# SOLAR DISH SYSTEM GENERATOR

MORAY GENERATOR

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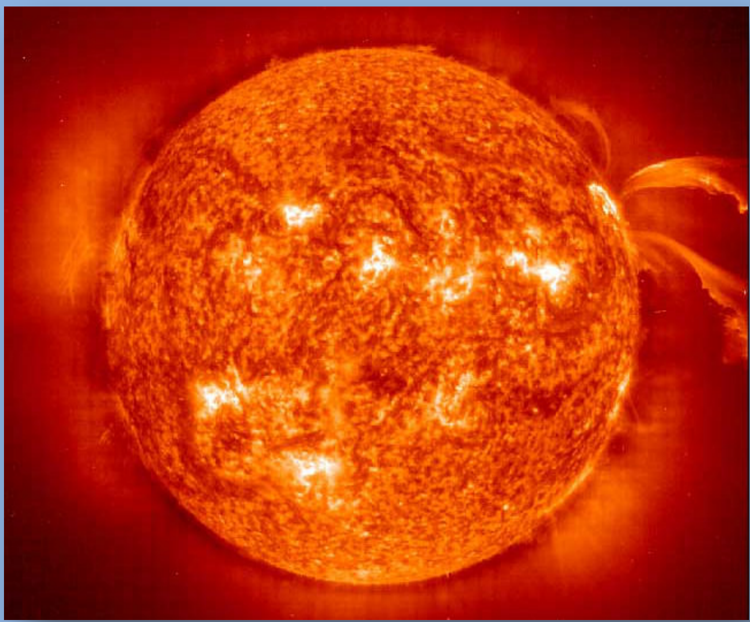
# Solar energy:
# What is it and how does it work?

The sun does more than for our planet than just provide light during the daytime – each particle of sunlight (called a photon) that reaches Earth contains energy that fuels our planet. Solar energy is the ultimate source responsible for all of our weather systems and energy sources on Earth, and enough solar radiation hits the surface of the planet each hour to theoretically fill our global energy needs for nearly an entire year.



Where does all of this energy come from? Our sun, like any star in the galaxy, is like a massive nuclear reactor. Deep in the Sun's core, nuclear fusion reactions produce massive amounts of energy that radiate outward from the Sun's surface and into space in the form of light and heat.

Solar power can be harnessed and converted to usable energy using photovoltaics or solar thermal collectors. Although solar energy only accounts for a small amount of overall global energy use, the falling cost of installing solar panels means that more and more people in more places can take advantage of solar energy. Solar is a clean, renewable energy resource, and figures to play an important part in the global energy future.

Solar is the first energy source in the world. It was in use much earlier before humans even learn how to light a fire. Many living things are dependent on solar energy from plants, aquatic life, and animals. Solar is mostly used in generating light and heat. The solar energy coming down to the planet is affected by the orbital path of the sun and its variations within the galaxy. Besides, it is affected by the activity taking place in space and on the sun. It was this energy that is believed to have been responsible for the breaking of ice during the ice age, which creates the separation of lands and sea.

Solar energy is one of the alternative energy sources that is used most widely across the globe. About 70% of the sunlight gets reflected into space and we have only 30% of sunlight to meet up our energy demands. While solar energy is used for producing solar energy, it is also used for drying clothes, used by plants during the process of photosynthesis and also used by human beings during winter seasons to make their body temperature warm. Solar energy can be extracted either by Solar Thermal or using Photovoltaic (PV) Cells. Learn more about these methods here.

There are two kinds of solar energy the active solar energy and passive solar energy. Passive solar energy uses duration, position and sun's rays intensity to its advantage in heating a particular area. It also uses it to induce airflow from an area to the next. Active solar energy uses electrical technology and mechanical technology like collection panels in capturing, converting, and storing energy for future use.

Solar energy does not create any pollution and is widely used in many countries. It is a renewable source of power since the sun will continue to produce sunlight all the years. Solar panels, which are required to harness this energy can be used for a long time and require little or no maintenance. Solar energy proves to be ineffective in colder regions that don't receive good sunlight. It cannot be used during the night and not all the light from the sun can be trapped by solar panels. Solar energy advantages are much more than its disadvantages which make it a viable source of producing alternative energy.

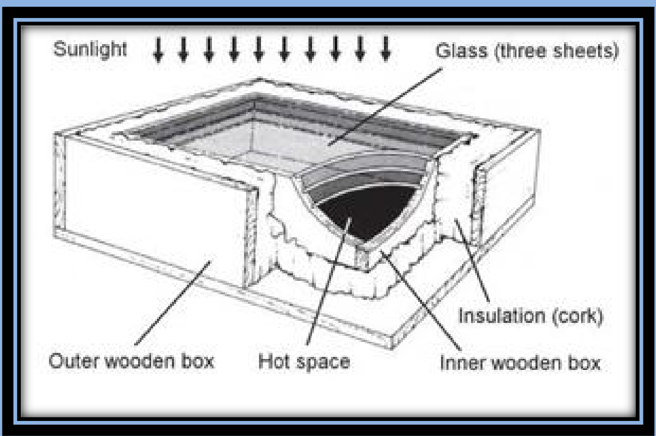
# A short history of photovoltaic solar power

Humans have always made use of solar energy. When man's earliest ancestor realized that a patch of sunlight was warmer than the shade, or that rocks heated all day by the sun remained warm long into the night, solar energy was being used.

Ancient Roman structures were routinely built with south-facing windows to gather in the warmth of the sun. So many Roman residences and public buildings made use of passive solar heating that the imperial enactments of the Justinian Codex, a part of the Corpus Juris Civilis issued between 529 and 534 by order of the Roman Emperor Justinian I, addressed individual citizens' sun rights.

Passive solar design is still popular today. Whether it is as simple as determining on which wall to place a barn entrance or as complex as the glass material selection and window placement for a multimillion-dollar design, architects and craftsmen continue to design and build structures that take full advantage of the sun's warmth and light. The only thing new about solar daylighting or passive solar heating is the name.

All early attempts to harness solar energy focused on heat. This is understandable because the warmth of sunlight is an obvious, tangible property. The basis for the Industrial Revolution was the steam engine, and so early works with solar energy attempted to concentrate the sun's heat to produce steam. In 1767, a Swiss scientist named Horace-Benedict de Saussure constructed an insulated box with an opening covered by three layers of glass. This device is generally considered to have been the world's first solar collector, and it could reach internal temperatures of 230 degrees Fahrenheit. In the 1830s, Sir John Herschel took one of these devices, commonly known as a Saussure's oven, on his South Africa expedition to cook food.




Solar economizers or concentrators are still widely used today. Systems of mirrors and lenses focus sunlight onto reservoirs of thermal transfer fluids to produce steam, control building temperatures, or heat saline storage ponds. Unlike Saussure's ovens, modern solar concentrators reach temperatures in the thousands of degrees. To the average consumer, however, heat isn't energy. Electricity is energy. Solar power is considered energy only when it is converted to useable electricity.

The first step in converting sunlight to electricity occurred in 1839 when a French scientist named Edmond Becquerel exposed two electrodes in an electrolyte to sunlight. He observed an increase in electrical current that he could not explain. This was a defining moment in the history of solar power. Although he did not understand the physics behind his observation, Becquerel is credited with first observing what is now known as the photovoltaic effect. It was a scientific curiosity, but it was not put to little practical use for many years.

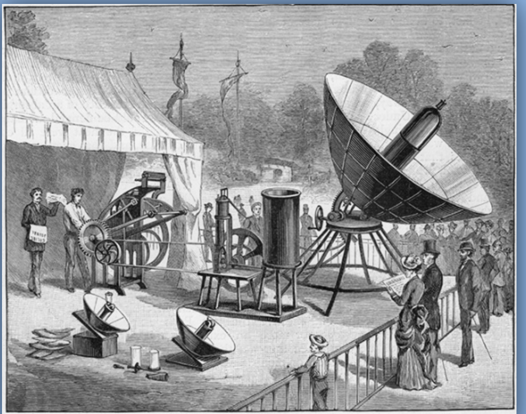


FIG. 11.—MOUCHOT'S SOLAR ENGINE. (FROM A FRENCH PRINT.)

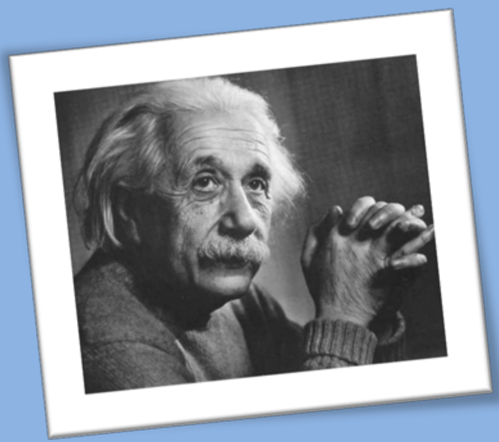
Investigation of solar energy has long been tied to the price structure and supply of other fuels. In the 19th century, France purchased coal to fuel its industrial growth from England. A French inventor named Augustin Mouchot believed that the supply was exhaustible and, in the hands of the English, unreliable. In 1860, he began building upon Saussure's oven and created a water-filled container that was enclosed in a glass envelope. Exposure to sunlight concentrated heat inside the glass envelope and caused the water to boil in the container. By connecting a small steam engine to this device, Mouchot created the first solar-powered steam engine.

His work was inventive, practical, and financially supported by the French government. Unfortunately for the history of solar power, France soon negotiated a new deal with England for cheaper coal and more reliable deliveries. Mouchot's work was no longer viewed by the French monarchy as a priority for that country, and his funding was discontinued. Without financial backing, his work fell to the wayside.

Other scientists continued to toy with the curious property discovered by Becquerel, and in 1873 another important advance in solar energy occurred when Willoughby Smith discovered that selenium was a photoconductive material. William Grylls Adams and Richard Evans Day experimented further with selenium. They were not able to produce sufficient quantities of electricity to do any useful work, but by 1876 they were able to demonstrate, for the first time, that a solid material with no moving parts could be used to convert sunlight directly into electrical energy.

An American inventor, Charles Fritts, used their discovery to create solar cells from selenium wafers ten years later. These primitive cells converted less than two percent of the available sunlight into electricity, but this was still a tremendous achievement at the time.

Most researchers at that time were also looking for a way to store electricity for later use. It was inconvenient to operate a conventional generating facility in the middle of the night, and it was impossible to collect sunlight at night. In 1904, Henry Willsie constructed two large solar generators and storage facilities in California. His facilities were the first to use power at night that had been generated through solar photovoltaics during the daylight hours. His facilities were expensive to operate, however, and his company went bankrupt without inspiring any additional innovations.



Albert Einstein contributed a tremendous advancement in solar energy when he published the explanation of the photoelectric effect in 1905. With his explanation of the phenomenon, physicists began to experiment with photovoltaics and to design materials that they predicted would demonstrate a photovoltaic effect.

Although early solar cells used selenium, the material most widely used in solar cells today is silicon. Jan Czochralski, a polish scientist, is credited with the discovery of the technique for growing single-crystal silicon in 1916. Many other materials also exhibit photovoltaic effects. Cadmium sulfide, for example, was shown in 1932 to produce a current upon exposure to sunlight, and cadmium sulfide solar cells were used by the French government to power remote schools in Algeria.

Photovoltaic materials produce electricity in differing amounts according to the band gaps of the materials and the wavelengths of light to which they are exposed. In 1953, an American Chemist by the name of Dan Trivich published a series of theoretical calculations that predicted the efficiencies of various materials as solar cells based on their bandgap widths and the spectrum of the sun.

The first real solar photovoltaic cell was created at Bell Laboratories a year later when Daryl Chapin, Calvin Fuller, and Gerald Pearson created a silicon crystal cell that could convert ordinary sunlight into a sufficient quantity of usable electricity to power equipment. The original cell had an efficiency of only four percent, but subsequent models reached 11 percent efficiencies.


In 1956, the United States began to develop solar cells for satellites. N-p junction silicon cells were invented by U.S. Signal Corps Laboratories in 1958. This design was much more resistant to radiation damage and was critically important for use in space, and the Vanguard I space satellite used a p-n junction silicon solar cell that produced less than one watt to power its communication radios. Explorer III, Vanguard II, and Sputnik-3 were all launched in 1958, and all featured p-n junction photovoltaic solar cell technology.

Silicon solar cells first became commercially available in 1959. By 1960, efficiency had been increased to 14 percent, and Bell Telephone Laboratories launched the Telstar telecommunications satellite, which featured a 14-watt solar-array panel, in 1962. By 1966, NASA satellites featured 1-kilowatt photovoltaic arrays.

