

# How to choose the best panel and accessories



## *Benefits of Solar Electricity*

*Solar electricity saves money, adds value to homes, and reduces air pollution*

Rising energy prices and growing environmental concerns are making solar electric systems more attractive to homeowners. A solar electric system reduces high energy costs and keeps your home up and running during power out-ages.



The advantages to buying a solar electric system include:

- Saving a significant amount on your electric bill
- Increasing your home's appraisal value
- Enjoying reliable, clean, free power for 25 to 30 years
- Helping to boost our economy by creating jobs and new solar companies.

Most solar electric systems last 30 years and pay for themselves in 4 to 5 years after tax credits and rebates. That means homeowners can enjoy free electricity for years. If you install batteries to back up your solar electric system, it will provide



emergency power in areas with frequent storms, hurricanes, and other natural disasters. In addition, going solar adds value to your home.



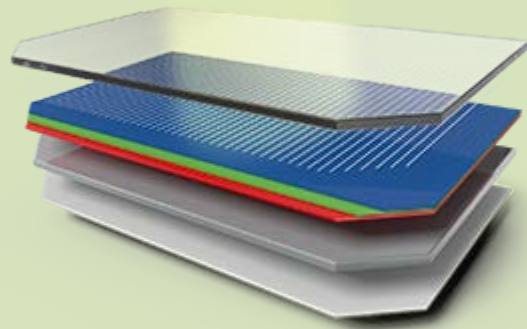
According to the analysts, a solar electric system increases your home's value by \$20 for every \$1 in annual utility bill savings, which means a system almost pays for itself with the appraisal value increase in some cases. Solar power reduces America's dependence on foreign oil and fossil fuels, making our nation more secure while reducing air pollution and greenhouse gases.

## How to Categorise the Different Types of Solar Panels

Different types of solar panels serve different needs and purposes. For a detailed description about the different types of solar panels, keep reading.

Given that sunlight can be used differently whether on Earth or in space points to the fact that location, itself, is a significant factor when it comes to choosing one of the types of solar panels over another.

Distinguishing between different types of solar panels often means differentiating between single-junctions and multi-junctions solar panels—or first, second, or third generations. Single-junction and multi-junctions differ in the number of layers on the solar panel that will observe the sunlight, whereas the classification by generation focuses on the materials and efficiency of the different types of solar panels.

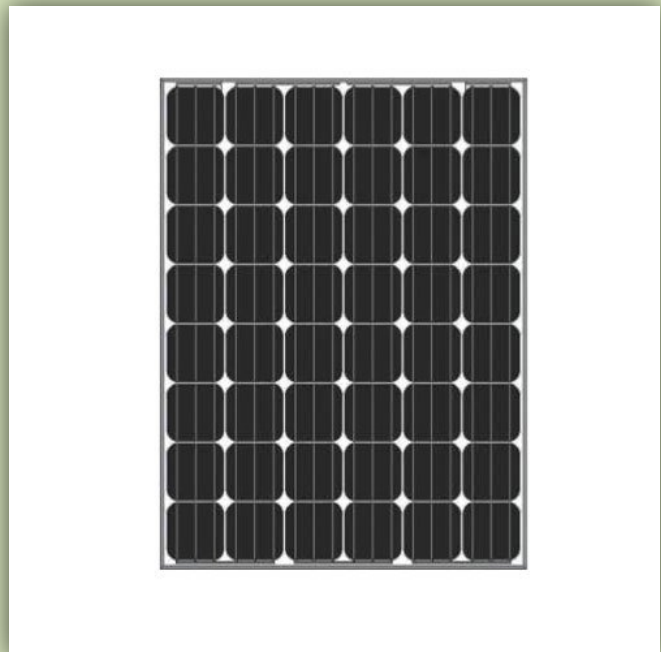


## 1st Generation Solar Panels

These are the traditional types of solar panels made of monocrystalline silicon or polysilicon and are most commonly used in conventional surroundings.

### *Monocrystalline solar panels (Mono-SI)*

This type of solar panels (made of monocrystalline silicon) is the purest one. You can easily recognise them from the uniform dark look and the rounded edges. The silicon's high purity causes this type of solar panel has one of the highest efficiency rates, with the newest ones reaching above 20%.



