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How to Install Solar Panels

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Introduction

Solar panel systems are growing increasingly popular for a variety of reasons as more people become interested in saving money as well as helping the environment. While at one time solar panel systems were relatively unique and were only used in areas where mains electricity was primarily unavailable, today that is no longer the case.

As a result of the increasing numbers of people that are becoming more interested in benefiting from solar power, it is important to begin looking at ways in which solar systems can be easily and efficiently installed.

This guide will walk you the process of installing solar panel systems using the most commonly used system, which is the roof mounting system. The guide will also walk you through various critical other aspects that must be understood about solar panel systems.

Let's get started.

Getting Started

Around the world many consumers are making the change from traditional electric power to solar power, creating a strong market for individuals who are interested in learning how to commercially install solar panels.

The future of solar panels is considered to be quite strong. The production of solar energy has been doubling at a rate of about every two years, meaning that since 2002 solar energy production has increased by an average of 48% every year. As a result, solar energy production is now the fastest growing energy technology in the world.

One day of sunshine is capable of producing enough energy to power the entire planet for a full year. Consequently solar panel technology has improved rapidly in order to harness the full power of this clean source of energy. It is little wonder that so many consumers are opting for solar energy, considering the rate at which the cost of electricity supplied by utility companies is steadily rising.

Beyond the fact that the cost of electricity is steadily rising, there are also many other factors that are typically considered when making the decision for solar energy systems to be installed.

One of those elements is the fact that solar panels do not contribute to global warming in the way that electricity from the utility company does. This is because solar energy is not capable of contaminating the air through the release of carbon dioxide and other pollutants. Fossil fuels such as oil, coal and natural gases that are used for conventional electricity emit more than 10 million tons of sulfur dioxide, nearly 4 million tons of nitrogen oxides, more than 2 billion tons of carbon dioxide and more than 50 tons of mercury per year. This is not only a dangerous situation for the environment, but it also creates a danger to individual health due to the fact that such emissions are quite toxic.

Each year the rate of emission of such gases rises at a rapid rate. It is estimated that fossil fuel electricity contributes to 36% of the emissions of carbon dioxide and is also the largest cause of global warming, according to the Official Energy Statistics, published by the Department of Energy.

Over the expected life span of a solar system, which is 35 years, a 10 kW system is capable of providing the equivalent C02 reduction of planting 1,450 trees. Such a system will be able to produce 575,000 kilowatt hours of electricity. This is the same amount of electricity that would be generated when burning 583,000 pounds of coal.

There are also many personal benefits associated with the use of solar energy as well. Once installed, a solar energy system provides renewable energy that is completely free, which is unlike the energy source that powers most current power supplies. This makes it possible for consumers to drastically reduce their fuel and electricity bills or even to get rid of them completely.

The California Solar Institute recently conducted a survey which revealed that it is also possible for a consumer to increase their home's value by $20 for every $1 of energy bill savings annually. As a result, it is entirely possible for the consumer to save $1,500 on their annual energy bill while adding $30,000 to the value of their home.

There are also possible tax credits and benefits that homeowners can take advantage of as well when they choose to have solar systems installed. This makes it possible for the homeowner to not only reduce their energy bills but also reduce the cost of having the system installed through tax credits.

Although there is an initial cost associated with having a solar system installed, once the consumer has recouped that cost through their energy savings, the electricity that the system produces in the future, for the remainder of the system's lifespan, will be completely free.

For many people, there is also the advantage of being able to live off-grid and maintain a completely self-sufficient lifestyle without the need to rely upon public utilities. This has become an increasingly important reason for many people to choose to have solar systems installed.

Individuals who choose to have their solar systems tied in with their local utility company may also be able to benefit by receiving credit from the electric company. This is because in the event that the consumer actually uses less power than their solar system produces, the excess power can then be sold back to the utility company. For example, if the homeowner is on vacation and their energy usage is reduced for a period, all of the power that is generated during that time is credited back to their account.

Furthermore, consumers no longer have to worry about the consequences of power outages, such as possible food spoilage.

As the demand for solar panels continues to grow, it is expected that they will become even less expensive, resulting in an ever increasing demand for this powerful technology.

Before delving into the nuts and bolts of how to install solar panels, it is important to first understand a few basic essentials about what comprises solar panels, how they work and how the total solar array is integrated together.

Understanding Amps, Watts and Volts

One of the first areas that need to be covered is some instruction regarding various references that will be found throughout the book. These include current, voltage, resistance and power. It is essential that you make sure you completely understand how each of these terms relate to one another and what they mean.

Each term has different units of measurement. These units of measurement are as follows:

- *Voltage* – This refers the possible difference that exists between two different points. Voltage is measured in terms of Volts, which is often abbreviated as V.
- *Current* – This refers to the flow of electrons within a circuit. Current is measured in terms of Amps and will typically have the symbol I.
- *Resistance* – Refers to the opposition of a material to an electrical current. Resistance is measured in terms of Ohms and typically has the symbol R.
- *Power* – Refers to the rate at which work is performed. Power is measured in terms of Watts and typically has the symbol P.
- *Energy* – Refers to the capacity at which work can be performed. Typically has the symbol of E. The Joule is the basic unit of energy; however, electrical energy is commonly expressed in terms of Watt hours, commonly referred to as Wh, or kilo watt hours, commonly referred to as kWh.

It is important to understand that one kWh is equal to 1,000 Wh.

The relationship between the various units should also be completely understood. For example, power is equal to voltage when multiplied by current. Voltage is the equivalent of current when multiplied by resistance.

Understanding How Solar Panels Work

In order to install solar panels correctly, you must also understand how they are put together. Solar panels are able to generate electricity from a light source through an effect known as photovoltaic. Solar cells are produced from materials that are used in semiconductors, such as silicon. There are then impurities which are added to the semiconductor material in order to create two different layers. One of the layers will have a large number of electrons while the other layer does not have as many electrons.

There is then a junction that is established between the two different layers. This junction is commonly referred to as the p-n junction because it is the junction between the p-layer and the n-layer.

Light is comprised of packets of energy which are known as photos. When photos strike the solar cell, one of three things will occur. The photos will be reflected, they will be absorbed or they will pass directly through the solar cell. The important factor that determines what happens is the wavelength. The energy from the photos that are absorbed into the solar cell can then be joined with the electrons within the material that has been used to create the layers, resulting in the photos crossing the p-n junction. When there is an electrical circuit placed between the two different sides of the cell, then it will result in a current flowing. The resulting current is proportional of the photos that have hit the cell and as a result, also proportional to the intensity of the light.

The modules that are utilized in solar panel installations are typically made from numerous solar cells that have been connected together. Each cell is capable of producing only about half a volt. Generally there will be about three dozen cells that are connected together in order to produce a voltage ranging between 18 and 20 volts. The result is a module which can be used for charging the average 12V battery. Typically, several modules will be connected together in order to form an array. This will result in the provision of more power than a single module would be able to provide on its own.

Storing Energy

In order for modules to generate electricity, light must fall upon them. The amount of power that is generated will be directly proportional to the intensity of the light that strikes the modules. The importance of understanding how and where to correctly place the modules in a solar array becomes quite apparent in order for the consumer to obtain the maximum benefit from the solar system.

Due to the fact that the solar module is only able to generate electricity when light is falling upon them, it becomes necessary for the light that strikes the cells to be stored and then released as needed. Otherwise, it would be impossible for a home to operate efficiently at night and on cloudy days when there is either no light or the light intensity is very low. The most common method for storing electrical power is to utilize a surplus power which is used for charging a lead-acid battery. This is a special type of deep cycle battery that is comprised of numerous cells. Each cell is then comprised of two separate lead plates within a container holding diluted sulphuric acid. Each of the cells is capable of producing a voltage of two volts, which means that several are connected together in a series fashion.

Conversion and Control

It is also essential to understand the basics of control and conversion when learning how to appropriately install solar panels. The electricity which is generated through the process described above is what is referred to as a low voltage direct current, commonly referred to as DC. Mains electricity is commonly a far higher voltage alternating current, commonly referred to as AC. Due to this fact, it may be necessary for further devices to be utilized in order for the battery to be controlled and for the power to be converted to the correct voltage.

There are two devices that are commonly used for this purpose. They are an inverter and a photovoltaic controller. The purpose of the controller is to ensure that the battery does not become over-discharged or overcharged. The goal behind using the inverter is to convert low voltage DC into a much higher voltage AC. This is accomplished by turning the DC power into AC first and then by using a transformer in order to increase it to a higher voltage amount.

Electricity is commonly generated into low voltage DC utilizing the modules when light strikes them. The power that is produced is then routed directly through a controller that is used for feeding the necessary amount of power to applicable DC appliances. Any surplus power is also used for charging the battery. In the event there is a lesser amount of power that is generated than the appliances in the home are currently utilizing, the power will then flow from the battery to the appliances. The job of the controller is to monitor the state of the battery's charge and actually disconnect the appliances in the event that the battery should become overly discharged. If there are any AC or mains appliances they are connected to the inverter, which is connected directly to the battery.

In order to properly install a solar power system, it can be helpful to have a good understanding of the different components that will be involved in the system and how they operate.

Types of Solar Panels

When it comes to modules there are basically three different types of solar modules that may be encountered. These types of modules are:

- Monocrystalline solar panels
- Polycrystalline solar panels
- Amorphous solar panels

Monocrystalline Solar Panels

Monocrystalline solar panels are comprised of a large section of crystal of silicon. This type of solar panel is considered to be the most efficient in terms of absorbing sunlight and then converting it into electricity, but it must be taken into consideration that they are also the most expensive type of solar panel.

This type of solar panel will typically perform better in lower light conditions than the other two types of solar panels, which is one reason why they are sometimes preferred over the other two types, despite the fact that they are the most expensive.

Polycrystalline Solar Panels

This is the most common type of solar panel that is currently on the market. Upon viewing, they are similar to shattered glass. Polycrystalline solar panels are somewhat less efficient than monocrystalline solar panels, but they are also less expensive to produce. Rather than using a single large crystal, this type of solar panel uses numerous smaller silicon crystals.

Amorphous Solar Panels

This type of solar panel is comprised of a film that is rather thin and produced from molten silicon that is spread over plates of stainless steel or a similar material. Amorphous solar panels are less efficient than the other two types of solar panels and they are also the least expensive.

One primary advantage of this type of solar panel over the other two panels, beyond the expense factor, is the fact that they are shadow protected. This means that even when part of the solar panel cells are in shadow, the panel will continue charging. This is one reason why this type of panel is commonly used on boats as well as other types of transportation.

Looking at Solar Panel Efficiency

Solar panel efficiency refers to the percentage of solar energy that is captured and then converted into electricity. It is not possible to determine a precise number, but the average percentage of efficiency for the three different types of solar panels is presented below. Keep in mind that thin film solar panels will typically degrade at a rate of about 1% every year. Crystalline panels will degrade at a rate of approximately .5%.

- Monocrystalline- 18%
- Polycrystalline- 15%
- Amorphous (thin-film)-10%

Types of Batteries Used

There is a variety of different types of batteries that can be used on a solar system, but one type is more commonly used than others. It is the lead-acid battery. There are a couple of different reasons that this type of battery is commonly used for solar power system installations. One reason is that it is capable of storing a large amount of energy for a lower price than what is available in other battery options.

It is important to understand that this type of battery can be easily damaged if it is exposed to too much discharge, so it is imperative to make sure that the battery is protected from this type of situation.

