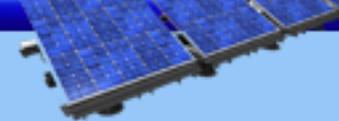


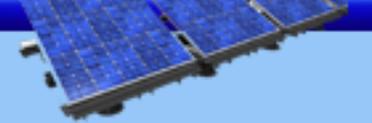
**A Beginner's  
Guide to**

# **SOLAR PANELS**



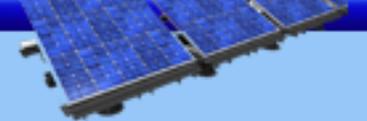


# A Beginner's Guide To **SOLAR PANELS**

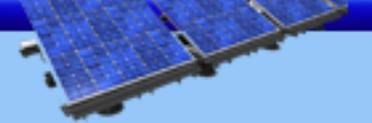


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## A Beginner's Guide to Solar Panels

### INTRODUCTION

Global warming is a huge problem which will significantly affect every country in the world. Many people all over the world are trying to do whatever they can to help combat the effects of global warming. One of the ways that people can fight global warming is to reduce their dependence on non-renewable energy sources like oil and petroleum based products. There has been a vast increase in the interest of businesses and everyday people in finding ways to live in a more environmentally responsible way and to find alternate fuel sources.

It's not always easy to find ways to be more environmentally responsible and still meet all the obligations of everyday life. For example, many people would like the chance to ride a bike to work everyday or walk instead of having to drive a car but for many of those people that's just not a feasible option.

Taking public transportation is a better alternative than driving to work everyday but that isn't much in your control. Whether or not you can take public transportation really depends on where you live and how much of a public transportation system there is in place in that city. It's not unusual for a large city to have a public transportation system that doesn't function well in reaching its population or a smaller city not to have any public transportation available at all.

So what are some options that are out there for people who want to live in a more environmentally-friendly way but still have to deal with certain day-to-day realities that don't always allow them to make the choices they'd like to make? One of them is using solar energy to help heat and power your home. Solar energy is a completely renewable energy source that will save you money on your heating and electricity costs as well as save environmental resources.

In the past using solar energy was not really something that most people could use at home because the technology was still being developed. In recent years the investment by government and industry into developing solar power technology has made using solar power much more affordable and feasible. Today homeowners and apartment and commercial building developers are able to use solar energy and help the environment while saving money.

Using solar energy as a main power source is still relatively new in the United States but other countries have been relying on solar power for a large amount of their energy needs for years. These countries have proven that with the right equipment and technology it is possible to reduce dependence on fossil fuels and non-renewable energy sources. Because solar energy produces no greenhouse gases, using solar power helps the environment.

### WHAT IS RENEWABLE ENERGY?

There is a lot of focus on finding ways to use renewable energy to fill the vast power needs of the world population. What exactly is renewable energy? Renewable energy means harnessing the forces of the wind, the sun, water, geothermal, and other natural occurring forces to create energy that can be used for electricity and heat.

Unlike fossil fuels which are also natural but are only available in limited supply. Renewable energy sources can be used over and over again without depleting them. There are five main sources of renewable energy that humans can use:

**1. Bio energy** – Bio energy is created from plants or grains that can be replanted and replenished. Ethanol is an example of using bio energy. Ethanol is a fuel that is a hybrid of petroleum and an alcohol-based fuel that is made primarily from corn in most of the United States, although some other countries, like Brazil, make ethanol using sugar cane instead of corn. Ethanol is widely used in other countries and is becoming more popular in the United States.

Many companies and scientific labs are experimenting with different bio fuels to find a bio fuel that works with already existing vehicles to help reduce dependence on petroleum. Hybrid vehicles that run on a combination of petroleum based fuel and bio fuels are becoming more and more popular. Some vehicles that run on diesel fuel are being converted to run on bio-diesel which is a fuel made from used vegetable oil that is discarded by restaurants and food plants.

**2. Hydro power** – Hydro power is using the power of flowing water to create electricity. Hydro power is one of the oldest continually used forms of creating energy and was extremely popular before it become common to use fossil fuels. For hundreds of years rushing water was used to create energy that would operate a grain mill and grind corn and wheat, power steam engines, and provide energy for other common tasks. The first known use of hydro power to provide electricity was in 1880, and hydro power has been used to generate electricity every since.