### *Advantages of Monocrystalline*

- Monocrystalline solar panels have the highest efficiency rates since they are made out of the highest-grade silicon. On October 2, 2015, SolarCity announced that it has developed the world's most efficient solar panels. The new panels convert more than 22% of sunlight into electricity.
- Just days later Panasonic announced it had trumped that achievement. A Panasonic solar panel has established a new world record module conversion efficiency of 22.5% on a commercial sized prototype using solar cells based on mass production technology. The test results were confirmed by the renowned Japanese National Institute of Advanced Industrial Science and Technology. The 72-cell, 270-watt prototype incorporates newly developed enhanced technology that will eventually

be scaled into volume production.

- Panasonic also says it is introducing the HIT® N330, the latest addition to the company's high-efficiency hetero-junction photovoltaic module product line and its most powerful photovoltaic module to date. It will be available in the UK and other European markets starting in March, 2016. Manufactured at Panasonic's state-of-the-art, vertically integrated solar fabrication facilities in Malaysia, HIT® N330 features 19.7% module-level efficiency and a nominal power output of 330 watts.
- Monocrystalline silicon solar panels are space-efficient. Since these solar panels yield the highest power outputs, they also require the least amount of space compared to any other types. However, monocrystalline solar panels produce marginally more power per square foot of space used in an array and so.
- Monocrystalline panels have a long lifespan. Most solar panel manufacturers put a 25-year warranty on their monocrystalline solar panels. Because both types of crystalline solar panels are made from crystalline silicon, a very inert and stable material it is very likely that these solar panels will last much longer than their 25-year warranty life.
- Monocrystalline solar panels tend to be more efficient in warm weather. With all solar cells, electricity production falls as temperature goes up. However, this degradation of output is less severe in monocrystalline panels than polycrystalline solar panels. However, in practice, the difference is very small. The level to which each solar panels production falls as temperature increase is called the temperature coefficient and is published with the specifications for each panel.

#### *Disadvantages of Monocrystalline solar panels*

- Monocrystalline solar panels are the most expensive. In recent years a rash in installation of polycrystalline ingot, cell and module production efficiencies have meant that polycrystalline solar panel have become more common and have benefited from costs advantages over mono panels. Most manufacturers that still make mono panels have targeted the premium end of the market.

## *Polycrystalline Solar Panels (Poly-SI)*



You can quickly distinguish these panels because this type of solar panels has squares, its angles are not cut, and it has a blue, speckled look. They are made by melting raw silicon, which is a faster and cheaper process than that used for monocrystalline panels.

This leads to a lower final price but also lower efficiency (around 15%), lower space efficiency, and a shorter lifespan since they are affected by hot temperatures to a greater degree. However, the differences between mono- and polycrystalline types of solar panels are not so significant and the choice will strongly depend on your specific situation. The first option offers a slightly higher space efficiency at a slightly higher price but power outputs are basically the same.

### *Advantages of Polycrystalline solar panels*

- The process used to make polycrystalline silicon is simpler and cost less. The amount of waste silicon is less compared to monocrystalline.
- Polycrystalline solar panels tend to have slightly lower heat tolerance than monocrystalline solar panels. Polycrystalline solar panels will tend to have a higher temperature co-efficient than solar modules made with

mono cells. This means that as heat increased output for this type of cell will fall less. However, in practice these differences are very minor.

