.
  - You can also find racks with adjustable tilt mechanisms to improve sunlight collection.

- You must seal the holes in the racks with a sealant once you install them to avoid rainwater coming into the van.

- Flexible panels:
  - Another option is to use flexible panels. You can simply place these on the roof, eliminating the need for drilled holes or extra racking. Flexible panels are also great if you want an aerodynamic installation. These are, however, a bit more expensive.

- Wiring:
  - We recommend using weatherproof roof cable entry glands for routing the wires.

- Battery selection:
  - Weight is an essential criterion for RVs, so using lead acid batteries isn't great. Lithium batteries are much lighter than lead acid batteries and have a higher depth of discharge, meaning you get more storage in the same battery bank size when using lithium. Additionally, they last much longer, making the extra cost worth it in the long run.

- Wiring your loads:
  - Using a fuse block for an RV or boat makes a lot of sense on the loads side. A fuse block is a device to which you can wire multiple DC appliances. The block has numerous fuses of different ampere ratings, making it convenient to attach different-sized loads. For the AC loads, simply install a distribution panel with standard wall ports near your desk or bed.

- Optimization:
  - You can optimize energy for RVs to make the most of your solar system. For example, having a fan instead of AC makes a massive difference in consumption, especially a roof vent fan that pushes hot air outside. You can also add a floor vent fan to pull in cooler air; you will just need a filter with it.
  - Something as simple as painting your vehicle white can also have a noticeable effect.
  - For heating, electric seat heaters and blankets work better than space heaters, and you can also explore passive heating if you are parked outdoors.

***Pro tip:** When it comes to cabling, 10 gauge cables are the most common for RVs*

Emergency Backup Power Systems

Extreme weather events and accompanying power outages are not new to Americans. At some point, we have all lived through the unpleasant, often dreadful experience that follows extreme events like these. Take Oklahoma's ice storm in October 2020 that left 300,000 power customers without electricity - or the 750,000 in Connecticut in the same year.

And none of us can forget the winter storm in Texas in 2021. Classified as the costliest storm in the nation's history, it left millions of homes and businesses without power. But it is not just blackouts; brownouts are a huge concern, too. Many utility companies also impose scheduled or rotating outages, where consumers face a few hours without power every week, sometimes even daily.

Living without power for days or hours is a horrifying thought, and everyone needs a backup plan, aka a backup power system. Traditionally, people used generators powered by fossil fuels. The problem with these is that you still rely on fuel you don't have a reliable supply of at your home. Driving to the gas station to get fuel is not a good idea in a petrifying storm.

These machines are also noisy and polluting. You have to keep them outside, making them impractical during dangerous weather. And, of course, generators are relatively inefficient machines that cost a lot per unit of electricity generated.

This is precisely why solar power systems are gaining popularity as emergency backup systems. Technically, emergency solar systems are not much different from our regular off-grid solar units. They comprise most of the same components that a typical solar system does. The significant difference lies in their ability to run selected essential loads in the event of a blackout or a brownout.

Emergency backup systems aren't necessarily meant to run all day every day, unlike regular systems. Some people prefer to store all equipment in their basement or garage and make a quick portable installation for when a blackout hits. Many people prefer foldable panels that they can store until they need them.

Let's see some more insights below.

Installation Insights

- Transfer switch:
  - A transfer switch makes switching between grid and solar power flexible and possible.
  - As the name suggests, it transfers between where the power comes from and where it goes. This is useful in the event of a blackout, where emergency power can be

pulled from your solar system to power a specific set of appliances.
    - To do this, you can select multiple circuits (often up to four or five) in your breaker panel and connect the transfer switch. For example, you can have one circuit with your refrigerator, another with your living room lighting, maybe a fan, and so on.

- Two different ways:
    - If you don't employ a transfer switch, you will need to run separate cords for all the appliances you want to power during a power cut. Doing it this way is not impossible, but it is a little complex and not as convenient as a transfer switch.
    - The transfer switch lets you use the existing circuits in your house, saving on complexity, time, and even some equipment. The transfer switch has ports to connect it to your solar system, grid power, and even a diesel or gasoline generator.

- Works best with:
    - A transfer switch works best with a solar generator, which we discuss in more detail in the next section, as it provides an easy and portable single point of connection.

- More complex installation:
    - Note that installing a transfer switch requires more technical knowledge and expertise than installing a basic solar off-grid system.
    - Most manufacturers recommend getting help from a registered technician for the same reason.

Solar Generators - Your Simplest Off-Grid Option!

Designing and installing an off-grid solar system is complex but not complicated - literally, anyone can do it. Despite that, it is okay to feel that it is a lot of work, making you unsure about undertaking the project. Or maybe you don't have the time to build a system.

Thankfully, there's a great shortcut for having an off-grid system, and we have even discussed it in one of the previous sections of this book. Let's talk more about solar generators.

We don't know who was first to come up with the idea of throwing all the components of a solar power system into a single box (except the panels, of course). But we think it is one of the best ideas anyone has ever had.

Solar generators are rugged units that enclose the battery, charge controller, and inverter in a single,

thoughtfully designed casing with outlet ports. Some also have modern perks, like Bluetooth connectivity, wireless mobile device charging, etc.

Installation Insights

To be honest, there isn't anything complicated about generators that needs explaining. But here are a few key insights:

- Simplicity:
  - Solar generators come with readymade, clearly labeled ports for solar input, DC output, and AC output.
  - There is zero hassle of wire cutting, stripping, or joining. You don't even have to loosen or tighten bolts.
  - This also makes them ideally suited for transfer switches - a perfect duo for emergency backup systems.

- Connecting solar panels:
  - One thing to consider is the correct panel selection. Most generators have a specified voltage and current input and come with a recommended set of panels, often by the same manufacturer.
  - You can connect multiple panels to power your generator, just like we did for a traditional system. Just be sure to check the feasibility for the same in the product manual/description.

- Truly portable:
  - Solar generators do not need clamping or installation on walls or ply sheets. They are portable in the true sense of the word and even come with handles for carrying.
  - Many models also come with wheeled carts for easy movement, especially those with heavier, higher-capacity batteries.
- Better batteries:
  - Solar generators mainly offer lithium-ion or lithium-phosphate batteries, making them maintenance-free, long-lasting, and more durable.