It is also important to understand the role that deep-cycle batteries play in the installation of the solar power system. These types of batteries are specifically designed for at least 50%, or more, discharging on a regular basis, which is an alternative that may be utilized in some circumstances.

Understanding Charging

Charging is another critical element that must be understood. It is imperative that the voltage which the lead-acid batter is charged at be regulated on a strict basis. In the event that the charging voltage becomes too high then excessive gassing will occur as a result. This can result in a loss of electrolytes as well as possible damage to the plates. On the opposite end of the spectrum, if there is too low of a voltage then the plates could potentially become sulphated, which can result in a loss of capacity.

Understanding Discharging

Discharging should be understood as well. The batteries in a solar system must be protected as well from becoming overly discharged, which can result in damage to the batteries. When the battery begins to discharge; the voltage decreases at the terminals.

Understanding Controllers

The purpose of the controller is to regulate the charge of the battery. There are some types of controllers which are also specifically designed to perform other functions as well. One of the most common of those functions is to protect the battery from becoming overly discharged.

There are two different ways in which a controller can function. They are shunt regulation and switch regulation. In the shunt method, the solar array output is shorted for the purpose of controlling the output as well as performing regulation. The switching method may be electromechanical or electronic.

Understanding Inverters

Inverters are used for transforming low voltage DC of the battery into higher voltage AC which can then be used for powering standard appliances. Inverters are critical when low voltage appliances are either cost prohibitive or they are simply unavailable or when there is a large system that is utilized and power must be distributed over a large area.

There are essentially two different types of inverters that may be used. They are sine wave and modified sine wave. Sine wave inverters imitate the wave form of regular electricity while modified sine wave inverters are feature a waveform with a square edge that have some characteristics of a sine wave. Typically, the modified sine wave inverter will have a lower cost and will also produce a higher efficiency rating. It must be understood that these types of inverters may not be the best option in some cases; however, because they can be rather noisy and also because there are certain types of equipment that simply may not operate as they should with this type of inverter.

Into the Grid or Off the Grid?

When a solar panel is installed, the consumer can choose to have it either hooked into the rid or off the grid.

Grid Tie

The term grid tie refers to a solar panel system that is hooked up directly to the utility company or the electricity provider. The solar system will use the energy which is produced by the solar panels first, during the day, and will then draw whatever remaining amount of energy is needed from the utility company during hours when the solar panels are not producing electricity, which will typically be at night and on days when the sun is not shining brightly.

If the solar panel system produces more electricity than the consumer uses during the day then the extra electricity will then be fed into the utility grid. This will generate a credit on the consumer's electric bill. When this occurs, the consumer will be able to literally see their meter spin backwards. This is one advantage of not having battery storage in addition to not having to deal with regularly maintaining the batteries.

Of course, the consumer may also wish to purchase batteries to store energy as well. In the event that the electricity should go out, the inverter will then switch to battery power in order to supply the needs of the consumer's home. Through this method, it will be possible for the consumer to ensure their equipment is kept running throughout energy outages. Battery storage is actually a good solution for homes where there is not convenient access to a utility grid or for homes that are located in areas where there are frequent outages.

In the event there is an outage and the consumer's home does not have batteries then the solar panel system will shut down. This is a safety measure that ensures surges of power do not travel the grid, which could result in injuries to repair persons who may be working on the lines. In the event the consumer has back-up batteries this will not be a problem and they will be able to continue to have their equipment function. If the electricity shuts down, the solar panel system will automatically disconnect itself from the grid of the utility company and then extract power from the battery storage. When the electricity is restored, the solar panel system will automatically reconnect.

If the grid tie option is what is best for the consumer, there are a couple of things that must be done before the system is installed.

First, it is important to contact the utility company and determine whether they will allow the consumer to hook up solar panels directly into the electricity grid. Most utility companies do allow this but there are some electric companies in rural areas that are exempt from the national law that allows connectivity to the grid, so if the consumer is in a rural area, this may not be possible.

Second, it is important to find out whether the electric company will buy energy from the consumer that is produced by their solar panels at a wholesale rate or a retail rate. In an ideal situation, the electric company should buy back any excessive electricity that the solar panel system produces at the same retail rate which the consumer purchases electricity at. This is referred to as net metering and it is actually the easiest way for a solar panel system to be set up.

With this system the consumer will only need one utility kWh meter and the meter will spin either forward or backward depending upon whether they are selling or buying energy.

In the event that the electric company does purchase energy at a wholesale rate, a second kWh meter will need to be installed in order to record any excess energy that the consumer will be able to sell back to the utility company. In most cases, the wholesale buy back rate will be a few cents less than the per kWh produced.

Off the Grid

Another option is off the grid. This means living in a completely self-sufficient manner. With this method the consumer will be able to produce all of their power needs themselves without any need to rely upon the utility company. The solar panels will not be hooked into the grid and all of the electricity that is produced will be stored in battery cells. All of the electric power that will be produced will be done so using the solar panels.

An increasing number of people are choosing to go off the grid each year for many different reasons. One reason is that is can be very liberating for the consumer to know that they do not need to rely upon anyone else to supply their power. There is also the additional benefit of not having to worry about monthly electric bills. It is estimated that currently there are about 200,000 people in the United States who are living off the grid, although that number is thought to be steadily rising.

It is expected that as the electricity prices continue to rise and the cost of equipment that is necessary to live off the grid decreases, the number of consumers who will choose to go off the grid will steadily increase.

When approaching a new installation it is important to always consider whether the system will be tied into the grid or will be off the grid. Although at the current time the majority of the systems installed on an annual basis are tied into the grid, the gap between the number of people choosing grid tie and off the grid is steadily decreasing.

Understanding Energy Requirements

When starting on any new installation project, it is essential to understand the energy requirements for the home or the building where the system will be installed. It is critical to understand that the amount of energy which is required for the building will play a strong role in determining the size of the solar power system that is needed. There are certainly ways in which consumers can reduce their energy requirements, but when approaching a new installation it is always important to consider the amount of energy that the consumer has been using up to that point. It is also important to consider the amount of solar power that the consumer hopes to utilize.

Many consumers today are approaching the installation of a solar system by establishing a goal of a zero utility bill. There are some consumers who may wish to only reduce their bill by a fraction, so it is important to always sit down with the consumer in order to understand the goals they hope to accomplish and how much energy they need to manufacture for their needs.

To determine the number of square inches of solar panel that you will need for the installation, you must first know the following:

- The amount of power that the home will consume on average
- Where the house is situated so that you will be able to calculate the mean number of solar days, the average amount of rainfall, etc.

One way to determine the amount of power that a consumer needs to replicate through solar power is to sit down and study their previous utility bills. When doing this, it is important to make sure that you do not just review the prior month's bill. This is important because looking at a single bill may not be an accurate reflection of the consumer's power usage.

Oftentimes, there are months during the year when the consumer may utilize more or less power. This is particularly true during specific seasons, such as during the coldest months or the hottest months. The consumer may also utilize more power during the holidays if they tend to run a lot of decorations.

The best method for determining the amount of power that the consumer will need is by studying all of the utility bills for the past year and then determining an average monthly usage.

1. For example, add up all of the bills for an entire year, divide by twelve and you will have an average monthly usage.

2. Once you have an average monthly usage amount, you will then need to break it down even further and determine the amount of kilowatt hours that the consumers is using on a daily basis. Once again, you will be looking at averages in order to have the best information for determining the size of the system that will be used. This information will be helpful in determining not only the size of the system that will be needed but also the amount of roof space that will be required for installing the system.

3. Take the total number of kilowatt hours and divide by 30, because there are about 30 days in most months, so that you will have a daily average use. In some areas, the utility bill may already have this information supplied. If that is the case you can then skip this step.

4. Once you have determined the average kilowatt hours of usage per day, you then take that number and divide it by the average number of full sun hours that there are per day in that area.

There are a few things that you need to understand before determining the number of full sun hours there are in a day. First, this varies from one locale to another. Second, you need to understand that the total amount of solar radiation energy is expressed in terms of hours of full sunlight per m^2.

Understand that one hour of full sun will provide one kilowatt hour. Sunlight intensity, also known as insulation, is measured in terms of full sun hours. One hour of the maximum amount of sunshine that is received by a solar panel is equal to one full sun hour. When considering the amount of full sun that is received on a daily basis, you should only count six to seven hours because the most productive hours of sunlight typically fall between the hours of 9:00 a.m. and 3:00 p.m. or 4:00 p.m., in some cases.

5. Next, take this number and then multiply it by 1.15. You do this in order to make sure that you have a good margin, just to be certain. As an example, let's suppose that the monthly kilowatt usage was 600. Divide 600 by 30 and you get 20 kilowatt hours per day. 20 kilowatt hours divided by seven (the number of full sun hours per day, but make sure you use the correct number of hours for the area of the installation) is 2.86.

6. Now, you take 2.86 and multiply it by 1.15 and come up with 3.3, which is the equivalent of 3,300 watts of solar panel that will be needed.

Generally, the solar systems will range in size based upon the needs of the consumer and how low they are trying to get their electric bill. A system that contains high efficiency cells is capable of producing 1kW per hour for every 100 square feet. Therefore, if you determine that you need 3kW for every hour of full sun then you will need 300 square feet of dedicated space.

Guidelines for Reducing Electric Usage

As discussed, it is important to understand how electric usage can be reduced. This is important for many different reasons. Reducing electric usage will ensure that the solar panel is more cost effective and will also help to have a positive impact on the environment as well as on the electric bill.

The different things that can be done to reduce electric usage range from some cost to no cost. Although it is probably one of the most expensive things that can be done to reduce electric usage, replacing badly insulated windows with more modern windows is also one of the single most effective steps that can be taken to reduce electric usage. Along the same lines, insulating ceilings and walls can be effective as well.

Furthermore, replacing older central heating units and other such appliances can also go a long way toward reducing electric usage. It should be understood that these are long term investments that will require a payback, but once that payback has been received, the savings will be additional money for the consumer.

In addition, changes to large appliances can make a difference as well. Large appliances comprise a large portion of electric consumption. The consumer can achieve significant gains by changing to models of appliances that are more energy efficient. This includes Energy Star compliant appliances.

There are also many small investments and chances that can be made as well in order to reduce electricity usage. Many such changes are actually a matter of changing personal habits. Most people today have personal habits that actually waste electricity. When they are able to make changes to those habits they will be able to save energy.

- One such example is turning off lights in rooms when the lights are not being used. Along the same lines, using compact florescent bulbs can make a big difference as well. Such bulbs are more expensive, but the payback on making this change can occur fairly quickly.

- It is also important for consumers to get into the habit of turning off computer monitors. Many people have a habit of leaving their computer monitor on all of the time. Rather than leaving it on it is much better to put it in sleep mode. Even better would be to turn the monitor completely off when it is not being used.

- Closing the blinds in parts of the house that receive direct sunlight can be helpful as well. When the blinds are left open, it causes the house to heat up significantly and that can increase the need for air conditioning.

- Choosing when to run certain appliances is also a good choice. Washing clothes at night and running the dishwasher at night are good ways to lower electricity usage. Many utility companies utilize scales that charge more during peak hours.

- Another good way to reduce electricity usage is to make sure that the water heater is insulated well. An insulation wrap only costs about $20 and can be used to surround the water heater so that it does not need to work as hard in order to heat the water.

