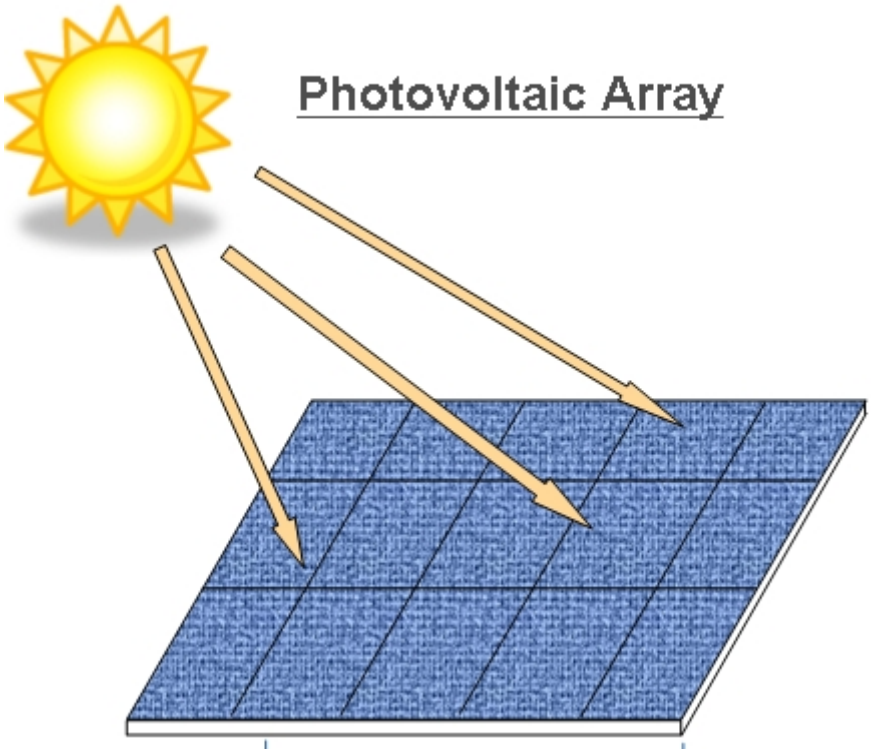
1. What is Solar Energy

a. Definitions

Solar energy is energy produced from Photovoltaic (PV) panels, which use sunlight to produce electricity

Solar power is one of the first things that comes to most people's minds when the subject of alternative energy comes up. Solar power first gained wide public awareness during the 1970's energy crisis, and while it may not be such a hot topic these days, solar technology has made great advances since then.



Photovoltaic (PV) - means the direct conversion of light into electricity.

Solar Cell - A solar cell, also called a photovoltaic (PV) cell, is the smallest element that converts light into electrical energy (DC voltage and current).. Each cell is made of silicon like a computer chip. The silicon is

treated so that it generates a flow of electricity when light shines on it. Solar modules are series of solar cells wired together.

PV array – A PV array is an interconnected system of PV modules that function as a single electricity-producing unit. The modules are assembled as a discrete structure, with common support or mounting. In smaller systems, an array can consist of a single module.

PV system - A PV system is a complete set of components for converting sunlight into electricity by the photovoltaic process, including the array and the balance of system components

PV conversion efficiency - The ratio of the electric power produced by a PV device to the power of the sunlight shining on the device.

Do solar cells store energy - No. Solar cells just convert sunlight into an electric current that must be used immediately or stored in batteries to be used later.

Are solar electric systems safe? Yes. Solar cells are mostly silicon, the primary component of sand. There is no exhaust and no toxic materials to leak out of the system. The electricity coming through the inverter is just like the electricity coming from household wall sockets; you should use the same care you would with utility power. All components are approved for utility interconnection and are installed according to standard construction practices.

Solar cells technology -Modern solar cells with practical efficiency were invented in the early 1950s, and have been used to power satellites since 1959. They became popular for terrestrial applications in the mid-1970s, mostly for remote telecommunications, navigational aids and other rugged, remote industrial uses including microwave, TV, radio and cellular repeater stations. They have been powering urban applications such as roadside emergency telephones and traffic sign boards since the mid-1980s. With prices dropping steadily, they are now becoming affordable for urban homes and businesses.

b. Solar Electric Panels

A solar electric panel, often called a PV panel is basically a set of treated silicon cells arranged in a series string that produces electric power when exposed to light. There are three common types of solar panels manufactured. Briefly, they are:

- **Monocrystalline** - made from a single large crystal, cut from ingots. Most efficient, but also the most expensive. Somewhat better in low

light conditions (but not as good as some advertising hype would have you believe).