Hydro power is still used today. About 7% of the electricity used in the United States each year comes from hydro electric plants. Because it's necessary for a large hydro electric plant to be located directly on a large body of water in order to have enough water to generate the kind of power that is needed to make electricity hydro electric power plants are not widespread. More than half of the many hydro power plants in the United States are located in only three states: Oregon, California, and Washington.

Hydro power is often considered to be the ideal form of renewable energy because it's practically free, it creates no pollutants that harm the environment, and it has almost no waste products of any kind. The drawback is that hydro power can only be located in a small number of areas with the right natural features. Plus, the large dams needed to harness hydro power can dramatically alter the landscape and affect wildlife.

**3. Geothermal power** - Geothermal power comes from using the natural heat from deep inside the earth. The core of the Earth generates a lot of heat and water that is heated deep within the Earth and released to the surface through hot springs and geysers. Even volcanoes can be used to heat buildings and homes as well to provide electricity.

The most common use of geothermal power is direct heating. Direct geothermal heating consists of piping hot water from below the surface of the Earth directly into buildings or homes to heat the buildings. Iceland gets up to 95% of their heat from geothermal direct heating. The island nation sits on the world's most easily accessible source of heat energy from volcanic magma close to the Earth's surface.

The United States is the biggest user of geothermal energy for electricity in the world but still less than 1% of all the electricity produced in the United States is generated from geothermal energy. There are about 50 geothermal electricity plants in the United States, mostly in California and Nevada. Since the easiest place to access the water heated within the earth is along fault lines and on the edges of tectonic plates it's not surprising that those two states have the most geothermal energy plants. Geothermal energy produces no pollution or greenhouse gases but can be expensive to utilize and can only be used in a small number of areas that have the proper geology.

**4. Wind** - Wind energy was probably the first type of natural, renewable energy that was used by people to provide power. Wind energy has no pollutants or contaminants and is great for the environment, but sometimes it can be hard to harness enough wind to generate significant energy.

Wind energy is mainly used locally, supplying electricity on and around wind farms. The United States is third on the list of countries that have the most capacity to produce wind energy yet wind energy is not yet widely used in the United States. In the past this was mostly because building the machines, called wind turbines, which are used to harness wind energy, was expensive and consumed a lot of natural resources. Since 2005 there have been some great technological advances that have made it much more cost-effective to build turbines so the use of wind energy is beginning to grow in the United States.

One of the biggest problems of producing enough wind energy to meet the huge electricity demands of the people in the United States is the weather. Since wind can't be grown like the crops that are used for bio energy, and wind is not as constant as the water used to create hydro or geothermal energy there is a limit to how much energy wind can produce. The variability of the wind is also a crucial factor. If there isn't much wind on a particular day there might be very little or no electricity generated that day. Another drawback to wind energy is that a large number of very large wind turbines (they can run up to 25 stories tall) are needed to create a significant amount of energy.

Wind energy is a good source of renewable energy under certain conditions but in the long run wind energy is not going to be the best source of renewable energy for countries to use.

**5. Solar energy** – Solar energy is collecting and then using the energy generated by the sun for things like electricity and heating. Solar energy is being used more and more by businesses and homeowners as a way to fight rising electricity bills and also to live in a more environmentally friendly way.

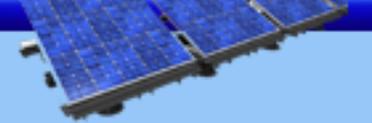
One of the first recorded uses of solar energy was in the 1830's when a British explorer in Africa built a box to collect the energy from the sun's rays and used it to cook his food. Today solar energy is used mainly to create heat and to create electricity.

There are two ways to generate electricity from solar energy. The first is using the Photovoltaic method. This method uses a collection of cells made of certain materials to grab the sun's energy and directly convert it to electricity. Since the sun's rays are diffuse it takes a large number of these photovoltaic cells working together to provide any real power.