- Air drying clothes can be another great change that can result in multiple benefits. Not only does it reduce electricity usage, but it can also increase the lifespan of clothing as well.

- Using warm and cold water rather than hot water can result in positive changes to electricity usage mounts too.

- Consumers should also consider turning down the refrigerator. A thermometer can be used to set the refrigerator temperature to near 37 degrees and the freezer to 3 degrees. Also, the energy saver switch should be turned on as well. This can make a difference in terms of the amount of electricity that is used.

- Air filters should be cleaned and replaced as needed to cut down on electricity usage.

- Using low-flow shower heads can result in using less hot water, which also means using less electricity.

- Finally, consider taking showers rather than baths because they utilize half of the amount of hot water.

Taking these steps can help to greatly reduce the amount of electricity that is used within the home, which can help to reduce the amount of electric power that is needed for the solar system to produce as well as reduce the amount of additional electricity that is needed to be obtained from the electric company, if the consumer is tied into the grid.

While it can take some time to establish the changes to habits mentioned in this section, it can most certainly be well worth the effort.

Mounting

In this section, we are going to discuss mounting options, but before we move on to that section, we first need to go over an important step that should be taken prior to beginning any work.

Before any work on the installation project takes place, it is imperative to check with the local zoning department or building department in order to determine whether there are any requirements that are needed to move forward with the installation project.

Keep in mind that it is the homeowner's right to have solar panels installed, there may be different requirements which are required in different areas of the country. Generally, local building and zoning departments will be concerned with ensuring that things are checked out properly, such as ensuring that the roof will be able to withstand the weight of the system if the roof mounted system will be used. Other areas that should be checked include making sure that the wiring is properly performed as well as other safety precautions.

If the site where the installation is to take place is in a planned development, then it will important to make sure that the Homeowner's Association has been consulted as well, due to the fact that they may have additional requirements as well.

Mounting and Installation Options

Okay, now it is time to take a look at different options when it comes to mounting the solar system. The options for having a solar system mounted include:

- A ground mounted system, provided that the area has sufficient sunlight and is clear from any possible obstructions

- A roof mounted system, which requires that holes be drilled through the roof and then mounted into the rafters of the roof
- A system where the solar panels are glued to the top of the roof. It should be noted that this system is only used with the thin film types of solar panels.

Ground Mounted Solar Panels

In looking at ground mounted solar panels, it is important to understand that these mounting systems require that the panels be affixed on poles that are then cemented into the ground. There are different options that can be selected with a ground mounted systems:

Static Mounted System

This is considered to be the most cost efficient of the ground mounting systems. It requires a static setup that will point the solar panels in the area that is most efficient for exposure to sunlight. There are different variations on this type of system. For example, the solar panels might sit on top of a single pole or they might sit on the side of the pole. There could also be panels that are situated on supporting legs that are adjustable.

Active Solar Tracker

This is a more expensive ground mounted option, but the benefit of this method is that it includes a special type of optical sensor that will follow the sun throughout the entire day and as a result maximize the amount of energy that is absorbed. It should be kept in mind that systems which are more mechanically complicated do have an increased chance of something going wrong. Ideally, this type of ground mounted system should be used by consumers who either can maintenance themselves or know someone who can handle the maintenance for it.

Passive Solar Tracker

This is yet another option that is fairly costly, but it is not as expensive as the previous option. With this system, the heat of the sun is used to move liquid from one side to the other inside the tracker. It allows gravity to turn it and then track the sun. There are no motors used or any gears, which means that there is no mechanical system which could fail.

The benefit of using either the passive or the active solar tracker is that the consumer will be able to ensure their solar panel gets the most exposure to sun as possible throughout the entire day.

Roof Mounted Systems

It is possible for solar systems to be mounted on a variety of different types of roofs. The easiest type of roof to work with is a shingle roof. Tile roofs can be more challenging than shingle roofs, but it can be done. The ideal situation would be for the solar panels to be installed while the roof is still being constructed, but of course, that is not always possible.

It should be understood that with the roof mounted system, the mounts will actually go through the roof using stainless steel bolts that will then be secured into the rafters of the roof. Locating the rafters will be important to make sure that the system is installed correctly.

Installing Thin Film Solar Panels

For the most part, thin film solar panels are not able to absorb as much sunlight with the same efficiency as other types of solar panels; however, there are certainly benefits to installing these types of solar panels. For starters, it is not necessary for the panels to be mounted onto the roof. Instead they can be glued onto the roof, which means there is no need to puncture holes into the roof.

If not done correctly, putting holes in a roof can void the warranty on the roof. Additionally, thin film solar panels are not as heavy as other types of panels which contain larger amounts of silicon and require structural support as well. These types of solar panels actually work quite well in extremely hot climates because they are more efficient at producing energy at the beginning as well as at the end of the day.

Facing Solar Panels in the Right Direction

Solar panels will provide the maximum output if they are pointed in the correct direction, which is true south if you are installing in the northern hemisphere. The panels must be pointed in a perpendicular direction to the sun during midday. There are different ways that this can be accomplished.

First, it is important to understand that magnetic south is different from true south. Magnetic south is the direction that you find when using a compass. True south refers to the direction of where the sun is actually located. The best and most accurate way of finding the true south is to find the magnetic declination. You can go to the following website and type in your zip code to find this information:

http://www.ngdc.noaa.gov/geomagmodels/declination.jsp

So, take the direction to which the compass is pointing and then add the number of degrees that is shown on the declination. So, if your compass shows 180 degrees and you see 14°33' E when you look up the declination then you will need to add 14 degrees to 180 and you will come up with 194 degrees, which will be the direction of true south for your area. Keep in mind that if your location is west rather than east then you will need to subtract degrees rather than add them.

Keep in mind that it is not absolutely necessary for the solar panels to be faced in a true south position if that is not possible, but it should be remembered that if they are not faced in a true south position then the panels will not produce the most energy possible.

The Site Survey

The site survey is another critical part of any solar panel system installation project. In order for the solar system to function effectively, it is imperative to take the time to evaluate the site for a variety of different factors that may impact the way in which the solar system functions.

Location

First, the location of the system will need to be analyzed. In a prior section, we discussed the importance of determining the size of the system needed in order to establish the amount of roof space that will be needed for installing the system. Whenever possible, the site should be visited in person, but in the event that it is not possible for the site to be visited in person, then photographs of the site as well as of the surrounding area should be obtained in order to understand how to best situate the system.

Shade

One critical area that should always be checked is the shading of the site. In order for the system to function effectively, you must determine that the sun will actually shine on the area where the system will be positioned. Consider where the system will be tentatively placed and then survey the horizon, taking into consideration the full arc of the sun. If the site in question is to be in the northern hemisphere then you will be considering the south, the east and the west.

If; however, the system will be installed on location in the southern hemisphere then you will be taking into consideration the north, east and west. For the purposes of this book, we will primarily be discussing the northern hemisphere but in the event that a system will be installed in the southern hemisphere then you will need to remember to consider the opposite. Conversely, if the location in question lies very close to the equator on either side, then keep in mind that you only need to consider the east and the west due to the fact that the sun will pass directly overhead.

When performing the site examination, you want to make sure that you are taking into consideration anything that might shade the solar system. Keep in mind that you are not just considering whatever might cause shade at the time of the year at which the system is being installed but also any other time of the year. For example, if you are doing an install during the dead of winter then you might not have much shade created by a nearby tree, but that would be an entirely different case during the spring and summer.

Some factors that could cause shading and should be taken into consideration include:

- Hedges – Remember that hedges are prone to growing unless the homeowner keeps them trimmed back on a regular basis, so you should plan for shading from the hedges at some point in the future.

- Trees – Trees always provide shading, although it may not be present during the winter. When taking into consideration trees and the amount of shading they provide, you also need to consider the amount of shading that a tree will provide as it matures. You always need to consider the entire life of the system. A small tree might not provide much of an impact today, but after 20 years of growth that will be a completely different story.
- Hills and Mountains – If you are installing a system in a location that is mountainous or that has hills, you need to be particularly careful due to the fact that during the winter the sun will always be closer to the horizon. If you happen to be doing the install during summer, be sure to find out where the sun rises and also where it sets during the winter season.
- Local climate – You also need to make sure you know whether there is anything that is different about the local climate that you might not be aware of. If you are not personally familiar with that particular geographical location, it is imperative that you find out whether any local climatic anomalies will make a difference, such as sea mist or anything else.
- Presence of buildings and other structures – Remember that this can always make a difference. Be sure to take the time to find out whether there are any plans for buildings that will be completed in the near site that could potentially obscure the site where the system will be installed.

It is imperative that you always take the time to envision the way the site will look throughout the year as well as in the future. Any change that is made to the area in terms of seasonal changes or growth and development can impact the way in which the solar system operates. With the right planning, a good quality solar system array can last the homeowners for years and provide long term power, but only when careful planning and evaluation is part of the installation process.

Location of the Array

In addition to the factors mentioned in the previous section, it is also important to make sure that you have the right location for the solar panel or solar array to be mounted. When mounting a system on a building, the most common method is for the system or array to be mounted on the roof. If this is not possible for some reason then an alternative mounting location will need to be devised.

Roof Mounting

The reason that the roof is the preferred location for mounting the solar array is the fact that it will typically slope towards the south, at least when in the northern hemisphere. If in the southern hemisphere then the roof will typically slope toward the north. The precise angle of the slope is important and ideally should be equal to about the angle of the latitude along with an extra fifteen degrees. In some cases the roof may be flat, in which case these conditions will not be met. If that is the case then it will be necessary for an angled support system to be utilized for the roof mounting.

Remember that when you are planning an installation project, it is always better if you can actually access the roof in order to completely survey it for planning purposes. If you are not able to survey the roof in person then photos will suffice, but you will have more information and the best chances of installing a fully functional system if you are able to inspect the roof in person in order to check the following factors:

- Shading – as previously discussed. In some cases you may not realize there is a problem with shading until you are actually on the roof. It may be a good idea to inspect the site at various times of the day.

- Angle of the slope-always make sure that you utilize a level for the purpose of measuring the angle of the roof.

- Direction – Use a compass in order to check the direction that the roof slopes.

- Construction material – You always want to make sure that you have inspected the materials that the roof is constructed from, particularly beneath the roof in order to be certain the structure has enough strength to support the full weight of the solar array.

- Area – It is imperative to make sure that you have measured as well as noted the dimensions of the portion of the roof's surface that is usable. You will need to determine whether the usable portion of the roof is enough for the size of the array that will ultimately be needed to meet the homeowner's power requirements. In the event that it appears there is not enough space on the roof or that the roof is unsuitable for some other reason, then you will need to consider locating an alternative type of support for the array.

A Word about Ground Mounting

For the most part in this book we are going to be discussing roof mounting because that is the most common way that solar array systems are mounted, but it must be understood that in some instances the roof may not be the ideal location for the system to be mounted. If that is the case then it will become necessary for a different type of support structure to be used.

You will find that vendors that supply solar equipment also sell a variety of different types of structures on which a system may be supported on-site. There are two different types of ground mounting systems that are commonly used. They are:

- Pole mounted – this is a type of mounting system in which the solar array may be attached to either a pole that has been specifically erected for that purpose or on a pole that is already in existence on the site.

- Ground mounted – this is a type of structure that utilizes a frame that is mounted on the ground. A foundation must be used with this system.