- **Polycrystalline** - basically, cast blocks of silicon which may contain many small crystals. This is probably the most common type right now. Slightly less efficient than single crystal, but once set into a frame with 35 or so other cells, the actual difference in watts per square foot is not much.
- **Amorphous** - "thin film", here the silicon is spread directly on large plates, usually of something like stainless steel. Cheaper to produce, but often much less efficient, which means larger panels for the same power. Unisolar is one example.
- **Vaporware** - this is the 4th type - the one that pops up in the news about every 2 months, proclaiming the next major breakthrough that will make plastic spray on solar cells that will cost around 5 cents a watt, or some similar claim. Well, after almost 30 years in this business, we are still waiting for one of those to actually reach production, and suspect we will be waiting for another 30.

For all practical purposes, how the three types work in applications is very similar. What is important when buying panels is to choose the right panel based on how much power you need, how much room you have, and where they will be mounted.

c. Type of Solar Panels and their use

Flexible panels are limited to smaller output sizes. They tend to be more expensive per watt of rated output, and less durable in long-term applications. However, they're extremely convenient for intermittent use where the panel may need to be stored and moved around regularly.

Unframed rigid panels also tend to be available primarily in smaller sizes. They're much lighter weight than the more common framed panels, and convenient for portable applications. What these panels lose in convenience as compared to flexible panels, they make up in cost per watt and durability.

Framed rigid panels are the most common type of solar panel for full solar power systems. They are the most durable type of panel, and are generally used in permanent or long term installations for household, RV or marine power systems. Large framed panels can get quite expensive, but with 20-25 year warranties, high durability and low maintenance, they're worth it.

Solar roofing is one of the newer styles of photovoltaic unit. For a large household system, solar roofing can be found that mimics the appearance of regular roofing shingles or regular metal channel roofing. Probably the

most cosmetically pleasing option for a full-house solar system, these products are now becoming available on a widespread basis.

d. Major components of a solar power system

Solar Array – The solar array consists of one or more Solar Panels (PV) modules which convert sunlight into electric energy. The modules are connected in series and/or parallel to provide the voltage and current levels to meet your needs. The array is usually mounted on a metal structure and tilted to face the sun.

Charge controllers – Although charge controllers can be purchased with many optional features, their main function is to maintain the batteries at the proper charge level, and to protect them from overcharging.

Battery Bank – The battery bank contains one or more deep-cycle batteries, connected in series and/or parallel depending on the voltage and current capacity needed. The batteries store power produced by the solar array and discharge it when required.

Inverter – An inverter is required when you want to power devices. The inverter converts the DC power from the solar array/batteries into AC power.

AC and DC Loads – These are the applications (such as lights or radios), and the components (such as water pumps and microwave repeaters), which consume the power generated by your PV array.

Balance of System – These components provide the interconnections and standard safety features required for any electrical system. These include: array combiners box, properly sized cabling, fuses, switches, circuit breakers and meters.

e. **Mount of solar Panels**

There literally thousands of mounts, configurations, and mount options for all the hundreds of various types, brands, models, and quantity of solar panels.

The common one are:

- Flush Mount
- Roof-Ground
- Top & Side of Pole
- Rail Mounting Systems

Flash Mount

Flush mounts are the simplest type of solar panel mount, and are commonly used for single or small quantities of panels. They are often used on RV's. They generally consist of nothing more than end brackets or "Z" brackets that mount to the panel frame and then screw or bolt into the roof. Despite some disadvantages, these are still the type we recommend for most RV's and single or two panel roof mounts.

Advantages: Very cheap, simple to install, low wind resistance and weight. Very common on RV's.

Disadvantages: Not suitable for large arrays, some types of roofs. No flexibility in tilt or orientation. Panels usually must be pre-wired before installing. May be difficult to remove if RTV or other sealant was used on roof.

Roof-Ground Mounts:

Roof-ground panel mounts have been the mainstay for many years, especially for off grid systems. They are less popular with grid tie systems in cities, for appearance reasons, and because the large arrays often used in utility intertie solar electric systems can have a pretty high wind resistance. In extreme cases high winds may cause roof damage. Or worse.

