Off-Grid Solar Power

The DIY Guide for Beginners to Design and Install a Mobile Solar Power System for Cabins, Vehicles, and Tiny Houses

Easy Survival Press

TABLE OF CONTENTS

Introduction
Chapter 1: What Is Off-Grid Living?
Advances and The Future
Chapter 2: Pros and Cons of Off-Grid
Advantages
Disadvantages
Chapter 3: Types of Mobile Systems
Monocrystalline Solar Panel System
Polycrystalline Solar Panel System
Thin-Film Solar Panel System
Chapter 4: What Is Needed
Load & Watt Hours
Amps and Peak Sun Hours
Tools
Components
Chapter 5: Where to Purchase
Online Options
Brick and Mortar Options
Chapter 6: Energy Calculation
Calculation Examples
Chapter 7: Design, Build, and Install
Chapter 8: Routine Maintenance
Required Maintenance
Optional Maintenance

Glossary
Terms
DIY System Components
Panel Components

Current and Future Advances

Introduction

Congratulations on purchasing Off-Grid Solar Power: The DIY Guide for Beginners to Design and Install a Mobile Solar Power System for Cabins, Vehicles, and Tiny Houses , and thank you for doing so. There are plenty of books on this subject on the market, so much thanks again for choosing this one! Every effort was made to ensure it is full of as much valuable and accurate information as possible.

Off-grid living is wildly popular among several individuals across the globe. You find various groups online dedicated to the off-grid way of life. Whether it's living in a tiny home, moving across the country using a skoolie or converted vehicle, or living by the sea on a houseboat, people en masse are seeing and utilizing the significant advantages of mobile units. Combined with rent costs rising in all areas and the housing market not being as kind to a number of those looking for a roof, going to a smaller and simplistic off-grid lifestyle has become more appealing. However, with all alternative lifestyles, there are advantages and disadvantages to the changes. We will briefly discuss those and also draw them in comparison to the more traditional on-grid living systems. There are also financial and environmental aspects to consider when moving towards this way of life, which we will briefly cover within this text.

Speaking of the financial aspects, we'll go over where to purchase items needed, either online or in-store, to build your system. We'll also explore what you will need to install your new system in your different units. Having the correct components and knowing how to maintain them will be an essential aspect of your new journey. We will go over the various components and items in detail and calculate the correct energy expenditure needed for your different units. We'll also compare each system in what situation you are needing, as no two mobile systems are precisely the same. By the end of going over all these aspects, you'll be able to help determine what you will need for your unit, how to install the said unit, and how to maintain it to have the longest-lasting effect.

Many different technical terms will also be thrown at you during this reading, which can seem overwhelming and demanding. To ensure there's no confusion over anything covered, I've included a glossary of all the technical terms contained at the end of the book. The glossary will describe the term itself and provide any necessary examples needed. Along with the terms' glossary, equations and formulas have also been included to ensure the right product and components are purchased for the suitable portable power unit you're looking to create.

If you're a beginner that's looking to invest yourself in this lifestyle fully, you've found the right book. This guide will help you in every aspect along the way. Thank you again for your purchase, and please enjoy!

Chapter 1: What Is Off-Grid Living?

Off-grid living is the ability to maintain a homestead without the need for publicly managed utilities, such as gas, electricity, and water. While this is a bare-bones definition, off-grid living can still mean a variety of different things. Over the years, we've seen a gradual evolution of what the term actually means. In the beginning, living off-grid was seen as more of a highly rural way of life. This was due to having to live off of no electricity at all, using springs or wells instead of water connections, and having no access to gas. It was more of a survivalist way of living and not precisely a neat way to live today. However, in recent years we're starting to see changes to this theory.

Continued evolution to technology on renewable energy has afforded many modern comforts to those who choose to live a simpler life. This has allowed individuals that live in more rural areas to live out their minimalist dreams with the added comfort of improved sustainability. As having a completely self-sufficient homestead becomes more appealing, individuals are instead ditching the traditional way of life. The option of downsizing to a smaller home, RV, skoolie, or houseboat is looked at as more cost-effective than the conventional means. We've also seen the rise of self-sufficient communities in states such as

Oregon, Missouri, and California. The popularity of off-grid living is growing exponentially.

Now, this isn't to say that living off-grid will be glamorous. There still will be some modern conveniences that will need to be sacrificed. We'll go over more of those in the next chapter in the disadvantages of the switch. Even with the advances, it begs to question why anyone would decide to go this way of life. It would seem like life on the grid would be much easier. Many different factors lead to this decision, and some may be a bit of a surprise.

In recent years, the issues with rising housing costs and maintenance and fluctuating rent prices have led others to look at alternatives. In addition to self-sufficient communities in general, we're seeing an emergence of tiny homes owned by individuals in some cities. Instead of buying larger homes or being stuck in a rental contract, individuals are opting to downsize to a smaller, more simplistic layout. Also, along the same lines, we're seeing more converted vehicles, such as RVs, skoolies, and houseboats, being used more frequently.

The skoolie phenomenon, van living, and converting RVs have caused an uptick in the mobile solar unit trend. As more of the skoolie communities and dwellers become popular on various social media sites, the intrigue to move to a simplistic yet nomadic lifestyle has been peaked by many. Coupled with the pandemic leading to more jobs going to being at home, this has caused many people to want to be more adventurous now that they have the ability with remote working.

Now that we've gone over off-grid living and a few reasons why people are making the switch, let's go over exactly how mobile solar power systems and some of their general components work.

HOW DOES MOBILE SOLAR Work?

So it does beg to question, how does a system of this caliber actually work? Why it's due to photovoltaic or commonly known as solar These panels generate power by absorbing sunlight and converting it into electrical energy through semiconducting materials or solar A cell is typically small, has a relatively small thickness, and produces about 1-2 watts of power. A mixture of glass and plastic protects these cells to withstand the hazards of nature over time. As outdoor hazards, such as heat, dirt, and shade, play a factor in energy absorption, this protection is precious to the cell. These cells are then connected together to form a larger power-generating unit or the panel. This process is done to boost the power of the cells.

A panel's ability to absorb sunlight and convert it to energy, or its photovoltaic energy is based on its The semiconductor is made of material that conducts electricity but needs the energy provided to it. In this case, sunlight will be the energy source. The main semiconductor used in solar cells, and most electronics for that matter, is silicon. As an abundant element that's found in sand, it's relatively inexpensive to find and manufacture. This silicon must be refined, however, before it can conduct electricity.

It goes through a chemical process that breaks it down into crystalline This is used to create the wafers within the cell to conduct electricity. This wafer is then processed on both sides to separate the charges, creating a diode. A diode is a device that allows the current to flow in one direction. The maximum efficiency level, theoretically, is around 32%. This is based on the portion of sunlight a silicon semiconductor can absorb above the bandgap or the behavior of electrons in a state that's not possible to form conductive bands.

The semiconductor then transfers that energy into negatively charged particles, called These electrons flow through the semiconductor as an electric current. This is due to layers of the cell, which are designed to extract the direct current from the semiconductor. The direct current then travels through the grid-like metal lines or contacts wrapped around the cell's diode. This allows the current to flow easily. Panels can be used individually or connected together to form what's called One or more of these arrays are then connected to the charge controller.

The charge controller will be one of the most integral parts of the mobile solar system. Its purpose is to regulate the power of electricity to the batteries for maximum output, but without damaging or overcharging them. It achieves this by switching any excess power to a load resistance. This helps tremendously in the maintenance portion, and it helps regulate the load of your energy absorption and reduces the wear and tear on your batteries. The controller does its work between the panels and the battery, so having the correct size is vital.

The voltage, or difference of charge between two and or the rate at which the charge is flowing, are the major parameters when making the selection for this device. The reason is that the controller must secure the maximum power produced by the panels while delivering the proper DC voltage and charging current to the

BATTERIES. WE WILL discuss this more in detail in Chapter 4 when we deep dive into the components needed to build the system.

Batteries are the heart of any mobile solar system. This is where energy is stored, once regulated by the charge controller, and can be used at leisure. While the panels generate energy during the day, the batteries store an excess that's generated to be used at night. These batteries are also charging during the day, which allows for continuous usage. The most common battery on the market currently is the lithium-ion There are also lead-acid which are the oldest form, and flow which have become popular in recent years for home solar systems. We'll take a much deeper dive into these components in Chapter 4, focusing more on the lithium-ion and lead-acid varieties.

An inverter is another integral part of the system. Its purpose is to convert the direct current from the cell into an alternating which is needed to run appliances and electronics. In alternating current, electricity flows in both directions as the voltage changes from positive to negative. The job of the inverter is to regulate this and ensure stability when appliances for a given time. As long as the panel is still receiving sunlight and the circuit is connected, the electricity will continue to be generated. The inverter accomplished this feat by rapidly switching the DC input back and forth. This results in an AC output being created. For off-grid, however, there are other factors to consider. There's no grid to draw from as energy created will be from the panels. Because of this, factors such as sun hours, average energy consumption, watt, and negative watt hours will all need to be calculated when determining which inverter to purchase. We will take a deeper dive into this further in Chapter 4.

Advances and The Future

The advances of solar energy and its technology are continuing to evolve as we speak. Researchers and scientists are developing more ways to make solar power more efficient, cost-effective and leave less of a carbon footprint. Researchers are achieving this through the development of multijunction solar cells , which are stacks of semiconductors. This device allows for absorption from a separate part of the solar spectrum, which allows for greater use of sunlight given as opposed to the current single-junction cells. Since different spectrums of light are absorbed by each layer of the cell, less energy is lost. Researchers have yielded efficiency rates as high as 45% with these new solar cells through this discovery. However, production of these has proven to be costly and difficult, so they are only in the observation and research stage at this time.

Other advances to the panel technology are also being researched. One, in particular, is quantum dot solar These are cells that conduct electricity through semiconductors that are mere nanometers wide. This provides a new way to create semiconductors, and it's a simple process to convert them into solar cells. They can be placed on nearly any surface because of their size, and they can capture any light that most semiconductors are unable to. Not to mention, cells can add multiple to other larger semiconductors to increase performance. The main obstacle with these is that it's difficult to create an electrical connection between them, rendering them inefficient.

Bifacial solar panels are emerging for their unique build. While most panels only have cells on one side of the panel, these pioneering panels will have cells on both. This allows for less sunlight being wasted, as the sunlight being reflected from the ground can also be generated into electricity. These panels also move along with the sun, maximizing the amount of light available for the most absorption. Studies have shown that this technology has yielded a 9% efficiency increase over traditional one-sided panels.

Another unique technology is concentrator photovoltaic This technique uses curved mirrors to harness solar energy cost-effectively. The panels themselves concentrate the sunlight on their own, so a large number of cells aren't needed. This lowers the cost in production, as more high quality cells won't be needed to build them.

Perovskite cells are also being looked at for their high absorption rate, relatively low cost, and ease of manufacture. However, the compounded crystalline substance has proven too unstable at this point to use on a large scale. The by-products of said cells also carry a high toxicity level, which also puts a hindrance on its production. This particular cell is still being highly researched by several scholars and scientists in the solar community. As many advances have been made on the compound, as it's been researched for close to the last two decades, there are still many more advances to be made before this particular cell can be mass-produced.

Organic photovoltaics are also being developed. These are carbon-based, solution-pressed compounds that can be dissolved. This lowers cell fabrication costs. OPVs work similarly to LED technology, as they use organic molecules and polymers to conduct and generate electricity. OPV devices also have the option to be either different colors or completely transparent. This is due to the molecules being able to be customized to different properties. This serves to be huge as it has led to different forms of solar absorption, such as through windows or walls or building-integrated The primary issue with this technology is the lifetime of the device and the limit of the effects of aging on the product.

The last bit of future technology is dye-sensitized solar The unique, five-layer thin-film cells use a special sensitizing dye to help with the flow of electrons. This helps in producing the current to conduct electricity. A huge advantage of this technology is that it has the ability to perform admirably in low-light situations. This also increases as the temperature rises, making efficiency better the more direct sunlight it receives but doesn't hinder in lower light situations. The main issue with these panels is in low temperature situations; they tend to freeze or perform lower to the point of being inoperable.

With all-new technologies being developed, there are growing pains. However, we can't say that strides aren't being made for continued improvement. This serves to show that the solar market is one that will continue to prosper over the years. As new technology continues to be brought forward, more advances will be made to ensure better quality off-grid living and solar energy consumption. With these new developments underway and the current technology that's at our disposal, it's safe to say that there's no limit to where solar technology will go. Because of this, off-grid living is and will continue to grow in popularity. In the next chapter, we'll take a deeper dive into the advantages and disadvantages of off-grid living.

Chapter 2: Pros and Cons of Off-Grid

Now that we have a bit of an understanding of what off-grid living is and how it works, let's discuss the advantages and disadvantages of switching to this particular way of life. We briefly touched on a few of these in the previous chapter but will go a bit more in-depth in this one. As stated prior, there are plenty of pros and cons to consider when switching to the off-grid lifestyle. You'll learn plenty in this journey, but there will be growing pains along the way. We'll first go over the advantages of the lifestyle and touch on some gained knowledge while living it.

Advantages

There are quite a few advantages to the off-grid lifestyle. First and foremost is the freedom of mobility and versatility. Having a portable solar power system affords you the benefit of having electricity in nearly any situation and location. This is due to the system itself collecting and storing solar energy during the day that can then use at leisure. With grid-style power, this luxury isn't afforded. To use the power that's being paid for, one must be in their dwelling. Also, with traditional grid services, things such as inclement weather could cause the utilities to fail. These fails are avoided with off-grid due to the energy storage. Having this storage also prevents blackouts, which are a concern in various parts of the country with on-grid services.