The second way is using solar power plants. These huge plants use sunlight indirectly to create electricity. In simple terms the sunlight heats water which produces steam and the steam powers a generator that creates electricity. There are 15 large solar power plants in the United States. 10 are in California, and 5 are in Arizona.

Solar energy is totally renewable and has no measurable impact on the environment which is why it's the renewable energy system of choice for many environmentally conscious people. However there are a few drawbacks to using solar energy. One disadvantage of using solar energy is that because the energy created by the sun is so diffuse it takes a lot of sunlight to generate power. This means that solar plants have to have a large surface area.

Another disadvantage of solar energy is that the amount of the sun's energy that reaches the solar cells depends on things like the amount of cloud cover, the temperature, the time of day and other factors that can't be controlled. Scientists are trying to develop ways of using solar energy to generate large amounts of power, similar to central power plants burning fossil fuels today.



Most experts agree that the best way to use solar energy for electricity and heating is for individual homeowners and building owners to use solar panels to generate heat and electricity for their own buildings.

## WHY IS IT SO IMPORTANT TO USE RENEWABLE ENERGY?

Scientists have been searching for reliable sources of renewable energy for decades because the United States is very dependent on fossil fuels for energy. The United States has some fossil fuel resources but those are getting used up at alarming rate, and national reserves and parks are at risk of being invaded by developers who want to come in and drill for oil or natural gas. Allowing the development of these protected areas would ruin the fragile ecosystems in those areas and could cause a lot of damage to local wildlife.

The United States also imports a lot of fossil fuels which is very expensive, and is getting more expensive by the year. Gas and electricity prices are rising and many people are being forced to choose between buying food or medicine and buying gas for their cars or electricity for their homes.

For many years fossil fuels were cheap and plentiful. People used oil and coal without any thought about what would happen when those natural resources were used up. Now, the natural resources that the United States has are disappearing everyday and foreign countries are charging more and more to buy their fossil fuels.

Fossil fuels are non-renewable and cause a lot of environmental damage. The air quality in some cities is so bad as a result of all the fossil fuels that are being used that people are developing health problems like asthma or even chronic obstructive pulmonary disease (COPD) and emphysema just from breathing in the polluted city air.

The environment is also changing because of the massive amount of fossil fuels and non-renewable energy being used all over the world. Scientists say that global warming is one of the results of the overuse of non-renewable energy by most of the industrialized countries in the world. Global warming is causing a lot of serious environmental problems that could lead to a lot of destruction all over the world. Weather patterns are changing, glaciers are melting, and many countries are facing more natural disasters than ever before because of global warming.

Even though many experts say that global warming can't be completely stopped at this point switching over to using as much renewable energy as possible could slow the progress of global warming or even help heal some of the damage that has global warming has caused to the planet.

## THE ADVANTAGES OF USING RENEWABLE ENERGY

Finding reliable sources of renewable energy is important in order to help slow the effects of global warming and to reduce the need for fossil fuels. There are also other advantages to using renewable energy to replace the burning of fossil fuels. Some of the biggest advantages of using renewable energy are:

- Renewable energy will never be depleted – No matter how much energy is needed by people all over the world renewable energy sources will never run out and can continue to make electricity and heat as long as there are people that need them.

- Renewable energy helps the environment – This chiefly comes from producing fewer greenhouse gases that contribute to global warming. In addition to slowing down the effects of global warming using renewable energy sources also helps preserve ecosystems that would be destroyed to develop the fossil fuels found in the land. When there are fewer pollutants in the air the plants and trees that make oxygen will be healthier and will put out more oxygen which will make people healthier.
- Renewable energy is safer than fossil fuel – Fossil fuels used to create heat and electricity and as fuel for vehicles creates toxic chemicals that are released into the air and lead to bad air quality and acid rain. Everything that is alive is affected by that kind of pollution including us humans. Renewable energy sources greatly reduce or even eliminate pollution of the air and water. With less pollution in the air and water people will be healthier and won't be at risk of health problems caused by pollution like asthma and other respiratory problems.
- Renewable energy sources create jobs and industry – Because renewable energy sources require specialized equipment and lots of research the business of creating renewable energy sources that are accessible to lots of people means that there will be a lot of new businesses starting and a lot of new jobs for people.
- Renewable energy means cheaper energy – When countries depend on renewable energy sources instead of foreign fossil fuels the cost of renewable energy will go down making electricity and heat more affordable for everyday people. Renewable energy also offers a chance for increased economic development. This is especially true for people who in the past have been struggling to make a living like farmers that grow grain and plants that can be used for bio energy.