#### *Disadvantages of Polycrystalline solar panels*

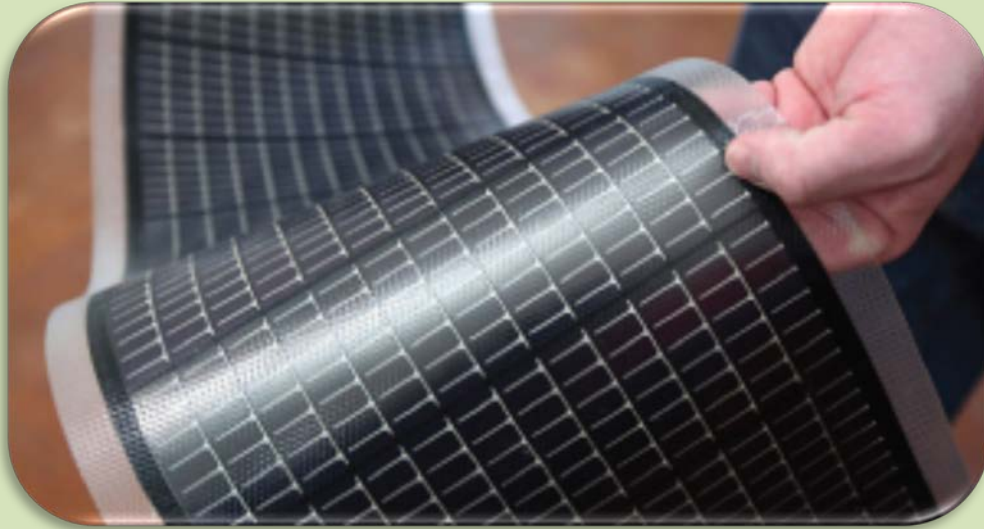
- The efficiency of polycrystalline-based solar panels is typically 14-16%. Because of lower silicon purity, polycrystalline solar panels are not quite as efficient as monocrystalline solar panels.
- Lower space-efficiency. You generally need to cover a larger surface to output the same electrical power as you would with a solar panel made of monocrystalline silicon. However, this does not mean every monocrystalline solar panel perform better than those based on polycrystalline silicon.
- Monocrystalline and thin-film solar panels tend to be more aesthetically pleasing since they have a more uniform look compared to the speckled blue color of polycrystalline silicon.



## 2nd Generation Solar Panels

These cells are different types of thin film solar cells and are mainly used for photovoltaic power stations, integrated in buildings or smaller solar systems.

### *Thin-Film Solar Cells (TFSC)*



If you are looking for a less expensive option, you might want to look into thin-film. Thin-film solar panels are manufactured by placing one or more films of photovoltaic material (such as silicon, cadmium or copper) onto a substrate. These types of solar panels are the easiest to produce and economies of scale make them cheaper than the alternatives due to less material being needed for its production.

They are also flexible - which opens a lot of opportunities for alternative applications - and is less affected by high temperatures. The main issue is that they take up a lot of space, generally making them unsuitable for residential installations. Moreover, they carry the shortest warranties because their lifespan is shorter than the mono- and polycrystalline types of solar panels. However, they can be a good option to choose among the different types of solar panels where a lot of space is available.

### *Advantages of Thin Film solar panels*

- Mass-production is simple. This makes them potentially cheaper to manufacture than crystalline-based solar cells.
- Their homogeneous appearance makes them look more appealing.
- Can be made flexible, which opens up many new potential applications.
- High temperatures and shading have less impact on solar panel performance.
- In situations where space is not an issue, thin-film solar panels can make sense.

### *Disadvantages of Thin Film solar panels*

- Thin-film solar panels are in general not very useful for in most residential situations. They are cheap, but they also require a lot of space. SunPower's monocrystalline solar panels produce up to four times the amount of electricity as thin-film solar panels for the same amount of space.
- Low space-efficiency also means that the costs of PV-equipment (e.g. support structures and cables) will increase.
- Thin-film solar panels tend to degrade faster than mono-crystalline and polycrystalline solar panels, which is why they typically come with a shorter warranty.

## *Amorphous Silicon Solar Cell (A-Si)*

Have you ever used a solar powered pocket calculator? Yes? Then you have definitely seen these types of solar panels before. The amorphous silicon solar cell is among the different types of solar panels, the one that is used mainly in such pocket calculators. This type of solar panel uses a triple layered technology, which is the best of the thin film variety.



Just to give a brief impression of what “thin” means, in this case, we’re talking about a thickness of 1 micrometre (one millionth of a metre). With only 7% efficiency rate, these cells are less effective than crystalline silicon ones - that have an efficiency rate of circa 18% - but the advantage is the fact that the A-Si-Cells are relatively low in cost.

### *Advantages*

The principal advantage of amorphous silicon solar cells is their lower manufacturing costs, which makes these cells very cost competitive.

One of the main advantages of a-Si over crystalline silicon is that it is much more uniform over large areas. Since amorphous silicon is full of defects naturally, any other defects, such as impurities, do not affect the overall characteristics of the material too drastically.