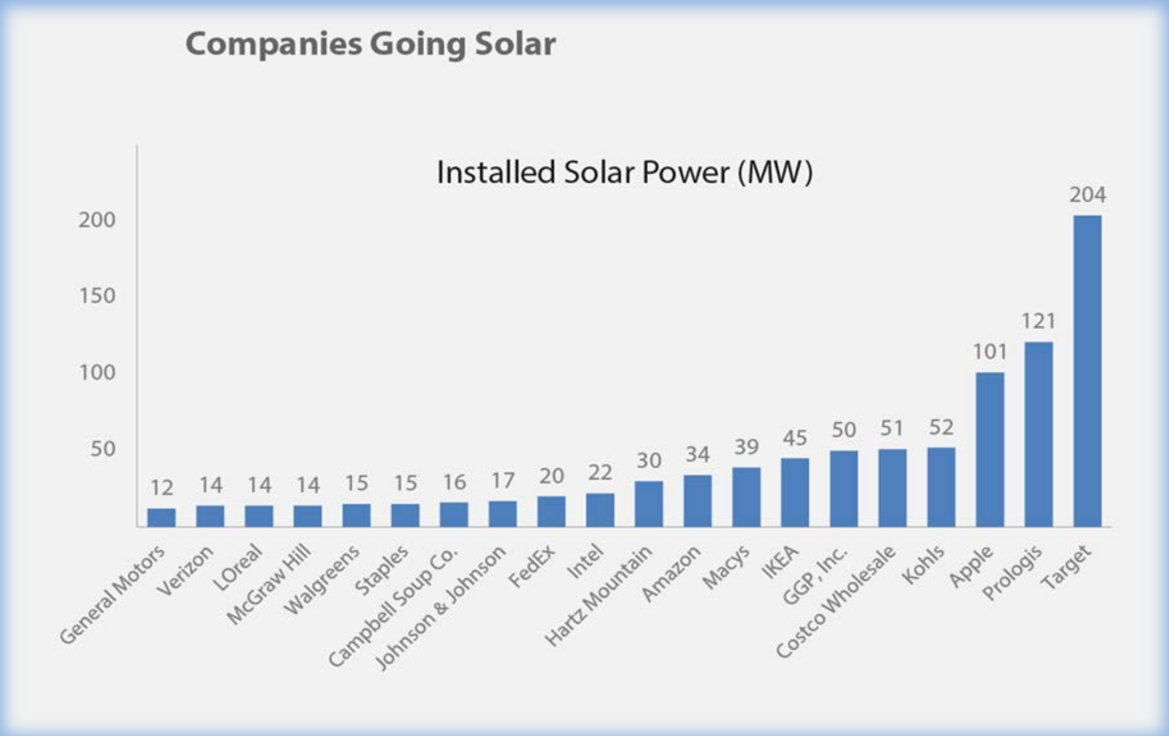
Although solar cells were available commercially at this time, they were by no means cost-effective. Electricity produced by conversion of solar energy typically costs $100 per watt at this point. The production price dropped to $20 per watt in the 1970s due to advancements made by Dr. Elliot Berman. His inventions were used at off-grid locations where power was required for emergency or safety applications.

In 1972 the world's first laboratory dedicated to the advancement of photovoltaic energy was founded at the University of Delaware. Thin-film PV systems were studied here. Silicon crystals are expensive to produce. One line of PV research has been the development of amorphous silicon photovoltaic cells. These cells lack a crystalline structure and are much less efficient than silicon crystal solar cells, but they are also much cheaper to produce. Because they are cheaper, more cells can be produced and used. The economy of scale overcomes inefficiency, and solar electricity can be produced by thin-film amorphous cells at lower costs per watt than through the use of crystal silicon PV cells.

History shows that advances in solar energy have been sporadic. In most cases, advances are seen to occur when conventional energy costs soar or when supplies are questioned. The advances made in the 1970s, for example, can be seen to correspond to the oil crisis of that same period. Mouchot's solar steam engine was financed when France feared England would limit technological expansion by limiting the availability of coal. When costs drop, public and governmental interests in solar power generally wane. That paradigm, however, may be shifting.

Governments have made an enormous investment in utility-scale solar plants during the past few years. Uncertainty about the Middle East, where much of the world's petroleum supply is concentrated, has increased governmental interest in alternative fuel sources. Unlike previous flirtations with solar power, however, the cost may not be the ultimate factor. Global warming phenomena and concerns over greenhouse gas emissions associated with energy production have also driven solar investments in recent years.

Current solar energy research focuses on cheaper methods of producing silicon solar cells, more effective means of storing solar energy, new super-thin copper-indium-gallium-selenide solar films, and the use of dye-laden glass or plastic plates to focus photons onto solar panels. These ideas may ultimately result in transparent materials that will turn every window into a solar panel, new construction materials that will allow all surfaces of a building to function as a giant solar panel, and batteries that store solar-produced electricity overnight or even for days.




As production prices dip lower and lower, arguments for solar energy production shift from economics to eco-friendliness. Many experts believe that the global economy will soon reach a point where solar energy is the preferred source of electricity even if the costs are slightly higher than conventional generation methods.

# Working of a solar panel

If my audience was a group of people who were not very well versed with scientific terms and weren't interested in finding out either, I would say the photons or particles of sunlight knock out electrons from the atoms and create a flow of electricity in the circuit, but clearly that is not the case.

A solar panel consists of a layer of silicon cells, a metal frame, a glass casing with a special film and, wiring. Now if multiple cells are grouped in an ordered series it forms a *Solar Array.*

The figure shows a Solar Array. A single unit among this array will be called as a solar panel. Usually, the term array is used to describe a large scale solar farm but technically, any grouping of solar panels is a Solar Array. This whole grouping works together as a system.

# What are Solar Cells made of?

Solar cells are made from *Silicon* or *Germanium.* Both are chemical elements, they are called as semi-conductors. Both of them have 4 electrons in their outer shell. Upon application of energy i.e in the form of photons or heat, the electrons leave their outer shell. These electrons are then called as free electrons.

A solar panel is made by joining 6”x6” cells of silicon with metal contacts on the face and covering it with glass and placing it on a protective back sheet. Panels usually come in 60 and 72 cells configuration.

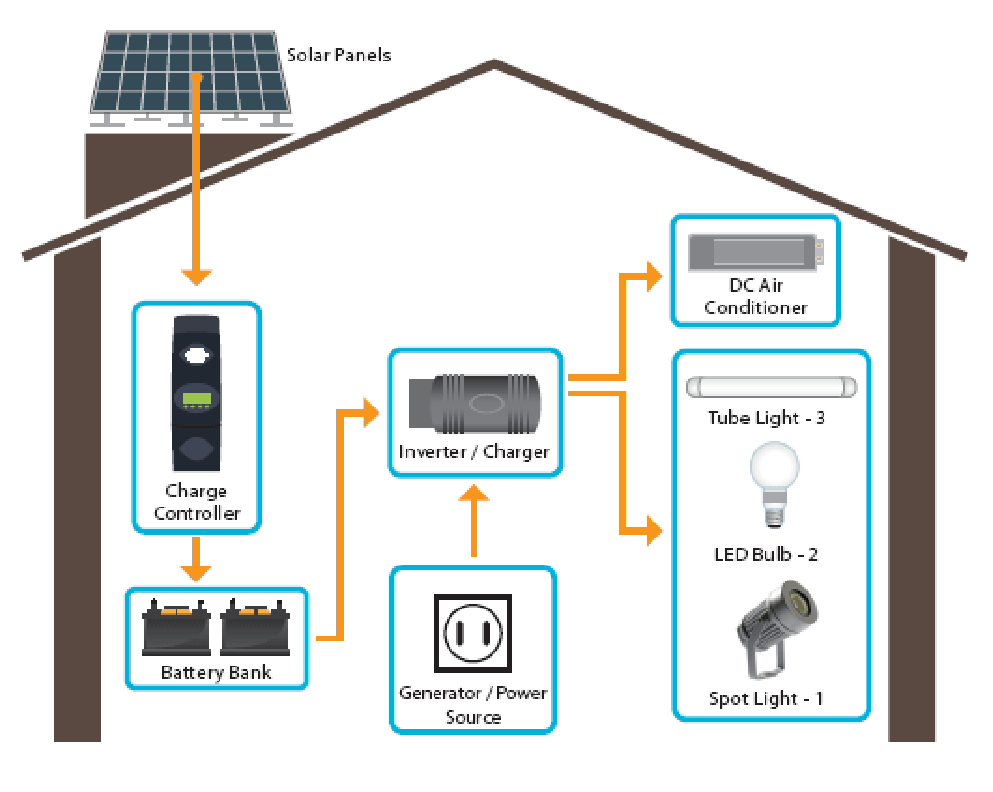
Multiple panels are connected to power a building or a house. Panels connected to the same inverter as called as a string of panels.

# A solar energy system

To generate your energy, you need a solar system. A solar system has some necessary components which cannot be ignored:

- Solar Panels
- Inverter
- Racking

Racking is the stand or a foundation on which you mount your solar panels. They are of prime importance as they play a vital in determining how you will receive an optimal amount of energy throughout the day.




Using these components you can use energy as it is produced. To store the energy you further need some components:

- Charge controller
- Batteries

# Solar parks around the World

If you want to be a superpower in the world in the 21$^{st}$ century, you need to be a leader in technology. Being a leader in technology means you need to be a mass producer of energy. Solar power has attracted a lot of investors and countries towards itself. Companies are shifting towards solar energy towards it exponentially. Compared to hydel power, solar power is cheaper. Solar power projects can be placed at any scale from an individual power source to a household power unit and extended to power a whole metropolitan like New York or Tokyo.

Countries are going to solar power with everything they got. Currently, the biggest solar power project in the world produces 1.5 GigaWatts of power.

Following is an overview of the biggest solar power projects in the world and their power capacity details:

- Copper Mountain Solar Facility covers 10 $km^2$ in Boulder City, Nevada, and was developed by Sempra Generation. Copper Mountain powers 18,000 homes with 552MW of power. It might seem surprising to see the US ranking lower in 2020 when it had been the leader of solar energy in 2016 and this is likely the result of President Trump's imposed tariff on the importation of solar panels in the US in January 2018, which froze some US$2.5bn in projects.

- Solar Star was originally the largest solar project in the world when it was completed in 2015, and its displacement is a testament to the speed at which solar power is growing internationally. Solar Star has a 579MW capacity, and powers over 250,000 homes near Rosamund, California. The power station is spread over 13 $km^2$.

- Pavagada Solar Park is one of the newest additions to this list, as 600MW became operational in March 2018. The park is one of many contending for the title of largest solar park in the world with its goal of reaching 2000MW by December 2020. It has yet to update its number of operational units.

- Kamuthi Solar Power Project is spread over 10 $km^2$ in Kamuthi, Ramanathapuram district, about 90 km from Madurai, in the state of Tamil Nadu, India. The site is the largest single-location solar in the world and has a capacity of 648MW. The photovoltaic panels are cleaned each day by self-charging robots.

- Villanueva Solar Park covers 24 $km^2$. The park has increased its output to 828MW from 754MW in 2018. Enel, the company responsible for the operation of Villanueva, also has a second solar project: The Don José facility. The Don José facility generates 260 MW, making Enel the largest producer of photovoltaic energy in Mexico.

- China is becoming a solar superpower and Longyangxia Dam Solar Park is located next to a hydropower station on the Yellow River in China's Qinghai province. The solar power station is integrated with the hydroelectric power station, allowing for the regulation of output to balance the variable generation from solar before it is connected to the grid. This helps to conserve water. The park now has expanded to 850MW, keeping it high in the ranks.

- Kurnool Ultra Mega Solar Park is situated in the province of Andhra Pradesh. The plant is 24 $km^2$ and currently has 2,500 employees. The park was the first to send 1GW of electricity into the public grid in December 2017. The government plans to open two more parks, increasing the output to the state grid to 2.75 GW by 2022.

- Datong Solar Power Top Runner Base completed its first stage or three with 1GW. The Base has plans in motion to expand it to the largest solar plant in the world once completed. Each phase is expected to generate 1GW. The powerbase features solar panels that are organized to look like pandas from an aerial view, to inspire interest in solar power from the general public.

- Though Bhadla is physically larger than Tengger Desert (40 $km^2$), its output remains lower with 1,365 MW. On a visit to the plant by The Indian Express, Amitabh Sinha described the area as "almost unlivable" with temperatures of 46 and 48 degrees Celsius. 40% of the technicians are from local villages, and work to keep the solar panels functioning. The plant plans to extend its operations up to 2,25GW

- The largest solar park in the world is Tengger Desert, Solar Park. Tengger Desert is located in Zhongwei, Ningxia, and covers 36,700 $km^2$, and has been the largest park in the world since 2016. In China, the park is known as “The Great Wall of Solar”, generating over 1.5GW of power. While it has held this position for the last three years, it could very soon be outranked by the expansions planned by other parks such as Kurnool, Datong, and Bhadla.