One of the limitations of solar generators is that, for the same size, they can be more expensive than a system built from scratch. However, if cost is not a significant concern for you but time and simplicity are, this is your best choice.

Another limitation of solar generators is the limit on their size. These devices are designed primarily for portability, not for large home systems. Connecting multiple solar generators to make them work for more extensive requirements is possible, but we don't feel it makes much financial sense.

MODULE 6

Maintenance and System Care Tips

Fortunately, one of the biggest pros of a solar power system is its relative lack of maintenance. These systems virtually have no wear and tear due to the absence of moving parts.

But there are still a few simple things you will need to attend to.

1. Cleaning Solar Panels

The cleaner your system's solar panels, the more power they churn out. Ideally, you should clean them every few weeks, but it depends on how dirty your panels get. Though it is easy, it may be a more frequent task in dusty areas. You can wash the panels with a water hose and then wipe them clean.

Panels on an RV may need more frequent cleaning, given that they are usually not as inclined as a stationary system. Avoid spraying high-pressure water on junction boxes or other connections/joints when cleaning panels with a water jet.

2. Battery Maintenance

Modern batteries, particularly lithium ones, do not require much mandatory maintenance, especially compared to older lead-acid batteries. However, it is good practice to check your battery's voltage as frequently as possible, even daily.

If you have a solar generator that you are storing for emergencies, we recommend cycling it at least once every six months. Just take it out, run the TV or fridge off it for six to eight hours, recharge it from a wall outlet, and put it back into storage. Doing so ensures good battery health and a routine system maintenance check.

Your charge controller will display the battery voltage, but you can also check it manually using a voltmeter/multimeter if you want to be 100% sure. The voltage reading for a fully charged battery bank will be equal to or slightly higher than the rated voltage. For example, a 48 V bank should show 48 to 52 V on the meter.

For mobile systems, take care that your battery bank is neatly secured. Battery terminals are relatively more exposed than other components and have a risk of short circuit, even from something as simple as a wrench dropped on a battery. If your batteries are tall with a smaller footprint, consider securing them with a rope.

3. Periodic Full-System Maintenance

Complete system maintenance may sound time-consuming, but it isn't. Once in a year, or even every six months, check every connection. If possible, shut down the system, disconnect all wiring, clean it with a brush, and reconnect. Doing so will improve system performance as well as extend its life.

Check any leaking chemicals, wires tampered by rodents, etc., every few months.

MODULE 7

Applications & Insights

Application Ideas (EVs, Well Pumps, Pools, etc.)

In the previous section, we covered the main areas where people commonly use off-grid solar power systems, but that does not mean these are the only three or four rigid system types. Application-wise, each of the above system types can serve many different purposes. Let's look at some interesting applications for off-grid systems you might not have thought of.

1. Electric Vehicle Charging

A common argument against EVs is that they indirectly use fossil fuels. The best way to combat this is to use a solar power system, making it truly zero-emission. Plus, you are literally able to use your car for free.

Your home has more than sufficient space to install enough solar panels to recharge your EV's battery.

Some people have also installed solar sheds with an integrated charger, providing the dual benefit of a shelter for your car plus free power.

EVs come in different capacities, and there is no one-size-fits-all for EV charging. However, now that you have learned the super-easy calculations for solar

panels, you can treat your EV like any other appliance and calculate based on the energy it uses per day in kWh.

Let's look at an example. An average EV could have a battery bank that stores about 40 kWh. Let us go back to our formula:

Power required in panels (kW) = Energy required per day (kWh) / peak sunshine hours (h)

Suppose you are in a part of Texas where you have five peak sunshine hours every day. Therefore,

Power required in panels (kW) = 40 kWh / 5 h = 8 kW

Yes, it is as simple as that. Once you have these numbers, everything else is as per the steps we discussed in the previous sections.

If you are looking for a system that powers only your EV and nothing else, then you can use a smart EV charger instead of a regular one. A smart charger often eliminates the need for an inverter. It can also optimize the charging to prioritize solar while drawing power from the grid.

2. Well Pumps and Sump Pumps

The second most basic necessity after energy in an off-grid setting is water. Those connected to the water network won't need to think about this, but water arrangement is a critical task for truly off-grid locations.

Even if you live by a pond or a stream, you still need to bring that water to your taps and bathrooms. Thanks to water pumps, water management is pretty straightforward.

When there is an unreliable grid power or no grid at all, how you use water pumps makes quite a difference. The intuitive way to do this is to connect your pump to your solar power system, like all other appliances. There's one catch, though. A typical AC solar pump pulls a lot of power (along with a spike when starting)

and only operates for a short period. So, you have two choices: overdesign your panels or do not use any other loads when running your pump. The first choice is expensive and not-so-logical, while the second makes a bit more sense, although it is slightly inconvenient.

Another method is to install a separate solar pump system. A solar pump system is different from a regular pump connected to solar. It usually employs a DC motor, which improves efficiency while reducing noise and reduces the need for longer cables and an inverter.

Solar pumps boast several advantages over traditional pumps:

1. They are cost-effective. A custom system often costs around $2000.
2. They are usually modular, and you can increase the capacity whenever needed.
3. They are easy and cheap to install and maintain.

Ultimately, the choice is yours if you want to optimize your usage with some inconvenience or spend a little more and not worry about power sufficiency.

All the above-discussed points apply to sump pumps, too, since they are very similar to well pumps.

3. Small Mobile Businesses

Off-grid systems aren't limited to residences. Physician clinics, farmer's market stalls, ice cream shops, and virtually any small business can be powered using solar. Even a tiny lemonade stall where you need 10W power to charge your phone.

The steps involved are the same: calculate energy consumption, check sunshine hours, calculate battery and panel size, and wire everything together.

4. Crypto Mining

One of the most exciting applications recently, crypto mining, can benefit tremendously from solar due to its high energy consumption.

People tout cryptocurrency as the currency of the future, and though we aren't experts in blockchain tech, we know that solar is a perfect power source to meet your heavy energy needs.

Many enthusiasts are getting into crypto mining, and utility companies often charge homes heavily when they surpass rate slabs. As such, mining crypto using grid power can cost a lot, sometimes even more than in industrial areas with different pricing structures.

For instance, mining one Bitcoin takes over 1500 kWh, a humongous amount of energy. The average time to mine one Bitcoin is about 30 days, with an average consumption of about 50 kWh every day, equal to or more than what a typical household consumes.