Another huge advantage is the lack of a utility bill. Grid power is a constantly running source set by a corporation that will fluctuate in price. These fluctuations can occur for any reason, whether due to the demand of other consumers on the grid, a change in how the system is maintained, or the provider's discretion. Solar power is a renewable resource that's collected at no cost to the consumer other than to build the actual system. With no middle man to charge for the energy stored or consumed, there's no price fluctuation. The builder is in control of how much power is generated, stored, and used. With these kinds of calculations, one can determine if they are paying for what they are using and not paying just to pay.

Living off-grid also affords several different living options that on-grid living can't provide. With the portability aspect, not only can those who choose it can live in seclusion, but this also gives traveling an option. This allows for a recreational vehicle, mobile tiny home, or skoolie conversion living. Not to mention, the many different design options for tiny homes on today's market make changes to the lifestyle that much more intriguing.

The lack of carbon footprint on the environment is yet another large advantage to this adaptation. It's long been known that solar energy production and usage yields a much less adverse effect on the environment at large. There's no burn-off of fossil fuels or hazardous chemicals to produce or refine the product, and it comes from a renewable resource that's readily available on most days. Other forms of energy, such as coal or nuclear energy, produce either a waste by-product that's difficult to impossible to dispose of or produce greenhouse gases that cause havoc to our ozone layer. Going off-grid reduces both of these effects immediately. Over a 30 year period, scientists determined that over 178 tons of carbon dioxide can be deferred just off of one single solar panel.

In addition to reduced adverse effects on the environment, living off-grid provides more of an appreciation towards it. Individuals begin to learn more about the environment by living in this lifestyle than they ever learned before. Simpler life allows you to appreciate what the earth has given while learning more about her gifts. Most people who change to this lifestyle say that they feel a bit more enlightened because of it.

Not to mention a huge selling point to the change, a survivalist instinct is gained. You're required to live more off of the land itself than using modern or conventional means. These learning experiences will be fruitful in the long run, as you'll be able to defend and depend on yourself in the worst of situations.

With all the advantages that are afforded to going off-grid, it is fair to mention that it isn't for everyone. As stated in the previous chapter, there will be some sacrifices that will need to be made to achieve the goal of maintaining an off-grid lifestyle. It's very important to consider what you may be giving up to make the switch. We'll explain some of the disadvantages below in detail and discuss some of the sacrifices that may need to happen to live it efficiently. We'll even look at some of the emotional and psychological aspects.

Disadvantages

One of the primary disadvantages to the initial changes is the start-up costs to begin the transition. Though switching will pay for itself over time, most individuals will find themselves dropping a lot of cash for panels and components. Not to mention any maintenance issues or replacements that need to be done will be at the owner's expense. Coupled with construction costs or having to pay for the dwelling of choice, it does add up after a little while and can be overwhelming at first.

If living the solo life, off-grid can be a bit lonely. Seclusion does sound nice, but there will be a point where running into someone from the general public will become scarce, possibly more than anticipated. You'll have to get used to doing everything on your own, including tasks you may not have considered before. This can add a further strain to what you are trying to accomplish, if not considered fully. This can also work the same way if the dwelling that's being considered is a traveling one. Time on the road can be quite lonely, and you may feel a bit more secluded than you wanted to. Occasional communities may be found and are becoming more popular, but they're still miles away from their on-grid counterparts. There just aren't that many people hitched to the lifestyle, but there are more being added per day. It is also worth noting that those within these communities create long-lasting relationships with each other, however.

There are also laws to be considered when going into the life of off-grid living. Not every state is keen on the lifestyle and does have restrictions or regulations that need to be adhered to. In terms of the dwelling, there may be building codes or size requirements that have to be met. Though you may want a particular size, the state you want to consider may not allow it. There are also certain off-grid mainstays, such as rainwater re-purposing or composting, which may have regulations placed on them as well. These regulations can vary from state to state, so it's highly recommended to reference your local government's laws before considering going off-grid in the area. You never want to be caught unintentionally breaking any laws. This will lead to a considerable amount of unwanted problems.

There are a lot of logistic disadvantages when it comes to off-grid living. Certain things won't be able to be found out on the road or living in the middle of nowhere, so knowing your surroundings will be vital. This means knowing exactly where the nearest store, hospital, or even truck stop will be needed, or this may make roughing it in comfortably a bit more difficult. This situational awareness includes knowing the road surroundings. All paths traveled won't be the safest. Be sure to be confident in where this journey may end up going, as preparedness for everything will be key.

Included in knowing the surroundings is being aware of emergency situations. Off-grid living is truly disconnected from most of civilization, which can render individuals vulnerable to accidents that most individuals on the grid would be able to solve immediately. Living off-grid can leave you susceptible to lost signals of cellphone and dead zones for internet usage, which can be seen as a burden for most. This takes into account the emergency situation issue, as contacting authorities would prove very difficult if not impossible. Police or any form of law enforcement is in the jurisdiction of that area also needs to be considered. It's recommended to have a radio or some form of secondary communication to avoid this kind of mishap. A scanner or weather radio may also be a viable option.

As stated previously, there definitely are plenty of advantages and disadvantages to living the off-grid way of life. There are plenty of things needed to sacrifice in order to live it, but there is also plenty of freedom related and environmentally friendly reasons to do so. It's a lot to consider when making a life-altering change such as this, and it's not a decision to be taken lightly or with little to no thought. One must take a lot into account and determine if this lifestyle is truly one to pursue. However, this guide will provide its valiant effort to give the best and most detailed descriptions, guidelines, and installation instructions to make the transition as smooth as possible. Now, let's move forward to the next chapter, which will discuss the different types of systems.

Chapter 3: Types of Mobile Systems

Though a lot of systems can be similar, none of them are truly the same—especially when building your own unit. In order to start, however, you'll need a way to retrieve your energy to convert. Determining the type of system to build will depend on the type of solar panels that are being used. Though all of the panels essentially do the same job, each one is different based on the style of cells used to manufacture the product and the overall efficiency of said panels. The three primary types are monocrystalline , polycrystalline , and thin-film solar panel systems. Each one has its own set of advantages and disadvantages, though all are good choices for building your DIY system. The one you choose to use for yours will be dependent on these factors.

While these are the main three currently, several other technologies are being developed, as we discussed previously. These included: organic solar cells, bifacial panels, concentrator photovoltaics, dye-sensitized solar cells, and quantum dots. The technology is definitely looking bright, no pun intended, for future systems. For now, we will go over the primary panels and describe their differences, advantages, and disadvantages in detail. We'll start off with one of the more popular types on the market today. That would be the monocrystalline systems.

Monocrystalline Solar Panel System

Monocrystalline solar panels are the oldest technology in the solar game. As these panels are the first generation in solar technology, there are still older versions of these panels from the 1970s in existence today! The average lifespan of these panels is 25 years, but some have survived as long as 50 or more, giving them the longest lifespan of any other panel on the market. This primarily comes from its construction, which is also how they get their name.

Monocrystalline solar cells each contain a silicon wafer that is made of a single crystal of silicon. This is achieved by using a seed crystal that is placed into a vat of molten silicon at high temperature, called the Czochralski This method also leads to a distinct aesthetic that has made this particular panel a very popular buy. These can be identified by their unique cell shape, which resembles a square with the corners cut, and their white, silver, or dark black colors.

Monocrystalline panels are the most efficient of other panels, offering an average of 17-22% in efficiency ratings. This means they absorb more solar energy in less space and produce a higher output than the other panels listed. This also comes down to the construction of the panel. Because only a single crystal of silicon is used, this allows electrons to move more freely within the cell. This free-moving action makes photovoltaic cell efficiency higher and requires less space to reach a given power capacity. If limited roof space is a concern, these panels will be the most efficient as they require the least amount of space to produce the same energy.

In comparison to the other panels, monocrystalline panels also work best in low light and high heat situations. This makes these particular panels ideal for less than sunny days. Even in low light, their absorption rate is a bit higher than their counterparts. This also means that their heat resistance is more so than other solar cells. If travel leads you to areas where you'll encounter extreme temperatures, these cells will be best in the journey ahead.

While these panels are highly efficient, they do come with their downsides. The cost to produce these panels is extremely high. Manufacturing of these cells also leads to a lot of wasted materials due to the heating of the silicon to produce the crystals and wafers. When in the production process, as much as 50% of the material is lost in cutting. This contributes to the higher production for the manufacturer, which in turn works its way to the consumer. It's one of those situations that you get what you pay for. They will be highly efficient, but they will also cost some money to attain. This also leads to production being slower for these panels. This is due to the meticulous nature in which the crystals must be made.

While the energy created is clean and renewable, the production of the panels does have an adverse effect on the environment. Production of these panels contributes to the highest carbon footprint than the other panels listed. It also leads to a lot of wasted materials as by-products from manufacturing. Researchers are still developing ways to reduce the amount of waste and emissions in the production of these cells due to their popularity. However, there's still research to be done on this matter.

While these cells perform well in low-light situations, the rise in temperature can lead to some efficiency issues. Some researchers have reported small amounts of loss in energy absorption can be related to temperature fluctuations. This is more related to rising temperatures. However, it's been reported that this efficiency loss is minor compared to other solar cells.

Though these cells and panels are built with the best protection in mind, they are still susceptible to damage and loss if encountered with debris or dander. It's highly important that these cells are properly maintained to avoid such situations. Snow coverage can also play a huge factor in efficiency ratings. Traveling to areas where this weather is encountered may not be ideal if using these cells. It goes back to knowing the surroundings ahead and making sure to plan accordingly.

There also can be circuit issues with these panels. This occurs if the panels are in a shaded area for an extended period of time. The best way to avoid this situation is to have these panels located where the most direct sunlight can be achieved. Anything beyond this could lead to issues down the road, possibly including energy efficiency and absorption issues.

Even with all their advantages and disadvantages, monocrystalline solar panel systems are still the most efficient and popular cells available on the market. Various brands are available, and they can be found most often in department stores. Given their efficiency ratings and generation ability with limited space, these are the most go-to panels for a lot of would-be off-grid enthusiasts. These aren't the only panels available, however, as we still have others to cover. Next, we'll look at next in the solar panel generation, polycrystalline panels.

Polycrystalline Solar Panel System

Polycrystalline solar panels are the second oldest technology in solar panels. These are also in the first generation but have a slightly different build than their monocrystalline counterpart. Like the name implies, the polycrystalline solar panels require multiple raw silicon fragments together to form square molds. Another difference is that the silicon is put in the molten vats to cool instead of using only one crystal. This process causes multiple crystals to form. Since these are made with multiple crystals, electrons flow in relatively less space. This manufacturing is what causes its distinct, speckled look and blue-colored hue.

Polycrystalline panels are cheaper to produce than their monocrystalline counterparts. This is due to their easier makeup, as being made of multiple silicon materials makes construction cost-effective. This also means that there is less waste during manufacturing. Most of the silicon materials are used and not burnt off for refinement, unlike the chemical process for monocrystalline panels. There are also fewer fossil fuels involved in their manufacturing, which means less of a carbon footprint to create them. Their design also plays a part in their lowering of waste. Since each wafer isn't required to be individually shaped and placed on the panel, there's less waste production.

Because of the construction of these solar panels, electron flow is difficult to achieve. This leads to a lower efficiency rate of 15 to 17%. However, new technology is being developed for this, and higher efficiency panels are said to be in production soon. Quality improvements to these panels have also pushed the standard 60 cell panels from 240 watts of power to 300 watts! These panels also have a decent lifespan to them, almost as good as their counterpart in terms of longevity with a span of at least 25 years.

Outside of efficiency, there are several other disadvantages to the polycrystalline system. Because of the low-efficiency rate, they require more space to absorb energy. This can be a huge drawback for those looking at smaller systems, such as an RV or tiny home. It may be difficult to attain the same power output for all the needs of the dwelling to be met, or creativity may be needed to use the space granted.

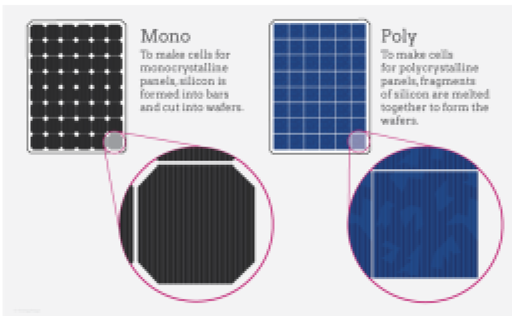
Temperature issues also play a factor in the stability of the product. High heat works adversely with these particular panels and may lead to additional wear and tear that wasn't originally expected. The maximum heat tolerance for this panel is 85ºC, relatively low compared to its counterpart. The minimum temperature is -40ºC to compensate, however. Other outdoor hazards, including debris, snow, or objects falling, could also lead to some constraints.

Retailers have also noticed that aesthetics play a factor as well. In comparison to the monocrystalline panels, which offer a little variety and have an eye-catching appearance, the polycrystalline is seen more as an eye-sore. With their usual matte black or blue look, thickness, and speckled design, most customers usually aren't placing that on their potential home. Coupling that with the look itself normally clashes with roof or shingle designs adds to more of the frustration with the aesthetic.