*Datong Solar Power Top Runner Base.*

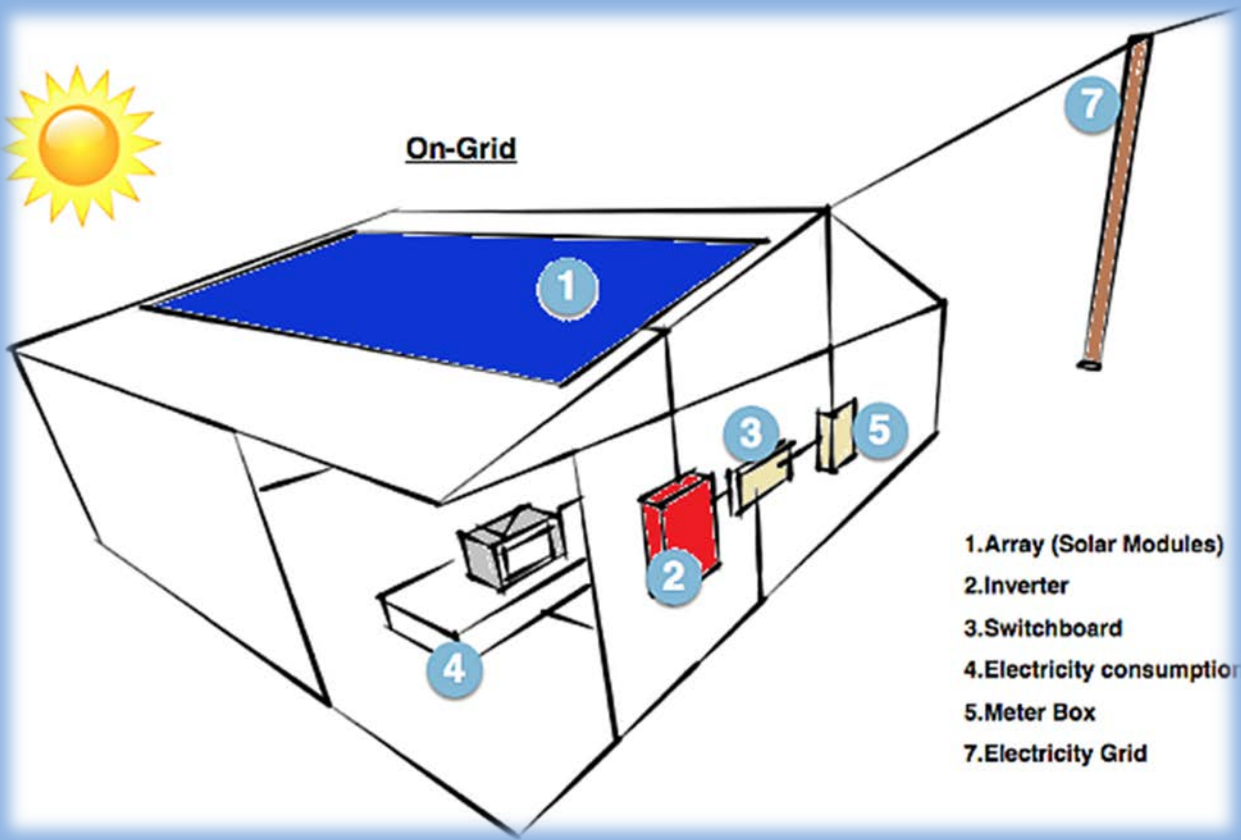
# Grid-tie and Off-grid Systems

All solar panels work on the same principle. The sunlight falls on PV cells, these cells release electrons, which produce a current in the circuit. The Solar systems are categorized into 3 types:

1. *On-Grid systems* also known as Grid-tie or grid feed systems
2. *Off-Grid systems* also known as stand-alone power systems (SAPS)
3. *Hybrid systems* in which solar power is used with battery storage and grid connection

The most commonly used solar systems by homes and businesses are Grid-tie or On-grid solar systems. These systems do not need batteries and use simple inverters and are further connected to the grid. The electricity is generated continuously and used simultaneously. The excess amount of energy that remains unused is loaded into the public grid, for doing this user gets paid in tariff or gets credit which can be redeemed at a later point.

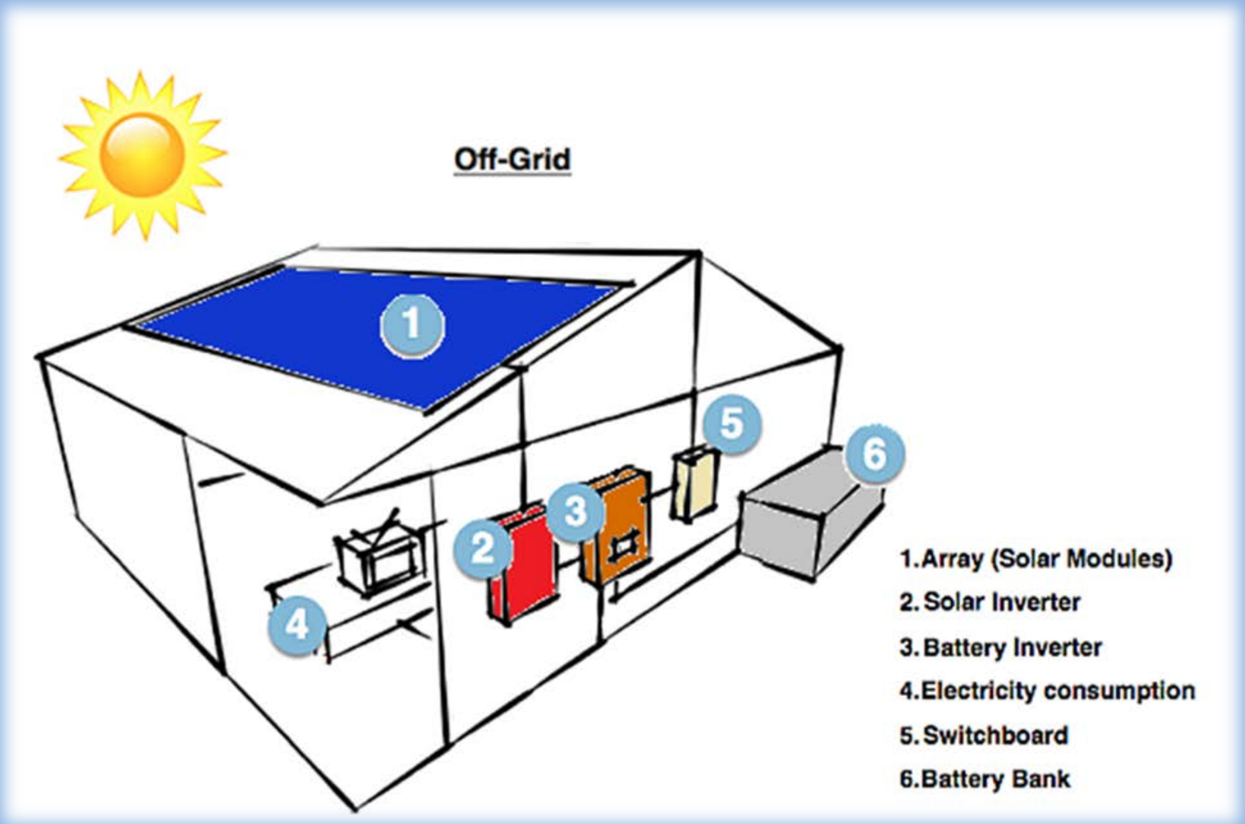
**<u>On-grid systems</u>** cannot generate or use electricity during a blackout. Since blackouts occur due to damage or fault on the public grid hence they cannot produce electricity otherwise the energy produced would get loaded onto the public grid and harm the workers working maintenance on the grid.




*A Grid-tie system*

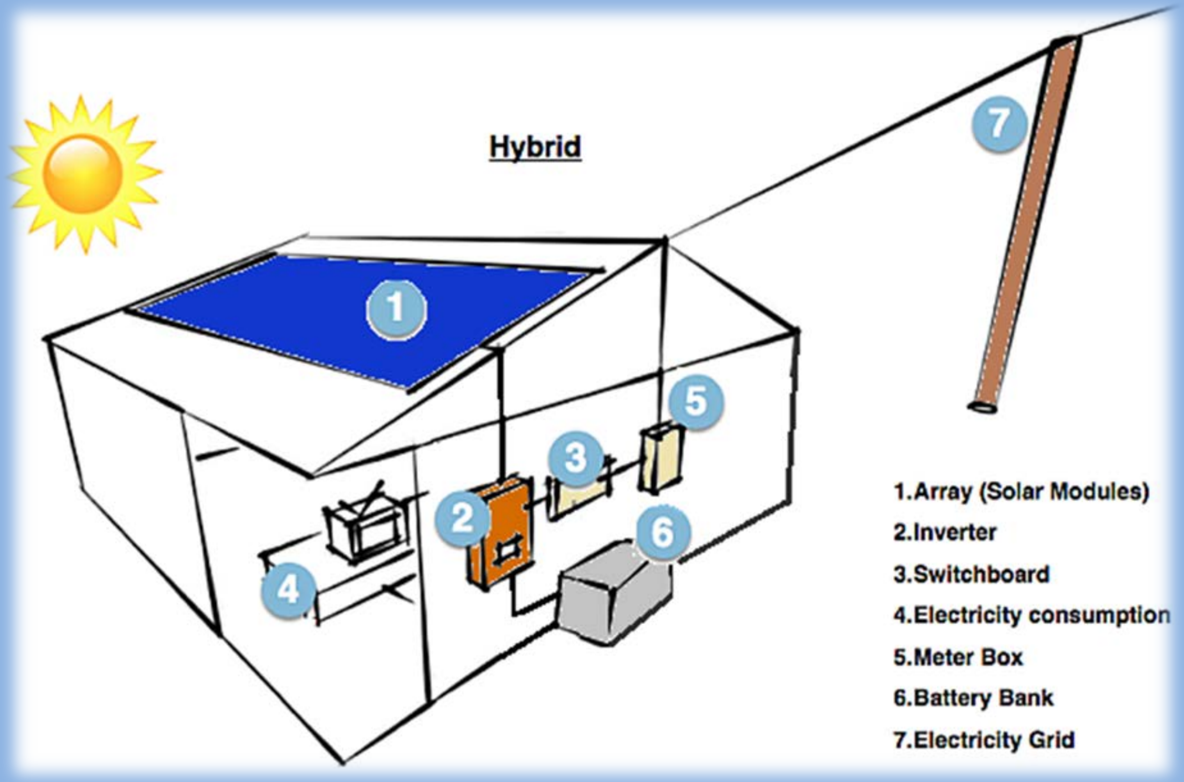
**An off-grid system** uses batteries since it is not connected to any grid (as the name suggests). When designing an off-grid solar system I, you need to keep in view the requirements of the house. Fulfilling the requirements of the house isn’t enough - the system should also be able to feed the storage so when the night comes there is enough energy them to be utilized.

The best way is to use batteries and off-grid inverters. In technical terms, it is basically an AC coupled system in a DC-coupled system. The power is first sent to the batteries from there it is sent to your appliances.




*The figure shows an Off-Grid system*

**Hybrid systems** combine solar and battery storage into one. They are available in different forms and configurations. Due to the decreasing cost of battery storage, systems that are already connected to the electricity grid can start taking advantage of battery storage as well. This means being able to store solar energy that is generated during the day and using it at night. When the stored energy is depleted, the grid is there as a backup, allowing consumers to have the best of both worlds. Hybrid systems are also able to charge the batteries using cheap off-peak electricity (usually after midnight to 6 am).




*The figure shows a Hybrid solar system*

All of these systems are used for domestic and commercial purposes. Each of them has their abilities and tradeoffs. The Grid-tie systems are inexpensive as compared to other systems but they aren't as efficient as hybrid and off-grid systems. Hybrid systems, on the other hand, are extremely efficient but they are also expensive. Off-grid systems are average in terms of efficiency and money consumption. All of these systems have different types of inverters.

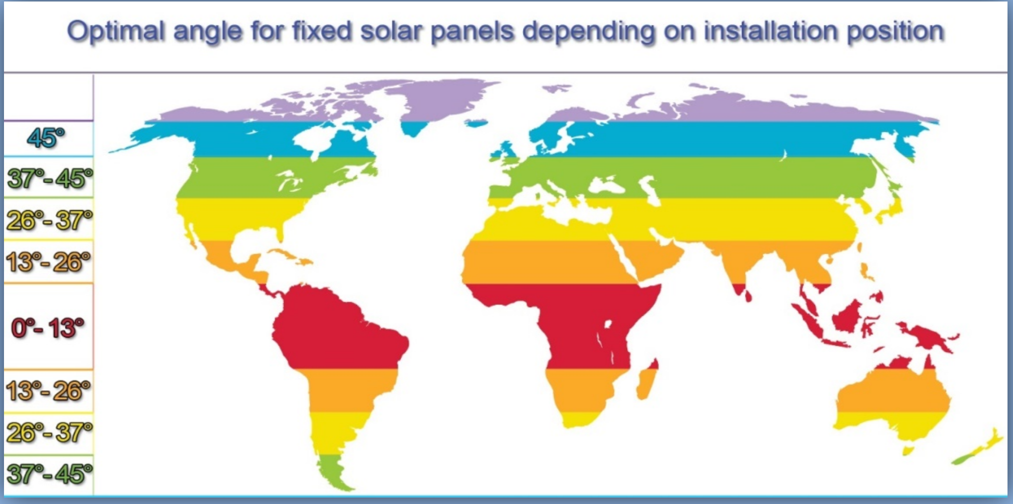
# How to place Solar Arrays

Sunlight hits the panels in the form of an array. The system is connected to inverters. When the sunlight hits the panels it generates *Direct Current (DC)* in the circuit. Keeping in view that sunlight is solely responsible to generate electricity, how the Solar Arrays are positioned is very important.

Naturally, if you're in the northern hemisphere, placing your array southward will help you receive more sunlight and in turn, you will get more electricity. You get the maximum efficiency when the sunlight is perpendicular to the solar array, for this purpose some farms use solar tracking systems which help the arrays stay perpendicular to the sun at all times. Since this setup is expensive, people generally choose an optimal position for their arrays. This optimal position is the one that receives the most sunlight throughout the day.

The tilt of the Solar Array also called angle is very important. The angle at which it must be set to give maximum efficiency is determined by geographical latitude. A general rule to obtain maximum efficiency from the system is to set it at the angle of the *Geographical Latitude* of the place. Say, a solar park is located near the northern pole, to obtain maximum energy from it, the arrays should be facing the equator and vice versa for the southern pole. For a solar park situated at the equator, the arrays should be pointing straight upward for maximum energy production.