You might need a solar array of 12 kW or more for the same. Suppose you have enough space to install panels of this size. In that case, you can save significant money while making it much more environment-friendly, addressing the most critical drawback of crypto-mining.

5. Air Conditioners

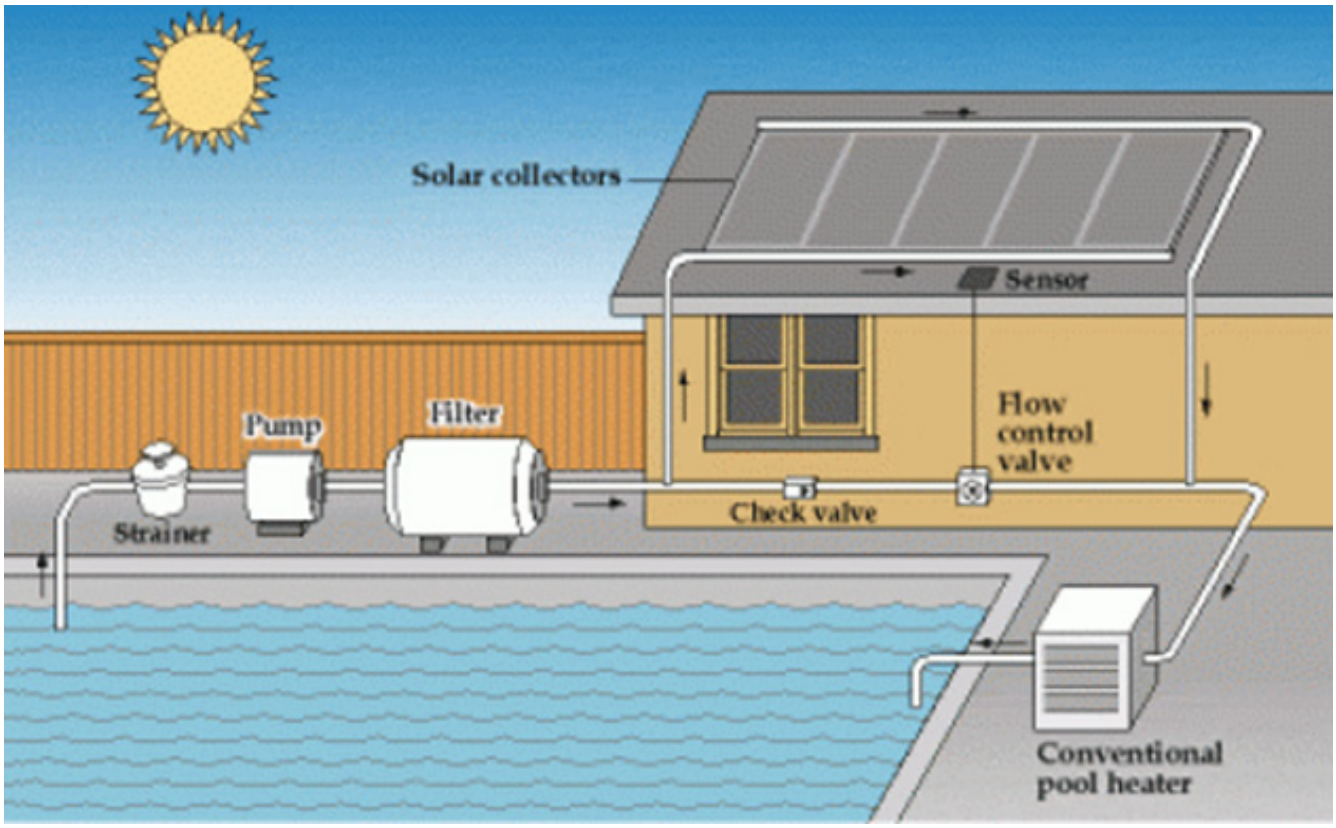
Few people have pleasant, comfortable climates year-round. The rest of us need to stay cool in the hot summer months, which is where air conditioners come in.

Most homes in North America have a centralized air conditioning system, which you can power using solar if you install sufficient panels. Air conditioning is generally a power-hungry beast, gulping multiple kWh in a matter of hours.

If you don't use your AC year-round, you may not need to include it in your solar calculations and spend more on your system. Just use some grid power. But if you live entirely off the grid, you must include your AC.

There are ways to optimize climate control devices. For instance, a mini-split AC instead of a centralized one requires less power since it will only be cooling a room instead of the whole house.

Whenever possible, using passive cooling also saves a lot of power. You can use fans instead of ACs for cooling and save huge amounts of electricity. For reference, ACs use hundreds, sometimes thousands of watts of power, but fans usually need just 50 or 100 W.



- Source: U.S. Department of Energy

6. Pool or Pond Heating

Few things are as relaxing as a warm pool in the backyard. But making and keeping the pool warm is tricky, and choosing the perfect way to heat it could be problematic.

Let's begin with electric pool heating. An electric heater uses a resistance coil running on electricity to generate heat. You can run one of these on solar, but resistance heaters are notorious for drawing massive amounts of power, and it might not be such a great idea.

Why convert the sun's energy into electricity and then back into heat if you can use the heat directly? Doing so saves the losses incurred in two different conversions. Solar thermal pool heaters employ an array of solar water heaters on a roof or the ground next to your pool. You can also use a conventional pool heater in tandem to heat the pool in the absence of sunshine.

Use the following image, cite "U.S. Department of Energy" as source

You can also opt for a smaller version of the solar thermal water heater. It is much more portable in nature and far cheaper than the one you can install on your roof. Although it is not as powerful, it is still an excellent option for smaller pools or slightly warmer temperatures.

Appendixes

Appendix A: Average Load Calculation (Hourly)

What Are Your Goals?

A common mistake people make is to think of solar as a standardized commodity, like a car or a TV. When it comes to solar, there is no one-size-fits-all. The best type and size of the system depends on several factors, bringing us to the following worksheet, which can help you get a clearer idea of what your solar system should look like.

Read each question and answer by simply circling an option from the following two columns. Then look at a quick meaning of your answer in the next row. An “insight” section provides information about each answer.

Once you have gone through all the questions, you will have better clarity on how big or complex your system will be and what the cost will look like. It will also help you follow the book more easily.