Amorphous silicon can be produced in a variety of shapes and sizes (e.g., round, square, hexagonal, or any other complex shape). This makes it an ideal technology to use in a variety of applications such as powering electronic calculators, solar wristwatches, garden lights, and to power car accessories. Small solar cells used in pocket calculators have been made with a-Si for many years.

Unlike crystalline solar cells in which cells are cut apart and the recombined, amorphous silicon cells can be connected in series at the same time the cells are formed, making it is easy to create panels in a variety of voltages (e.g, for use in solar battery rechargers).

The human eye is sensitive to light with wavelengths of 400 nm to 700 nm. Since amorphous silicon solar cells are sensitive to light with essentially the same wavelengths, this means that in addition to be used as solar cells they can also be used as light sensors (e.g., outdoor sensor lights, etc).

Some amorphous solar panels also come with shade-resistant technology or multiple circuits within the cells, so that if an entire row of cells is subject to complete shading, the circuit won't be completely broken and some output can still be gained. This is especially useful when installing solar panels on a boat.

The development process of a-Si solar panels also renders them much less susceptible to breakage during transport or installation. This can help reduce the risk of damaging your significant investment in a photovoltaic system.

Another principal advantage of this type of technology is greater resistance to heat. According to a four year NREL study – it was observed that amorphous silicon PV modules experience higher results as temperatures increase.

### *Disadvantages*

As mentioned previously, these panels have a lower efficiency than mono-crystalline solar cells, or even poly-crystalline solar cells. Attempts to increase the efficiency, such as building multi-layer cells or alloying with germanium to reduce its band gap and further improve light absorption all have an added complexity. Namely, the processes are more complex and process yields are likely to be lower and costs are likely to be higher as a result – thus reducing the cost advantage of this type of solar cell.

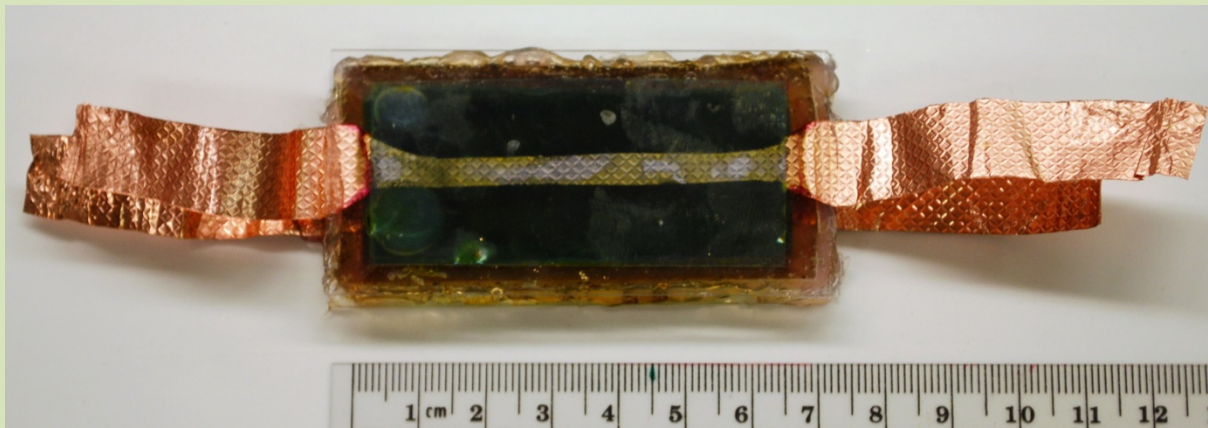
The expected lifetime of amorphous cells is shorter than the lifetime of crystalline cells, although how much shorter is difficult to determine, especially as the technology continues to evolve. From reading through the literature, it appears that the expected life is still in the order of 25 years or so. For example, Uni-Solar offers the following performance guarantee on their 144 Wp panels: 92% at 10 years, 84% at 20 years , 80% at 25 year (of minimum power).

### 3rd Generation Solar Panels

3rd generation solar panels include a variety of thin film technologies but most of them are still in the research or development phase. Some of them generate electricity by using organic materials, others use inorganic substances (CdTe for instance).