The following diagram shows the optimal angles of installation throughout different locations in the world.



# DIY SOLAR DISH

Our team has come up with an efficient solution to all of your solar energy problems. This system is an optimal way to get solar energy for your house throughout the year with any kind of average consumption throughout the hours. The ***DIY SOLAR DISH*** needs 5 sets of solar panels and 8 sets of reflective panes. Moreover, we will explain step by step how to build it yourself.

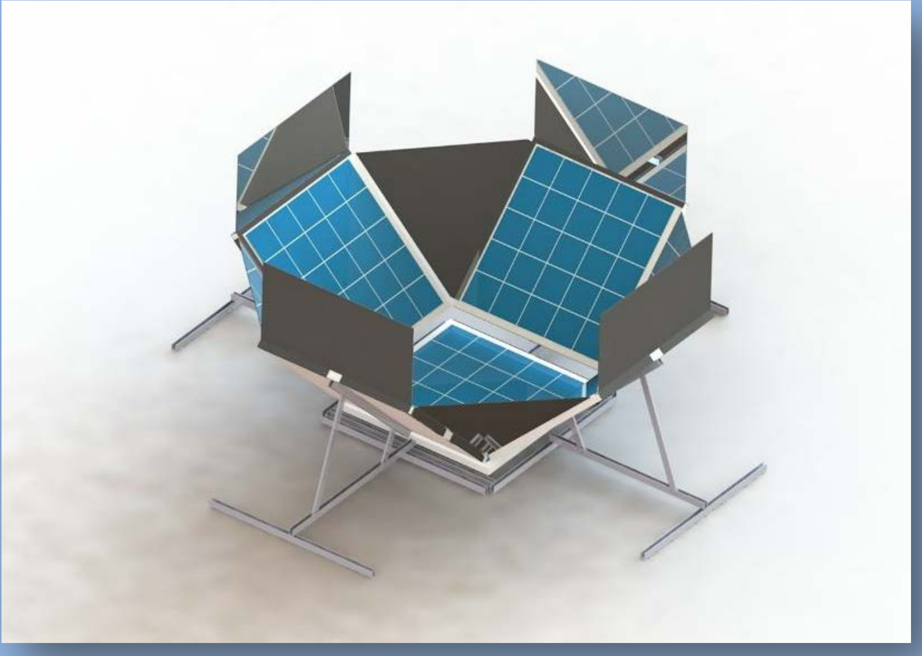
# COMPONENTS

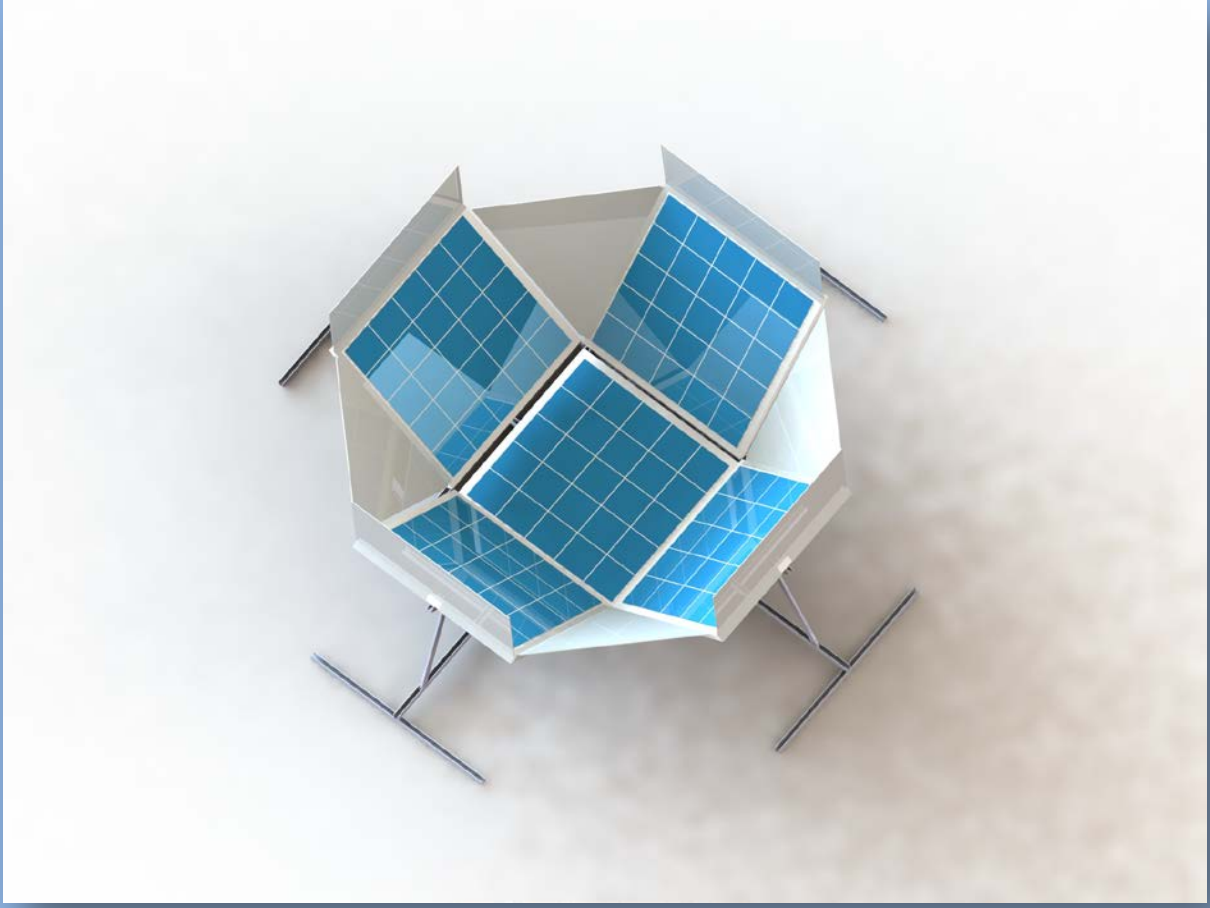
You will need the following items:

- Solar panels
- Reflective panes
- Stands
- Hinges
- Cables
- Battery
- Inverter
- Test Kit

# WORKING OF DISH SYSTEM

As said earlier, the Dish system contains 5 panels and 8 panes. The setup works to get maximum efficiency out of these 5 panels. A panel is laid down straight, the rest of the panels are mounted around this on an angle of 45° at each side. The voids between the interface of the panels are filled with reflective panes, 4 of them. Now the rest of the 4 reflective panels are mounted on top of the side solar panels making an angle of 135° with the base panel.





*The figures shows how the final assembly will look like*

The system is designed as such no matter what is the angle of the sun, the sunlight will always fall on one of the five panels, giving it maximum efficiency. You can place it anywhere either on the ground or your rooftop. You also don't have to care for the geographical latitude or the solar tracking system. You will be getting a constant amount of electricity as long as the sun shines and not only. And even when it isn't shinning, you can use the reserve power in the batteries. Hence, the DIY SOLAR DISH KIT has got you covered all round.

# Inverter

The Solar Inverter is an essential device in any solar power system. Its basic function of the inverter is to change the variable Direct Current output of the solar panels into Alternating Current. The converted Alternating Current power is used for running your appliances like the TV, Refrigerator, Microwave, etc. There are 3 main types of inverters:

a) Off-grid inverter

b) Grid-tie inverter

c) Microinverter

**Off-grid inverters** are utilized in remote frameworks wherein the solar inverter is fed DC power from a battery panel. This battery board is charged by solar panels. Several such inverters have interfaced with essential battery chargers which can be utilized to boost the battery from an AC power source.

Another type is the **grid-tie inverter**, these are used to supply the power from the batteries to the grid. They match the phase and frequency of the power in the main grid with the power generated with the help of solar panels and they load it onto the grid.

The main purpose of the inverter is to convert a positive cycle sine wave to a full cycle sine wave. For this purpose, a PWM inverter IC MOSFET is used and setup voltage is provided by a transformer.

These inverters can work directly with the power coming from the solar panels or they can also be used with batteries, depending upon the conditions. Some intelligent systems use high-end inverters which automatically switch between solar energy power and batteries.

There's a maximum number of panels an inverter can support. They have an upper limit, which tells us how many panels can be connected to this inverter. Say, a panel has an upper limit of 20 and a building will need 40 panels to power it perfectly. 2 of such inverters will be used to power the building. And the solar array will have 40 panels connected in a string.

*The picture shows a solar power inverter*

## Charge Controllers

A charge controller or charge regulator is a voltage or current regulator that keeps the batteries from overcharging. It regulates the voltage coming from the solar panels going into the batteries. Most 12 volt solar panels put out 16 to 20 volts. So if there is no regulation, the batteries will be damaged due to higher voltage levels. Most batteries need 14 to 15 volts to get fully charged.

Another question that arises is why do 12-volt panels put out 16 to 20 volts. The reason is that the solar panels are designed as such that they will put out 12 volts even under very dim sunlight. Hence, the voltage output is dependent on the intensity of light as well. When the sunlight is good i.e. at peak hours, the solar panels put out 20 volts.

A 12-volt battery is at 12.7 volts at rest and around 14.4 volts when charging. The solar panels are designed to put out 12-volts when they have a very dim reception of light. When the sunlight is good, they usually put out 16 to 20 volts. Moreover, to charge the batteries solar panels have to put out at least 14.4 volts. Hence, under the worst operating conditions, solar panels should put out more than 14.4 volts. The regulator will need to regulate this 16 to 20 volts to the value that battery needs at that time which is usually between 10.8 to 14.4 volts depending upon the state of the battery.

A 12-volt battery is at 12.7 volts at rest and around 14.4 volts when charging. So the solar panel has to put out this much potential difference under the worst-case scenario. The regulator will need to regulate this 16 to 20 volts to the value that battery needs at that time which is usually between 10.8 to 14.4 volts depending upon the state of the battery.

Charge controllers come in all shapes, sizes, and price ranges. They range from 4.5 amps to 80 amps that are controlled by computers. Generally, there are three types:

- Simple one or two-stage controllers. They rely on relays and shunt transistors which control the voltage in one or two steps. They just shorten the connection with the solar panels once the desired level of voltage is reached. Their real claim to fame is their reliability. They do not have a lot of components, hence there are very small wear and tear and electrical components. They are also the cheapest ones around.

- 3 stage or PWM, these are the industry standard nowadays.

- Maximum Power Point Tracking (MPPT). These are the ultimate charge controllers with prices top of the line as well but their efficiencies are around 94 – 98%. They are also an efficient way to save money on large scale systems since they provide 10 to 30% more power to the batteries.


*The picture shows a newer Charge Controller with Digital interface*

Many controllers which fall in average price range come with LEDs and digital meters to show input and output levels. The newer versions and costly ones have digital computer interfaces that help monitor the performance and set the rating to different levels.

Equalizing lead-acid batteries is a process designed to de-sulfate the battery plates by carrying out a controlled overcharge. Battery plates tend to acquire a sulfate coating over time which then hinders the chemical action between the electrolyte and the plate. By equalizing the battery in this controlled overcharge the outer layer of the plate, including the sulfate coating, is blown off, thereby rejuvenating the battery and allowing all the surface area of the plates to interact with the electrolyte. This is one of the most important functions of a charge controller. The controller needs to monitor if one cell of the battery is more depleted than the other one then the controller needs to provide more charge to it.

PWM stands for Pulse Width Modulation. PWM is often used as a method of float charging. Instead of sending a steady pulse to the battery, it sends out a series of short charging pulses.

A *Battery System Monitor* is different from a controller. It monitors the voltage levels and charge levels on each cell but it doesn't perform the regulation process. Although, the charge controllers use a battery system monitor, to sense the voltage levels of the battery during charge and discharge cycles.

## Cables

The common types of wires used are copper and aluminum conductors. Copper has greater conductivity hence it carries more current than aluminum with the same circumference of the conductor. Aluminum is also bent during the installation and its conductivity decreases considerably. But aluminum is cheaper as compared to copper.

The cable can be either solid or stranded. A stranded cable is the one that contains multiple wires of smaller circumference wrapped into a bigger wire. A stranded cable is recommended for larger systems. As it allows flexibility. The current always tends to move outward, if you see a current density diagram of current flow across the cross-sectional surface, you will notice that the current flows outward. Hence, stranded cable is better since it has a more cross-sectional area.

The insulation covering the wire is also important as it helps the wire against heat, moisture, and UV rays. THHN is commonly used in indoor and dry locations. USE-2 and RHW-2 can be used in outdoor and moist locations. These cables are UV resistant as well.

*The cross-sectional view of a stranded cable*

## Batteries

In simple terms, a battery turns chemical energy into electrical energy due to a chemical reaction induced by the application of a voltage across its ends. There 2 types of batteries primary and secondary. Batteries that cannot be recharged are called as Primary batteries like dry cells. On the other hand, batteries that can be recharged are called secondary batteries like Lithium-Ion cells.

## How to Assemble

Firstly you need to gather all components: solar panels, reflective aluminum panels, stands, hinges, cables, batteries, inverter and, screws.

Following is a step by step approach to set up the system:

1. Layout one panel on the back. This will be your base panel.

2. Mount the base panel on it.

3. Take 4 hinges of 45° from the kit and fix them on each side of the base panels with screws. There will be 4 interstices on each of the solar for the hinges to fit in.