	Question	Answers	
1	How many appliances are you looking to power?	**A few**	**Many**
	A few - smaller system Many - larger system **Insight:** Remember that your system size is directly proportional to the power drawn and, hence, the number of appliances. The fewer the appliances, the smaller the system.		
2	Do you plan to operate heavy appliances (air conditioner, heater, pool heater, baking oven, etc.)	**Yes**	**No**
	Yes - larger system No - smaller system **Insight:** Heavy appliances consume large amounts of power, e.g., an AC can use up to 3000 W compared to only 50 W of a fan. So you would need an extensive system, increasing the cost with it.		
3	How much space (or roof space) do you have for installing panels?	**Limited**	**Ample**
	Limited - smaller system Ample - larger system **Insight:** Building off of the previous question, the more appliances, the higher your power requirement, and the more space you need for panels. You may have insufficient space if you operate too many loads in a small area.		
4	Where are you located, and what are your peak sunshine hours?	**Low**	**High**

	Low - larger system High - smaller system **Insight:** Simply put, sunny areas with longer days generate more power. For instance, a system in Arizona generates more power than a similar-sized one in Michigan. The better the sunshine hours of your location, the smaller system you need. To find the data for your location, just Google “peak sunshine hours in <your city’s name>”.		
5	Do you have an existing backup generator?	**Yes**	**No**
	Yes - fewer batteries No - more batteries **Insight:** Getting solar panels does not mean you have to get rid of your diesel or gasoline generator. It can come in handy when there’s insufficient power generation and storage for a few days, extended grid power outages, or if you live in a remote place and throw a party, needing twice the power your solar panels are designed for. If you have a backup generator, you may save on some of the battery costs.		
6	Do you plan to use this system regularly or periodically, such as on weekends?	**Everyday**	**Periodic**
	Everyday - larger system Periodic - smaller system **Insight:** Naturally, the less frequently you use a system, the fewer panels you need. For example, a weekend system will need batteries for two to three days and just enough panels to charge those batteries in four to five hours.		
7	Do you want the system to be tied to the grid?	**Yes**	**No**
	Yes - fewer batteries No - more batteries **Insight:** A grid-tied system means you can use grid power whenever there isn’t enough sunshine or juice in your batteries. In this case, you can opt for fewer batteries, reducing the cost.		

Load Calculation

Each of your appliances consumes power in watts. The first step is adding up the wattages of all appliances. For this, you will have to know how many watts each device consumes. One way to know this is to use the following table. It covers the most common appliances used in a typical North American home.

Appliance	Wattage
Room light	20-50 W
Coffee maker	600-1200 W
Microwave oven	1000-1500 W
Toaster	1200 W
Refrigerator	500-750 W
Washing machine	500-1000 W
Household fan	50-120 W
Mobile phone charger	10-25 W
Desktop with monitor	200-400
TV 50”	100-150 W
Well pump ⅓ hp	750 W
Air conditioner	1000-1500 W
Dishwasher	1200-1500 W
Laptop	100-150 W

Fridges usually don’t use the rated power continuously. They shut down when they reach the preset temperature and start again when it starts rising. Also, most fridges use lower power than specified, so if your calculation yields a high number, you can disregard some of your fridge’s consumption.

You must be wondering which value to select for those appliances with a range in the table and what to do if you have an appliance not listed here.

Well, there are two more ways to find appliance wattage. First, almost every electrical device has a sticker with basic information about power consumption. Look for a value followed by W or kW or denoted as power. Here’s an example:

Second, once again, the internet comes to the rescue. Just enter the appliance name and model followed by the words “power consumption” or “average wattage,” e.g., “LG 270 liter single door refrigerator average wattage,” and you will find the value. For more straightforward appliances like mobile chargers or smaller LED lamps, approximate values should work fine as long as the load does not constitute a large portion of your total consumption.

Your intuition might tell you that you must now add up all the appliance wattages and look for the equivalent-sized solar panels. And that would work - if all your appliances operated non-stop and you had continuous sunshine for 24 hours.

Power is a unit strictly showing consumption or generation in one hour, and it does not provide sufficient information on its own; hence we need to calculate energy. In the real world, you use one device for an hour and another for twelve, while the sunshine levels fluctuate during the day.

We have a worksheet below you can use to list all your appliances and add up their energy consumption values to find a total daily consumption value. Let’s look at a quick example to get a clearer idea of how to use it.

Appliance	Wattage/ power consumption (W)	Quantity	Hours of use (h)	Total energy consumed per day (Wh)
LED lights	25 W	6	5 h	750 Wh
Laptop	150 W	1	8 h	1200 Wh
Fans	60 W	3	4 h	720 Wh
TV	200 W	1	4 h	800 Wh
Coffee machine	800 W	1	0.25 h	200 Wh
Refrigerator	800 W	1	6 h	4800 Wh
TOTAL				8470 Wh

For further calculation, it is easier to convert the final value to kWh by simply dividing 8470 Wh by 1000, giving us 8.47 kWh. Before we move to the further calculations, it’s your turn to do step one.

List every small or big appliance you need to power. Naturally, consumption can’t be uniform throughout the year, but try to get as close as possible to the average hours of operation, and you should have a decently accurate system size. You may also be designing a system for a recreational van or a small cottage. In either case, the procedure is the same: start with listing appliances and adding wattages.

Alright, here comes your table:

Appliance	Wattage/ power consumption (W)	Quantity	Hours of use (h)	Total energy consumed per day (Wh)
TOTAL				

Appendix B: Wiring a Battery Bank

Battery Bank Connections

Working from a wiring diagram might feel intimidating, but it is actually quite simple. Looking at the wiring diagram of a solar system is similar to looking at the map of a new place. You don't need to understand or memorize the whole map at once. Just focus on the next point of your trip. Similarly, installing and wiring a solar system is pretty easy as long as you focus on connecting one item to the next, one at a time.

One thing to always take care of is connecting cables correctly. Every part of an electric circuit has a positive and negative side, known as its polarity. Unless you are connecting batteries or panels in series, you should always connect +ve to +ve and -ve to -ve. A common way to ensure this is to use colored cables, usually red for positive and black for negative.