While there are disadvantages to this system, they are pretty minute in comparison to the monocrystalline system. Efficiency is a big factor, but more research is being done to improve the rates and absorption ability. Recent studies have shown that, with recent advances, polycrystalline systems have the ability to absorb up to a 22% efficiency. This proves to be very beneficial to the consumer.

In addition, the lifespan, cost, and lack of carbon footprint offer a lot to think about in terms of choosing. They offer a lifespan similar to the monocrystalline, aren't nearly as costly, and don't provide any waste in production. While you may give up some efficiency at first, they may make up for it in the long run.

We've broken down the two older forms of solar panel systems. Both of those have definitely been intriguing and give a lot to think about. There is a third system; however, that also deserves a breakdown. Let's take a closer look at the thin-film solar panels.



Thin-Film Solar Panel System

Thin-Film solar panels are the newest solar cells on the market, as they are second and third generation solar systems and only date back to the 1980s. Thin-film panels, just like their previous counterparts, get their name from their construction. These panels are made by placing a thin layer of a semiconducting substance, normally no larger than a micrometer, onto a solid surface. These semiconducting elements are highly absorbent of solar energy, which is why only a thin layer is used. The primary surfaces used are normally glass, plastic, metal, or other malleable surface. The substances normally used for these types of panels are amorphous silicon , cadmium telluride , copper indium gallium selenide , and gallium arsenide . Though these are viewed as different 'types' of panels, they all fall under the thin film panel category. We'll briefly go over each of these types.

Amorphous silicon cells are the oldest panels on the market. These are the panels you commonly used in watches and calculators for photovoltaic capabilities. This type of silicon is noncrystalline, which sets it out from its other counterparts. This makes this panel cheaper to produce and manufacture. There are also no toxic effects from the production, and the source is abundant, which adds to the popularity of this particular type. They have a relatively low-efficiency rate, however.

Cadmium telluride panels are the most common type of panel in the thin film type used in installations. The reason is due to the relatively inexpensive cost to produce them in comparison to other thin-film types. They also produce the lowest carbon footprint and the quickest payback or the time it takes for a panel's solar generation to cover cost and installation, than any other thin-film counterpart available. The water usage is also very low with these panels compared to all other panels in the market, which makes them more cost-effective to manufacture. There is a toxicity issue when manufacturing these panels, however.

Copper indium gallium selenide panels are very unique, as they use a separate semiconductive used for thin-film cells. The material used has yielded impressive efficiency rates, almost comparable to its mono and polycrystalline counterparts. However, these panels are usually more costly and aren't normally used in the market due to this. Gallium arsenide cells are also primarily by NASA and satellite companies. Similar to CIGS, Gallium arsenide also produces high efficiency rates. In the same vein, the manufacturing costs are also extremely high.

Outside of the naming standpoint, these panels are vastly different from the others. Thin-film panels are a solid black color and are noticeably free of the cell outlines that are normally seen on mono and polycrystalline panels. These panels are usually lightweight and flexible, which makes them easier to install. This provides a huge advantage to those looking to place panels in areas that may have been virtually impossible before. For example, if you've seen any of the extremely flexible or sticker type solar panels on the market, it's a thin film panel style.

A huge advantage to these panels is the quickness with which they can be produced. Because the refining process isn't needed, like in crystalline silicon panels, and there are a variety of ways to produce them, manufacturers are able to mass produce them faster and cheaper than their other counterparts. Because of this, a rise in their popularity has begun.

Their relatively low cost, in comparison to their two other counterparts, has played a huge factor. Thin-film panels are, at this point in time, the cheapest panel available to the market. Even less expensive than the polycrystalline models. This cost-effectiveness has led to more of these styles of panels being available on the market. Major brands as big as Sanyo have joined in on the thin film market. The addition of a major brand, accompanied by their relatively low cost, has added to the growing appeal of this particular panel.

A big disadvantage to these panels is their environmental impact and toxicity. Some of the materials, namely cadmium, are hazardous chemicals that can have adverse health and environmental effects. This ingredient can be harmful if inhaled or ingested and has water and soil toxicity properties. Recycling these panels would be the best way to avoid these issues; however, the technology to achieve this has not yet occurred. As more of these panels get produced, the risk of toxicity happens to grow. There are promising results on developing a less toxic version of this style in the future, however.

While the cost for these panels is relatively low now, they may see a rise over time. The usage of rare materials to create the cells, namely cadmium telluride, copper indium gallium selenide, and gallium arsenide, can potentially limit the production of larger amounts of the panel. This leads to a downside as precious metals and rare materials are extremely hard to come by. With the three other cells in production being made by these, it doesn't bode well for the future of those particular solar cells.

Another huge drawback is the efficiency rating for these panels. In comparison to the two other counterparts, the thin-film panels offer the lowest efficiency of any panel on the market. A few years ago, these efficiency rates were in the single digits, and recent developments have current market thin-film panels at 10 to 13% efficiency. Compared to its other counterparts, this is a considerable drop-off. This low efficiency rating means these panels will require the most space to produce the most energy. While they are cheaper to purchase upfront, they cost more to maintain in the long run. Researchers, however, do have prototypes in development for better absorption. At the last test, the record showed that current prototypes were yielding just over 23% in efficiency. These are prototypes, however, and are still not quite ready for the market.

The last huge drawback to this particular panel is the relatively low shelf-life in comparison to the other panels. Because of its malleability, this panel becomes susceptible to the dangers of life rather easily. They don't have the same density as the monocrystalline or polycrystalline models and are more prone to rips and tears due to the materials used. Though it isn't common, as a lot of companies have placed a bit more emphasis on the structure basis, it is something that does happen. They also have a higher degree of degradability than it's counterparts. When in high use, the panels themselves degrade at a much faster rate, mainly due to the materials used. This caused efficiency issues relatively early and the need to replace them at a faster rate. This is a major drawback for those looking for a more long-haul purchase. These panels do last a little bit, but not near as long and the monocrystalline or polycrystalline.

The thin-film panels offer a third, cost-effective alternative to those looking to jump into a build but are also on a tight budget. The added flexibility of the panel also gives those more building options than may have been offered with other panels. Though efficiency is a huge factor, and some of the thin-film types have toxicity issues, it still offers another option to those who may not have had it before. Coupled with the continued research and development of prototypes, there's no telling where this technology may be in a few years. In fact, researchers believe that thin-film technology has the ability to overtake monocrystalline and polycrystalline panels at the rate it's being developed and tested. However, we are still years away from this happening.

As you can see, each of these systems definitely has its advantages and disadvantages. The primary aspect to think of when selecting is which is going to give the best efficiency and output for the least amount of wear and tear. Price will also be a factor, as budgeting is important as well. There will be some extra steps that will need to be taken to achieve this, and all factors need to be considered. Decisions on components for building your system shouldn't be taken lightly, and we will go over them, in detail, in the next chapter.

Chapter 4: What Is Needed

In addition to the panels themselves, which is discussed in the previous chapter, you will also need various other components and tools to build your mobile solar power unit to perfection. Each of these will be important in your build as you want to have the correct components to avoid issues running your solar power unit. We'll go over the different batteries and their types, inverters and their sizes, and the different versions of charge controllers.

Before getting into components and tools, calculating your watt-hours, and peak sun hours will be most important. This will determine the size and type of components you will need to run the various appliances in the dwelling and the best times for energy absorption to use towards the mobile system. We will go over peak sun hours in detail, determine your load for appliances, and watt-hours to determine your daily consumption.

Load & Watt Hours

Before we dive into watt-hours, we should first discuss the difference between a watt and a watt-hour. A watt is a measure of power or the ability to do work. One thousand watts are considered a kilowatt, commonly marked as kW. A watt-hour is the amount of work done over a certain period of time or a measure of energy. A kilowatt-hour is similar but is based on 1000 or more watts. To help in calculating your watt/kilowatt-hours, you'll need to know your load amount.

Load is the list of items you want to run and how long you want to run them. This is imperative in terms of calculating your watt-hours, as this will help determine the number of watts needed per day to run your system efficiently. To determine watt-hours, multiply the power rating, or the number of watts of the appliance, by the time, in hours, you wish to run the device. You'll find your appliance's power rating in its product specifications. Knowing your load and watt-hours is beneficial for several reasons. Mainly, this will determine the majority of the sizes of components you will need if multiples of those components are necessary, and what type of cables to harness the energy would be needed. It is imperative to have these numbers as close to precise as possible. This will also help determine how much battery life you'll need on backup support, as well as daily support. Be sure to have a good understanding of your load before getting your items, or you may end up with components that won't fit your appliances and other personal devices.

Amps and Peak Sun Hours

In addition to knowing the watt and watt-hours, you'll also need to know the number of amps you'll need. Amps are the measurement of the volume of electrons. This will be important for the size of the charger controller needed and to determine the most efficient battery to use. To determine the amps, you'll need to divide the watts of your solar panel from the voltage of your battery or batteries. From there, you'll get the amp size needed for your charger controller. There are other calculations you can determine with getting the amps as well, such as maximum cable current output. We'll go over all of these parameters a bit more in Chapter 8.

A peak sun hour is an hour in which sunlight reaches an average of 1000 watts of energy per square meter or roughly 10.5 feet. This represents a lot of sunlight, and the average solar panel is likely only to receive that much when facing the sun directly at its strongest, which would be midday. This amount was also used to rate solar panel efficiency in lab tests. What this means is, over the course of a peak sun hour, a given solar panel should be producing, not accounting for environmental and temperature factors, at or close to its full output. To further explain: if your solar panel offers a maximum output of 400W, then during peak sun hours, it should yield 400W/m^2.

Given that we know that all days or locations won't have equal amounts of sunlight, fluctuations to this calculation will occur. This is when you have to adjust for those different locations and less-than-ideal conditions. For example, the sun isn't out as bright on one given day in the morning, only giving off about 300W/m². Whereas during midday, the sun is beaming and giving off over 1000W/m², going with 1500W/m². How that breaks down to is an hour in the morning that receives an average 300W/m² yields 0.3 peak sun hours. An hour in the midday that averages 1500W/m² yields 1.5 peak sun hours. Now, this doesn't mean that your panels will absorb the full amount given, just up to the amount of its capacity. What this shows is the amount available at these particular time periods.

Knowing your peak sun hours is also highly important, mainly because the sun will be your source of energy. Having an understanding of when the sun will be its brightest will give you a better advantage in having the energy you need. As stated, some locations have fewer peak sun hours than others, so it's important to compensate for those aspects and to calculate what you need to make up for it without having to sacrifice much of your storage bank. This also helps in knowing when it will be its hottest in areas. While direct sunlight is great for solar panels, high temperatures are not and can wreak havoc on your system. While you want to absorb, you don't want to overheat. Knowing when the sun will be at its highest and hottest will allow you to gauge the time you need to be in and make up the sun hours necessary without burning up your panels to do so.

It may seem that these calculations are complex, but once you look into them further and begin working with the numbers, the calculations become easier. Another way to help determine this is to find your area's peak sun hours. You can find this information online or through various solar energy research groups. You can also consult with your local area's conservation department. We'll also go over more examples of calculations in Chapter 8. Next, let's go over the tools you'll need to build your mobile solar power system.

Tools

There are several tools necessary in the build of your DIY Solar powered system. Be sure to have these readily available in order to build the desired mobile system properly. We'll go over, briefly, each tool that is needed and their purpose if necessary.

Cable cutters, wire cutters, and wire strippers will be a must. There will be plenty of components that you'll need to wire together and plenty of wiring that will need to be run. Having both of these tools will be necessary. A wire crimper will also be needed because of this same reason.

A hot glue gun and silicone sealant will also be needed. You'll need these items to prepare your case for your system. A case, though it could be optional, is important to maintain the system itself. The last thing needed is any debris or spillage to occur in your system. Other tools such as a screwdriver, hammer, needle nose pliers, a soddering iron for wiring, and a sander may also be used for the construction of your system.

The upside to the tools is that you won't need anything too out of the ordinary to build your system. Pretty much why this section is pretty brief. The majority, if not all, of these items, can be purchased at your local hardware store, department store, or online retailer. You may also have these tools already available or know a friend that may have them. Long story short, these tools are available, and you won't have to hunt for them truly.

We've briefly gone over the tools that are needed, and we've gone over the importance of load, watt-hours, and peak sun hours. It's now time to go over the most important elements to our build, the parts to the system itself. With our calculations known, we'll have a better understanding of which components we will need to continue. The next section will go over all components and the different types and sizes.

Components

Outside of the panels themselves, the components needed for this system are extremely vital. This section will go over each component and the different versions of each. We'll also go over the pros and cons of each as to how they would pertain to the mobile solar power system. We'll first go over the heart of the system, the batteries.

Having the correct battery is highly important, as mentioned before. Ensuring that there's enough storage for the power that's being generated and making sure these batteries are properly charging is key and vital. When choosing the right battery, there are four things to consider: lifespan, depth of discharge, efficiency, and energy density.

Since solar power is absorbed in direct current, and our electronics run on alternating current, we'll need to invert the direct current in order to store it. Because of this, you'll need to decide if you want to go with an AC Coupled battery or a DC Coupled It's important to know the difference, as each has its pros and cons. We'll go over each one in some detail.

AC Coupled batteries are the most common form that is used in solar storage. This battery takes the DC current, stores it, then inverts it to AC to use for electronics. Though it sounds efficient, there is a drawback. When AC and DC inverts, losses occur on each inversion and can add up. To put into perspective, once the panels have converted the energy, the inverter will turn that into AC, but then your storage inverter in the battery will invert it back for storage. Lastly, to use the stored current, it will need to be inverted once more. In each invert, more energy is lost.