4. After the hinges are fitted on the base panel, fix one solar panel on each side with the help of screws. After this, all the solar panels will be fixed.

5. Next, we need to fix the aluminum panels that will reflect the stray arrays into one of the panels.

6. Take 8 hinges of 45° and fit them onto all the panels on their horizontal sides.

7. Take 4 triangular reflective panels. Fit each one of them between 2 hinges with screws.

8. Take 5 hinges and screw them on top of all 4 panels.

9. Take 4 reflective panels from the kit and mount them on top of the panels with screws.

10. Place the whole system on the stands panels for extra support.

The setup of Solar Array is complete at this point. Make sure you tighten the screw nicely. The materials used for the system can resist natural wear and tear.

Next, you need to connect this setup with the inverter, batteries, and the main supply of the house.

1. Connect all the 5 solar panels in series with one another using cables.

2. Plug the other end of the cable into the input port of the charge collector.

3. Take the cable from the output port of your charge collector and plug it into the inverter and the batteries (which are connected parallelly).

4. From the output port of the inverter, take the cables and plug them into your AC household main supply.

Once all these steps are completed, you are good to go. Now you have inexpensive, clean, and renewable energy around the clock 24/7.

## Placement of hinges

You will be needing 2 types of hinges to work with this system:

1. 45°

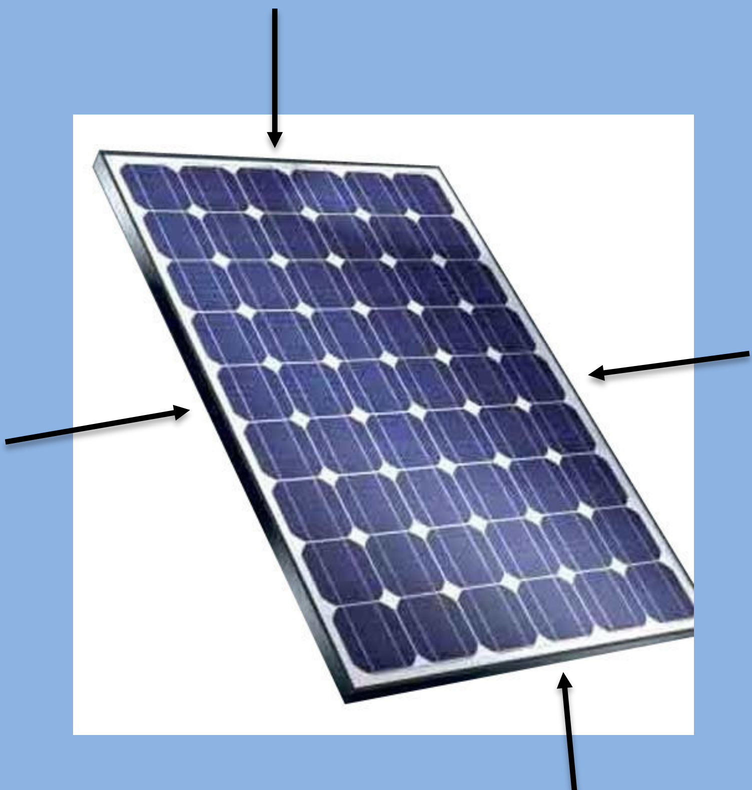
2. Adjustable hinges

The 45° hinges are to be fixed at all the four sides of the base panel. And also for the horizontal sides of the 4 side panels.

Whereas the 90° hinges are used only to mount the top reflective panels.

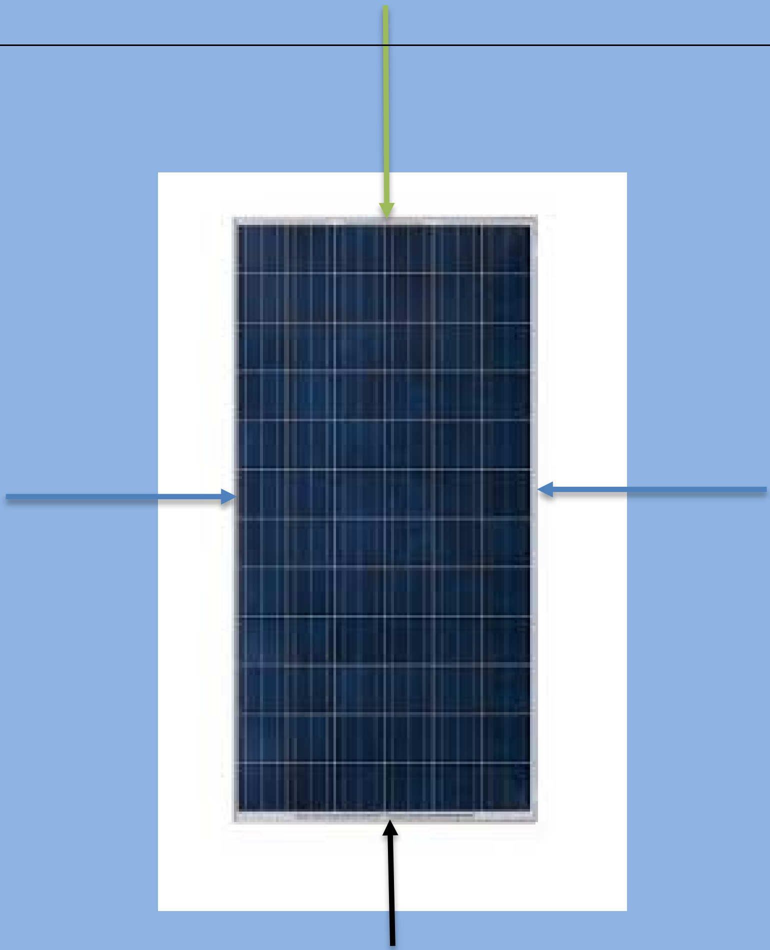
*A hinge at 90°*

*An adjustable hinge*



*Base Panel*

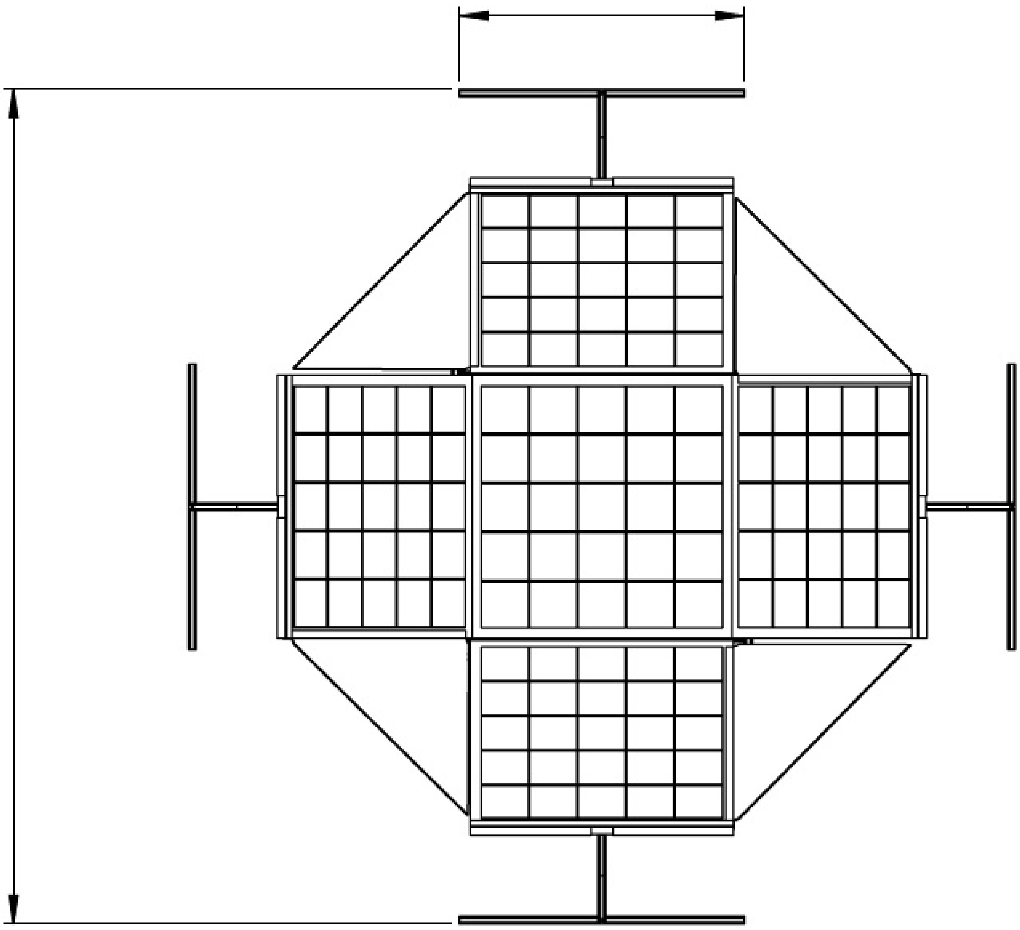
1. The above figure shows the base panel and the arrows indicate where the 45° hinges will be placed.



*One of the side panels (can be square)*

In the above-shown figure, there are 3 types of arrows and each one of them represents something different:

- The black arrow shows where the 45° hinge with the base panel will be connected.
- The blue arrows show where 45° hinges will be connected to fit in the triangular reflective panels.
- The green arrow shows where the adjustable hinge will be connected to fix the top reflective panel.



*The above figure shows how the Dish system will look from the top once completed*

# Stand

The stand can also be designed in such a way that it is easy to erect. Build the stand however you please, but keep in mind it has to be steady and strong. The different components of the stand are very easy to connect.

Components you will be needing to build one type of stand:

1. Flathead circular rough surface x5
2. 450 units long rods x4
3. 150 units long rods x4

4. A base rod of your own choice, since it will be placed under the base panel to support your whole system. It will be the center of gravity and center of mass so it is suggested it is as close to the ground as possible. This way your center of gravity stays as low as possible and the whole system becomes stable against harsh weather.

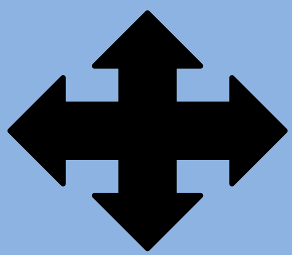
Now moving on to how to assemble all this:

1. Join 450 units long and 150 units long rods together, perpendicularly.

The assembly will look as depicted above. You need to make 4 pairs of these.

2. Layout these rods at the ground with a 90° difference between each pair, just like 4 quadrants on the XY plane.

This is how the assembly will look.



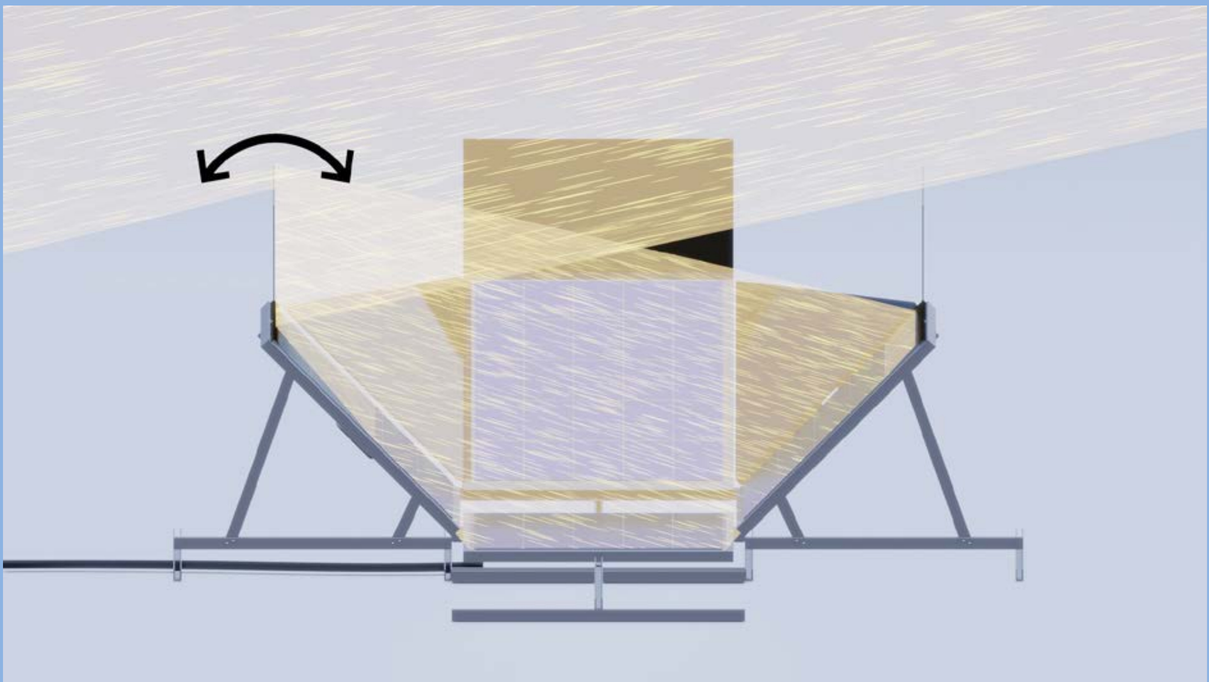
3. Next, join the center smaller rod in the middle of the current assembly.