When considering the use of a ground mounting system, it is imperative to take into consideration many of the same factors that are considered in a roof mounted system as well as a few other factors:

- Ground conditions
- Shading
- Area of ground that is available
- Distance of the site from the location of the batteries
- Any poles that are in place which may be suitable for installation

Location of the Batteries

The location where the batteries will be placed must be taken into consideration as well. There are many different options where the batteries could be potentially placed including a separate building, a space within the home or the building itself or even inside a special type of housing that is specifically erected for that purpose. In determining the most appropriate location for the batteries, there are many different conditions that will need to be met. These factors include the following:

- Ventilation – remember that even sealed lead-acid batteries must have adequate ventilation in the event of gassing
- Protection from the environment – the batteries will also need to be protected from the elements, including temperature extremes, direct sunlight and rain.
- Safety – due to the fact that it is possible for explosive gasses to be given off and also due to the fact that there exists a strong potentially for very high currents, it is also important for batteries to be maintained in an area that is completely secure and which children are not able to access.
- Protection from ignition sources – lead acid batteries can give off a mixture of oxygen and hydrogen, the combination of which can be highly explosive, therefore it is imperative that the batteries not be location in such an area where they will be exposed to possible ignition sources, including exposed flames.
- Location of other components in the system – you also need to consider where other components in the system will be located so that the cable runs can be as short as possible.

Taking the time to understand where everything will be positioned can be time consuming, but it is an important step that should never be overlooked. Taking the time to take care of this step now will ensure that the system will be able to operate at peak efficiency and that it will be able to produce the most electricity possible.

In the next section, we are going to begin going over the actual process of mounting the solar system. Although there are certainly different methods for mounting and installing the solar panel system, as discussed in this section, for the purpose of this manual we are going to be looking at the roof mounted system because that is the most commonly used system for installing solar panel systems at this time.

Installation

Now it is time to turn our attention to beginning the actual mounting of the solar system array as well as the additional equipment that accompanies the system. This is a critical area that must be carefully considered in order for the entire system to work effectively.

In this section, we are going to cover how to install several different types of mounting options, including the traditional roof mounting option, an option for mounting modules on a tile roof, using a ground mounting system, a top of a pole mounting system and even how to install the new thin film type solar energy modules.

When determining which type of mounting option is right for a particular situation, it is important to take several factors into consideration. Ideally, it is better to determine how to install solar panels when you have a new construction building or home. This is because it will be easier for the panels to be mounted while the roof is still being constructed, which will allow for optimization of the solar array placement. Ultimately, this will allow the solar panels to be placed so that they can take full advantage of the sun throughout the entire day.

That is not always possible; however, which means determining the best mounting option based on existing conditions. Some types of roofs can be more difficult to work with, including tile, although it is certainly not impossible to install solar panels on a tile roof.

In most cases, solar panels are attached to the roof of a building or a home, typically on a southern façade in order to make the best use of the sun during the day. Other factors that could potentially effect where and how the solar panels are placed include the climate and weather of the local area. For example, if the area where the solar panels are to be installed is in a location that is considered to be a high wind zone, then it may be necessary to consider using an alternative mounting system.

The degree of tilt that is needed to take advantage of maximum sun exposure is also another important factor that must be taken into consideration when determining the most appropriate mounting system for the situation. Generally, this will depend upon the latitude of the location of the building. For example, the higher the latitude of the building site, the higher the tilt will be required in order to have the highest efficiency of the solar panels.

Placement of the Batteries

If you have identified a location indoors that will be suitable for placing the batteries, you can generally place them right on the floor. If that is not possible then you may need to use a battery box for mounting the batteries or you may also need to use racking in order to ensure the batteries are adequately protected or to make the best use of the space that is available. Always make sure that you have measured the batteries boxes or the racking first to be certain that the batteries will fit as they should.

Placement of the Control Equipment

In most cases the control equipment, including the inverter and the controller, will be mounted on the wall. Ideally, this should be as close to the batteries as possible. You will need to pay careful attention to this, particularly if there are any restrictions regarding the maximum length that the battery cables can be run.

Keep in mind that inverters can often be heavy so you want to make sure that you choose a location that has sufficient strength for mounting the inverters. The last thing that you want to have happen is to mount the inverter and then find out after the fact that the space you have chosen does not have sufficient strength for the mounting.

You also need to check the existing breaker box in order to ensure that there is sufficient space for at least a couple of extras to be added. Keep in mind that in many localities the local utility company prefers for there to be a main shut off that can be used to quickly shut off the system in the event that there is an emergency. This will likely never occur, but in order to be in compliance with local regulations, this is often a requirement, so make sure you keep that in mind and check to be certain there is sufficient space on the area where the box is mounted for the shut-off to be situated as well.

Placement of the Cabling

You also must take care to make sure you know the best route for the cabling to be location. This is particularly important when considering the heavy cables that will need to be run from the array to the controller as well as the batteries. Always make sure that you have taken the time to measure the length of the cables so that you can be certain of adequate placement.

Getting Ready for the Installation

Before you actually begin the process of installing the equipment, it is best to make sure that you have taken the time to familiarize yourself with the instructions that are provided by the manufacturer for each of the components of the solar system. By now you should have identified a mounting system for each of the items that will be needed for the entire system.

You may find it helpful to establish a wiring diagram before you actually begin the installation. This will allow you to mentally walk through the entire process and also have something to reference when you begin to actually install each of the components.

Staying Safe

During every element of the installation, it is imperative to make sure that you have taken steps to ensure the safety of yourself as well as others. Always make sure that you have taken precautions to keep the general public away from the installation site while work is progressing. You can do this by using fencing or barriers, but do not overlook this critical step. If there will be children in the vicinity, you will need to pay careful attention to them as well.

Keep in mind that the output from the inverter is the same as mains voltage and when handled improperly it can be lethal. You should always make sure that you treat it just as you would any other main electric supply. It is also important to make sure that you keep in mind when you are working with wiring that the grounded connector is black.

It is also important to remember that a solar array is going to produce electricity when it is exposed to the sun, regardless of whether it is actually connected to the control equipment. This means that you must take care to treat any output cables from the array as though they are live and when you are making connections that you may sure you cover the array.

Bear in mind as well that the open circuit voltage of the array is going to be much larger than the system voltage. This can be particularly dangerous and even lethal to children, the elderly and anyone who has a heart condition, so keep that mind.

Batteries are capable of producing currents of hundreds and even thousands of amps. This greatly increases the risk of fire, which means that you will need to exercise great caution in order for the battery terminals to be protected from shorting. Always make sure you have removed all jewelry and be careful using tools.

Dilute sulphuric acid is contained inside lead acid batteries. In addition, batteries have the ability of giving off hydrogen when they are charging, which can be quite dangerous. To maintain safety, always make sure that you do not smoke near the batteries. Such batteries can also be quite heavy so it is a good idea to ensure that everyone working on the site utilizes appropriate lifting gear when it is necessary for the batteries to be lifted.

In almost all cases, solar panels are going to be made as glass, which means they are very fragile. Exercise great caution when handling them to avoid the risk of breakage and injury.

When installing solar panels, you are going to typically be working at a height. Make sure that you are prepared to take all appropriate precautions for working at such heights.

Installation

Tool List

Before you get started, you will need to make sure that you have the correct tools. You will need the following:

- Cordless drill
- 3/8" masonry drill bit, if you are installing on a tile roof
- 3/15" carbide masonry drill bit
- Cordless impact wrench with ½" socket

It is a good idea to work on installing the splice kit on the ground. This makes it much easier to handle and support the rails rather than trying to do it once you are on the roof. Once the splices have been installed, you can then set the lengths against the home or the structure. For the most part, you will be able to pull the lengths onto the roof without needing to use any mechanical equipment and will also be able to handle the lengths as though they are a single unit.

1. Take the support rails and turn them upside down so that the bottom will be facing upward.
2. Now, place the lower support over the rails. This will give you a template to follow.
3. Next, center the lower support over the rails and use a felt pen to mark along the v-groove drill guide. You will be drilling two holes utilizing a ½" #10 UniBit. Make sure that you drill at the intersection of the V groove drill guide and the reference mark.

4. Now, take the splice A and insert it into the channel and then install the B piece into the support C. Use a ½" socket to tighten everything. Keep in mind that the splice insert is specifically designed so that it will expand into the walls and force the rails to come into alignment, so you want to make sure that you do not tighten it too much. You will now be able to handle and install the support rails as a single solid rail.

Attaching the Support Rails to the FastJack®

1. Position the support rail upside down near the attachments. Using your pen, mark the channel that is adjacent to the attachment devices.

2. Now, align the intersection V groove drill guide on the rail and mark it.

3. Next, drill a ½" hole through the rail. After you have drilled the hole, place the rail directly over the attachment feet and the install the 3/8" washer and nut.

4. Use a 9/16" deep socket wrench to tighten it. The support rails should not be completely secure and ready for the modules to be installed. Most people will find that it is much easier and convenient to assemble the bolt, lock washer and clamp on the sliding insert before they bring them up onto the roof. This, of course, is purely a matter of personal choice, but you may wish to experiment with pre-assembling to determine if it is more convenient for you.

5. Once the support rails have been completely fastened you will then be ready to install the solar modules. You will find there are two different sets of clamps. They are the outside clamps, or the end clamp, and the inter-module clamps that are used for installation between the modules.

6. Slide the two outside clamps close to the end of the support rail and then install the end module first. Be extremely careful to ensure that the module is squared to the frame and then tighten the clamps utilizing a ½" drive socket or box wrench. Make certain that you do not tighten too much. Ideally, you should not use more than a torque of 12 foot pounds in order to ensure there is no damage to the module.

7. Once the first module has been secured, you can then slide two of the inter-module clamp sets onto the first of the module side frames. Remember that these are specifically designed to remain in place, which means you can then be free to slide as well as align the subsequent module.

8. You will repeat this entire process until all of the modules have been installed onto the support rail.

9. Once the last module in the panel has been installed, you will then install the module end clamp onto the end of the last module. Do not fully tighten the bolts yet because you will need to make any adjustments that may be necessary in order for the array to be completely square and even.

10. After all of the modules are in position use a 5/16" socket impact set to 12 feet pounds to tighten the bolts on the clamps.

11. You may need to cut off any excessive support rail that has not been used. A reciprocating saw can be used for this purpose.

Installing a Tile Track Mounting System

A tile track system is a good option that can be used on both a composition roof as well as a concrete tile roof.

Tools Needed

The tile track mounting system will require the following tools for installation:

- Chalk line
- Cordless standard drill with a 3/16" long drill bit
- Cordless rotary hammer drill with 3/8" carbide masonry bit
- Cordless standard drill with ¼" carbide masonry bit-needed for a composition roof only
- Cordless impact wrench with ½" socket
- Roof sealant
- Lumber crayon
- Stud sensor
- 3/16" t-handle hex key-for composition roof only
- Dead blow hammer

1. The first step is to layout the system and do your chalk line markings. It is a good idea to have a sketch or drawing of the way that the system will look when you are going through this step. Chalk lines can be used for marking where the support rails will be located. Remember that the support rails will be located 48" apart along the full length

of the modules. The distance of the rails from the end of the modules will vary based upon the actual size of the modules. Take the chalk line and snap it along the location where the support rails will be situated.

2. The next step in the installation process is to locate the roof rafters along the chalk lines. Keep in mind that in most buildings and homes, the roof rafters will be located every 48" on center. Once you have located one, you should be able to locate further rafters by measuring 48" from the first rafter that you located.