National Electrical Code
Allowable Ampacities of Insulated Conductors Rated 0-2000 Volts

As Excerpted from the 2002 National Electrical Code

Ampacities of Not More Than Three Current-Carrying Conductors in Raceway, Cable or Earth. Based on Ambient Temperature of 30°C (86°F)

SIZE AWG OR kcmil	Copper Conductors			Aluminum Conductors		
	Temperature Rating of Conductor			Temperature Rating of Conductor		
	60°C	75°C	90°C	60°C	75°C	90°C
	TYPES TW UF	TYPES RHW THW THWN XHHW USE	TYPES RHH RHW-2 XHHW XHHW-2 THHW-2 THHN THWN-2	TYPES TW UF	TYPES RHW THW THWN XHHW USE	TYPES RHH RHW-2 XHHW XHHW-2 THHW-2 THHN THWN-2
14**	20	20	25	-	-	-
12**	25	25	30	20	20	25
10**	30	35	40	25	30	35
8	40	50	55	30	40	45
6	55	65	75	40	50	60
4	70	85*	95*	55	65	75
3	85	100*	110*	65	75	85
2	95	115*	130*	75	90*	100*
1	110	130*	150*	85	100*	115*
1/0	125	150*	170*	100	120*	135*
2/0	145	175*	195*	115	135*	150*
3/0	165	200*	225*	130	155*	175*
4/0	195	230*	260*	150	180*	205*
250	215	255*	290*	170	205*	230*
300	240	285	320	190	230*	255*
350	260	310*	350*	210	250*	280*
400	280	335*	380*	225	270	305
500	320	380	430	260	310*	350*
600	355	420	475	285	340*	385*
700	385	460	520	310	375	420
750	400	475	535	320	385	435
800	410	490	555	330	395	450
900	435	520	585	355	425	480
1000	455	545	615	375	445	500
1250	495	590	665	405	485	545
1500	520	625	705	435	520	585
1750	545	650	735	455	545	615
2000	560	665	750	470	560	630

Secondly, always use the correct cable size. Cable size is generally governed by the current that flows through it. Use the below table that shows the correct cable sizes based on the current flow and temperature.

You can also use an online cable size calculator tool for the same. If you do not know how much current will flow through a wire, go back to the basic power equation and find the current value.

W (power) = V (voltage) x A (current)

Therefore,

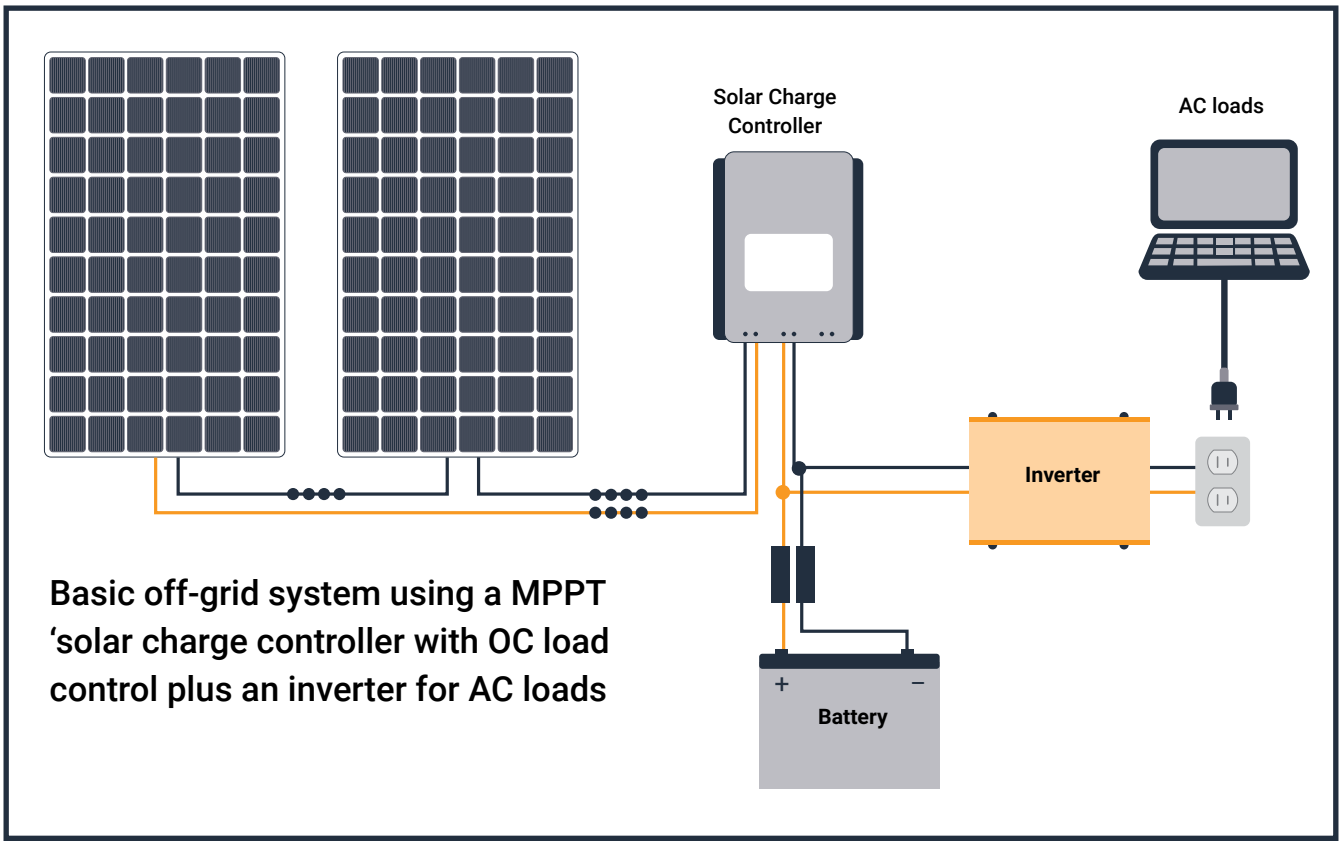
A (current) = W (power) / V (voltage)

For example, for 1000 W power flow at 24 V, the current value will be

1000 W / 24 V = 41.66 A.

Pro tip: *If possible, go for higher voltage and lower current configuration in your system. Cables do not need to be thicker for higher voltage, and you will reduce losses and save money*

Alright, here comes the wiring diagram for a typical off-grid solar system. When installing your system, you will look at this diagram many times, so make sure you understand it perfectly.



Basic off-grid system using a MPPT 'solar charge controller with OC load control plus an inverter for AC loads

Let us work on this step by step.