Roof-Ground mounts are called that because they pretty much mount either on a roof or on the ground with little or no change in mount setup. All provide some kind of tilt, either adjustable or fixed. In very high wind areas they require a good anchor point or they tend to blow away, and that is not usually a good thing.
Roof-ground mounts are simple to install, but in some cases it is preferable to mount the panels first if you are mounting them directly on the ground, as the lower row of panels in multi-tier rack can be hard to get to. Many people raise them up a few feet by setting them on short poles, concrete blocks, or steel feet. This also keeps them up high enough so you don't get any panel shading from weeds or grass growing nearby.
Advantages: Relatively inexpensive, fits a wide variety of panels. Can be used almost anywhere - even on the side of buildings. Most are available

Pole Mounts:
This includes Top-of-Pole, Side-of-Pole, and Tracking Mounts for solar panels.
Pole mounts, especially top-of-pole, have been popular for a long time. Top-of-pole mounts are essentially a steel or aluminum rack and rail system bolted or welded to a large sleeve that sets on top of a pole with set-bolts to keep in place. Side-of-pole mounts are often used when you need to mount to the side of a telephone pole or communications tower. Tracking mounts are similar to top-of-pole mounts, but they also have a method of automatically aiming the mount to follow the sun.
Zomeworks and Wattsun are the two major manufacturers of tracking mounts. Both have a wide variety of sizes available. Wattsun sells a 2-axis (tracks both vertical and horizontal), but in our opinion they are not cost effective - stick with the single axis type.
Top of pole mounts (including trackers) are one of the simplest (but not always easiest) of mounts to install. They essentially only need a single steel pole set in the ground (usually in concrete), and the mount slips onto the top of the pole. Most common sizes use a 2-inch to 8-inch pole, usually around 11 to 13 foot in length (11.5 foot is 1/2 of a standard 21

foot pipe). They can go higher - most commonly where you need to get the panel up more to avoid shading from nearby shrubs, or to keep animals such as cows and elk from using them for a scratching post if not fenced off.
Several companies manufacture top and side of pole mounts, including Direct Power, Two Seas, Zomeworks, and UniRac. Most have a wide variety of types to fit nearly any current solar panel. Our available mounts are listed on our online store.
There may be two hard parts to actually installing them - larger mounts will require a good anchor, which can mean in soft soil that you may have to dig a hole as much as 7 foot deep to avoid them being turned by the wind. The second is that large mounts can be very heavy, so you will need either a small crane, gin pole, or a few people to lift it up. One advantage of top of pole mounts is that they are very easy to wire up, since the back of the panels is easily accessible. We usually recommend that you do not mount the panels before getting the mount on top of the pole, especially for larger sizes. If something drops, you could have a smashed panel disaster.

f. Solar Panel Power Production

Power Rating and Calculation
The output of a solar panel is usually stated in watts, and the wattage is determined by multiplying the rated voltage by the rated amperage. The formula for wattage is VOLTS times AMPS equals WATTS. So for example, a 12 volt 60 watt solar panel measuring about 20 X 44 inches has a rated voltage of 17.1 and rated 3.5 amperage.
V x A = W
17.1 volts times 3.5 amps equals 60 watts
Watt/Hour
If an average of 6 hours of peak sun per day is available in an area, then the above solar panel can produce an average 360 watt hours of power per day; 60w times 6

Amperage & Voltage

- Solar panel current (amps) output increases nearly linearly with increase in light intensity.
- Solar panel voltage however is not linear with light intensity. At 10% of full sun intensity, panel operating voltage is about 95% of it rated capacity. Example- if the panel has a Typical Power Voltage of 17.0V, at 10% lighting it will read about 16V.

Solar Panel Specifications

Photowatt solar panels will have the following specifications:

- Typical Power – The average (advertised) wattage rating of the panel.
- Minimum Power – The minimum voltage of the battery & system the panel is designed to operate with –i.e. 12VDC, 24VDC, 36VDC, or 48VDC.
- Open Circuit Voltage – The full voltage of the panel with no loads connected and no circuit between the positive and the negative terminals.

Maximum Power Point (MPP)

Solar panels have a "maximum power point" (MPP). For the Phtowatt panels, the MPP is called the Typical Power point. For all solar panels, this is the combination of voltage and amperage (current) that produce the maximum amount of power (watt). The MPP voltage is roughly 75% of the Open Circuit Voltage and is designed in the Photowatt Specifications as the Voltage at Typical Power.

g. Benefits of Solar Energy

- PV Systems operate with no moving parts,
- Have no impact on the environment
- Require little maintenance.
- Can be installed in difficult to reach areas.
- They have a long life and durability
- Low operating cost.
- Can expand at any time to meet electrical needs
- Creates independency from the grid.