#### *Biohybrid Solar Cell*

The Biohybrid solar cell is one of the types of solar panels that is still in the research phase. It has been discovered by an expert team at Vanderbilt University. The idea behind the new technology is to take advantage of the photosystem and thus emulate the natural process of photosynthesis. Many of the materials being used in this cell are similar to the traditional methods, but only by combining the multiple layers of photosystem 1, the conversion from chemical to electrical energy becomes much more effective (up to 1000 times more efficient than 1st generation types of solar panels).



*This is a biohybrid solar cell that uses the photosynthetic protein from spinach*

### *Cadmium Telluride Solar Cell (CdTe)*

Among the collection of different types of solar panels, this photovoltaic technique uses Cadmium Telluride, which enables the production of solar cells at relatively low cost and thus a shorter payback time (less than a year). Of all solar energy technologies, this is the one requiring the least amount of water for production. Keeping the short energy payback time in mind, CdTe solar cells will keep your carbon footprint as low as possible. The only disadvantage of using Cadmium Telluride is its characteristic of being toxic, if ingested or inhaled. In Europe especially, this is one of the greatest barriers to overcome, as many people are very concerned about using the technology behind this type of solar panel.



### *Concentrated PV Cell (CVP and HCVP)*

Concentrated PV cells generate electrical energy just as conventional photovoltaic systems do. Those multi-junction types of solar panels have an efficiency rate up to 41%, which, among all photovoltaic systems, is the highest so far.





## *Concentrated Solar Cell*

The name of such CVP cells is related to what makes them so efficient, compared to other types of solar panels: curved mirror surfaces, lenses and sometimes even cooling systems are used to bundle the sun rays and thus increase their efficiency.



By this means, CVP cells have become one of the most efficient solar panels, with a high performance and efficiency rate of up to 41%. What remains is the fact, that such CVP solar panels can only be as efficient if they face the sun in a perfect angle. In order to reach such high efficiency rates, a solar tracker inside the solar panel is responsible for following the sun.

## How To Choose a System

Your home's power requirements, roof type, and solar resource will determine system type and size.

Producing electricity by changing the photons in sunlight to clean power, solar electric panels work in all climates - even in space, which is a very cold climate.



For solar electricity, the amount of sunlight your home receives is much more important than the temperature. Many states, such as Colorado, receive a great deal of sunlight throughout the year, despite the colder temperatures in the winter and spring.

In fact, some vendors claim solar panels actually work better in colder climates because they don't overheat, which can cause performance issues. When purchasing a solar electric system, the right choice will depend on how much sunlight your area receives, your budget, how much conventional power you want to offset with solar power, how much

room you have on your roof or in your yard, and where the solar panels will be mounted.

We included the next option in case you want to go solar with a larger system.