Wiring the Batteries

Your battery bank voltage primarily depends on the input voltage of your inverter because your battery outlet is your inverter inlet. If you choose an inverter with 48V DC input, your battery bank must produce 48V power.

Batteries are traditionally available in 12V, but thanks to a large spectrum of modern equipment available today, you probably will not need to handle multiple 12V batteries and connect them to create, say, a 24V or 48V battery bank. There are three main options you can choose from:

Option 1 - Solar Generators

The simplest possible option is to get a solar generator unit with a battery, a charge controller, and an inverter in a single casing. In this case, you would connect the panels to the generator on one end and your load to the generator on the other. Often, connecting is a piece of cake thanks to readymade ports and plugs, eliminating any wire cutting and stripping.

The only drawback here is that solar generators are available in limited sizes and can often be more expensive for the same capacity. We discuss this in more detail in one of the book's final sections.

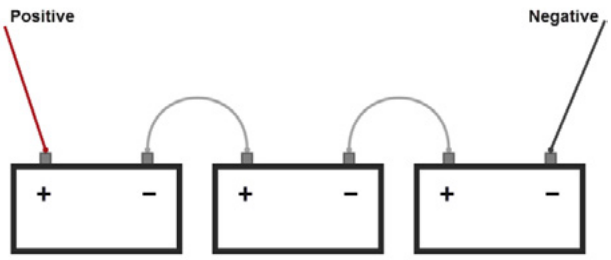
Option 2 - Batteries with Required Final Voltage

Although 12V has been the standard size, you can get a battery box with your final desired voltage. For example, buying a 24V battery bank instead of two 12V ones. Here, you will have ports on the battery for the charge controller on one end and the inverter on the other.

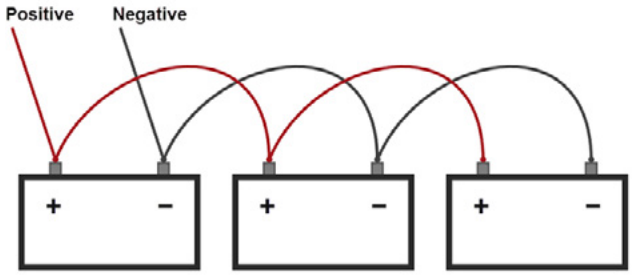
Option 3 - 12 V Batteries Connected Together

In the unlikely case that you get more than one 12V battery and your system voltage is higher than 12V, you will have to connect them to add up the voltage. Here's where we learn about series and parallel connection (and it will also be helpful for panel wiring!).

Imagine you need to store 4 kWh of energy and choose three 1 kWh 12V batteries. Your inverter input voltage is 48V. Here, connecting the positive terminal of one battery to the negative of the next, and so on, leads to adding their voltages. This is called "series connection". Here's a simple image explaining the same.



Sometimes, you may need a higher storage capacity (kWh) but not a high voltage. In this case, batteries are connected in parallel, which increases the current (and hence kWh capacity) while keeping the voltage the same as a single cell. Here's how to connect in parallel:



In most cases, you will need a series connection or a combination of series and parallel. Let's look at an example. Say you have eight 1 kWh 12V batteries, and you need 8 kWh 48V. If you connect all of them in series, you will end up with 8 kWh (with low current) and 96V, where the voltage exceeds your requirement. If you connect them in parallel, you will have 8 kWh (and high current) but only 12V output.

Neither of the above options is feasible since we either exceed the voltage or do not meet it. And that's why we choose a combination of series and parallel. We connect the number of batteries in series that gives us the required voltage - in this case, four batteries, making a "string" of 4 kWh 48V. We make two such strings and connect them in parallel, giving us 8 kWh and 48V.

When connecting traditional batteries to each other or to other equipment, you will need to strip the ends of cables, attach crimp connectors, and bolt the connector to the respective terminal. Here's an image showing these steps:

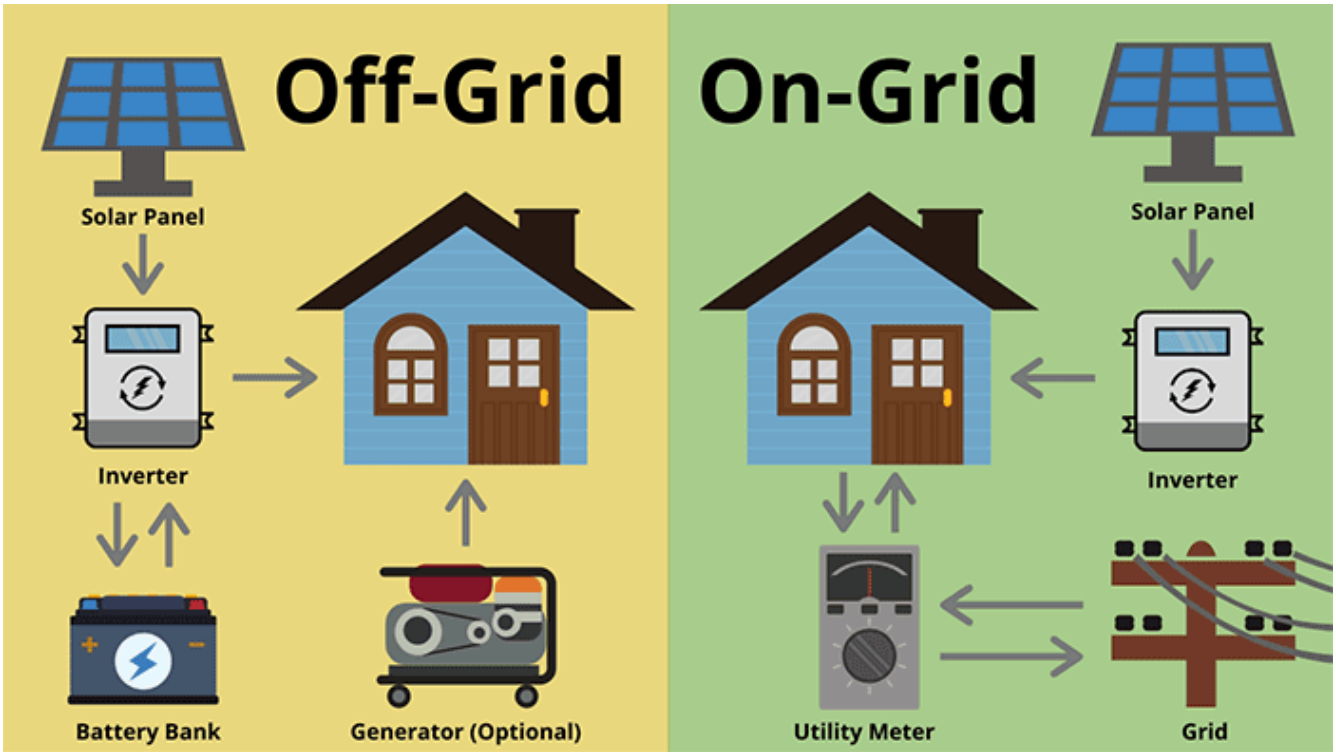
Be sure you place your batteries in a dry location. Conductive fluids, most commonly water, can lead to serious short circuits, damage to equipment, and sometimes even fires.