With DC Coupled batteries, there's no need for multiple inversions. This battery stores the energy converted from the panel directly to storage without the need for the first inversion. The reason being is this battery has an internal hybrid inverter that works for both solar and storage. However, the problem with these batteries is the inverter can sometimes fail, which can hinder the performance of the battery in general. In essence, with these batteries, you're stuck with either a possible loss of energy or possible performance issues.

There are definitely pros and cons to each, but it boils down to overall efficiency between the two. Though you may suffer some energy loss with the AC Coupled battery because of the inversion process, it has to endure. It is still an efficient process that safely stores the energy needed and discharges it where necessary. With the DC Coupled battery, you have the internal inverter already equipped, so it removes an unnecessary inversion. Still, there are possibilities of the inverter failing, which could lead to losing all the power gained or not having the total power absorbed being converted. Ultimately, it'll boil down to which is more efficient for the system itself and which process you deem is worth more for the money spent.

Once a determination has been made on the current couple battery style, we need to look at the three different types as discussed in Chapter 2: lithium-ion, lead-acid, and flow batteries. We'll dive into more detail about each, with a larger emphasis on the lead-acid and lithium-ion varieties. However, the flow batteries will be discussed briefly, as well as the pros and cons of all three batteries.

Lead-acid batteries are the oldest battery type: dating back all the way to the 19th century! These are also the most commonly recognized battery types, as they are used in automobiles and other passenger vehicles. These batteries use lead compounds at the positive and negative electrodes and an acidic electrolyte, thus giving it its name. These batteries will be the cheaper of the ones available and come in a variety of sizes: from the 6V to the 48V. These batteries also come in three different types: flooded absorbent glass and gel All three batteries share very similar storage properties but are either less than cost-effective or require a bit of maintenance.

Flooded lead-acid batteries are the least inexpensive out of the three types, making their appeal very high. However, these batteries do require proper ventilation and maintenance to be used to their full potential. As these batteries are used, hydrogen build-up occurs and must be filtered out immediately. If this small bit of product care isn't utilized in any way or form, it could cause disastrous effects. Hydrogen is a highly flammable gas, and it needs to dissipate accordingly. Not doing so could lead to an explosion, which is way more of a problem than you need. With these batteries, you also have to maintain the water levels. Not adhering to the levels can lead to battery balancing issues and a potential overheating issue. You'll need to regularly check these levels and will need to change them out with distilled water every 2-4 weeks.

Absorbent glass mat batteries are a sealed style lead-acid battery. They are made with special glass designed to absorb the electrolytes between the charging plates. Because of this glass, there's no need to check or adjust the water levels in the battery. The battery also breaks down hydrogen compounds for energy, so it doesn't give out any hydrogen gas, unlike its flooded counterpart. Because of those two aspects, these batteries require little to no maintenance, other than the occasional wire check.

Gel batteries are also sealed-style lead-acid batteries. They use a special silica that thickens in an electrolyte mixture to allow the flow of electrons between the charging plates. Because of this design, there's no need to ventilate for gas reasons either. There's also no need to check the water levels for these batteries due to the gel being used instead of water. They require very little maintenance to ensure efficiency and can also be used for almost all aspects of charging or storage due to their gel-like substance for energy flow.

The main issue with the sealed style batteries is their prices. For as many advantages that they have, they are very pricey in terms of buying off the market brand new. You may be able to find a discounted used version of these online, but the price variance may not be that much different. Even with the cost, however, both of these options are still formidable to look into, given you have the budget for them.

The main drawback to standard lead-acid batteries is that they only discharge for short bursts and don't have much power density. This is why standard lead-acid batteries wouldn't be the best option for solar storage. However, with lead-acid deep-cycle a deeper discharge is achieved by design. This is due to the thicker lead battery plates that help add to the depth of discharge or the percentage of the battery that has been discharged in comparison to the overall battery capacity. The average lifespan of a deep-cycle lead-acid battery is 4 to 8 years if well maintained, whereas a standard lead-acid is 3 to 5 years in similar conditions.

The most common deep cycle batteries are ones found in RVs or boats, which are classed as recreational are fine for smaller systems. Popular deep cycle batteries are from golf carts. Though these are a bit more expensive than their recreational counterparts, they're a good choice for systems being built on a budget but still need a decent battery for storage.

Lithium-ion batteries are the most common type of battery used in solar power systems. You'll find more of these in grid-tied solar systems, but as more electric cars and carts are coming out, more of these types of batteries are being tied with them. These batteries use lithium compounds for electrodes and use the flow of ions away from said compound to store the energy, and this is how they get their name. These batteries offer a longer shelf life of 5-10 years and come in two varieties: lithium nickel manganese cobalt oxide and lithium iron

Lithium iron phosphate batteries work more like the deep cycle battery and are more used for mobile systems. These batteries also offer a higher efficiency rate and higher depth of discharge in comparison to its counterpart. They also have a long and slow charge that is beneficial in storage as well as usage in a mobile system. The main issue is the price tag. Lithium batteries are still pretty expensive to attain and may not necessarily fit into your budget.

Lithium nickel manganese cobalt oxide is the most common lithium-ion battery on the market. Large companies, such as LG and Tesla, already use this technology for home solar storage systems. Though there aren't many being used in the mobile solar market, they are beginning to emerge. This is mainly due to the cobalt compound being used. There's little toxicity in the manufacturing, and the cobalt allows for the absorption of hydrogen as opposed to releasing it. This causes less hazardous gasses to be released and producing a potential fire hazard. However, these batteries are more used in home systems and haven't quite made a foothold in the mobile arena as of yet.

The last batteries are still relatively new to the off-grid world but have been around for quite a while, the flow battery. Flow batteries are rechargeable batteries having nickel oxide-hydroxide positive plates and iron negative plates, with an electrolyte of potassium hydroxide. This is also known as the Edison Ni-Fe battery, as Thomas Edison introduced them at the turn of the last century. These batteries offer a nearly full depth of discharge and have a long lifespan compared to their other counterparts. They also offer a slower discharge than any of the other batteries and a particularly long lifespan. The issue, unfortunately, is the price for the component, which makes it a niche buy. Also, being able to find an Edison battery is very difficult. There are tutorials available online to build one, should you want to go that route.

Choosing a battery is going to come down to cost, efficiency, lifespan, and energy density. Spending the money on a lithium battery would be ideal due to its lifespan and density. However, getting a deep-cycle lead-acid battery to start may be the best decision fiscally while offering similar efficiency. You also have the option of the Edison battery, which does give a third option, but the price would again play a factor in the choice. Ultimately, whichever battery is chosen will do the job needed for the mobile system, and a battery bank of any time, if properly maintained, will work to its full potential. Next, we're going to look at the charger controller and the different versions of those.

The choice of a charger controller will come down to how well it regulates the power going to your batteries. The charger should provide maximum output for storage, but not so much that it overpowers them and requires any avoidable maintenance. Choosing the proper charger controller will be ideal for maintaining your system properly. We'll go over the different types in more detail. The two different types of charger controllers are MPPT controllers and PWM Both are similar in what they do but offer different benefits and quirks between them. There are also advantages and disadvantages to each type. We'll go over PWM controllers first.

Pulse width modulation (PWM) controllers are standard charger controllers that work by slowly reducing the amount of power as the battery approaches capacity. This charger is one of the most common among retailers and is simpler than its MPPT counterpart. It's also normally the cheaper of the two and more widely available in stores. In order to use a PWM controller, the panels you own and the batteries you're using must be the same voltage. Because of this, PWM controllers are more suited for smaller systems as, in most cases with larger systems, the main battery and the panel don't match up. If you have a system that is bare-bones and doesn't require a lot of switches, then the PWM controller would be your best option.

Maximum Power Point Tracking controllers are a bit more complex than its counterpart. They provide the same power reduction near battery capacity trait as the PWM controllers but differ in other ways. Unlike PWM controllers, the main battery and the panels don't have to match. These controllers will adjust to their input to provide maximum power from the panel and will adjust their output power to match the battery. This makes the MPPT controller more efficient than its counterpart and will more effectively utilize the power coming in from the solar panels. The caveat, of course, is the price. Because of this aspect and the complexity of the machine itself, it retails quite a bit higher than the PWM controller.

When choosing your charger controller, it will once again come down to efficiency, cost, and overall usage. The MPPT controller would be most beneficial to larger systems with more complexity. However, there are a bit more bells and whistles with the MPPT controller, which makes it more expensive as well. The PWM controller doesn't offer as many extras and has the drawback of needing the voltage of all components to be the same. However, it does do the same work as the MPPT controller and doesn't cost near as much. Once again, it'll ultimately come down to which of these controllers provides the most efficiency for the system we're building while not breaking the bank completely.

The next component we're looking over will be the inverters and their types. When choosing an inverter, there are several things to consider.

Your calculations will be very important in determining the best size and voltage of this device for your system. Determining your load plays a huge factor, and you will need to have this as close as possible to your need in order to achieve the best results. There are two separate inverters to choose from: pure sine wave and modified sine Both are very different in how they do their work, even if their names sound similar.

Pure sine wave inverters provide electrical output that is very similar to what you would find on the power grid. There are also no fluctuations as this version of the inverter provides a consistent stream of steady output. This is ideal for sensitive electronics and avoids the need to have to monitor any of your devices. There are no issues of having to worry about frequency issues or problems with using anything plugged into the mobile solar system's power.

Modified sine wave inverters have been known to cause issues with certain electronics. The reason being is because modified inverters fluctuate between positive and negative charges. This can cause issues in many different devices that run on your system's power. Motors, compressors, and pumps tend to run hotter and sensitive electronics like computers and laptops suffer damages as well. These inverters also typically cause noise in stereos and a reduction in audio and video quality in some televisions. Older tube-style televisions and older devices have no issues running on this style, however.

After conducting research and looking at various sources, the unanimous choice is the pure sine wave inverter. As technology has advanced, the need to use devices on the road and off-grid has become more evident. As the pure sine wave inverter provides a more steady stream for all the devices we need, it's a much better buy.

When choosing the correct size inverter, there are three things to consider: the input voltage, the output voltage, and the output frequency. The input voltage is the system voltage. This essentially means that all your components, mainly the inverter, panels, and battery bank, need to be the same voltage. For example: if you selected to have a 12V battery, you must then have a 12V array and a 12V inverter. The output voltage is the amount of output the inverter gives. The common output voltage is 120VAC in the United States and 240VAC overseas. Most inverters have this as a standard voltage. To keep in mind, however, there may be some appliances that may work on 240V instead of 120V. Because of this, you may either have to stack your inverters to cover both voltages or purchase an inverter that covers both voltages.

Keep in mind; these are slightly more expensive as they do a bit more work but may be more cost-effective in the long run. We also have to consider the When speaking of this aspect, we are talking about the nominal frequency of the alternating current. You would need this to be the same as on the grid. The two most common frequencies are

50Hz and 60Hz. The United States standard is 50Hz, which is what we would need for our system.

Other components will be needed to complete your build as well. Be on the lookout for copper wiring, MC4 connectors for your solar panel cables, fuses, and fuse boxes, and ground wiring, should you decide you want this option for your system. When looking at your cables and wiring, you want to ensure that you're getting the proper gauges for each system. To determine this, you'll need to divide the wattage of your total load from the voltage of your batteries. This will get you the maximum cable current output for the cable and will help you determine the proper gauge you'll need. This can be used to help find the inverter cable you'll need. We'll discuss those more in detail once we get to designing and building your mobile solar power system.

Now that we know what components to get, how to calculate your watt-hours, and how to calculate load to determine what sizes are needed, the next thing is to discuss retailers. The upside to solar energy is that it's an ever-growing market with more people joining daily. With that, this gives us the advantage of finding plenty of retailers to help us with our decisions. The next chapter will discuss these retailers a bit more and will break them down into online and brick and mortar. Let's head on over and discuss these shops.

Chapter 5: Where to Purchase

Now that we've narrowed down your components and tools, it's time to determine where to purchase your items to begin your build. Luckily, with the rise in popularity of solar technology and the uptick of independent retailers, there are plenty of places to purchase a number of these items, both online and in-store. We'll go over each option to let you know where to buy components needed, either online or in-store and where your best options for more needed items will be located. Let's start first with the online options.

Online Options

The primary online option for a majority of these components will be Amazon. This website offers the ability to order the majority, if not all, of the components and tools needed to fully design and build your system. From various components to solar panels to even the wiring, you'll be able to find it all in this one-stop-shop. eBay is also a healthy option to find the components needed. As a large open marketplace, it's easy to search for the needed component and possibly for cheaper than what you would find elsewhere. This also makes options close to endless, so finding the right size of any panel or component isn't much of an issue. Keep in mind, when ordering from these marketplaces, that new and used options may be available.

Though new is more recommended, budgets can also be tight, and going used could be a great option to save cash to begin your transition. Be mindful of a storefront or individual seller's reputation and the condition of any used product when going this route. Also, keep in mind that warranties may not be in effect or offered if going through this particular medium. This risk is higher if you're considered going with used products. Lastly, be mindful of any shipping costs and sales taxes as they can vary from state to state.

Tesla also offers solar panels and storage units to purchase online. They don't seem to offer much in the components department, such as inverters, charger controllers, or smaller batteries. Their solar panel costs are competitive to the market, which gives them an advantage in buying their brand.