## WHAT ARE SOLAR PANELS?

Solar panels are flat collections of solar cells that are used to catch the Sun's energy and use it to create electricity and heat. Because the sun's energy is so spread out it takes a collection of solar cells to generate enough energy to make electricity or heat. Solar panels come in different sizes and shapes so that they can be used on a variety of different types of buildings but no matter what shape or size they are the basic design of a solar panel is the same.

### How do solar cells work?

Solar cells are wafers made of a semi-conductive material, usually silicon, combined with rarer elements such as phosphorus and boron. The silicon is what grabs the energy from the sun and traps it to be used for electricity while the phosphorus and the boron help excite the molecules and intensify the energy that is coming into the cell. When the sun's rays hit the silicon and are channeled through the cell the molecules excite and travel through an attached electrical circuit, creating electricity.

Solar panels convert anywhere from about 14% to about 22% of the sun's energy that hits the panel into electricity. That doesn't seem like a lot of electricity produced but the amount of electricity that a solar panel can generate also depends on where the panel is positioned and how much direct sun it gets. When there is no sun or the panel isn't in the directly sunlight it gets little or no sun and will produce little or no electricity. The low efficiency of solar cells is a problem to their large-scale use. It takes many large solar panels of solar cells to provide enough electricity to power a house or a building.

Solar panels produce electricity that can be used for lighting but solar panel energy can also be used to heat a home or building. A solar thermal heating system consists of solar panels that are arranged in a specific spot where the solar panel energy is used to heat a tank of water. The hot water runs under the floors of the house, heating them, and then the water is piped back to the tank to be heated again.

Thermal solar heating systems work very well and are a cost effective and environmentally friendly alternative to expensive gas or electric heating systems. Solar thermal energy is often used quite a bit by people that have pools and outdoor hot tubs to heat the water they use. It's a lot less expensive to heat a large pool or a hot tub with thermal solar energy than it is to use fossil fuel heaters that can cost a fortune.

## WHAT ARE SOLAR PHOTOVOLTAIC SYSTEMS?

Solar photovoltaic systems, or PV systems, are the components in a solar cell that actually grab the energy from the sun and turn it into energy. PV systems are the fastest growing area of technology in the world and production of solar cells that use PV systems has been consistently doubling about every two years. Mainly this is due to rising interest solar energy and the desire of more people to buy solar panels to create their own electricity and heat for their homes. The demand for improved solar power technology encourages governments and businesses to invest time and money into improving the technology and making it more cost efficient.

Some governments around the world, especially in Europe, are giving financial incentives both to companies that are working on developing PV systems and making them more efficient and less costly to the average consumer and also to the consumers that buy them. Because PV solar cells are still relatively new when it comes to solar energy the cost of a solar panel containing PV cells is still fairly high in most places. Also, one solar panel is not usually enough to power an entire home which makes using solar PV systems even more costly for the average homeowner.

The good news is that more and more homes are being built with PV systems already installed which makes it easier and less costly for consumers to buy environmentally friendly homes that run on solar power. Businesses that want to operate factories more cost effectively and in a more environmentally friendly way while collecting some nice government incentives are also installing solar PV energy systems. Germany is currently the biggest market for solar PV systems with the United States, Australia and Spain not far behind.

Solar PV systems are being used successfully around the world to power devices like roadside signs, traffic lights, emergency phones, and other stand alone devices that might be difficult to power using traditional electricity or batteries. Solar PV energy has proved enormously successful at powering these devices. Using solar PV systems in these types of devices and in other everyday machines like parking meters has saved many cities and towns a lot of money because they don't need to send out regular maintenance crews to make sure that these things are still running properly.

Critics of solar PV systems say that while the solar energy produced by the PV cells doesn't have any harmful effects to the environment the production of these cells does result in some pollution. Advocates of the solar PV cells say that they are working on developing a type of PV energy cell the production of which won't produce any pollution. While the production of the cells does create some pollution it doesn't create as much pollution as other types of materials do when manufactured or used to create energy.