3. Now, you are going to take the lumber crayon and mark all of the locations where the holes will be drilled so that you will be able to properly seal the roof. Choose one of the tiles where you have located the rafters and then carefully remove the tile. In most cases, the tiles will be held in place using a small nail. Pushing and pulling the tile should remove it. Take the stud finder and locate the rafter center. Use the lumber crayon to mark a reference point. You could also use a dead blow hammer to lightly tap the rafter until you hear a solid sound and then mark that location.

4. Take the drill and drill until you have found the center of the rafter. You may need to drill several holes. It is a good idea to use a 3/16" drill bit. Insert the lag bolt as well as the washer through the tile track and make sure that you have applied sealant to the base.

5. Install the lag bolt, using a ½" socket drive. Be sure that the lag bolt is completely seated, but make sure that you do not over-tighten. Once the tile track has been bolted to the roof, slide the upper carriage into the correct position under the tile's crown. Always make sure that all holes are properly sealed.

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6. Replace the tile, lining up the snap lines. You can now mark and drill the tile.

7. Use a 3/8" carbide bit and a rotary hammer to drill through the crown of the tile at the intersection of the reference marks and the chalk line.

8. Take the threaded shaft and insert it through tile to the upper carriage. There are two 3/8" nuts that will be provided with the system. These should be bound using two 9/16" wrenches. Tighten to 14 pounds.

9. Apply sealant around the threaded shaft and then compress a 3/8" washer, using a 3/8" box-end wrench. Sealant should be applied completely around the washer to be certain everything is waterproofed.

Installing Thin Film Solar Panels

Thin film solar panels, also known as thin film photovoltaic laminate modules, are among the newest on the market. They are growing increasingly popular due to the fact that they are not as heavy or as unwieldy as other, earlier types of solar module systems.

With these types of systems, all that is needed is to simply peel of the laminate and then adhere the module to the roof. Keep in mind that these types of systems are ideally utilized for a standing seam metal roof. The installation process takes about ten minutes per panel.

<u>Steps for Installation</u>

1. Apply the PV laminate

2. Install the roof panel

3. Connect the output from the PV to the invert

4. Turn on the switch.

Installing a Ground Mounting System

A ground mounting system can be used when it is not appropriate to mounting the solar panels on the roof. One of the benefits of using this type of system is that it is not as labor intensive as installing a roof mounted system. Be aware when installed a ground mounted system that you will still need to pay attention to important factors, such as shading and southern placement (when in the northern hemisphere) to ensure that the solar panel system works efficiently.

Tools Needed

The ground mounting system utilizes #40 1 ½" galvanized pipe. In addition to the pipe, the installer will need the following tools and equipment in order to install the system:

- Post hole digger
- Shovel or wheelbarrow
- Drill
- String line
- Line level or a builder's level
- ½" Uni-Bit
- Marking pen

- Tape measure
- ½" wrench
- Phillips head driver
- 7/16"deep socket and ratchet
- 3/16" hex wrench
- Pipe cutter or a reciprocating saw
- Framing square
- Large hammer or a mallet
- Two pipe wrenches

Steps for Installation of Ground Mounted System

1. The first step in installing the ground mounted system is going to be excavating the footings. The footings will need to be excavated to a 12" diameter and 42" deep.
2. Next, you will need to determine the appropriate angle for the solar module array and then install the grade stakes. Make sure that you do not go beyond five feet of vertical post length from the grade.
3. Note that installation of the supports braces will actually hold the pipe at the correct fixed angle until such time as the footings are poured. It is a good idea to utilize drywall screws for holding the horizontal brace in place while the concrete sets.
4. Install the end braces. Next, use a string line to be sure that you have the right alignment.

Supports should be placed at a distance that will allow the pipe beam to be properly supported without sagging occurring.

5. Now, you may assemble the pipe support beams and the vertical post supports, resting on the support bracing. You will need to use a 3/16" hex wrench and two pipe wrenches for assembling the pipe and support legs. You will then be ready to install the deep channel rail.

6. The next step is to drill the support rails. Make sure that you have aligned the support rails so that the bottom side is up on a flat surface. Utilize a framing square and then measure from the center of the channel 41" outward and use the marking pen to mark a line on the support channel.

7. Next, mark another line that is 2 ¼" outward from the center of the first line.

8. Now, drill the holes so that they are aligned with the marked line as well as the V groove that you should see on the channel. A Uni-Bit can be used for this. At this point, you should have holes that are perfectly aligned and ready for the support pipe beams to be installed.

9. Next, attach the support rails to the pipe and make sure that you have tightened the u-bolts for proper alignment.

10. The next step is to set the concrete footings. Make sure that you have aligned the end of the channel utilizing a string line. All of the U-bolt assemblies should be tightened. Take the time to check to be certain the vertical pip supports are aligned.

11. You may now pour the concrete for the footings. Make sure that you tap the concrete to be certain that it makes contact with the vertical pipe support.

12. Once the concrete has set, remove the support bracing. It is now time to install the modules.

Tips for Estimating the Correct amount of Pipe and Concrete

You will need to make sure that you have the correct amount of galvanized pipe to form the rack as well as the correct amount of concrete for this installation project. In order to make sure that you have the right amount of pipe, tally the total number of panelized modules that will be used.

Consider the width of the module, for example, 58" multiplied by the total number of grouped panels. Galvanized pipe is available in lengths of 21" so take that into consideration when determining the number of lengths that you will need. Determining the right amount of pipe will help you to avoid having to cut and thread pipe.

Keep in mind that you will need about 2.7 cubic feet of concrete for the footings per post.

Installing a Top of the Pole Mounted System

<u>Tools and Materials Needed</u>

- Mounting system kit
- 2" steel pipe to be used for mounting pole, approximately 8 feet in length
- Post hole diggers
- Concrete

Steps for Installation

1. First, you will need to dig a hole to approximately 36" depth and about 12" in diameter. Place the pole into the hole and fill the hole with concrete to the top.

2. Brace the pole so that it is plumb and then allow time for the concrete to set.

3. Place the mounting sleeve assembly onto the pole and then bolt the module rails to the plates using the supplied washers and nuts that come with the mounting system kit.

4. Mount the module to the rack using the hardware. Be sure that the bolts are tight. Check to be sure that the rack is pointed in a southern direction.

5. Tighten the screws in the mounting sleeve so that the rack is secured to the pole.

6. Be aware that the pivot bolt should be loosened before attempt to adjust the elevation angle of the rack. Once the rack has been re-positioned, make sure that all bolts are tight.

Keep in mind when installing a top of the pole mounting system that all areas are prone to having different soil conditions. The depth and diameter of the hole as well as the amount of the concrete that will be used will depend upon the type of soil that is present in the area where the system is to be mounted.

If the system is installed in soil that is loose and sandy, there will need to be a deeper and larger hole with an additional amount of concrete used than what would be needed in soil that is hard and rocky. It is also important to take wind speeds in that particular area into consideration when determining the height of the pole.

The module size can play an important role in determining factors such as the size of the pole that is needed, the length of the pole that should be placed in the ground and the diameter of the hole that should be filled with concrete. Consult the following chart for help in determining these factors:

Module Area	**Pole Size**	**In-Ground Length**	**Height**	**Diameter of Hole Above Ground**
15 SQ. FT.	2”	30”-36”	48”-72”	8”-12”
20 SQ. FT.	2.5”	34”-40”	48”-72”	10”-14”
28 SQ. FT.	3”	36”-42”	48”-72”	12”-16”
35 SQ. FT.	3”	38”-44”	60”-72”	12”-16”
60 SQ. FT.	4”	42”-48”	60”-72”	16”-24”
90 SQ. FT.	6”	48”-60”	60”-84”	24”-30”
120 SQ. FT.	6”	48”-72”	72”-84”	24”-30”
160 SQ. FT.	8”	60”-78”	84”-102”	30”-36”
180 SQ. FT.	8”	60”-78”	84”-102”	30”-36”
225 SQ. FT	8”	72”-84”	96”-120”	36”
260 SQ. FT.	8”	72”-84”	96”-120”	36”

Keep in mind that if you should need to use a pole that is taller in order to clear any nearby obstructions or in order to clear snow, then you will need to make sure that there is more length in the ground. A good rule of thumb to keep in mind is that for every additional foot of pole that is above ground, you will need to add 6 inches in ground, set in concrete.

In the event that you need to go further than three feet higher than the data references in the table, keep in mind that you will typically need a pole with a larger diameter.

Once the hole is ready, the pole can be placed in the hole so that it is resting at the bottom. You may find it helpful to fill the bottom of the hole with a couple of inches of rocks. Brace the pole and then pour concrete fully around the pole and up to the top of the hole. Pour some extra concrete and then mound it around the pole using a trowel. The concrete should slope downward away from the pole. Allow the concrete to set for a full 24 hours before installing the rack.

Installing the Inverter

The inverter takes power from the DC source, in this case the modules, and then converts it to AC power for the utility grid. The power is first delivered to local loads, including lights, appliances, etc. and then excessive power is fed to the utility. The power that is consumed by local loads reduces the amount of power that is needed from the utility company.

When there is excessive power that is not being consumed by the household, the utility meter may actually spin backwards, although this could depend upon the type of meter that is installed in the system. The excessive power can be recorded as power that is credited to the homeowner by the utility company.

51 The first step in installing the inverter is to choose a place for it to be mounted. You should look for a location where it will not be exposed to direct sunlight as higher temperatures within the unit can actually cause reduced output from the total solar system. In addition, the inverter should be installed in an area that will not be accessible to children.

2. You should be aware that when the inverter is operating it tends to make a slight

vibrating noise. This is completely normal and does not affect performance in anyway, but it can be bothersome if the inverter is mounted on a wall that is shared with a living area or particularly a sleeping area. The noise may also increase if the inverter is mounted on certain types of materials, such as sheet metal or wood paneling that is very thin.

3. The inverter should also be installed at eye level and should be installed vertically. This will ensure easy operation as well as the most energy yield. Take care that the surface where the inverter is mounted is strong enough to fully support it.

   The inverter should never be installed on sheet-rock or on any type of paneling that is made of thin wood. You will need to make sure that any electrical conduits as well as nay communication cables have been positioned or sealed so that there will be no chance that water will be able to enter the inverter.

4. The inverter will typically have a wall mounting bracket in the shape of a T. This mounting bracket should work fine for most walls. The horizontal part of the bracket will have two holes that are spaced for 16" centers for mounting on wall studs. You can also install and mount it on stone or concrete walls.

5. Take the wall mounting bracket and position it against the wall where the inverter is to be mounted. Place a level on the top edge of the bracket and adjust it until the bracket is completely level. Mark the wall, using the mounting bracket, through the two holes in the horizontal part of the bracket. Always check to make sure that there are studs in the walls at the locations where you will drill the holes to mount the bracket.

6. Now, lay the bracket aside and the drill the holes in the places you have marked. The diameter of the holes that you will drill absolutely must match the hardware that you will be using to mount the inverter. As an example, if you are going to be mounting the inverter on a stone wall, the diameter of the hole should be about the same size as the outside diameter of the anchors you plan to use. If you are going to be mounting the inverter on a wall with wooden studs, then the diameter of the hole should be about the same size as the lag screws you will be using for mounting the bracket. Keep in mind that when mounting the inverter outside, the lag screws should be made of stainless steel.