There are also plenty of independent online retailers outside of the Amazon marketplace that may offer the same or similar components. In recent years, more independent companies have been springing up and offering mobile solar units and components. This is mainly due to the rise in popularity among going to the off-grid lifestyle. A few examples of companies are Solar Electric Supply, Lion Energy, and Backwoods Solar. From scouting these examples, all offer a variety of solar panels and components and deliver directly to your door, similar to Amazon and eBay. An advantage to online retailers, as opposed to an open market, is quality assurance. Most independent retailers offer warranties. Keep in mind, like with open online markets, that pricing may vary depending on the retailer, and to be mindful of any shipping costs and taxes associated.

Online, however, doesn't have to be your only option. There are several brick-and-mortar locations that also carry the components and cables needed to build your system. With them being at a shopping center, you can also have access to these items quicker than having to wait for them to be delivered. We'll go over those options in the next section and some of the pros and cons of shopping brick-and-mortar.

Brick and Mortar Options

If online isn't necessarily comfortable for you, there are also brick-and-mortar options that you can choose from, and some may even surprise you. While it may not be the first store that comes to your mind, Wal-Mart actually offers a variety of solar components and panels in-store, depending upon location. If you're unable to find it in-store at that particular location, there is an online option of site-to-store that allows you to purchase brand new online and have it shipped to the store of your choosing. Though it doesn't fully remove the online aspect, it lowers the risk of having an unwanted product. It also has the added benefit of being able to return to the same store, even if purchased through the online medium, for a quicker turnaround.

Home Depot is another brick-and-mortar option. A mainstay in home improvement and do-it-yourself, this large chain has embraced the off-grid lifestyle. Besides the panels themselves, Home Depot offers various components and tools to help you along the way. For a brick-and-mortar store, they provide a lot of the selection that some of the online markets and retailers offer. In the same vein, Lowe's is another brick-and-mortar hardware store that gives similar options. Both specialize in home improvement and do it yourself, so there's really no limit to what you may find in either of these places. Not to mention, if you have any additional questions, some of their staff may have some knowledge in the field as well.

Depending upon the state, there may also be smaller companies and electric co-ops that offer the option of mobile solar. States such as Florida, Texas, and California have various smaller companies within their state that offer these items. Smaller and smaller companies are beginning to form as well, especially in the Midwest. These smaller shops may also operate online exclusively, which may be able to widen your options should you not want to go to a big box store or a larger online retailer. Most of these places have a more personal feel and may offer more services and knowledge on top of the products.

However, keep in mind that with the smaller retailers and even big-box brick and mortar stores, the options may be limited in what you can buy at that time. Though some have online options that may have more items available, they still may not be exactly what you're looking for. There are also stocking issues with this particular option as their supply may be smaller than the demand, or the demand at their location may not be enough for them to carry that item. The best bet when going this route is to shop around at various locations and see what's available. There's a good chance you can find a better price for a particular item at one place than another, and saving money is always a plus.

With both options, you do have a tremendous amount of resources at your disposal to find the correct components you need. There's even a possibility you may luck up on some quality product for a reasonable price. Keep in mind; however, you never want to sacrifice cost for efficiency, as that will end up costing more in the long run.

With the resources afforded, it's still safe to shop around each option to determine where to buy what you need. The options are there for you to explore and research to see what fits your design, need, and budget to hit the ground running. Now that we've seen the buying options, it's time to calculate for purchases. We have to be certain that our calculations are as close to exact as we can possibly get. This is to ensure we get the proper components and items to make an efficient portable solar power unit. We'll go over all of the calculations and provide examples in the next chapter.

Chapter 6: Energy Calculation

Energy calculation for your self-built system will be the most important component of your design. These calculations will help determine how much energy and the size of the unit you'll need to run all of your items. Remember, when determining these calculations, there are four important aspects to consider: how many items will be running, how many hours they will be running them, the number of watt-hours needed to sustain them sufficiently, and the number of sun hours needed to attain the energy needed. This is also the time to consider which of those aspects can be done without, to reduce energy consumption. This chapter will overview these calculations discussed in Chapter 4 and provide examples for two different scenarios: a converted vehicle and a modular tiny home. The examples will go into detail and break down the steps of each equation given.

Calculation Overview

As we discussed in Chapter 4, there are several calculations to go over when determining your components. First and foremost, you must calculate your load. As we discussed before, your load is the items you're looking to use and the amount of time you're using them. You'll also need to determine the power rating or watts, which can be found on the specifications for the items you're using. You will then need to determine the amount of time you'll be using all of those items in hours. This will give you the watt-hours needed to determine the best panels and batteries needed. The formula to calculate watt-hours is as follows:

watt-hours = watts (hours of use).

For example, if I'm running a television set with a power rating of 80W, and I plan to use it for 3 hours a day, I would calculate it as 80W(3hrs) = watt-hour total. In this case, I would need at least 240Wh of power to run the television set.

To determine the full load and watt-hours for the full day, you'll need to determine this formula for all your items. We'll go over this further a little later in the chapter in the examples section. Next, we'll need to determine the peak sun hours needed to maintain the watts needed.

As we discussed in chapter 4, peak sun hours are an hour in which sunlight reaches an average of 1000 watts of energy per square meter or roughly 10.5 feet. This means, at the highest point of sunlight during this time, your panels should be operating at it's highest capacity. The calculation for this particular formula is as follows:

peak sun hour = hour/watts per square meter.

This calculation, not only can help you determine your peak sun hours wattage at a given time, but also how much energy you'll need to store in order to run your items on a given day. This also helps in determining the size battery you'll need for said storage. We'll go over this a bit more later in the chapter, in the review sample calculations portion.

You can also use this same calculation to determine the peak sun hours in not-so-ideal situations. Once again, we'll go over this a bit more in the calculation examples portion. Knowing this information will be vital in selecting the correct components, which is why it is stressed to have these numbers before you decide to make your purchases and builds. This will help in making sure no unnecessary purchases or future maintenance is needed.

The last calculation we'll need to go over is amps. This will help determine the size charger controller you'll need for the best efficiency. This will also help determine the battery bank size you'll need to store any excess energy. In order to calculate your amps, you'll want to divide the total wattage of your solar panels by the number of volts of your battery. Or, to break it down by the formula:

amps =

The amps calculation will actually be pretty imperative to several components. You'll need this calculation for several different aspects of the design and even the build. We'll go into this a bit more in those sections of Chapters 7 and 8, respectively.

For these sample calculations, we'll look at two different mobile solar units. One unit will be based on calculations for a recreational vehicle or houseboat, and the other will be based on average watt-hours for an off-grid tiny home. Recreational vehicles and houseboats, per research, only run up to 3 kWh, while an off-grid tiny home's average is around 3-5 kWh. Your scale may vary, depending upon your load size and the components you're looking to use. These calculations, however, can account for those fluctuations by plugging in the corresponding numbers to the right unit of measurement.

Calculation Examples

In this section, we'll go over some sample calculations based on the average power ratings of common appliances needed for a tiny home or converted vehicle. This will help us determine how many solar panels we'll need for the array, the peak sun hours needed for the daily watt-hours we'll be using, the number of batteries needed for energy storage, and the size charger controller we would need to control the currents. Knowing these exact calculations will be crucial to building your mobile system and its efficiency. Through these examples, we'll go through how to calculate for a smaller system in an RV or converted vehicle and in a modular tiny home that may require more items. This is to ensure that we are able to calculate correctly and with all numbers involved.

We'll start with our converted vehicle calculation. We've made a list and determined that this will be the minimum amount needed in storage to run all of our items. To determine this, we used the following calculation:

load amount in watts(hours in use) =

From the items, we're looking to use, their wattage, and how long we're looking to use them, we'll provide a glimpse of our energy output. This will give us the minimum load amount needed to store. For example:

Television at 100 watts for 3 hours = 300Wh

Refrigerator at 100 for 5 hours = 500Wh

LED Lights at 10 watts for 24 hours = 240 watts

Stove at 50 watts for 3 hours = 150 watts

Dishwasher at 70 watts for 3 hours = 210 watts

Laptop at 20 watts for 5 hours = 100 watts

Given the amount of load we have for the number of hours given, we add those up and come up with 1.5 kWh, or 1500Wh of total load for a given day. It's important to get this as precise as possible, as you'll need this to determine your storage. Under-compensating for your appliances can lead to issues in the very short term or having to scramble to compensate for what was missing. Now that we have the load determined, we'll need to determine the size of our battery bank for storage.

We could just go with the 1.5 kWh, or the 1500Wh, listed, but this is the bare minimum and doesn't take into account less than stellar sun days. When accounting for solar energy, it's best also to consider the days in which you may have to run on just banked energy. In this instance, having the minimum won't be able to cut it. This is when we consider the average and multiply it by the load in question. On average, a given week may have only four days of constant sunlight, making three days unaccounted for. We'll take those three days and multiply it by the load as follows:

watt-hours(days of backup) = watt-hours needed for storage

1500Wh(3 days of backup) = 4500Wh needed for storage

Based on the calculations, we would need to bank at least 4.5 kWh to maintain the dwelling through all facets. That sounds high, but it's always better to overcompensate than to undercompensate. You never want to be stuck with no utilities, and this is the best way to avoid the situation. This will take into account any days that we may have to require the backup so that the calculation will skew higher. However, with this calculation, we can use this to help determine the size of the battery that we'll need to run everything.

When it comes to batteries, the general rule of thumb is you don't want to run any more than 4800 watts off one battery, and you don't want to exhaust all of your battery's energy in one sitting. Given the number of watts that we are looking to store, a singular 12V battery will do very little. From here, you have the option of using one 48V battery, which is more cost-effective in the long run, or we can string four 12V batteries together, or two 24V batteries, to achieve the voltage needed. You want to be on the bigger side of the issue, as it's better to have the space and not need it than need it and not have it. Since this is for a smaller system, space may not be the most ideal. A recommendation would be to spring for the bigger batteries now to avoid any tight squeezes. However, we also know that budgeting may not allow for this, in which stringing a series would probably be a more cost-effective measure for the time being. Just keep in mind of spatial issues, as you don't want to over-populate any compartments.

Next up is calculating your minimum required solar panel output. To do this, we'll take our load into account and divide that by the peak sun hours in your area. As peak sun hours vary from area to area, this calculation will fluctuate based on your location. We'll use Florida as an example, which has four peak sun hours on a given day. The calculation is as follows:

Total watt-hours/peak sun hours = Minimum solar panel output requirement.

1500 Watts/4 peak sun hours = 375 watts minimum solar panel output requirement.

In this instance, we know our total watt-hours are 1.5 kWh, and our peak sun hours are 4, which nets us 375 watts of power needed from our solar array in order to maintain our daily output. Since this is the minimum, you may want to consider rounding up. Also, you'll want to account for less than ideal days and inclement weather. Rounding up to 500 watts would be beneficial, as you don't run low in these times. Also, take into account that the solar panels will be the least costly component to your system; it's better to spring a little more on them to ensure you have the right amount of energy to produce.

Next up, we need to calculate our amps to determine the size of the charger controller that we need. Since the charger controller regulates the voltage in the system, we need to be as close as possible with our calculations. This is to avoid any mishaps or unneeded maintenance down the line. As we explained before, amps are calculated by taking the array's watts and dividing by the volts of the battery. From here, we can determine the exact size we'll need for maximum efficiency. For example:

solar panel wattage output/voltage of the battery = minimum amps needs in control charger

500 Watts/12V = 41.67 Amps needed

For a 12V battery and a 500 Watt solar array, you would need a minimum of a 45-50 Amp charger controller. However, you can reduce the size of your charger controller by using a larger wattage on your batteries. As we mentioned previously, to run the 4.5 kWh for your vehicle, you would need 24-48V of battery power. By using either two 24V batteries, or one 48V battery, this will change up the equation and require fewer amps to regulate the charge. For example, with the 24V battery:

500 Watts/24V = 20.84 Amps needed

Because of the increase in the volts on the battery, this decreased the size of your charger controller. This will also save you more money as the larger the controller, the more expensive it can be. This also works for the 48V, as follows:

500 Watts/48V = 10.42 Amps needed

Once again, the larger battery yielded a need for a smaller size in charger controller. This is one of many things to consider in your design. Amps can also help you consider the most efficient battery for your system. As not all batteries are the same, determining the amps can also determine the amps in the battery that would best store your energy, which leads to less waste.

For inverters, the calculation is pretty simple. Since we already have a handle on the maximum load we will need, or 500W, and the voltage of the batteries for our storage bank, we just use those parameters to determine the size. For example, if we're using a 12V battery bank and needing 500W of daily load, then we would need a 12VDC inverter with a maximum capacity of 500W. If you decide to go up in voltage, then you would need to increase the voltage amount on the inverter to 24 or 48 respectively; however, the wattage would remain the same.

There will be other calculations to consider when building your system as well. Ensuring the right cables for certain devices may require calculations to determine. We'll hit on those during the building stage more in-depth but will briefly go over here. A prime example is a gauge on the inverter cable. This will involve needing the size of the inverter and the voltage of your storage system. Dividing these numbers will give you the inverter cable's maximum current output in amps. The calculation goes as follows:

inverter wattage/battery voltage = cable's maximum current in amps

We'll discuss this a bit more once we get to the build section and have our inverter size selected for this solar unit build. For now, it's imperative to know the formula in order to calculate. You'll also need to calculate for the charger controller cable gauge as well, but there are online calculators through retailers that can help with that gauge.