Appendix C: Grid Tie vs. Off-Grid Solar

Grid Tie vs. Off-Grid Solar

I quickly want to cover the differences between the solar power most of us know and see on a daily basis vs. off-grid solar power systems.

grid. There's no independence with these systems; it's simply a way to utilize the real estate on your roof to generate a bit of beer money. No one is getting rich selling solar power from their residential home back to the grid.



The Difference Between Off-Grid and On-Grid Solar Energy

- Source: www.paradisesolarenergy.com

Grid Tie Solar

When you drive down the road and see solar panels in residential neighborhoods, chances are 99% of these are grid-tied solar systems.

With this setup, people slap panels on their roof and then "sell" any power they make back to their local utility company. They will also be without power if it goes out since these systems connect directly to the

Off-Grid Solar

Off-grid solar means you are NOT dumping juice back into the grid. All that juice goes into your stand-alone battery bank and pulls power from the battery to run your appliances.

You could add a battery to a grid-tie system giving you the ability to be either on-grid or off-grid, thus giving you some independence when the grid goes down, but this is known as a sort of hybrid system.

The off-grid systems we're interested in learning about and sizing here have nothing to do with the grid. They could hypothetically suck the juice from the grid to recharge your battery bank during cloudy times. Still, realistically, most people use a fuel generator as a backup for their off-grid solar systems.

To go back to the bathtub analogy, the main difference between these two systems is that instead of dumping the water you're making into the local utility's pond that you don't own or control with a grid-tie system, with off-grid, you dump all that precious water into your own bathtub.

Why Do I Even Need a Battery Bank?

You might be wondering, why do I even need a battery? What is the battery for? I wondered the same thing when I was first starting, and to answer that question now, I simply ask, *"How are you going to power your appliances every single night when the sun goes down and it's no longer shining on your solar panels?"*

And I find it sort of clicks for people. You use your battery every night after 5 to 6 pm when the sun stops shining. So from that point on, you're running on battery until 8 or 9 am, when the sun is back up and hot enough to start producing a meaningful amount of juice.

What Does an Off-Grid Solar System Look Like?

There are three main parts: your solar panels (array), battery bank (storage), and power inverter. There are many other electrical components like cables, fuses, bus bars, etc., but don't worry about those right now. **They are not crucial for helping you understand how to size the perfect solar power system for your needs.**

Below is what a typical system arrangement looks like. Don't worry; we'll go over every single component and connection in detail. This image is meant to serve as a primer, to give you a rough idea before you begin, and maybe even to get you a little excited on this journey!

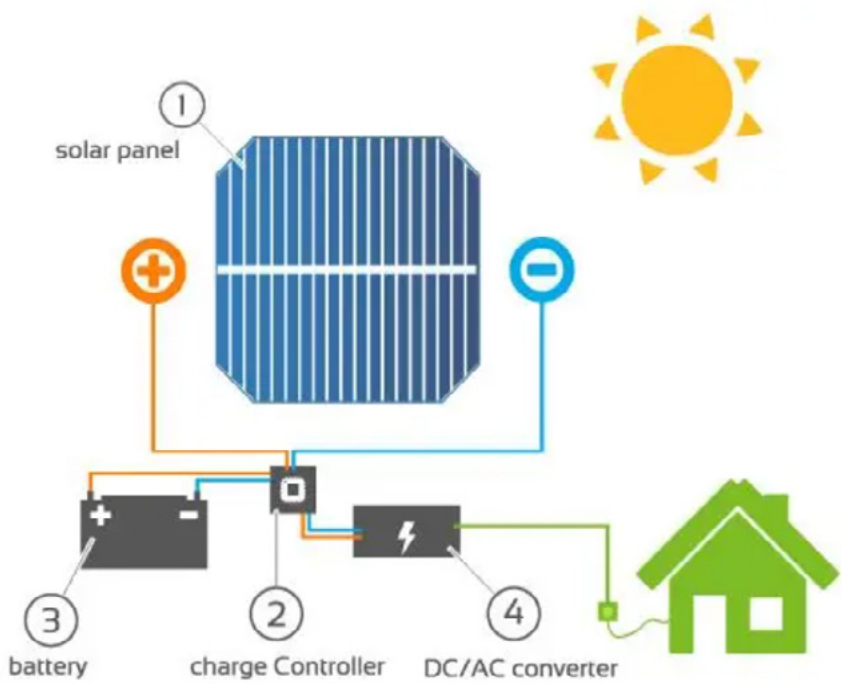
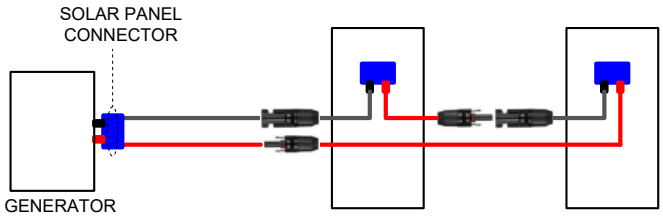


Image showing a off grid solar system pushing power directly into a battery - Source: www.solarreviews.com

Appendix D: Example Solar Generator Kit - Panel Diagram

WIRING DIAGRAM:
2 X SOLAR PANELS CONNECTED IN SERIES



LEGENDS

MC4 FEMALE:

MC4 MALE:

POSITIVE WIRE:

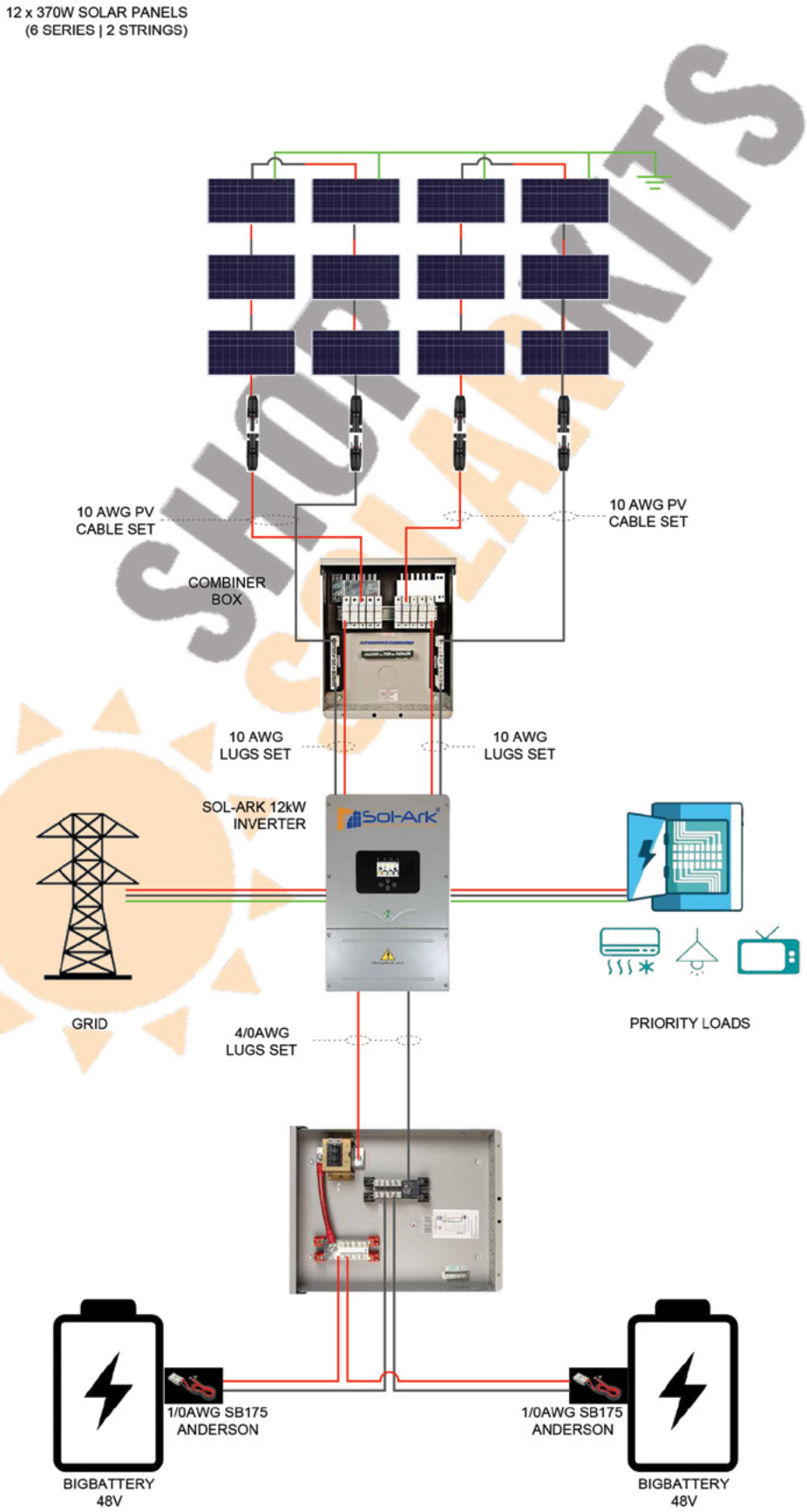
NEGATIVE WIRE:

USE FOR SOLAR PANELS:
-100W, 12V RIGID
-100W BRIEFCASE
-200W, 12V RIGID
-200W BRIEFCASE

IMPORTANT NOTES:

- Both panel output wires usually comes in black. Just make sure to connect with right polarities.
- Make sure to follow diagram for your intended use.
- PV output can be extended using PV cable extensions. Use one (1) extension on every two (2) pieces of briefcase type solar panels.
- Female connectors must be connected to Male connectors and vice versa at all times. Use this as your guide when connecting cables.
- Ensure that connectors are properly secured and connected to avoid gaps or loose connections which might lead to poor production or in extreme conditions, might heat up and cause fire.
- SOLAR PANELS NOT LISTED HERE SHOULD BE VERIFIED FIRST IF COMPATIBLE WITH THE ALLOWED INPUT IN THE MANUAL OF SOLAR GENERATORS

Appendix E: Example Custom Solar Kit - Schematic Diagram



Appendix F: High-Level Off-Grid Solar System Parts Lists

The previous sections discussed the equipment required and the specs and features, but nothing beats a good list, so we have compiled one with all the recommended parts for the three main system types.

1. Home or Small Business Systems

- Monocrystalline solar panels
- MPPT charge controller
- Pure sine wave inverter
- Lithium batteries
- Mounting racks
- Cables
- Fuses/Circuit breakers
- MC4 connectors
- Busbar/combiner box
- Lugs

2. Portable or Mobile Systems

- Monocrystalline solar panels
- MPPT charge controller
- Pure sine wave Inverter
- Lithium batteries
- Mounting brackets
- Fuses/Circuit breakers
- Cable glands

3. Emergency Backup Systems

- Monocrystalline solar panels
- All-in-one solar generator
- Mounting racks
- Cables
- Transfer switch

About ShopSolarKits.com

We are a small, fast-growing company on a mission to disrupt the solar industry. How? By ripping down the barriers to adopting a cleaner, more independent way of living through education, simplicity, and affordability.

As our massive electrical grid infrastructure becomes less and less reliable, we believe our energy future lies in smaller, flexible, more independent power sources. This mindset also informs how we've built our company. Our team of 20+ people is dispersed all over the world and works hard every single day to help more people like you live a more sustainable lifestyle and achieve grid independence.

Originally founded in Canada, we quickly expanded into the USA and have grown to become the nation's #1 source for mini off-grid, portable, and emergency backup solar power. Since 2018, thousands of customers have come to know us for our extremely affordable prices, legendary customer service, and rapid shipping.