7. Insert the lag screws through the holes in the horizontal part of the bracket and into the two holes that you have just drilled into the wall. Now, tighten the screws until the bracket is positioned firmly against the wall, but make sure that you do not over-tighten the screws.

8. Next, carefully lift the inverter into position on the mounting bracket. There should be a bracket at the back of the inverter, near the top edge, that will fit over the top edge of the bracket.

9. Be aware of the fact that the inverter can be heavy, so you will need to use extreme caution when lifting it into place. It may be helpful to have someone assist you with this part of the installation process.

10. Once the inverter is in place, inspect it carefully to be sure that the bracket on the back of the inverter is fully engaged with the top edge of the bracket and also that the inverter is centered on the bracket.

11. Take the mounting strap on the back of the inverter and insert a bolt through the hole that you will see in the mounting strap and then also into the threaded hole that you will see in the bottom portion of the mounting bracket. Tighten the bolt, but be sure not to over tighten it.

Wiring and Connecting the Inverter

The next step is to wire and connect the inverter to the array, the circuits of the household and the utility grid. In order to accomplish this is the most efficient as well as the safest manner possible make sure that you follow these steps precisely.

Before you get started make sure that you have turned off all of the switches and the breakers in the system before attempting to connect any wires to the inverter or disconnect any wires from the inverter.

Make sure that you de-energize all of the DC and AC sources by switching all of the disconnects and the breakers to the off position.

<u>Steps for Wiring the AC Output</u>

1. First, make sure that you have turned off the main breaker in the main utility breaker box. Install a ½" conduit fitting in the inverter's AC wiring knockout. Next, fasten the fitting on the inside of the invert with the nut that will be supplied for this purpose.

2. Now, install ½" conduit between the main breaker box and the inverter's AC wiring knockout. Pull the AC wires through the conduit from the breaker box interior to the interior of the inverter. Take care not to use any wire nuts for joining wires together or

for making any connections in the system. Wire nuts frequently cause connections that are unreliable as well as ground faults.

3. Connect the equipment grounding wire to the terminal labeled PE in the inverter and then tighten to a torque of 15 in-lbs.

4. Next, connect the AC line, or the L1 wire, to the terminal labeled N in the inverter. Now, fasten the wires while at the same time applying a torque of 15-in lbs.

5. Finally, verify that all of the connections have been correctly wires and that they are also properly torqued.

Steps for Wiring the DC Input

In this section we are going to look at the steps for configuring the inverter's DC input-voltage range as well as for wiring the DC input from the array to the inverter.

1. When completing this part of the process you always want to make sure you know how much DC input voltage the inverter you are using was designed for. Usually, this will be a maximum DC input voltage of 250 V DC, but make sure that you check to be certain. You will be able to configure the input voltage range to match the output of the array.

2. Before beginning the next steps, make sure that all AC and DC breakers and switches in the array have been turned off. Additionally, wait a full five minutes for the inverter to completely discharge before you make any attempt to connect any wires to the inverter or disconnect any wires from the inverter. Failure to do so can result in exposure to lethal voltages tat can cause serious injury and/or death.

3. Before you attempt to connect the DC wires to the inverter, make sure that you have verified the polarity as well as the open-circuit voltage from the strings on the array.

4. Make sure that the main breaker in the main utility breaker box is switched to the off position. Next, open the DC disconnect in the DC disconnect enclosure and then install ½" conduit fitting in the inverter's DC wiring knockout.

5. Now, fasten the fitting on the inside of the inverter with the nut that is specifically supplied for this purpose.

6. Next, install ½" conduit between the inverter's DC wiring knockout and the DC disconnect enclosure. Now, pull the DC wires from the DC disconnect through the conduit and into the inverter's interior. Connect the positive DC wire to the terminal that is labeled DC+ in the inverter.

7. Next, connect the negative DC wire to the terminal that is labeled DC- in the inverter. Connect the positive and the negative DC wires to the correct terminals in the DC disconnect enclosure and then fasten the wires while at the same time applying a torque of 15 in-lbs. Make sure that all of the connections have been correctly wires and torqued.

Wiring the AC-DC Disconnect

Previously we discussed the fact that in many localities the local utility company prefers for an AC-DC disconnect to be installed so that in the event there is ever a problem that it can be quickly and easily shut-off. Below, we will go through the steps of wiring the AC-DC disconnect and ensuring that it is installed correctly.

The AC-DC disconnect is a type of AC and DC circuit breaker that works to disconnect the PV generator from the inverter.

1. Connect the AC equipment ground wire to the PE terminal labeled in the AC-DC disconnect.

2. The next step will depend upon which type of V you are using. If you are using the 208/240/277 V, you will connect the Hot wire to the terminal that is labeled L1 in the AC-DC disconnect. If you are using the 208/240 V then you will connect the L2 and the N wire to the terminal that is labeled L2 and N within the AC-DC disconnect.

3. Be sure that you have connected the wires to the terminal blocks within the AC-DC disconnect and then tighten them to a torque of 15 in-lb.

4. Now, connect the white wire within the AC-DC disconnect to the terminal that is labeled NJ and then the black wire to the terminal that is labeled L1 in the inverter.

5. Be sure the wires to the terminal blocks inside the inverter are connected and tightened.

You may now turn the DC switches and/or breakers back to the on position and then turn the AC switches and breakers back to the on position.

Commissioning the Inverter

Begin by ensuring that any covering that has been placed over the array has been removed. Next, connect the grid voltage to the inverter. This is done by switching on the main AC circuit breaker inside the main utility panel.

Now, switch the DC disconnect to the on position. If there is enough available sunlight, the inverter may enter the wait mode and you may see a green light blinking. If there are not any AC faults detected at this time the wait mode will top after a few seconds and the green light will stop blinking and will instead remain on. The inverter should operate normally at this point.

Testing the Inverter

It is a good idea at this point to check the system and make sure that it is operating normally. Keep in mind that it may take a few minutes for the inverter to start running, but after that you should be able to see that everything is functioning normally.

Maintenance and Operation

Once everything has been installed, you will then be ready to move into the maintenance and operation phase, which includes handing over the system to the homeowner. Helping the homeowner to understand how to properly care for and maintain their system will allow them to enjoy it for many years to come and experience as few problems as possible.

Solar panel systems are quite capable of lasting for decades when they are cared for properly, which is why it is absolutely essential that they be maintained on a regular basis. The good news is that they do not require significant maintenance, which means that taking care of them should not be a burdensome chore.

Before leaving the site, it is important to make sure that the homeowner fully and completely understands the following:

- The principals of the system's operation

- The effects that season and weather can have on the amount of available energy
- How important it is to keep energy usage to a minimum, whenever possible
- How to operate the low voltage disconnect
- The indicators on all of the control equipment and what they mean
- How to safely handle the batteries
- Provided with instruction manuals for all of the components associated with the system

Maintenance Tips

One of the wonderful benefits of solar panels is that they do not require extensive maintenance. All they really need is to be cleaned occasionally. If located in an area where there is regular rain, they will not need to be cleaned as often. If located in an area where there is a significant amount of dust, such as the dessert, then cleaning will need to occur on a more frequent basis.

It should be kept in mind that solar panels are designed as well as tested to withstand high winds as well as hail, so there is no need to be concerned that they will be susceptible to such problems.

When cared for properly solar panel systems are capable of lasting for 20 years and beyond. Following these maintenance tips can help to ensure the life of the system:

- When there is a noticeable build-up of soiling deposits on the array, it may be necessary to wash it. This should only be done during the coolest times of the day.

- It is important to make sure that the system is inspected periodically to be certain that all of the supports and wiring are still intact.

- It is also a good idea to review the system's output twice each year. The best times for doing this are around mid-March and mid-September, on a sunny day, at noon. The system's output should be reviewed to determine if the system is performing near the reading of the prior year. Maintaining a log of such readings will enable the homeowner to determine if the system's performance is remaining consistent or if it is beginning to decline, which could signal a problem that may need to be addressed.

When testing solar panels, you will need a multimeter. They can be purchased for around $20. The solar panel should be placed in direct sunlight and should not be connected to anything. The panel will need to be pointed directly towards the sun.

Measure the voltage and then make sure that the amount is about the same that is given by the manual for the panel. Remember that it is not always possible for the numbers to match exactly, which is fine. Next, it will be necessary to turn on the voltmeter and switch it to current and then measure the current. The voltage should be multiplied by the current in order to calculate the power. The resulting number should be near the wattage of the solar panel.

Conclusion

As the world becomes more attuned to the need for energy conservation as well as the benefits that are associated with solar panel systems, it is expected that the number of solar panel systems that are installed will continue to increase.

Solar panel systems are not only good for the environment, but they also produce numerous benefits for the homeowner, including a way to save money and make more effective use of the ability to harness the power of the sun.

When installed and maintained correctly, solar panel systems can provide tremendous benefit to the homeowner. Although there are multiple steps involved in correctly installing a solar panel system, taking the time to perform each step will ensure that the system is operational in the least amount of time possible and thus able to begin providing immediate benefits.

Quick Step by Step Reference

Quick Reference for Roof Mounting

1. Utilize the splice kit to assemble the support rails.
2. Attach the support rails to the FastJack®
3. Install the Modules

Quick Reference for Ground Mounting

1. Excavate to the correct depth for the footings
2. Set grade stakes for the pipe
3. Install the pipe
4. Drill the support rails
5. Attach the support rails to the pipe
6. Set the concrete footings
7. Install the modules

Quick Reference for Top of the Pole Mounting

1. Excavate hole for pole
2. Place pipe in hole and pour in concrete. Set for 24 hours.

3. Place mounting sleeve on pole.

4. Bolt the module rails to the mounting sleeve.

5. Mount the modules to the rack.

6. Point the rack south.

Quick Reference for Installing Thin Film Solar Panels

1. Apply the PV laminate

2. Install the roof panel

3. Connect the output from the PV to the invert

4. Turn on the switch.

Quick Reference for Installing the Inverter

1. Mount the inverter

2. De-energize the AC and DC sources

3. Complete wiring from the AC breaker to the AC disconnect switch

4. Complete wiring from the AC disconnect switch to the inverter

5. Complete wiring from the PV wires to the DC disconnect

6. Complete wiring from the DC disconnect to the inverter

7. Turn on the DC switches and breakers

8. Turn on the AC switches and breakers

Test

1. If you mount a solar system array at a greater angle than you would typically have to mount it, you must take ___________________ into consideration.

    A. Total height

    B. Wind load

    C. Weight load

    D. Visual appearance

2. The array may be mounted:

    A. Flush to the roof

    B. Glued directly to the roof if using thin film type panels

    C. On a pole mounting system

    D. All are correct

3. Load may be expressed in:

    A. Kilowatts

    B. Kilowatt hours

    C. Volts

    D. Both A and B

4. When working with wiring, the grounded conductor is

    A. Green

    B. White

    C. Red

    D. Black

5. ________________ refers to the amount of useful sunshine that is available for panels on an average day during the year.