The upside about these calculations is that they are basically plug-in-play. You can use these on any size system to determine the components you'll need. We just went over how to use these for a 1.5kWh converted vehicle system, so let's use these same calculations for a larger, 5kWh system. We already have the amount of load, but we'll go over briefly how to calculate. It'll be the same process to calculate as previously, but we'll have a bit more load to contend with. This means our load list may be a bit longer, so we have to be as precise as possible with our calculations. We have to ensure that everything we're using appliance-wise is accounted for, or it could lead to efficiency issues really quickly. Remember, you'll need the number of watts for each appliance you're looking to run and the amount of time you're looking to run them. The calculation is as follows:

watt-hours = watts of appliances(hours to run them)

Before we can calculate the amount, we'll have to determine how we came up with 5000W of load. This is where, again, the list becomes a factor. We'll list our items out, and the amount of time we're looking to use them. It'll go as follows:

Heating/AC at 200W for 12hrs = 2400Wh

Television at 100W for 2hrs = 200Wh

WiFi Router at 50W for 12hrs = 600Wh

Stove at 100W for 2hrs = 200Wh

Fridge at 50W for 24hrs = 1200Wh

Combo Washer at 200W for 2hrs = 400Wh

The load list above lets us know that we have a total of 5000Wh, or 5kWh, of load we have to contend with. Since we have a longer list, we have many more watt-hours of the load because we're looking to use more. There are ways to cut down if needed, which we'll go over in the maintenance section in Chapter 8. We'll now take this load amount and begin to look at what we need for our storage bank.

As we discussed before, the 5kWh is the minimum amount we would need to keep things running, but we still have to account for the less-than-ideal days. For the less-than-ideal days, we'll again use the average of three backup days as a litmus test. With this information handy, we'll calculate for the answer as follows:

watt-hours(days of backup) = maximum storage amount

5000Wh(3 days of backup) = 15000 Watts

Essentially, to run 5kWh on a daily basis, with no issues of losing power, you would need about 15kWh of production. Again, this may seem like a lot, but it's better to have it handy than to need it later. With a number of watts this large, it's recommended to use a higher voltage battery. 24-48 Volts would be your best bet, as trying to amass this much energy with a 12V will lead to a lack of space issues. To put into perspective, to conserve this much energy, you would only need four 48V or seven 24V batteries. You would need thirteen 12V batteries to compensate for that amount.

The calculation will also be similar to determine the number of solar panels. You would take the total load amount or 5kWh and divide that by the area's peak sun hours. Once again, we'll use Florida's peak sun hours as an example, but it will fluctuate depending on the area you choose to inhabit or travel to. To calculate for this, we'll use the following equation:

total load amount/peak sun hours = minimum solar panel output requirement

5000W/4 peak sun hours = 1250 watts of minimum solar panel output

In order to achieve the minimum amount of 5kWh needed to run all of our items, we will need a solar array that is capable of a minimum of 1250 Watts of output. We'll once again take into account less than stellar days and round up, giving us 1500 Watts as the requirement to run with little to no issues. As stated previously, it's better to round up and take the overage than to be too few. Doing this puts you at risk of being without enough energy and stranded in the worst possible way.

Determining the charger controller also works the same way as before. We'll calculate for both the 24 and 48V batteries needed. Remember, we'll need to divide the watts of the panel array by the volts of the battery as follows:

1500W/24V = 62.5 Amps needed

1500W/48V = 31.3 Amps needed

From the calculations above, we determined that either a 65-70 Amp or 35-40 Amp charger controller will be needed for this system, depending on the voltage. Again, the higher the voltage of the battery, the lower the amps needed for the charger controller, which will also save money in the long run. This also ensures maximum efficiency for the items running and the components on the system. As with the rounding up for the amps, it's similar to the watts for the solar panel output. You'd much rather have more than what you need than less, mainly to avoid any situations where energy loss and efficiency hang in the balance.

The inverter calculations would also be the same as with the smaller conversion. We determined that we need at least 1500W of total power to run all of our appliances with the calculations we have. We also know that our battery storage bank will house, at minimum, 24V of total power. Because of these two factors, we'll need an inverter that's at least 1500W and 24VDC. Anything less will hinder the load that we have or cause efficiency issues with the batteries we are using.

Similar to the smaller build, we'll have to calculate for the gauge size of the inverter cable for the larger build as well. The plus side to this is the calculation is exactly the same as before:

inverter wattage/battery voltage = cable's maximum current in amps

Like previously, you'll take the size of your inverter in watts and divide it by the battery voltage, getting your cable's maximum current intake in amps. In addition, just like previously, we may also need to calculate for the charger controller cable, but that can be done online through most retailers. We'll dive a bit more into these instances we get to the building stage of the chapter. Again, it's more or less to go over each stage in the calculation process before getting to the build and install.

We're now heading to the next important step, designing your system. Having the calculations that we have, we can now determine the size of the components: such as the batteries, inverter, and charger controller. Knowing the calculations to get the correct sizes is imperative to running an efficient system. Now that we have these calculations, we can continue forward. This will also help us determine if we need any other items, such as circuit breakers, fuses, or additional stacks of other components. With our calculations, we can also determine the sizes of certain cables needed to continue our build properly.

All this information will be useful going into the next chapter, and we will use every bit of it. So, let's not wait any further. On to the next chapter so we can begin our designing process.

Chapter 7: Design, Build, and Install

We've gone over the separate components, panels, tools, and calculations needed to design a self-made solar power system. We've also determined where to purchase said items and how to determine which types and sizes would be most beneficial. Now let's get into the building and installing of this brand new personal unit! This chapter will go over all aspects of the design and building process and how to install them in a converted vehicle, tiny home, or small cabin. Though we calculated for two separate systems, the design, build, and installation for each won't be too distinctly different. There may be some differences in components, however.

Design Your System

Before getting into the build of your mobile solar power system, we'll have to determine the design. With the calculations we used in the previous chapter, we can determine the different designs we will need for our system. This chapter will look at designing a system to accommodate the two systems we calculated for: the converted recreational vehicle and the modular tiny home. There won't be much of a difference between the two, minus the sizes of certain components. Once we go over the design, we'll begin to build our system.

The first part of the design, of course, is choosing the solar panels. When choosing this component, we have to consider three major aspects: the amount of load, the efficiency of the panel, and the location of the array. With this being a mobile solar unit, the best place would be on the roof of the said dwelling, so roof racks will also be necessary for the system. Going based on efficiency to price point, monocrystalline panels would be the best option, as they offer the best absorption rate for the amount of space we have. We won't need as many panels to make up the energy for the work needed. Based on our calculations, we also know that we'll need at least a 500W, 12V array for the recreational vehicle and a 1500W, 24V array for the modular tiny home.

With the calculations for each system, we've determined the number of batteries needed. We'll need roughly four batteries for each system to run the total load and account for any less than ideal weather conditions. We will be connecting the batteries through a series connection or connected by the positive terminal to the negative terminal for the larger system, which is ideal. This makes the voltages of the devices additive and will net us a total of 24V for the system we're looking to run while keeping the amps the same. This is also a more cost-effective measure as purchasing a larger battery may not fit the budget currently.

For the smaller system, connecting the batteries through a parallel or connecting the same charged terminals together, which will change the amps but maintain the same voltage between the batteries, works a bit better. This will ensure that all the items have enough volts and amps to run and regulate without much hassle or maintenance. This process can also be used to connect your solar panels to increase their voltage or add more amps if needed. We'll discuss this a little more in the build and install section.

The next components will be more about the size of your load and the voltage of your other components, the charger controller and the inverter. The inverter will be more based on the size of your load and the voltage of your batteries. You'll want to ensure that you have enough wattage and volts from the inverter to convert the input your components are using and to add to the storage bank once inverted. The total power rating of the inverter becomes highly important. With that, you'll also want to ensure that the inverter doesn't do any damage to the appliances it's creating the energy for. When we spoke about inverters in Chapter 4, we discussed two main versions: pure sine wave and modified sine wave. We determined that the pure sine wave inverter is the best one to use for either system with the appliances we need to run. This inverter more mimics the power that's on the grid and won't cause any issues with lower wattage or sensitive electronic devices.

To determine the size needed for each, we'll need the inverter with the best total power for the load. We determined that 500W and 12 or 24V inverter would be needed for the converted vehicle system with the calculations we used for each system. A 1500W 24 or 48V inverter would be needed for the modular tiny home. This provides us the total power needed to run both systems. This accounts for the minimum power needed and any less than stellar sunny days or loss in inversions.

We'll also need to determine the voltage of the items that we have. Are they all 120V, or are some of them 240V? This is imperative to know, as we'll need to either purchase a 240V inverter, run the risk with a 120V, or stack a set of inverters to provide the voltage we need. To lessen the blow of potential maintenance, we're going to skip the second option. For efficiency, we're going to go with the 240V option for each system. Though it may be slightly more expensive, it will cost less in the long run than the stacked version and ultimately have less wear and tear.

The stage is now set. We've got all of our numbers, our sizes, and we've gone over our design. Now, it's time to begin the building and installing of your new portable solar power unit.

Build and Install

We've gone over calculations and the overall design. We can now begin to build and install your new system. Before installing, you'll need to determine where you will house your batteries, charger controller, and inverter. You can either build a. separate compartment, use a cupboard or small access port in an RV, or have a small closet area in your tiny home.

With the tools that we have, we have the option to build a compartment for either system. Most RVs may need this built as they may not have a small area to house your components. Houseboats may have a bit more space to provide but also may require a holding unit for the items. Either way, you want your batteries to be in an area that's out of the way but easy to access. You may also want to place your other components in this area as well, which will go over once we get to those particular devices. For now, let's focus on putting the battery bank in said compartment.

The ideal placement for the compartment would be somewhere between the solar panels and your main usage point. This will make wiring easier and give you access to everything you need for any maintenance. You'll want to ensure this area is properly ventilated and insulated to prevent the batteries from getting cold. While lead-acid batteries don't need to be heated, they do lose charge once they get cold. Lithium-ion batteries cannot be frozen and must be heated, so a heating pad may be necessary for that component. You also want to have proper ventilation as, if you're using flooded lead-acid batteries, you'll need the excess hydrogen gas to be released. This is to avoid an explosion hazard. A simple installation of a ventilation pipe or vent exhaust fan should suffice. Once hydrogen is released into the open air, it will dissipate quickly.

An important part of the install is panel placement. In our calculations for each type of system, we determined the load needed. We now have to decide the best place to put our array and the best position. Since this is for an RV or tiny home with limited space, the best option would be on the roof. While racking to the roof, we have to ensure proper ventilation of the panels themselves. It's good to have the panels about 6-8 inches about the roof for proper ventilation. This is to avoid any overheating issues that may affect overall efficiency.

For the most absorption, your solar panels should face south and be tilted at the proper angle. For fixed panels, you want to find the optimum tilt angle or the angle that offers the maximum yearly output. This angle is normally your latitude, so your optimum tilt angle would be 0 or pointing straight up if you're on the equator. Finding your latitude can be fairly simple, as most mapping apps can provide you this information. It's recommended to find your proper angle to avoid any shading issues.

With the solar panels in place and the battery bank placed in the proper compartment, we can now get down to the wiring. Since we've already calculated our load, voltage and have chosen our supported charger controller, we can determine a proper wiring pattern. We've decided to use an MPPT controller for this build, so wiring in a series connection format is ideal. As discussed prior, a series connection is wired from positive to negative. This will allow us to increase the voltage of the array but won't have to worry about matching the voltage of the batteries, which will provide more efficient power to our storage bank. This will also save us on copper wiring, which helps the wallet.

It's also important to point out that mixing different forms of panels is not ideal. One bad string in a series connection can lead to efficiency issues within the array. As different panels offer different power outputs, it could put a strain on the entire array. This option is only acceptable if it's in a parallel string and you are using a PWM controller for an extremely small system. We'll discuss this a bit more in the maintenance section in Chapter 8.

Since we'll be using multiple batteries for our bank, we'll use a mix of series and parallel connections. This allows us to use a chain of batteries to achieve the voltage needed to run our system while not affecting the amps extensively. Plus, this allows us to have a larger voltage without sacrificing a lot of space. Our system will require at least four batteries to run, so using a parallel connection for each pair, then a series connection between the pairs. This will allow for the best use of the space we have while also saving on any extra needed wiring. Some systems will require a battery management system or a device used to monitor each battery bank's voltage constantly. Luckily, most lead-acid batteries have internal systems, so we won't have to worry so much about this purchase. We'll go over this a bit more in the maintenance section, however.

Next up for wiring is your charger controller. Located on the bottom of the charger should be positive and negative terminals for your solar array, battery bank, and for your direct current load. You'll want to match the positive and negative connections from your array to your charger controller and connect them accordingly. Start with connecting the battery to the charger controller. This allows for calibration of the controller to determine if it needs to run 12V, 24V, or possibly a 48V system. You'll also want to connect the negative wire first, then connect the positive wire. After this connection, you'll see the charger controller begin to light up to indicate the battery level. Since we've already calculated our load for two separate systems, we know that our controller should run at 12V for the converted vehicle system and 24V for the modular tiny home system.