4. After this is done place the flatheads on each of the ends.

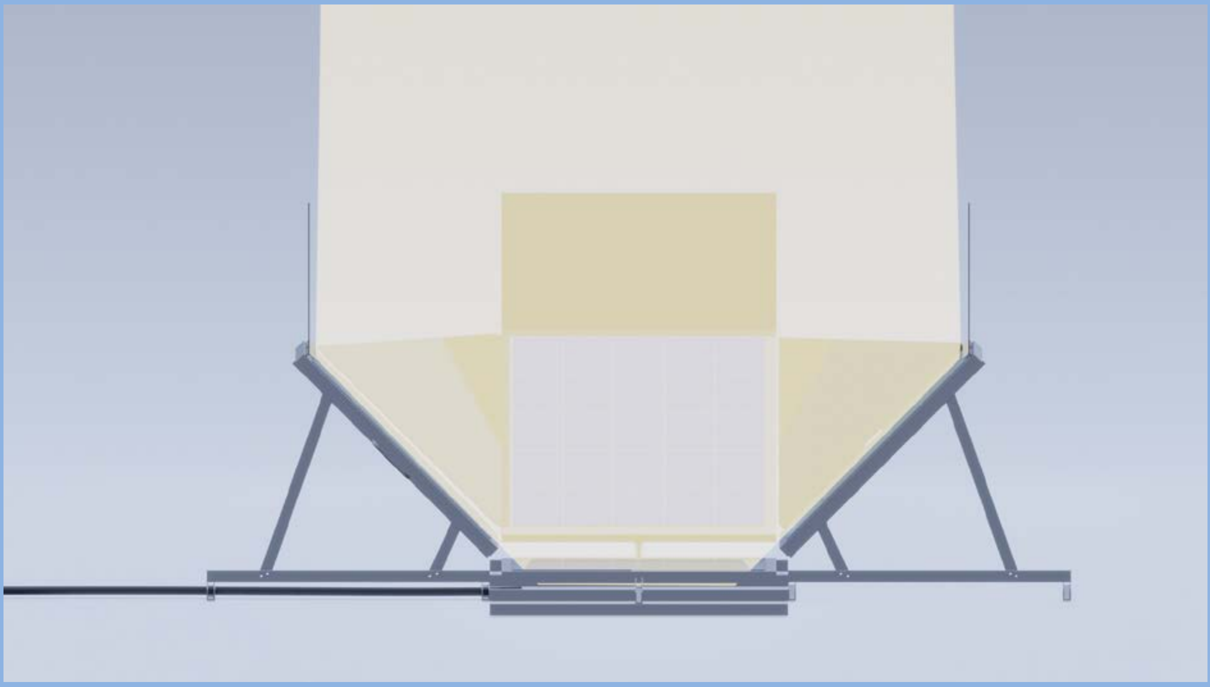
5. Your stand is ready and the system can be mounted on it now.

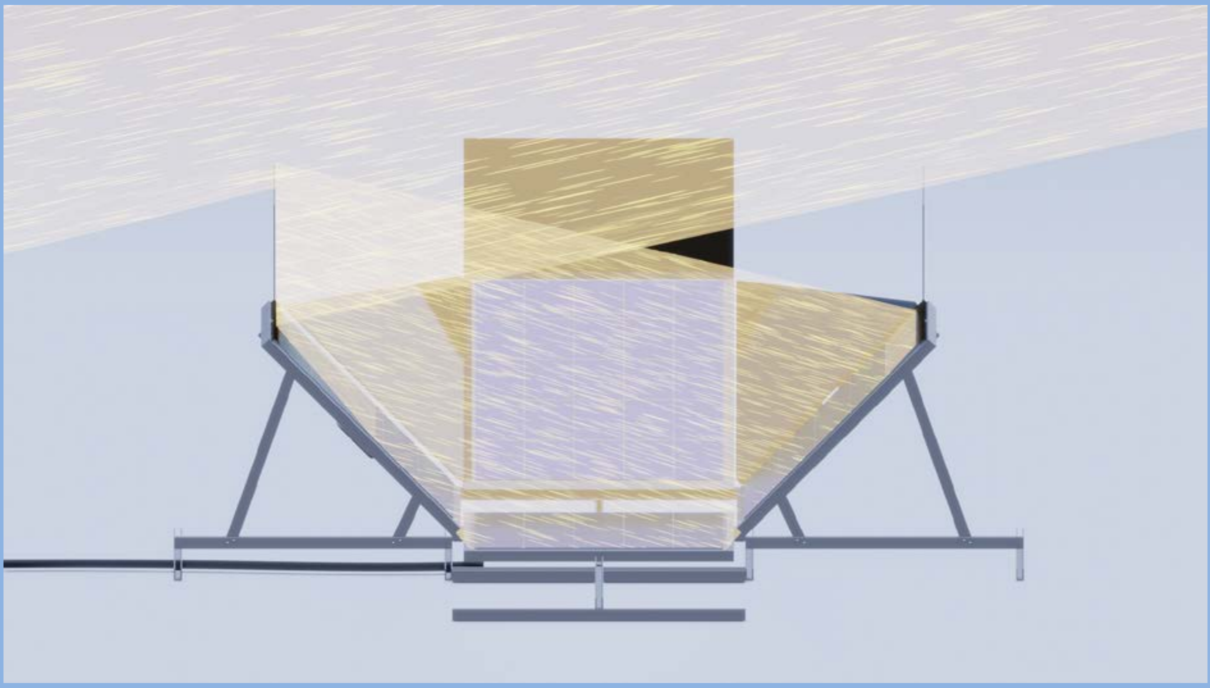
# Purpose of the Reflective Aluminum Panels

The aluminum panels are the main agent in increasing the efficiency of the whole dish system. They do not let any of the sunlight entering the dish go to waste or astray. They reflect it to one of the five solar panels in the system. No matter how crooked is the angle of the sunlight entering into the system, the reflective panels find a way to direct it to the solar panel.



Say sunlight hits the top panel at the angle greater than 90°. It will be reflected, either towards the base panel or the tilted panel opposite to it. Similarly, a ray hits the triangular reflective panel and it will be reflected towards the opposite titled solar panel. In this way, you will be getting the maximum juice out of these five solar panels.





# Portability

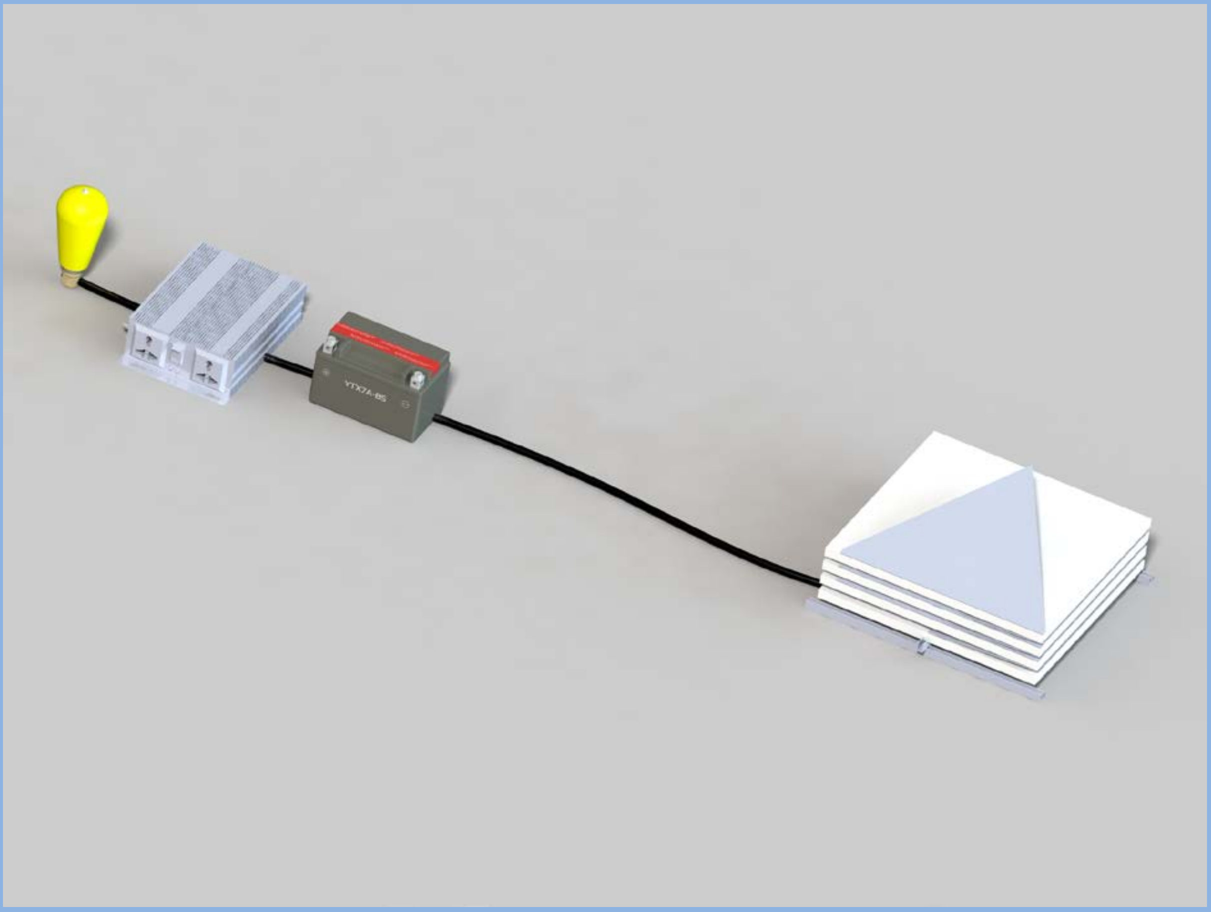
The adhesive pieces in the whole system are hinges. Hinges work on the principle of radial movement. This great ability of the hinges allows our system to be folded and be moved from location to another. Once it is folded the system becomes so small that it can be placed in the trunk of your car and can be taken along on one of your trips or picnics. It can also be mounted on top of your RV.

*The figure shows how the system can be folded*

- The rectangular top reflective panels are folded onto the side solar panels.

- Then, the triangular panels are folded and placed on the top of the base solar panel.

- At last, the side panels are folded and they go at the backside of the base solar panel.



*The picture shows the system folded*

## *Tools*

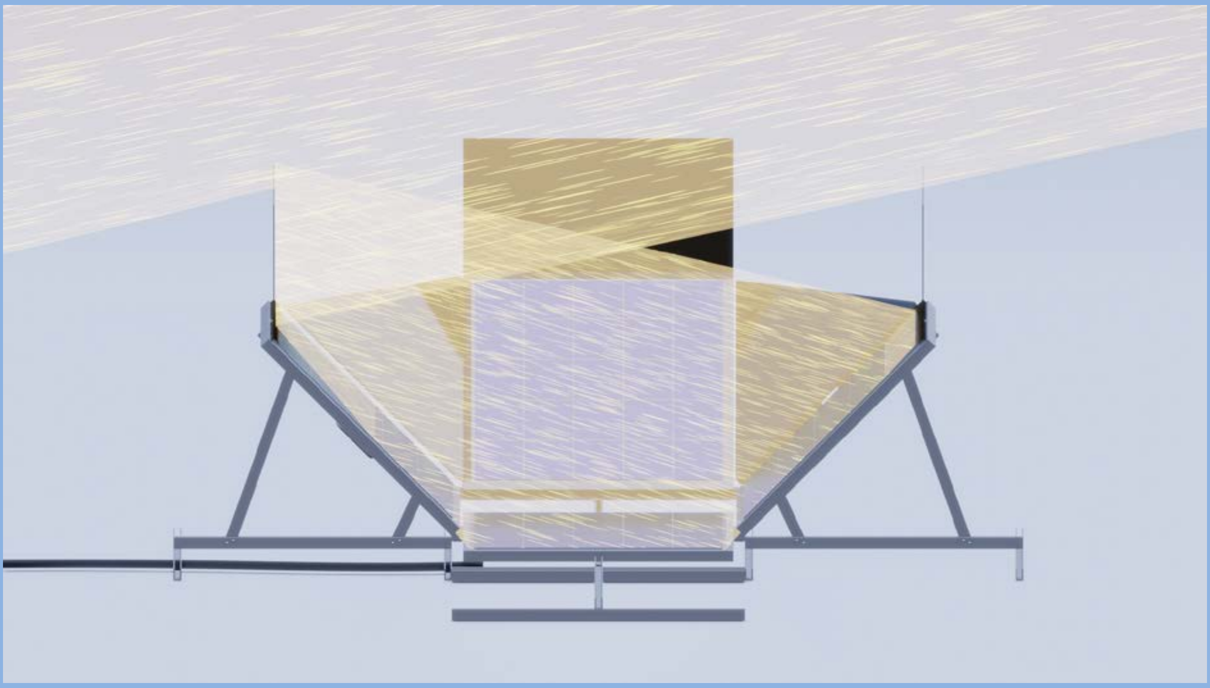
You don’t need a lot of tools to complete this job. Simple tools can be used to carry out this job. These tools can be found in your house garage.