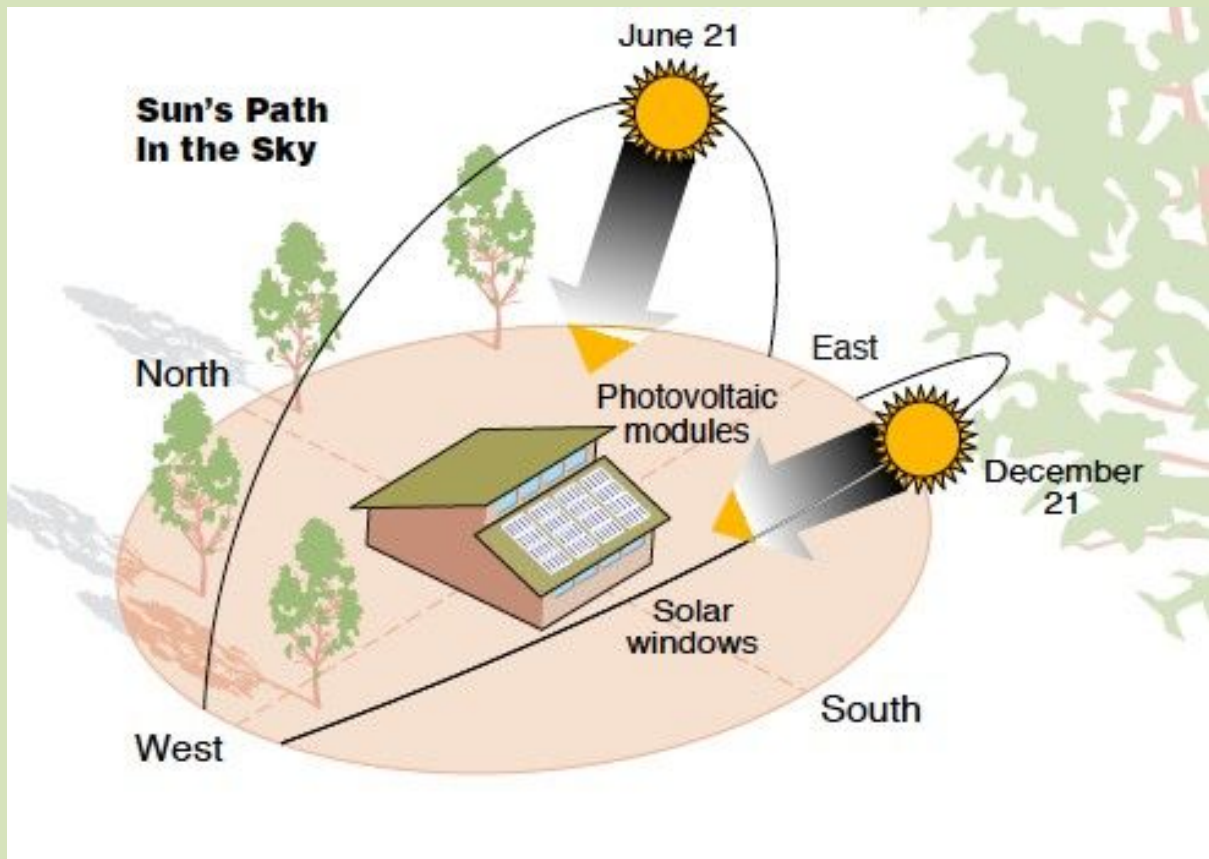
### *Roof Requirements*

Before purchasing a solar electric system, homeowners need to determine available roof space and condition.



### *Space and Orientation*

North America's sun follows a southern path. For maximum performance, your solar electric system needs about 100 square feet of unshaded south-facing roof or yard space for every kilowatt of electricity produced. Thin-film systems may require 175 square feet of space per kilowatt. If your roof does not face south, you can still use a solar electric system, but the performance will be about 5% less with a southeast- or southwest-facing system. Eastern, western, and northern exposures are not recommended for solar electric systems.



Roof tilt is also important to capture the path of the sun, but the requirements vary with location. Your solar vendor and installer should be able to calculate the proper

tilt based on the solar resource for your area (the amount of sunlight your area receives). When a south-facing roof is not available, some people install solar electric systems on garage roofs or use them as window awnings and porch coverings.

Solar panels are usually roof mounted, but if you have a shortage of roof space, they can be mounted on a pole or in your yard. Solar panels can also be integrated into roof shingles and tiles. Some even come as “peel-and-stick” laminates for metal standing-seam roofs.

### *Condition*

If your roof is more than 15 years old, you may want to consider replacing it when you purchase your solar electric system. Most solar vendors recommend using roofing material that will last as long as the system, which is about 25 to 30 years.

Make sure the roof can hold the weight of the system, which is estimated at 3 to 5 pounds per square foot, depending on the type of technology used and installation methods.