## THE HISTORY OF SOLAR PANELS

Photovoltaic power was first discovered by a French scientist, Antoine Becquerel, in 1839. Many scientists that followed experimented with solar power and tried to build a device that would capture the sun's energy and redirect it but they were not able to find a way to make a working PV cell. The solar cell was first successfully made by the scientist, Charles Fritts, in 1882. Since they didn't have the same types of materials that we have today the first working solar cell was made of thin sheets of Selenium, a mineral, that were then coated with gold.

Even though the use of solar panels for generating electricity and heat seems like a relatively new development it's actually been widely used to generate power since the early 1900's. Photos from that period show a series of parabola shaped "sun catchers" that would harness the power of the sun and focus it on water tanks. Once the water was heated it made steam which was used to power farm machinery. The solar heated water created enough steam to power 55 horsepower machinery which was cutting edge at the time.

Then, in the middle of the Industrial Revolution, businesses found that they could use the sun's energy to heat water which created steam to power the machines in the factories. At that time solar energy was considered the wave of the future and a lot of companies began developing better ways to use the sun's energy until after WWI when fossil fuels became more attractive to companies and farm owners to run their machinery.

The first working silicon solar cell didn't come along until 1941 when an employee at a Bell laboratory, Russell Ohl, patented his design for a silicon based PV cell. In 1954, Bell labs mass produced the first crystal silicon solar cell. The Bell PV cell converted 4% of the sun's energy into electricity a rate that was considered the cutting edge in energy technology.

Scientists continued to reinvent and rework the design of the original silicon PV cell and were eventually able to produce a solar cell that was capable of putting out a 20% return electricity rate. In the 1980's solar cell technology was being used almost exclusively for space travel.

The use of solar power in space is a natural given that spacecraft can't burn fossil fuels in the vacuum of space and in space the rays of the sun are not reduced by the Earth's atmosphere and clouds. In the late 1990's as awareness grew in the science community about the effects of global warming and the need for renewable energy sources scientists continued to refine the silicon PV cell until by early 2000 they were able to make a solar cell with 24% electricity return.

In just 7 years scientists were again able to increase the electricity return of the silicon solar cell using space age materials. By 2007, modern silicon PV solar cells were operating with a 28% electricity return. As scientists continue to make better solar cells it will become more common and more cost effective for homeowners to use solar cells and solar panels to power their homes.

## TYPES OF SOLAR PANELS

Today there are essentially four different types of solar panels that you can purchase easily and use if you want to install solar panels on your home to generate electricity or heat your home. They are Monocrystalline Silicon Panels, Polycrystalline Silicon Panels, String Ribbon Silicon Panels, and Amorphous Silicon Panels.

**Monocrystalline Silicon Panels** - Monocrystalline (or single-crystal) silicon solar panels have a return electricity rate of anywhere from 14% to 18%. These panels are made from one continuous sheet of silicon that has pieces of metal nailed to the edges to increase the conductivity and to excite the electrons.

Monocrystalline panels are more expensive than some of the other types of solar panels that you can buy but they are also more effective, so in the long run you're better off buying these panels if you can afford the up front cost.

**Polycrystalline Silicon Panels** - Polycrystalline (or multi-crystal) silicon panes have an electricity return rate of about 12%-14% so they are less efficient than monocrystalline silicon solar panels. These panels are made up of lots of individual PV cells that have metal conducting materials nailed to the sides that will help excite the electrons and also connect the cells together.

Polycrystalline silicon panels are the cheapest solar panels to produce so they are usually the cheapest for consumers to buy. The maintenance costs of polycrystalline silicon panels is lower than the maintenance cost of monocrystalline solar panels because if one of the cells on a polycrystalline panel is damaged you can have the individual cell replaced without having to replace the entire panel.

**String Ribbon Silicon Panels** – String ribbon silicon panels are made in a similar way to the polycrystalline silicon panels and have about the same electricity return rate. The difference between string ribbon silicon panels and polycrystalline silicon panels is that the PV cells in a string ribbon panel are made of strips of silicon attached to metal bars that connect the strips to form a cell. Using strips of silicon to form the cell instead of using one solid square of silicon make the production cost of string ribbon silicon panels a bit lower than the production cost of polycrystalline silicon panels.