Now, let's get our solar array connected to the charger controller. Before this, ensure that your array is covered or is facing away from the sun, so it isn't absorbing any power. Not doing so could cause damage to the charger controller due to the sudden high voltage being conducted. This provides the potential personal hazard of unregulated electricity being sent directly to the panel. On the underside of the panel, you'll notice a junction box with the positive and negative terminal wires. These wires are normally smaller than what is needed for the connection to the charger controller, which is why an MC4 or a single contact electrical connection, will be needed to bridge the gap. These connectors are widely available online, as they are the universal standard for solar connections.

Now, we can connect our solar inverter and our load to our controller. This would also be the best place to connect a low voltage disconnect or a device that monitors battery voltage and cuts off devices running low to avoid damaging them. Luckily, our MPPT controller has this option built-in, so we won't need to add this to our build. However, for those with a PWM controller, it may be ideal. This is to ensure that if you have any low voltage items running, the disconnect will put an end to them, so they don't end up damaging themselves or your unit. This is vitally important for the overall efficiency and health of the system. You'll want to wire this in between the battery bank and your fuse box. Be sure to connect the ground wire to the negative, the battery wire to your battery bank, and the positive wire to the fuse box positive terminal.

Speaking of fuse boxes, since we're powering several different items within our system, it's important that we wire one in. This increases the safety of our current to avoid any fire hazards and allows you to cut power to systems at will. Though the charger controller and the inverter have built-in fuses, having the added protection of a fuse box will help avoid future maintenance. You can also add switches in between the solar panel and charger controller, the charger controller and the battery bank, or the battery and inverter for additional isolation. These switches are optional, however.

To determine the fuses, you'll use the load calculations for your items. You'll want to then group these items by circuit or devices on one current. The best way to group is by like items. For example, place all of your lights on one circuit, smaller appliances on one circuit, etc. You'll add up all the currents for each circuit to determine the maximum draw, then choose a fuse for that circuit that's a few amps higher than the maximum drawing power. You can also choose the nearest fuse that exceeds the limit. You'll want to wire the fuse box by connecting the load positive wire to the common lead. This is usually at the bottom or top center of the box.

Be sure to label your fuse socket as you're connecting so you don't lose track of what is leading to where. Next, connect each socket's terminal to the positive wires of your appliances and items. After this, connect the circuit's negative lead into the load negative. Lastly, insert your fuses for each circuit, and now you have your own circuit breaker. I recommend placing this in the same compartment as your charger controller and batteries.

We've gotten the majority of the system built and installed at this point. The next thing left to wire and install is the solar inverter. Since we're building a hybrid AC/DC system, our inverter will need a fuse. This will give the inverter its own DC current. When creating this fuse, make sure that you use one with the same rating as the inverter's maximum input current. For the AC current, you would wire it as you would normally. Since this will be a larger inverter, it'll be wired through the fuse box we have for our load items. Follow the similar wiring properties as listed in the previous passage. Keep in mind that DC power systems have very different plugs than your standard AC power systems. The majority are normally USB and are normally available in the 12, 24, and 48V variety. Other versions also include cigarette lighter sockets and XT60 connectors. You can find these plugs at various hardware stores and can use your own if you don't want to hardwire anything in permanently. As with the fuse box, batteries, and charger controller, you'll want to place your inverter in the ventilated electronic compartment we created earlier.

Now we'll need to wire the solar panels to the storage bank to get everything interconnected. For this, you'll need to select the correct solar cable, which is vital to maximum efficiency and avoiding hazards. You also want to have the strongest connection to your batteries, with the least amount of space in between. This is to help avoid resistance or voltage loss due to missing contact with the battery.

Resistance is determined primarily by three factors: the length of the cable used, the cable cross-section area, and the material used for the cable. With the first factor, it's pretty simple. The longer the cable is, the more resistance there will be. It will be beneficial to have the solar panels as close to the battery bank as possible for that close connection. On the plus side, in most converted vehicles and tiny homes, this issue is primarily avoided. For the cable cross-section area, it's again pretty self-explanatory—the larger the cross-section area, the more resistance. There will be voltage loss if the cable has to travel a considerable distance from the storage bank to the panels. Lastly, the material used for the cable plays a huge factor. The normal materials used are either aluminum or copper. Aluminum is the more cost-effective of the two, but copper is preferred because its resistance is lesser.

In order to properly gauge your solar cable and size, you'll need the following: your solar panel operating voltage, the panel's operating current, the cable length from the panel to the battery, and the expected voltage loss. You can find the first two parameters in the specifications of the solar panels. As far as cable length, that would be determined by the installation process. Since we're in a smaller cabin or converted vehicle, we have the advance of smaller space to avoid needing a huge length of cable. The loss percentage is normally a rough guess. The general rule is to have at the very minimum a 3% loss. To attain the correct solar cable, you can use online calculators that cable retailers like Renogy provide.

Lastly, we'll need to get the correct inverter cable to connect to the battery. This is highly imperative to the system. Failure to do so can result in an onslaught of maintenance issues, not limited to overheating, failure to support full loads, and potentially starting a fire. When looking into this cable, the important things to consider are knowing your inverter size, knowing the DC voltage of your batteries, then calculating the amps by dividing your inverter's wattage by your batteries voltage to give you the maximum current for your cables. For this, we'll use both sets of calculations to determine the correct size.

When we first calculated for our converted vehicle calculation, we determined that we would need an inverter size of 500W because of the daily absorption we would need. We used a string of 12V batteries for our bank. The calculation would go as follows:

inverter wattage/battery voltage = cable's maximum current in amps

500W inverter/12V battery = 41.67 Amps

Based on the calculations above, we can conclude that the maximum current that the cable for our system can handle is 41.67 amps. For this, we know that we can use the minimum 80A cable, which is a size 2. We can use this same calculation for our larger tiny home calculation as well. The formula would be the same, but we would plug and play the load and voltage for the larger system. In this instance, the calculation would go as follows:

inverter wattage/battery voltage = cable's maximum current in amps

1500W/24V battery = 62.5 Amps

Based on the calculations above, we can conclude that the maximum current that the cable for our larger system can handle is 62.5 amps. For this, we know we have to scale up to a 100A cable, which is a size 2/0. We used the same formula as above but plugged in the corresponding numbers to determine the correct amps for the maximum current. This method can be used for all system size types to determine the proper cable size. There are also charts and calculators online through various retailers, should you not want to do the full math associated with it.

We now have everything wired and installed in our unit. This will get you off and running, exploring the world, but living off-grid while doing so. Having this bit of freedom allows you to do so much, including traveling to destinations you may not have considered before or lived in those same locations. The main thing now, outside of enjoying your new system, is maintaining it to last beyond. Maintenance and upkeep will be the backbone of keeping your mobile solar system efficient. Developing a routine for it will be beneficial for you and it in the long run. The next chapter will discuss the primary maintenance you'll have to do routinely and some optional measures you can also take.

Chapter 8: Routine Maintenance

This chapter will focus on the examples of each type of system we discussed earlier. On top of that, we'll also go over the routine maintenance that will need to be performed for each system to maintain maximum efficiency.

Required Maintenance

To maintain proper system efficiency, routine required maintenance will be needed on all components. We'll go over the required steps to keep your system running at its peak performance. We'll also discuss some optional maintenance options you add for further efficiency to your system. We'll start first with solar panel maintenance.

Taking care of your solar panels is extremely vital to the lifeblood of your solar power system. As these are the primary means of absorbing your energy, maintaining their efficiency will be key to running everything you have. First and foremost, you must account for the environment. Extreme heat or cold can wreak havoc on your panels and put a drain on their efficiency. Be mindful when you're traveling and know the weather conditions before you map out your journey. Try to avoid places that will cause your panels to fall susceptible to said conditions to ensure maximum use and life. This also goes for debris and dander.

Cleaning your panels is absolutely necessary as well. Whether you're traveling on the road or stationary at the moment, you're going to run into dust and debris. It's pretty much a certainty. This is why it's imperative to have proper cleaning and maintenance supplies handy, as they will be needed. The best way to clean your solar panels is with a soapy sponge and then wipe dry with a squeegee or terry cloth. Do this regularly to avoid having future maintenance issues. It's recommended to at least check for any debris or dander at gas stops whenever the unit is stationary.

Another consideration is to make sure you don't have any shading issues. Solar panels need to have the maximum sunlight available in order to perform a peak efficiency. If the panels are experiencing constant shading issues, this will lead to lowered absorption and quick replacement. Check for any instances of plants growing near the panels, obstructions during drives and while parked, or the path of the panels themselves. All of these can attribute to your shading issue and will lead to absorption issues quicker than expected.

Routinely check your cables and wiring as well, especially the MC4 connectors. Wear and tear on these connectors can also lead to lowering of absorption. As these connectors are what are used to bridge the gap to the charging controller, it's vital that they're kept intact. Having loose or worn connections can affect the reads of the charger controller and even cause it to malfunction. Not to mention that it doesn't allow for the panels to provide maximum output, which further strains them. It's more headaches that aren't needed and just necessary to stay on top of those connections. Along with this, be sure not to expose any wiring to excess sunlight. Most wiring isn't rated for sure, and though some exist, it's quite expensive. Be sure to run these wires through a conduit or paint over them with a UV protectant if possible.

You also want to check the wires for any kind of corrosion or acid buildup that wears the endings of the wiring. This causes them to not fit into the terminals properly and affects the performance of the panels and charger controller. One primary buy for yourself would be a voltmeter, which will test the output of your solar panels. You can check this by placing the handheld device into your charger controller's solar panel input. Voltmeters are readily available at most hardware, department, or online retail stores.

Also, as mentioned before, do not mix solar panel types. This can cause absorption issues within the other panels, which leads to a quicker replacement. Different brands also have different outputs, which can wreak havoc on your charger controller. If you need to add panels, and they must be a different type, the best way to do so is by adding another charger controller. You can add the new controller to the same battery bank, as long as the voltages are the same. This can also help in the long as if one of your charger controllers malfunctions, you'll have the other to fall back on.

Battery maintenance is just as ideal as they are essentially the heart of the system itself. With the batteries, the temperature is of great importance. You don't want your batteries to overheat, which can be from overcharging or incorrect wiring. This is a potential fire hazard and can be damaging to the other batteries in your system. Ensure that all wiring is of standard and nothing is out of where it should be. This also works for cold situations. Though lead-acid batteries don't have any issues running in cold conditions, it does affect their ability to store if ran too cold. Lithium-ion batteries cannot withstand any sort of cold conditions. They either must be heated or fitted with a charger controller with temperature capabilities. Proper insulation for your compartment is key to avoid these kinds of situations.

Coupled with insulation, you want to ensure your compartment is properly ventilated. While sealed lead-acid batteries, for the most part, don't give anything in excess, flooded versions can produce excess hydrogen gas. This is a potentially explosive gas, which can be hazardous in many ways. Using a simple pipe or having some form of ventilation system will be beneficial to avoid the said situation. Even for the sealed batteries, proper ventilation can greatly reduce overheating issues.

Battery corrosion is also something to adhere to. As batteries go through their lifespan, they're susceptible to corrosion issues. This can happen due to collecting dander from travels to loosening of cords and wires from movement. Make sure to check your wires regularly to ensure they're properly connected to the battery. Any loose connection can cause issues with charging or even overcharging. Speaking of overcharging, battery balancing is definitely key. There will be instances where different series-connected batteries can absorb at different levels during normal wear and tear. This can become a problem for two reasons: the charger controller only works off of total bank voltage, and the lower charged battery could damage itself, even f the charger controller is reading everything fine. This can become more of an issue when adding new batteries to an existing bank. When adding new batteries, be sure to manually level the bank to avoid this issue. That way, there's no issue with any readings, and your battery will maintain its expected lifespan.

With lithium-ion batteries, it's imperative that manually leveling takes place, as well as installing a battery management system. These types of batteries can fail on a grand scale without regular leveling, which can cause a host of issues with your entire system. Though we primarily used a lead-acid battery, which has an internal system, for our calculations, there may be a point in time where more battery power will be needed, and lithium-ion is the only option available. Series connecting a lithium-ion battery in the lead-acid battery storage bank will be grounds to a manual level, and it will need its own battery management system. Within this same concept, be sure that the management system chosen is of the same voltage as its managing battery. Not doing this will lead to further maintenance and efficiency issues.

There is also maintenance that needs to be done with the charger controller and inverter. It's imperative to check the charger controller to ensure it's in the proper charging stages for your battery. The controller will cycle through each type, but these systems can fail on occasion. Always double-check the charger profile on your charger controller. It's also important to clean any debris or dander from the charger controller system. As you travel, you'll encounter different environments, which may play a factor in the charger controller's output. Be sure the controller is well ventilated and properly cleaned at least quarterly. Checking the wires on a routine basis is also ideal, as with any other component. Corrosion can happen at any time, and it's always best to be on top of practices early to stay ahead. All charger controllers have what's called the upper voltage limit. This is the maximum voltage in which charger controllers can handle from a solar array. You do not want to exceed this amount for any reason. Failure to do so will burn out your charger controller and have adverse effects on the rest of your system.

With the inverter, cleaning is also imperative. Make sure that the cooling fan for the inverter is clear of any dust or debris. Having any form of dander blocking the fan can cause major efficiency issues and may also cause the inverter to burn out and fail. Checking for any loose connections is also ideal, as this could skew conversion rates and leave you with less energy than what you thought you had. Also, be sure to check the fuses in the inverter. Charger controllers and inverters but have built-in fuses to help with regulation. As they continually are being used, they will wear over time. You don't want to wait until it's too late to get them replaced. If you notice that you're not generating enough power or that the readings are way out of wack, it could be fault fuses gumming up the works. It's a general rule of thumb to check these on a quarterly basis, similar to checking your wiring. Staying on top of these matters will be very beneficial in the long run, ultimately allowing your mobile solar unit to run longer and more efficiently.