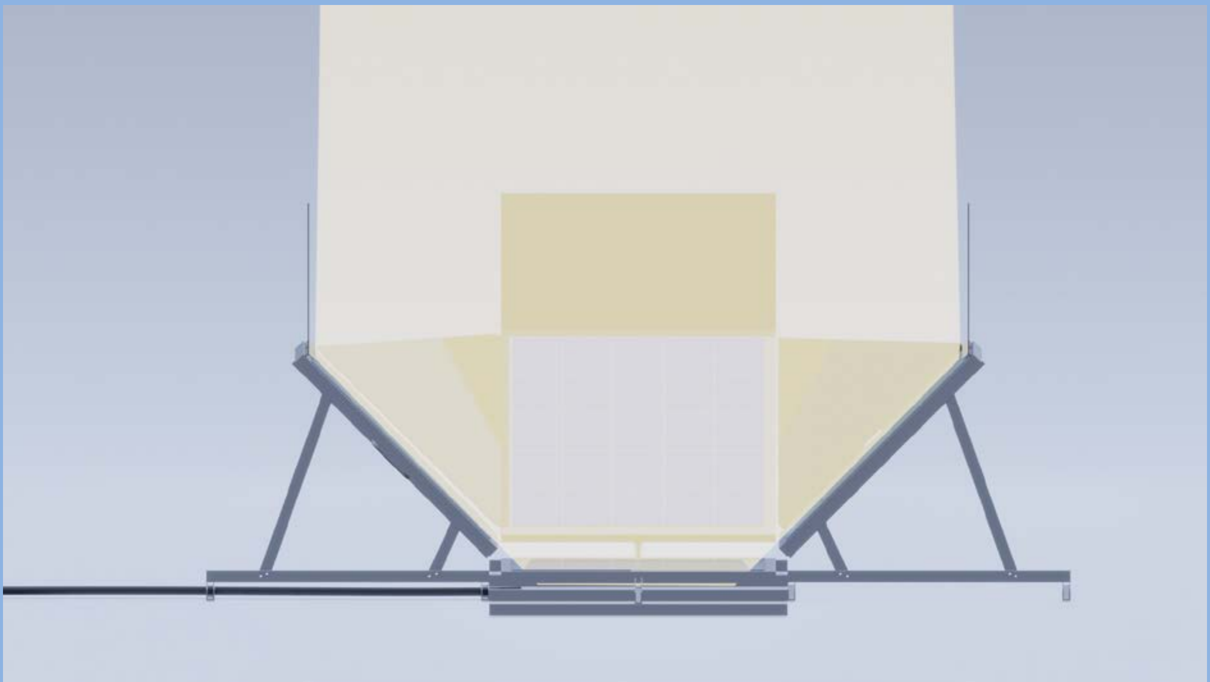
- Screws
- Screwdrivers
- Wire stripper/cutter
- Measuring tape
- Hammer
- Saw
- Wrench
- Insulation tape
- Drill Press
- Soldering iron
- Multimeter
- Safety Equipment

Different tools used.


# How will DIY Dish System increase efficiency?

The solar dish system is designed in such a way that it will trap all of the sunlight that incidents on it from any angle, at any place.





The above images depicts the sun at three different times of the day. And the rays coming from it and how they are trapped in the system for maximum power generation.

At the 1st position, the sunlight hits directly on one of the side solar panels. The stray rays hit the triangular reflective panels next to the solar panel and are directed towards the opposite solar penal for energy generation.

At the 2nd position, the sunlight falls straight on the base panel, some rays hit perpendicularly, others hit at different angles which are trapped by the 4 side solar panels. So all of the sunlight that incidents on it will be utilized in energy generation.

At the 3rd position, the sunlight hits the rectangular reflective panels on top. The rectangular panel reflects the sunlight towards the base solar panel and the side solar panel on the opposite side of it. This way all of the sunlight is utilized as well.

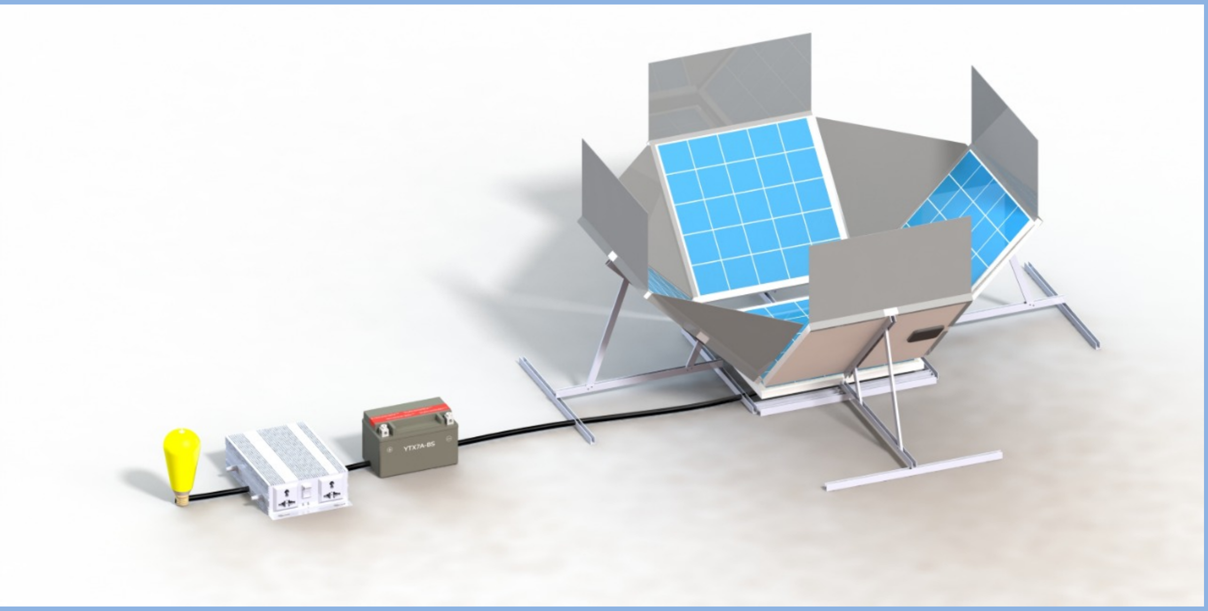
Given the fact that the vertical panes are adjustable, depending on the moment of the day or on the position of your system, you can adjust them to capture as much sunlight as you can and redirect it inside the system to get even more power from it.

Analyzing all these scenarios, it is safe to say that the efficiency of the dish solar power system is more than any other solar power system which involves solar arrays.

## Functionality

We built the system with 100 watts panels. The more power you want, the more watts you need from the panels.

A solar panel produces *100 watts* of energy. Say you get 5 hours of direct sunlight throughout the day. Hence each solar panel will be producing *500 watt-hours* of energy throughout the day. The total energy produced every year by the whole system is around *1500 - 2000 kWh*. That is a lot of energy!



The energy produced by a solar panel depends upon its make and quality. There are solar panels that produce *450 watts* of power as well. The tradeoff is the money. The more energy you want, the more money you would have to invest in the system. A good solar panel requires money. There are also solar panels that will produce as low as *55 watts* of power.

Electricity output (in Watts) of solar panel manufacturers

| SOLAR PANEL MANUFACTURER | MINIMUM | MAXIMUM | AVERAGE |
|---|---|---|---|
| Amerisolar | 240 | 330 | 285 |
| Axitec | 250 | 385 | 302 |
| Boviet Solar | 320 | 340 | 330 |
| Canadian Solar | 225 | 410 | 320 |
| CentroSolar | 250 | 320 | 278 |
| CertainTeed Solar | 63 | 400 | 329 |
| China Sunergy | 290 | 410 | 343 |
| ET Solar | 255 | 370 | 306 |
| Grape Solar | 160 | 285 | 237 |
| Green Brilliance | 230 | 300 | 266 |
| Hansol | 250 | 360 | 304 |
| Hanwha Q CELLS | 285 | 395 | 328 |
| Heliene | 250 | 370 | 306 |
| Hyundai | 265 | 385 | 343 |

The above table shows different manufacturers of solar panels and how much power do those solar panels produce on maximum, minimum, and average. The power produced i.e. power output is listed in Watts.

# Price Analysis

Typically, the metric of price used for solar panels is USD per watt. Since people use different solar panels of different capacity so it is a useful metric. The average price is 2.85 to 3.80 USD per watt. A 6 kW solar power system costs around 15,000 USD. Similarly, a 10 kW solar power system costs around 25,000 USD.

100-watt solar panel costs about 32 USD. You need 5 of these. So the total cost for the panels will be 160 USD.

Reflective aluminum sheet costs 40 USD per $m^2$. You need an estimate from a professional for how much aluminum sheet you need. And then buy according to your needs.

Photovoltaic Stranded cable costs about 0.5 USD per meter. You will be needing almost 20 meters, depending where you place your system. The cost of the cable will be 10 USD.

Stainless steel hinge costs about 1.5 USD per piece. You need 16 of these. The cost of the hinges will be 24 USD.

The total cost of the DIY Solar Dish system will come to 250 USD. This is very small sum compared to any price any installer will provide. You will be making cuts on the labor and engineering solutions costs. The cost of the stand is not included as it is your own choice if you want a light stand or a heavy-duty stand. Depending on your needs, you can buy the materials and process a stand yourself.

As always, you can choose to buy second hand solar panels that will cost a lot less and will lower the costs of the entire system.

# Degradation of Solar Panels

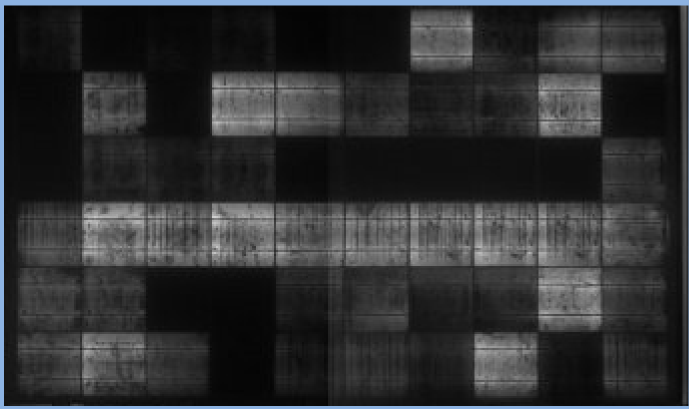
Solar panel performance declines as solar cells degrade due to unavoidable circumstances such as *UV exposure* and *weather cycles.* Other than these 2 reasons there are other factors as well that contribute to solar panel degradation and possible failures.

*Potential Induced degradation (PID)* is one of these outside forces. Potential induced degradation happens when different components in the same system like solar cells and the panel frame are at different voltage potential. Which allows current to leak and modules to lose their peak performance. Potential induced degradation occurs in crystalline photovoltaic cells which can cause power losses up to 30%.

The increased use of transformerless inverters on solar projects has raised the threat levels of potential induced degradation on solar panels. Usually, simply grounding the system removes potential induced degradation concerns but transformerless inverters are ungrounded.

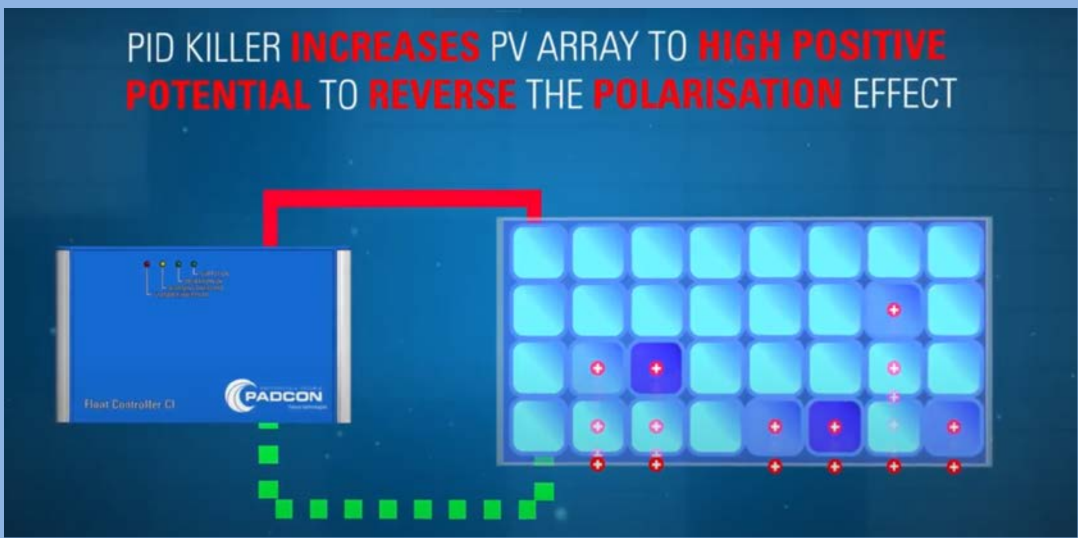
Frameless modules can help reduce the possibility of potential induced degradation since there is no metal frame to disrupt the voltages between different components of the system. Many manufacturers now develop modules that cannot be affected by potential induced degradation. When designing a system, it is important to know which components can cause potential induced degradation in the system.