### *Shading*

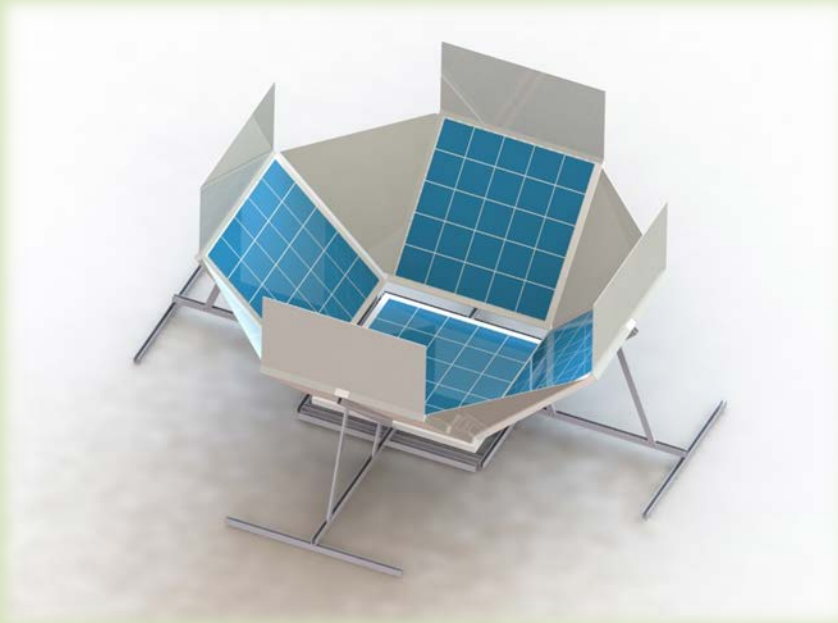
Shading a panel reduces its performance because it blocks sunlight. The most common items that shade solar panels are trees, chimneys, nearby buildings, and electrical cables, as well as heating and cooling equipment. Also check shading from pipes, skylights, and



vents. To determine possible shading problems, consult a solar professional who uses a software program that can estimate site shading. Some people will examine a proposed location throughout the day and year to see how the area shading changes. For example, shading in an area can change from summer to winter because the sun's path changes.

## *Ground-Mounted Systems*

If you don't have a south-facing roof or enough roof space, consider a ground or pole-mounted solar system, which can be installed with the same orientation and tilt as a roof-mounted system. Ground-mounted systems are great for homes with large yards. Some systems come mounted on a tracker that follows the sun's movement.



However, our system is the perfect fit for any home as it takes very little space and it has a high efficiency.

# Important PV Solar Accessories You Need To Have In Your Solar Panel System

## *Cabling*

Very high requirements are placed on the cables, which connect the solar PV modules to each other, modules with solar power inverter and inverter with the grid connection point.

Particularly the cables between the solar PV panels and between the modules and inverter and because of their exposed position are subject to considerable weather conditions through sun, rain snow and, mechanical loads.

Therefore, here you cannot use any cables, but only appropriate solar cables. The cables, which connect the modules to each other, are pre-assembled.

## *Direct current cables*



When choosing the direct current cables (cables between solar PV panels and solar power inverter) two factors play a decisive role, namely the length of DC cable and the right cable cross-section.

These two factors decide the resulting losses in the DC cables. Large cable cross-section and short cables mean less losses. DC cables with large cross-section are more costly than with a smaller cross section.

There are also suitable tools for the calculation of the ideal cable cross-section.



## *Alternating current cables*



When choosing the cables on the AC side, also from the solar power inverter to the feed-in point, make sure that the cable cross-section is large enough.

Moreover the AC cables should be as short as possible, because the losses occurring in the AC wiring are higher than in the DC wiring.

## *Solar data logger*



Solar data logger is an electronic device, which records not only the data of the solar power inverter but also data of additional installed sensors (e.g.temperature and solar radiation sensor).

Besides, with the aid of suitable tools, solar data logger offers the possibility to present the stored data as diagrams in a comprehensible manner.

Solar data logger also offers the plant monitoring. Besides, some solar data loggers have the ability, in case of malfunctions to send an alarm message by SMS and can even remotely be regulated with PC, laptop or smartphone.

## *Lightning protection system*



A lightning protection system is indispensable for the solar PV plant, on the one hand to protect the expensive investment, on the other hand when taking out of a photovoltaic cover insurance companies demand the proof of a lightning protection system.

The lightning protection concept should include two types of protection:

- An external lightning protection, which prevents that a lightning strikes the solar PV system.
- An internal lightning protection ensures the potential equalisation with the aid of special photovoltaic arrestors in order to protect solar power inverters or solar cables.

## *PV Fireman's switch*



In the case of fire, the presence of solar PV system can lead to significant problems. Direct current always flows from the solar PV panels to solar power inverter, when radiation strikes the solar PV modules.

This can have dangerous consequences for fire-fighters. Therefore, the so-called PV fireman's switch is required to disconnect centrally the whole solar panel system.