**Amorphous Silicon Panels** – Amorphous silicon panels have the lowest electricity return rate of any type of solar panels. Traditionally amorphous silicon solar panels have an electricity return rate of between 5%-6%. That's because these panels aren't made with crystalline silicon. They are composed of a piece of semi conductive metal, like copper, with a thin silicon film over the top that is attached to some metal pieces.

These panels are very cheap to produce but when you're buying solar panels for home use you need to consider the long term efficiency of the type of panel that you're buying. Unfortunately, though cheap to begin with they do not produce much energy, therefore amorphous silicon panels are not going to be cost effective in the long run.

## SOLAR PANEL SHINGLES

If you're building a new home or if you are replacing the roof on your house you might want to consider using solar panel shingles for your roof. Solar panel shingles are cutting edge technology that only recently hit the consumer market.

Solar panel shingles are the same size as traditional asphalt shingles but they are actually small PV solar cells. They fit together like traditional roof shingles. You can also use a combination of solar panel shingles and traditional shingles if you can't afford to do your entire roof in solar panel shingles although you won't get a very high return electricity rate if you use just a few solar panel shingles.

Solar panel shingles are weather resistant and function just like normal shingles except that they also can provide clean, environmentally safe and free solar energy to power and heat your home. Using an entire rooftop of solar panel shingles is usually more than enough energy to power your home except for some exceptionally large appliances like a washer and dryer.

Solar panel shingles aren't cheap, but they can help you save money on energy costs over time. Here are some of the other benefits of using solar panel shingles to power your home:

- Solar shingles are easy to integrate with existing roof structures and shingles.
- Solar shingles fit into any design style.
- Solar shingles can decrease your electricity bill significantly, sometime by more than half.
- Solar shingles are environmentally friendly.
- There are lots of state and Federal Green Building financial incentives to use solar shingles.
- Solar shingles will increase the resale value of your home.
- Solar shingles are a smart long term investment in your home equity.
- Solar shingles are easy to install.
- Solar shingles have at least a 20-year output meaning you won't have to roof your home again for probably 20 years.

## SOLAR PANELS AND THE ENVIRONMENT

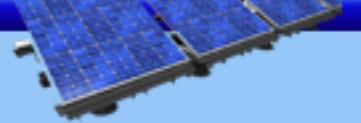
You already know that switching to solar energy can have a big effect on the environment, but you might be wondering just how big an effect. After all, can one person or one family switching to solar energy for heat and electricity really make that much of a difference on the environment?

Yes! One person or one family can save 20,000 tons of greenhouse gas from polluting the environment just by using solar energy to heat your hot water and heat your home. 20,000 tons is a lot of greenhouse gases! And that's just if one home just switches to solar energy. Imagine the decrease in greenhouse gases that could happen if 20,000 people per year switched to using solar energy to heat their hot water and heat their home. Add to that the effects of reducing energy consumption by 50% if you use solar energy for electricity and suddenly the impact on the environment is enormous.

In addition to reducing the amount of greenhouse gases that you put out switching to solar energy has a big impact on the environment because you will be reducing the amount of fossil fuels that you are using. Fossil fuels are very bad pollutants and contribute directly to poor air quality and other environmental problems.

The environment isn't just hurt by people burning fossil fuels for energy. The environment is also hurt by what is necessary to get those fossil fuels. Enormous portions of the earth need to be dug up, processing plants and refineries built, and natural ecosystems destroyed all over the planet just to get to the fossil fuels that are buried in the earth. Most of the pristine wilderness is gone in any country that has natural deposits of fossil fuels because of the ever-growing demand that countries around the world have for fossil fuels.

When fossil fuels are processed there is a huge amount of solid waste, much of it toxic, that is left behind. This waste takes up space in landfills and then seeps into groundwater while the runoff flows to the waterways polluting the water and the soil. The carbon dioxide and other gases that are released poison the air for miles around the processing plants of these fossil fuels.



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