With the cables that you have, especially to main components like the charger controller and the inverter, you want to ensure that they are properly secure and placed in areas where optimum performance is guaranteed. If these cables are further away from the unit than need be, the current has to travel further. There may be lost energy in those travels. Take into account that, with the inverter, you're already prone to lose some efficiency with the inversion process; this can add to further robbing your system of more energy. It's recommended to regularly check these cables and make sure they're running properly. Leaving this to chance and not making it a routine can and will lead to disaster in the not-so-distant future.

Optional Maintenance

In addition to the routine maintenance that needs to be done, there are several optional items you can also do to increase the efficiency of your mobile solar system. While these ideas are not mandatory, it may not hurt to involve them in your routine or in your solar power unit.

To have a handle on your output, having readers for energy consumed. Though it's not required, having energy meters can give you an advantage in knowing your system's full efficiency while maintaining your load elements. Energy meters measure the appliances and other devices that are being used on your battery's storage supply. With this knowledge, you can get a clearer gauge on the hours you use your energy and properly set parameters for said usage. In the long run, this could lead to your components last longer, as they won't have as many constraints on them, and you'll add more energy to your storage bank.

Speaking of your storage bank, maintaining the temperature is very important. Depending on your charger controller, some models have a temperature compensation feature. This changes your controller's charger profile based on the temperature of your storage bank. Again, while an optional maintenance feature, it's not one to necessarily ignore. Keeping a gauge on the temperature of your storage bank will work wonders for the efficiency. As stated in previous chapters, batteries that run too cold may not charge or discharge properly, and lithium-ion batteries can't withstand freezing temperatures. Extreme heat and overheating can also cause problems to your batteries, to the point of rendering them inoperable. Having temperature compensation will reduce these instances and keep you ahead of the problem instead of scrambling to find a solution.

If your charger controller does have a temperature compensation feature, you'll see a "temp" terminal on the back of the device. You'll need a thermostat to hook into the said terminal. These are available at most major home improvement stores and online retailers, but keep in mind that not all thermostats are the same. Be sure to read your charger controller's manual to determine which thermostat is proper to run the feature. Once determined, you want to run the device from your storage bank to the charger controller to have proper readings.

Another optional maintenance idea is stacking components. While we know that we can stack batteries and panels for more power-generating capabilities, but you can also stack charger controllers and inverters if necessary. Doing this also provides a secondary option, should the others fail and you're in-between times of having replacement resources. This is a decent way to help prolong the usage of your system, as one component is containing all of the work and gives the ability for potential expandability. Having flexible options is always nice and will add to efficiency in the long run. It's almost like having two wins.

One option to also help increase optimum solar input is installing rolling racks instead of stationary ones. This helps with solar panel tracking or a panel's path with direct sunlight. Though it's always ideal to find your optimum tilt, we're all aware that the sun itself doesn't often cooperate. It could hide behind clouds, move in different directions, or plainly doesn't come out at all. Although we can't do much about the last one, you can work around the other two with solar panel tracking. With this, you can use a motorized mechanism to follow the sun's path and maintain maximum energy absorption. This option is also available in the non-motorized fashion, should you want to save some dollars on the investment. Again, not a required addition, but it could help in the maintenance of your mobile solar power system in the long run.

Lastly, your load will ultimately decide how efficient your system will be. Although calculating the load is required, what you add to it isn't, which is why I've elected to put this in the optional maintenance. With that being said, this decision shouldn't be taken without a lot of thought. It's at this point that you truly need to decide what you're willing to give up in order to maintain this style of living and put less strain on your system and components. Take into account all your appliances and what would be considered necessities over luxuries. Is a dishwasher really needed if you can hand wash? Is the extra television or additional outlet really necessary? How often do I really need to run my items per day? It'll ultimately be up to you how you run this particular calculation.

With that in mind, you also don't want to short yourself and be without what you truly need. This task may seem small at first, but you will decide exactly what all you will have wherever you end up traveling. Keep all of this in mind when making your decisions on load. What you use and how you use it will truly mean dollars and cents in this case.

With everything you have here at your disposal, you have enough information to get started on your journey to off-grid living. All you'll need to do is determine what you'll build in and go on from there. Keep in mind that making this move won't be an easy decision, and there will be growing pains associated. However, with the knowledge in this text, you'll be able to power your dream with little hassle.

Thank you so much for your purchase of this book, as we sincerely hope it has helped you learn a bit more about building your mobile system and the off-grid lifestyle to an extent. Included after this is an extensive glossary, complete with all the major terms, components, and equations that we used to help with our ending design and build. Feel free to use these equations as you see fit, as the figures are interchangeable and can be used for more than just the examples we have here. Good luck on your journey, and thank you again for this purchase!

Glossary

Congratulations on making it to the end of the book! To further help in the journey of building a DIY Solar Unit, we've provided a glossary of all the terms listed in the text, a definition of each term, and the page number of where to find the term. There's also a list of all the formulas we used for the calculations and a breakdown of each. Thank you again for your purchase!

Terms

amps – the unit of energy that measures the volume of electrons. This calculation will be needed to determine your charger controller

alternating current – the current needed to run load items. This inverted from the direct current that's absorbed from sunlight

Bandgap – the behavior of electrons in a state that's not possible to form conductive bands

corrosion – acid buildup that wears the endings of the wiring, causing issues with maintaining current

current - the rate at which charge is flowing

Czochralski method – a method achieved by using a seed crystal that is placed into a vat of molten silicon at high temperature

direct current – the current received from absorbed and converted solar energy. This must be inverted to alternating current to be used in systems or can be stored on a DC-coupled battery depth of discharge - the percentage of the battery that has been discharged relative to the overall capacity of the battery.

electrons – negatively charged particles, transferred as energy through the semiconductor

frequency – the nominal measurement of alternating current. This is in reference to the inverter frequency, which can be 50Hz or 60Hz depending on location

load - the list of items you want to run on your system and how long you want to run them

optimum tilt angle – the angle of the solar panel that offers the maximum yearly output. This is normally the latitude of the current location

off grid living – the ability to maintain a homestead without the need of publicly managed utilities, such as gas, electricity, and water

payback time - the time it takes for a panel's solar generation to cover the cost and installation parallel connection – a string connection of devices by the same charged terminals, which makes the amps additive but maintain the same voltage

peak sun hours - an hour in which sunlight reaches an average of 1000 watts of energy per square meter, or roughly 10.5 feet

photovoltaic energy efficiency - a panel's ability to absorb sunlight and convert it to energy

photovoltaic technology – devices used to absorb energy from sunlight

resistance – voltage lost due to a cable missing contact with the battery bank

semiconductor – materials in solar panels that conduct electricity from sunlight absorbed

series connection – a string connection of devices by the positive terminal to the negative terminal, which makes the voltages additive while keeping the amps the same. (p. 40)

voltage - the difference in charge between two points watt-hours - the amount of work done over a certain period of time. 1000Wh = 1kWh

watt - a measure of power or the ability to do work. 1000 watts = 1kW

DIY System Components

array – two or more solar panels connected together

AC Coupled battery - the most common form of battery used in solar storage that takes the DC current, stores it, then inverts it to AC current to use for common household electronics

absorbent glass mat battery – a sealed style, lead-acid battery that uses special glass to absorb

charge controller – an integral system device used to regulate the power of electricity to the batteries for maximum output, but without damaging or overcharging them.

CADMIUM TELLURIDE – a low cost, crystalline silicon-based, thin-film solar panel that has the smallest carbon footprint and the shortest energy payback time

DC Coupled battery – a battery that stores the energy converted from the panel directly to storage without the need for the first inversion. This battery uses an internal hybrid inverter

flooded lead-acid battery – a fairly inexpensive, unsealed style, lead-acid battery that requires proper ventilation, as hydrogen buildup occurs and must be filtered out while being used. Water levels must also be attended to ensure battery balancing

gel battery – a sealed style, lead-acid battery that uses a special silica that thickens to allow the flow of electrons

hybrid inverter – an inverter inside a DC-coupled battery that works for both solar and storage

inverter - a device used to convert the direct current from the cell into an alternating current, which is needed to run appliances and electronics

lead-acid battery – the oldest battery type, that uses lead compounds at the positive and negative electrodes and an acidic electrolyte

lead-acid deep-cycle battery – a lead-acid battery with a deeper discharge due to the thicker lead battery plates. These are more suitable for solar storage than the standard counterpart lithium-ion battery – the most commonly used home or large system battery that uses lithium compounds for electrodes and use the flow of ions away from said compound to store the energy

lithium nickel manganese cobalt oxide – a larger lithium-ion battery, more commonly used as a backup for on-grid solar systems

lithium iron phosphate – a deep cycle cell style lithium battery more commonly used for a smaller cabin or mobile systems

low voltage disconnect – a device that monitors battery voltage and cuts off devices running low to avoid damaging them

MC4 connector – a single contact electrical connection and are the universal standard for solar connections.

MPPT controller – MPPT stands for maximum power point tracking. This controller will adjust to their input to provide maximum power from the panel and will adjust their output power to match the battery.

modified sine wave inverter – an inverter that fluctuates between positive and negative electrical output, causing issues with common electronics, motors, and pumps

PWM controller – PWM stands for pulse width modulation. They are standard charger controllers that work by slowly reducing the amount of power as the battery approaches capacity. To use this, the panels you own and the batteries you're using must be the same voltage. Therefore, these are more built for smaller systems.

pure sine wave inverter – an inverter that provides the same or similar electrical output to what is found on the grid, making it safe for common electronics

recreational batteries – a term used to describe automotive batteries for boats and RVs. These are the most common type of electric batteries and can be used for smaller solar power systems

solar panels - devices that generate power by absorbing sunlight and converting it into electrical energy through semiconducting materials

Panel Components

amorphous silicon - a noncrystalline silicon of the thin film variety, commonly used in calculators and watches.

battery management system – a device used to monitor the voltage of each battery bank constantly. Lead-acid batteries have these built-in, but lithium-ion batteries need separate systems

circuit – a set of devices on one current. Used to connect to a fuse for a fuse box

contacts - grid-like metal lines, which are wrapped around the diode of the cell

crystalline silicon - a silicon created through a chemical processed and used to create the wafers within the cell to conduct electricity

diode - a device that allows the electric current to flow in one direction

monocrystalline panels a first generation panel made with a single silicon crystal to form a silicon wafer. The most popular panel on the market

polycrystalline panels - a first generation panel made with multiple raw silicon fragments together to form square molds. This is the second most popular panel on the planet

Solar cells – a small device connected to a panel, used to absorb sunlight and convert it into electrical energy through semiconducting materials

thin-film panels - second and third generation panels, made by using a thin layer of an ultra-absorbent semiconducting substance, normally no larger than a micrometer, onto a solid surface.

Current and Future Advances

bifacial solar panels – solar panels that have semiconducting materials on both sides of the panel, yielding a 9% higher efficiency rating

building-integrated photovoltaics – thin-film panels that are used on walls or windows

concentrator photovoltaic technology devices that use curved mirrors to harness solar energy, and concentrate sunlight on their own, so a large number of cells aren't needed

copper idium gallium selenide – a higher cost, thin-film solar panel system primarily used by NASA. It's unique as it doesn't use crystalline silicon as its semiconductor

dye-sensitized solar cells - unique, five-layer thin-film cells that use a special sensitizing dye to help with the flow of electrons

flow battery – a rechargeable battery having nickel oxide-hydroxide positive plates and iron negative plates, with an electrolyte of potassium hydroxide. Also, know as the Edison Nickel Iron battery. This is relatively new and is just catching on in the off-grid field

gallium arsenide – a secondary, higher cost, thin-film solar panel system that doesn't use crystalline silicon as its semiconductor.

multijunction solar cells - stacks of semiconductors that allow for absorption from a separate part of the solar spectrum, which allows for greater use of sunlight given

Organic photovoltaics - carbon-based, solution-pressed compounds that use organic molecules and polymers to conduct and generate electricity.

Perovskite cells – a prototypical solar cell that uses crystalline properties along with methylammonium, lead, iodine, and chlorine that can absorb a greater spectrum of sunlight than silicon. Though advances have been made with this technology, it's still years from mass production

quantum dot solar cells - cells that conduct electricity through semiconductors that are mere nanometers wide

Calculations

amps = watts/volts – This is the calculation for amps. This calculation will be used for various components and size interpretations.

peak sun hour = hour/watts per square - The formula to calculate peak sun hours. This is an hour in which sunlight reaches an average of 1000 watts of energy per square meter or roughly 10.5 feet. This means, at the highest point of sunlight during this time, your panels should be operating at it's highest capacity

Total watt-hours/peak sun hours = Minimum solar panel output requirement – This is the calculation to determine the minimum solar output requirement for your solar panels.

watt-hours = watts (hours of use) – This is the formula to calculate watt-hours. Watt-hours are used to determine your load amount. This will give you the watt-hours needed to determine the best panels and batteries needed

watt-hours(days of backup) = watt-hours needed for storage – This is the formula used to calculate the minimum amount of watt-hours needed to power the unit, account for days of less than ideal sunlight

Thank you for reading my book, if you have any comments to make, or you want to tell me what you liked and what you did not like, or you simply want to express your opinion on the book you can do it by leaving a short review