    A. Available sunlight value

    B. Isolation value

    C. Net sunlight value

    D. Degraded value

6. To determine the size of the array that will be used on a daily basis to provide solar energy, you will:

    A. Multiply the daily energy requirement by the sun-hours per day

    B. Divide the daily energy requirement by the sun-hours per day

    C. Add the daily energy requirement to the sun-hours per day

7. When installing a roof mounted system, the first thing that you must make sure that you do is to:

    A. Seal any roof penetrations that are present

    B. Ask the owner where they would like the system positioned

    C. Ground the system for safety

    D. Make sure the roof is able to support the total weight of the system

8. The __________ changes the DC solar power into usable 120 V AC electricity, which is the most common type that is used by most household appliances and lighting:

    A. Array

    B. Inverter

    C. Converter

    D. Controller

9. The size of a home solar system depends on:

    A. Energy requirements of the home

    B. Hours of peak sun

    C. Available roof space and shading considerations

    D. All of the above

10. Most batteries used in solar systems release __________ as a result of the charging process.

    A. Carbon dioxide

    B. Electrical energy

    C. Hydrogen gas

    D. Small amounts of gaseous acid

11. Which of the following refers to the flow of electrons within a circuit?

    A. Voltage

    B. Current

    C. Resistance

    D. Energy

12. Which of the following is the most commonly used type of solar panel today?

    A. Monocrystalline

    B. Polycrystalline

    C. Amorphous

13. When pointing the compass, you will get which direction?

    A. True south

    B. Magnetic south

    C. Delineated south

14. Which of the following is NOT a factor that should be taken into consideration when placing the batteries, if batteries are to be used in the solar system?
    A. Environmental protection
    B. Ventilation
    C. Protection from sources of ignition
    D. Ground material

15. Why is it important that the inverter not be placed in direct sunlight?
    A. The sunlight can cause the inverter to fade and not look as attractive
    B. Direct exposure to sunlight can cause higher temperatures inside the unit to reduce output
    C. Direct sunlight may damage the inverter

Writing Section

1. What are the steps involved in installing the inverter?

2. Discuss different ways in which electricity usage can be reduced in order to reduce the amount of electricity that needs to be generated by the solar system as well as the additional amount that needs to be obtained from the utility company:

3. Discuss shading factors that must be taken into consideration when determining the placement of a roof mounted solar system array:

4. Discuss the steps involved in wiring and connecting the inverter:

5. Discuss the steps involved in maintaining the solar system once it has been installed:

Answers

1. If you mount a solar system array at a greater angle than you would typically have to mount it, you must take ___________________ into consideration.

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    B. Direct exposure to sunlight can cause higher temperatures inside the unit to reduce output

    C. Direct sunlight may damage the inverter

Writing Section:

1. What are the steps involved in installing the inverter?

The first step in installing the inverter is to choose a place for it to be mounted. You should look for a location where it will not be exposed to direct sunlight as higher temperatures within the unit can actually cause reduced output from the total solar system. In addition, the inverter should be installed in an area that will not be accessible to children.

You should be aware that when the inverter is operating it tends to make a slight vibrating noise. This is completely normal and does not affect performance in anyway, but it can be bothersome if the inverter is mounted on a wall that is shared with a living area or particularly a sleeping area. The noise may also increase if the inverter is mounted on certain types of materials, such as sheet metal or wood paneling that is very thin.

The inverter should also be installed at eye level and should be installed vertically. This will ensure easy operation as well as the most energy yield. Take care that the surface where the inverter is mounted is strong enough to fully support it. The inverter should never be installed on sheet-rock or on any type of paneling that is made of thin wood. You will need to make sure that any electrical conduits as well as nay communication cables have been positioned or sealed so that there will be no chance that water will be able to enter the inverter.

The inverter will typically have a wall mounting bracket in the shape of a T. This mounting bracket should work fine for most walls. The horizontal part of the bracket will have two holes that are spaced for 16" centers for mounting on wall studs. You can also install and mount it on stone or concrete walls.

Take the wall mounting bracket and position it against the wall where the inverter is to be mounted. Place a level on the top edge of the bracket and adjust it until the bracket is completely level. Mark the wall, using the mounting bracket, through the two holes in the horizontal part of the bracket. Always check to make sure that there are studs in the walls at the locations where you will drill the holes to mount the bracket.

Now, lay the bracket aside and the drill the holes in the places you have marked. The diameter of the holes that you will drill absolutely must match the hardware that you will be using to mount the inverter. As an example, if you are going to be mounting the inverter on a stone wall, the diameter of the hole should be about the same size as the outside diameter of the anchors you plan to use. If you are going to be mounting the inverter on a wall with wooden studs, then the diameter of the hole should be about the same size as the lag screws you will be using for mounting the bracket. Keep in mind that when mounting the inverter outside, the lag screws should be made of stainless steel.

Insert the lag screws through the holes in the horizontal part of the bracket and into the two holes that you have just drilled into the wall. Now, tighten the screws until the bracket is positioned firmly against the wall, but make sure that you do not over-tighten the screws.

Next, carefully lift the inverter into position on the mounting bracket. There should be a bracket at the back of the inverter, near the top edge, that will fit over the top edge of the bracket.

Be aware of the fact that the inverter can be heavy, so you will need to use extreme caution when lifting it into place. It may be helpful to have someone assist you with this part of the installation process.

Once the inverter is in place, inspect it carefully to be sure that the bracket on the back of the inverter is fully engaged with the top edge of the bracket and also that the inverter is centered on the bracket.

Take the mounting strap on the back of the inverter and insert a bolt through the hole that you will see in the mounting strap and then also into the threaded hole that you will see in the bottom portion of the mounting bracket. Tighten the bolt, but be sure not to over tighten it.

2. **Discuss different ways in which electricity usage can be reduced in order to reduce the amount of electricity that needs to be generated by the solar system as well as the additional amount that needs to be obtained from the utility company:**

   Any of the below:

   The different things that can be done to reduce electric usage range from some cost to no cost. Although it is probably one of the most expensive things that can be done to reduce electric usage, replacing badly insulated windows with more modern windows is also one of the single most effective steps that can be taken to reduce electric usage. Along the same lines, insulating ceilings and walls can be effective as well.

   Furthermore, replacing older central heating units and other such appliances can also go a long way toward reducing electric usage. It should be understood that these are long term investments that will require a payback, but once that payback has been received, the savings will be additional money for the consumer.

   In addition, changes to large appliances can make a difference as well. Large appliances comprise a large portion of electric consumption. The consumer can achieve significant gains by changing to models of appliances that are more energy efficient. This includes Energy Star compliant appliances.

   There are also many small investments and chances that can be made as well in order to reduce electricity usage. Many such changes are actually a matter of changing personal habits. Most people today have personal habits that actually waste electricity. When they are able to make changes to those habits they will be able to save energy.

   One such example is turning off lights in rooms when the lights are not being used. Along the same lines, using compact florescent bulbs can make a big difference as well. Such bulbs are more expensive, but the payback on making this change can occur fairly quickly.

It is also important for consumers to get into the habit of turning off computer monitors. Many people have a habit of leaving their computer monitor on all of the time. Rather than leaving it on it is much better to put it in sleep mode. Even better would be to turn the monitor completely off when it is not being used.

Closing the blinds in parts of the house that receive direct sunlight can be helpful as well. When the blinds are left open, it causes the house to heat up significantly and that can increase the need for air conditioning.

Choosing when to run certain appliances is also a good choice. Washing clothes at night and running the dishwasher at night are good ways to lower electricity usage. Many utility companies utilize scales that charge more during peak hours.

Another good way to reduce electricity usage is to make sure that the water heater is insulated well. An insulation wrap only costs about $20 and can be used to surround the water heater so that it does not need to work as hard in order to heat the water.

Air drying clothes can be another great change that can result in multiple benefits. Not only does it reduce electricity usage, but it can also increase the lifespan of clothing as well.

Using warm and cold water rather than hot water can result in positive changes to electricity usage mounts too.

Consumers should also consider turning down the refrigerator. A thermometer can be used to set the refrigerator temperature to near 37 degrees and the freezer to 3 degrees. Also, the energy saver switch should be turned on as well. This can make a difference in terms of the amount of electricity that is used.

Air filters should be cleaned and replaced as needed to cut down on electricity usage.

Using low-flow shower heads can result in using less hot water, which also means using less electricity.

Finally, consider taking showers rather than baths because they utilize half of the amount of hot water.

3. **Discuss shading factors that must be taken into consideration when determining the placement of a roof mounted solar system array:**

Any of the below:

Hedges – Remember that hedges are prone to growing unless the homeowner keeps them trimmed back on a regular basis, so you should plan for shading from the hedges at some point in the future.

Trees – Trees always provide shading, although it may not be present during the winter. When taking into consideration trees and the amount of shading they provide, you also need to consider the amount of shading that a tree will provide as it matures. You always need to consider the entire life of the system. A small tree might not provide much of an impact today, but after 20 years of growth that will be a completely different story.

Hills and Mountains – If you are installing a system in a location that is mountainous or that has hills, you need to be particularly careful due to the fact that during the winter the sun will always be closer to the horizon. If you happen to be doing the install during summer, be sure to find out where the sun rises and also where it sets during the winter season.

Local climate – You also need to make sure you know whether there is anything that is different about the local climate that you might not be aware of. If you are not personally familiar with that particular geographical location, it is imperative that you find out whether any local climatic anomalies will make a difference, such as sea mist or anything else.

Presence of buildings and other structures – Remember that this can always make a difference. Be sure to take the time to find out whether there are any plans for buildings that will be completed in the near site that could potentially obscure the site where the system will be installed.

It is imperative that you always take the time to envision the way the site will look throughout the year as well as in the future. Any change that is made to the area in terms of seasonal changes or growth and development can impact the way in which the solar system operates. With the right planning, a good quality solar system array can last the homeowners for years and provide long term power, but only when careful planning and evaluation is part of the installation process.

4. Discuss the steps involved in wiring and connecting the inverter:

Before you get started make sure that you have turned off all of the switches and the breakers in the system before attempting to connect any wires to the inverter or disconnect any wires from the inverter.

Make sure that you de-energize all of the DC and AC sources by switching all of the disconnects and the breakers to the off position.

First, make sure that you have turned off the main breaker in the main utility breaker box. Install a ½" conduit fitting in the inverter's AC wiring knockout. Next, fasten the fitting on the inside of the invert with the nut that will be supplied for this purpose.

Now, install ½" conduit between the main breaker box and the inverter's AC wiring knockout. Pull the AC wires through the conduit from the breaker box interior to the interior of the inverter. Take care not to use any wire nuts for joining wires together or for making any connections in the system. Wire nuts frequently cause connections that are unreliable as well as ground faults.

Connect the equipment grounding wire to the terminal labeled PE in the inverter and then tighten to a torque of 15 in-lbs.

Next, connect the AC line, or the L1 wire, to the terminal labeled N in the inverter. Now, fasten the wires while at the same time applying a torque of 15-in lbs.

Finally, verify that all of the connections have been correctly wires and that they are also properly torqued.

4. Discuss the steps involved in maintaining the solar system once it has been installed:

When there is a noticeable build-up of soiling deposits on the array, it may be necessary to wash it. This should only be done during the coolest times of the day.

It is important to make sure that the system is inspected periodically to be certain that all of the supports and wiring are still intact.

It is also a good idea to review the system's output twice each year. The best times for doing this are around mid-March and mid-September, on a sunny day, at noon. The system's output should be reviewed to determine if the system is performing near the reading of the prior year. Maintaining a log of such readings will enable the homeowner to determine if the system's performance is remaining consistent or if it is beginning to decline, which could signal a problem that may need to be addressed.

Glossary

active solar energy systems – refers to a type of solar system that is in direct contrast to a passive solar energy approach. With this type of solar system, outside energy is used to operate the system, which then transfers the collected solar energy from a collector to storage and then distributes it throughout the entire unit. An active system can provide space heating and cooling and domestic hot water.

altitude – refers to the angular distance from the horizon to the sun.

auxiliary energy – refers to the auxiliary heat plus the energy required to operate pumps, blowers, or other devices.

auxiliary heat – refers to the heat that is provided by a conventional heating system for periods when it is cloudy or there is intense cold weather. During these times a solar heating system may not be able to provide enough heat.

azimuth – refers to the angular distance from true south to the point on the horizon directly below the sun.

backup energy system – refers to a backup energy system that uses conventional fuels that are provided for heating and domestic hot water. This type of system is capable of providing all of the energy demand during any particular period when the solar energy system is not operational. Components as well as subsystems may be used as parts of both types of systems where the component or sub-system is a recognized, acceptable product in the conventional building industry.

coefficient of heat transmission – refers to the rate of heat transmission that is measured per degree of temperature difference per hour, through a square foot of wall or through some other building surface. It is usually referred to as the U-value.

collection – refers to the process of trapping solar radiation and then converting it to heat.

collector – refers to a device that collects solar radiation and then converts it to heat.

collector aperture – refers to the glazed opening inside a collector that admits solar radiation.

collector efficiency – refers to the ratio of the heat energy extracted from a collector to the solar energy striking it.

collector tilt – refers to the angle between the horizontal plane and the solar collector plane, which is designed to maximize the collection of solar radiation.

comfort zone – refers to the range of temperature and humidity in which most people feel comfortable.

concentrating collector – refers to a collector with a lens or a reflector that concentrates the sun's rays on a relatively small absorber surface.

conduction – refers to the flow of heat between a hotter material and a colder material that are in direct physical contact.

conductivity – refers to the property of a material that indicates the quantity of heat that will flow through one foot of a material for each degree of temperature difference.

convection, forced – commonly refers to the transfer of heat by the forced flow of air or water.

convection, natural – refers to the motion of a liquid or a gas, caused by temperature or density difference, by which heat is transported.

cooling pond – refers to a large body of water that loses heat from its surface, largely by evaporation but also by convection and radiation.

cooling tower – refers to a device for cooling water by evaporation.

cover plate – refers to a layer of glass or transparent plastic that is placed above the absorber plate in a flat-plate collector in order to reduce heat losses.

damper – refers to a control that permits, prevents, or controls the passage of air through a duct.

degree day – refers to a unit of measurement for outside temperature; it is the difference between a fixed temperature(usually 65°F [18°C]) and the average temperature for the day.

design heating load – refers to the total heat loss from a building under the most severe winter conditions likely to occur.

design outside temperature – refers to the lowest outdoor temperature that can be expected during a heating season.

diffuse radiation – refers to the indirect scattered sunlight that casts no shadow.

direct radiation – refers to sunlight that casts shadows, also called beam radiation.

direct solar gain – refers to a type of passive solar heating system in which solar radiation passes through the south facing living space before being stored in the thermal mass for long term heating.

distribution – refers to the movement of collected heat to the living areas from collectors or storage.

diurnal temperature range – refers to the variation in outdoor temperature between day and night.

double-glazed – refers to the covering by two layers of glazing material (commonly glass or plastic).

double-walled heat exchanger – refers to a heat exchanger that separates the collector fluid from the potable water by two surfaces; it is required if the collector fluid is nonpotable.

drainback – refers to a type of liquid heating system that is designed to drain into a tank when the pump is off.

emissivity – refers to the ratio of the energy radiated by a body to the energy radiated by a black body at the same temperature.

energy audit – refers to an accounting of the forms of energy used during a designated period, such as monthly.

eutectic salts – refers to a mixture of two or more pure materials that melts at a constant temperature; a material that stores large amounts of latent heat.

evaporative cooling – refers to a method of space conditioning that requires the addition of bodies of water or of moisture for cooling the living spaces.

fan coil – refers to a unit consisting of a fan and a heat exchanger that transfers heat from liquid to air (or vice versa); usually located in a duct.

flat-plate collector – refers to a solar collection device in which sunlight is converted to heat on a flat surface; air or liquid flows through the collector to remove the heat.

flywheel effect – refers to the damping of interior temperature fluctuations by massive construction. (See diurnal temperature range.)

forced-air heat – refers to a conventional heating distribution system that uses a blower to circulate heated air.

galvanic corrosion – refers to the deterioration of tanks, pipes, or pumps that occurs when a conducting liquid permits electrical contact between two different metals, causing the more active metal to corrode.

glazing – refers to a material that is translucent or transparent to solar radiation.

heat capacity (specific heat) – refers to the quantity of heat required to raise the temperature of a given mass of a substance 1°F.

heat exchanger – refers to a device that transfers heat from one fluid to another.

heat gain – refers to heating or cooling load, that amount of heat gained by a space from all sources (including people, lights, machines, sunshine, etc.).

heat pump – refers to an electrically operated machine for heating and cooling; when heating, it transfers heat from one medium at a lower temperature (called the heat source) to a medium at a higher temperature (called the heat sink), thereby cooling the source (outside air) and warming the sink (the house); when cooling, the heat pump functions much like an air conditioner— taking unwanted heat from the heat source (a building) and dumping it to the heat sink (the outside).

heat sink – refers to a medium (water, earth, or air) that is capable of accepting heat.

heat source – refers to a medium (water, earth, or air) from which heat is extracted.

heat transfer – refers to conduction, convection, or radiation (or a combination of these).

heating load – refers to the rate of heat flow required to maintain indoor comfort; measured in BTU per hour.

heating season – refers to the period from early fall to late spring during which heat is needed to keep a house comfortable.

hybrid solar energy system – refers to a hybrid system is one incorporating a major passive aspect, where at least one of the significant thermal energy flows is by natural means and at least one is by forced means.

indirect gain solar – refers to a type of passive solar heating system in which the storage is interposed between the collecting and the distributing surfaces.

infiltration – refers to the uncontrolled movement of outdoor air into a building through leaks, cracks, windows, and doors.

infrared radiation – refers to the invisible rays just beyond the red of the visible spectrum; their wavelengths are longer than those of the spectrum colors (.7 to 400 microns), and they have a penetrating heating effect.

insolation – refers to the amount of solar radiation (direct, diffuse, or reflected)striking a surface exposed to the sky; measured in BTU per square foot per hour (or in watts per square meter).

insulation – refers to a material that increases resistance to heat flow.

isolated solar gain – refers to a type of passive solar heating system in which heat is collected in one area to be used in another.

kilowatt – refers to a measure of power or heat flow rate; it equals 3,413 BTU per hour.

kilowatt-hour (kwh) – refers to the amount of energy equivalent to one kilowatt of power being used for one hour; 3,413 BTU.

langley – refers to a measure of solar radiation that is equivalent to one calorie per square centimeter, or 3.69 BTU per square foot.

latent heat – refers to the change in heat content that occurs with a change in phase and without change in temperature; the heat stored in the material during melting or vaporization. Latent heat is recovered by freezing a liquid or by condensing a gas.

life-cycle cost analysis – refers to the accounting of capital, interest, and operating costs over the useful life of the solar system compared to those costs without the solar system.

liquid-type collector – refers to a collector that uses a liquid as the heat transfer fluid.

microclimate – refers to the variation in regional climate at a specific site; caused by topogaphy, vegetation, soil, water conditions, and construction.

movable insulation – refers to a device that reduces heat loss at night or during cloudy periods and permits heat gain in sunny period. It may also be used to reduce heat gains in summer.

nocturnal cooling – refers to cooling through radiation of heat from warm surfaces to a night sky.

nonrenewable energy source – refers to a mineral energy source that is in limited supply, such as fossil (gas, oil, and coal) and nuclear fuels.

passive solar energy systems and concepts – refers to passive solar heating applications generally involve energy collection through south-facing glazed areas; energy storage in the building mass or in special storage elements; energy distribution by natural means such as convection, conduction, or radiation with only minimal use of low-power fans or pumps; and a method controlling both high and low temperatures and energy flows. Passive cooling applications usually include methods of shading collector areas from exposure to the summer sun and provisions to induce ventilation to reduce internal temperatures and humidity.

payback – refers to the time needed to recover the investment in a solar energy system.

peak load – refers to the maximum instantaneous demand for electrical power, which determines the generating capacity required by a public utility.

percent possible sunshine – refers to the amount of radiation available compared to the amount that would be present if there were no cloud cover; usually measured on a monthly basis.

photovoltaic cell – refers to a device without any moving parts that converts light directly into electricity by the excitement of electrons.

preheat – refers to the use of solar energy to partially heat a substance, such as domestic potable water, prior to heating it to a higher desired temperature with auxiliary fuel.

pyranometer – refers to an instrument for measuring direct and diffuse solar radiation.

pyrheliometer – refers to an instrument that measures the intensity of the direct radiation from the sun; the diffuse component is not measured.

radiation – refers to the process by which energy flows from one body to another when the bodies are separated by a space, even when a vacuum exists between them.

renewable energy source – refers to solar energy and certain forms derived from it, such as wind, biomass, and hydro.

reradiation – refers to the emission of previously absorbed radiation.

retrofit – refers the ability to modify an existing building by adding a solar heating system or insulation.

seasonal efficiency – refers to the ratio of the solar energy collected and used to the solar energy striking the collector, measured over an entire heating season.

selective surface – refers to a surface that is a good absorber of sunlight but a poor emitter of thermal radiation, used as a coating for absorbers to increase collector efficiency.

sensible heat – refers to heat which, when gained or lost, results in a change in temperature.

shading coefficient – refers to the ratio of the amount of sunlight transmitted through a window under specific conditions to the amount of sunlight transmitted through a single layer of common window glass under the same conditions.

solar access or solar rights – refers to the ability to receive direct sunlight that has passed over land located to the south; the protection of solar access is a legal issue.

solar collector – refers to a device that collects solar radiation and converts it to heat.

solar constant – refers to the average intensity of solar radiation reaching the earth outside the atmosphere; 429.2 BTU per square foot per hour (or 1,354 watts per square meter).

solar fraction – refers to the percentage of a building's seasonal heating requirement provided by a solar system.

solar furnace – refers to a solar concentrator used to produce very high temperatures; also a trade name for a modular air heating system, usually ground mounted, with rock storage.

solar gain – refers to the part of a building's heating or an additional cooling load that is provided by solar radiation striking the building or passing into the building through windows.

solar noon – refers to the time of day when the sun is due south; halfway between sunrise and sunset.

solar radiation – refers to the energy radiated from the sun in the electromagnetic spectrum; visible light and infrared light are used by solar energy systems.

solar thermal electric power – refers to the indirect conversion of solar energy into electricity by solar collectors, a heat engine, and electrical generators.

solarium – refers to a living space enclosed by glazing; essentially a greenhouse.

specific heat capacity – refers to the quantity of heat needed to change the temperature of one pound of a material by one degree Fahrenheit .

storage capacity – refers to the quantity of heat that can be contained in a storage device.

sunspace – refers to a living space enclosed by glazing; a solarium or greenhouse.

sun tempering – refers to a method that involves a significant daytime solar gain and an effective distribution system but generally lacks a storage system.

vapor barrier – refers to a waterproof liner used to prevent passage of moisture through the building structure. Vapor barriers in walls and ceilings should be located on the heated side of the building.

zoned heating – refers to the control of the temperature in a room or a group of rooms independently of other rooms.