Hand to hand transport also affect the panels. Especially if installers are carrying the modules on their top hats that flexing and bouncing, up and down can take a real toll on the panels. It can also lead to micro-cracks in the cells. Smartly buying your solar panels can mitigate the chances of potential induced degradation

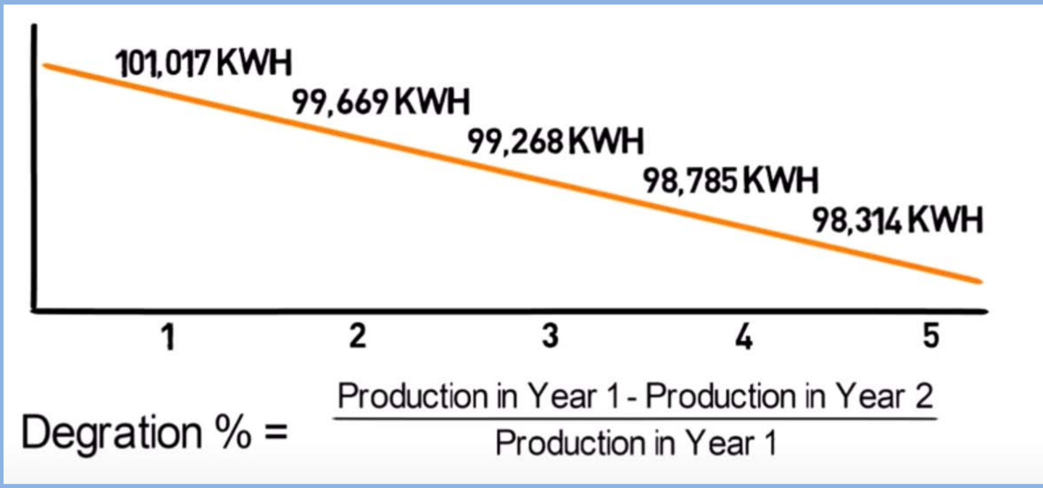


*The figure shows Potential Induced Degradation on a solar panel*

This process can be controlled by installing Potential Induced Degradation killers. They bring the PV array to high positive potential to reverse the polarization. Many companies are also now producing potential induced degradation free solar panels as well. Another great method to reduce potential induced degradation in your system is to negatively ground the whole metal work-frame.

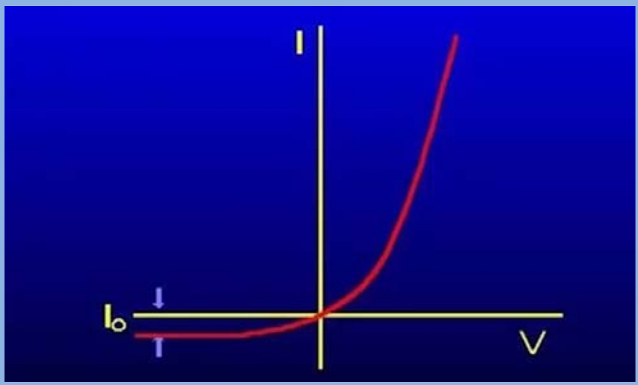



*The diagram shows the working of a PID killer*




The above figure shows the degradation of a solar panel during its first five years of use. If the degradation percentage is increasing with the time you can have a claim on the warranty of your solar panels from the company. Usually, the degradation in the 1st year of use is the most. Degradation is a linear phenomenon.

Since the photovoltaic cells are made by doping of semiconductor material. They are either forward biased or reverse biased diodes. You must check the IV characteristics of the diode being used.




*The above figure shows the current-voltage characteristics of a forward-biased PN junction diode*

Companies also warrant the years of service of Solar Panels. On average, a single solar panel lasts around 25 – 30 years. After that, they need replacement. It doesn't mean that after twenty-five or thirty years, the solar panel will stop producing power. They still produce power but the quantity of production decreases significantly. Hence it is recommended that you replace your solar panels after twenty-five to thirty years of usage.

# Future Advancements

Nowadays, solar panels used have an efficiency of 33%. Meaning most of the sunlight that enters the solar panel goes to waste even under such ideal circumstances. Even tho their exponential growth in today's market and energy industry, researchers must figure out a way to solve this issue and increase the overall efficiency of the system. Due to this inefficiency, the solar industry is heavily investing to find solutions to these problems. Three of the main developments are:

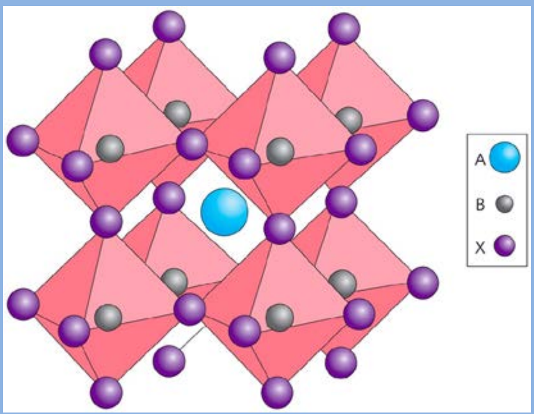
a) Solar energy storage

b) Perovskites

c) Multi-junction cells

For storage you can use any type of battery – even car batteries. This way you can store energy and use it when you need it.

Since 1954, silicon has been used to make solar cells to be used in solar panels. Silicon is an intrinsic material and cannot produce usable energy. Researchers have been looking into other materials like perovskites, to replace the current silicon technology.




*A Perovskite crystal*

Perovskite (CatIO3) is a naturally occurring mineral and it has a wide set of properties such as superconductivity. Perovskites are a group of crystalline materials. The most interesting thing about perovskites is that they can be produced synthetically, hence they can be cheaper to produce in years to come and easier to work with as compared to silicon.

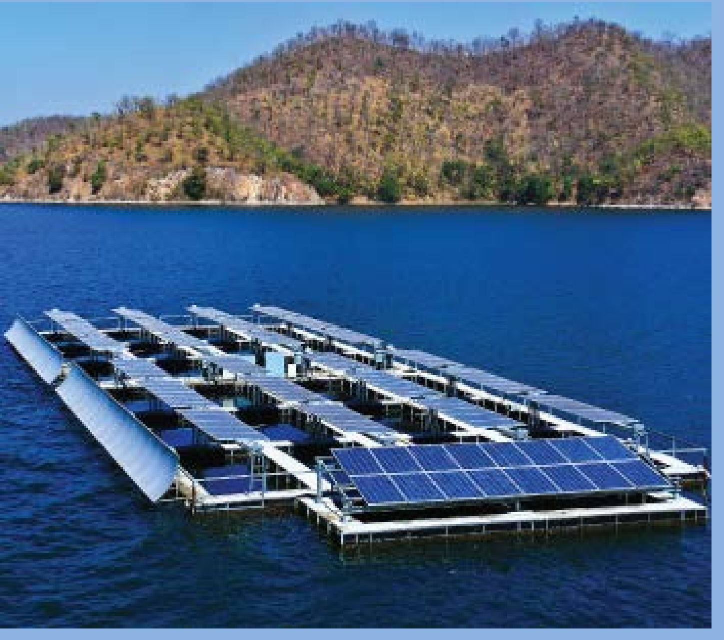
The solar cells developed using perovskites have gone from 3.8% to 20.1% efficiency. This kind of progress is promising to researchers and industry leaders. Although there are some hurdles to implement them. Perovskite PV cells decompose so quickly that they cannot be employed in real-world applications. If these problems are overcome and the efficiency of perovskite cells surpass silicon cells, solar energy will be cheaper and the industry will make the switch.

While researchers and industry are busy with finding alternatives for silicon, solar developers are employing their methods like using multi-junction cells to increase efficiency. Multi-junction cells are regular silicon PV cells but with added layers to increase efficiency. Each layer of a multi-junction cell is optimized to a particular wavelength which helps increase the efficiency as high as 40%. When these multi-junction cells are used in arrays, the amount of electricity they yield is exponentially greater than those of ordinary cells. But since adding extra layers means adding more cells which means more money, these cells become extremely expensive and hence aren't used commercially or for domestic use. They are widely unpopular among solar energy system designers as well.

Investors are going out of their way to install solar panels. Usually, when we talk about the solar energy system, solar panels mounted on a rooftop and a park installed in a very open field in a desert or some far-flung area come to mind. But 71% of earth's surface is covered with water and it isn't inhabited by humans. *Floating Solar Farms* are being installed all over the world. They provide energy from 2 sources:

- Solar
- Tidal

The solar panels are mounted on top of tidal energy systems. This way the efficiency of the whole operation increases significantly. The tidal system works 24/7 all round the clock, with the help of tides and waves. The only drawback of this scheme is that how will the energy be transported and maintenance. Since these systems are installed in deep waters, far from land, it is hard to transport all the energy produced and the Maintainance of these solar and tidal energy systems.



*A solar and tidal energy farm in China*

While rooftop solar installations can reduce one's energy bill, they're also a bit unsightly to those who care about the outward appearance of their home. However, companies such as Tesla are working on future solar panels that are more aesthetically pleasing, and have now nearly reached the point where you can't even tell that there are any solar panels installed at all. Tesla's "solar roof" is comprised of PV panels that look just like any other panel that might be used on the roof of a home, but provides the added benefit of solar energy generation. This technology, in combination with home energy storage, is a perfect example of how solar energy is becoming literally "built-in" and more a part of our world than ever before. With further advancements and creative thinking in future solar energy projects, it might not be long before the vast majority of our surfaces are generating electricity.

As demand for new solar installations continues to rise, landowners and developers have many more opportunities for generating additional income than ever before. For landowners who own considerable amounts of property, it's not out of the realm of possibility to be approached by a solar developer looking to enter into some sort of solar lease agreement. Such an agreement would grant the developer the necessary rights to construct a solar installation on the property, and in exchange, the landowner would receive a monthly rental fee.

## Pros and Cons

Solar power is a revolutionary technology but like any other energy source, it has its advantages and disadvantages. Its merits and demerits must be weighed against each other before making any final decision. Going over the pros first:

- The first and main benefit of installing solar power for domestic usage is that it can drastically reduce or even eliminate your electricity bills. When you install your solar energy system, it means you are generating your electricity and are not dependent on the electric companies, meaning you are getting self-sufficient. A solar energy system life span is around 25 to 30 years which means you will be cutting off your electricity bills or decades to come with the upfront investment. The costs of solar systems are decreasing all over the world day by day.

- Solar systems increase the value of your house and property. Many homeowners are keenly interested in solar power but they haven't made the efforts to know how to get them installed. This consumer reality and undeniable benefits of solar energy have proved that the value of your house and property increases manifold once you install the Solar energy system on it. So even if you're planning to move somewhere else and relocate, the investment in solar systems will not go to waste. You will earn back the money you spent on it once you sell your house.

- Solar energy can earn you money even when you're taking a service from them and using your investment. Your solar panels keep on generating electricity as long as the sun is shining. And in most of the cases, this power is more than your actual needs, instead of letting it go to waste, you can load this excess power on the public grid and get electric credits or compensated with money as per the tariff. So using this methodology you can get refunded for your investment in solar energy. The credits can be redeemed later.

- Sometimes due to new tariffs and energy consumption laws, the prices of the per-unit consumption increase. This causes anxiety for a lot of users. If you have a solar energy unit installed at your home you don't have to worry about the new prices of electricity. According to a study, the costs of solar systems has decreased by about 70% while the costs of electricity from public companies has increased by about 5% in the past decade. This trend is expected to continue for the years to come. Going solar puts you in the driving seat when it comes to energy generation.

- Solar power reduces carbon emission and keeps the environment clean while helping the world move towards cheap and independent energy. Unlike conventional fuels like oil and gas, solar energy generation does not affect the environment directly. Solar energy does not radiate carbon dioxide into the air. It keeps the environment clean and fresh and free from any kind of pollutants. Nuclear and thermal energy, both contribute to pollution at great percentages. Hydel does not cause any pollution, although it causes noise pollution of unparalleled amounts. When we talk about pollution-free in terms of energy production, solar comes on top. Perhaps the most patriotic and admirable advantage of solar energy is that it helps preserve the environment while simultaneously helping us move away from fossil fuels which are a major cause of weather change and global warming.

Well, we've discussed the advantages of solar power systems. But like any other system, it is not perfect, it has its flaws. Listed below are the major disadvantages of using solar energy:

- Solar panels can not be mounted on top of every kind of roof. Rooftop solar systems are installed by using a mounting system called *Racking.* Certain rooftops are made up of cedar or slates and it is very hard to install a system on these roofs. These kinds of rooftops become a roadblock for the installation of solar energy systems. Eventually, if you install them, you have to go through wear and tear of your roof which destroys the ambiance of your house from outside and decreases the value of your property. If you have a lot of space available you can install your solar energy system there.

- Solar is not an ideal option if you are thinking to relocate, unless you use our system. Even tho investing in solar energy is great thinking but it takes a significant amount of time to reach the breakeven point. The average solar energy break-even time is seven and a half years. As discussed earlier, the investment is refunded in terms of an increase in property value but still, it's not the same as the amount of money you invested. If you're getting a solar system installed on loans or installments then you can turn this disadvantage to your benefit, not to mention the benefits of our system.

- The ultimate goal of the solar energy system is to provide you clean, cheap, and all around the clock energy. But if you're living in an area where electricity costs are less than the average cost of the region than installing is not a smart option. That way you will not be making any cuts on your electricity consumption costs. Instead, you will be paying a lot more in electricity as you would be if you were using electricity from a utility public grid. However, if you fall into this category, using our system will surely reach zero costs on electricity or even better.

- If you do not have the financing in hand for the solar energy system installation, the prices can be intimidating. The solar energy system installation prices are undeniably high and if you do not have the money it takes, it can be a toll. You can apply for a loan for help with upfront investment but still, that is not a great idea since you will have to pay back the loan with interest. That's why using DIY Solar Dish is the optimal solution for everyone.e

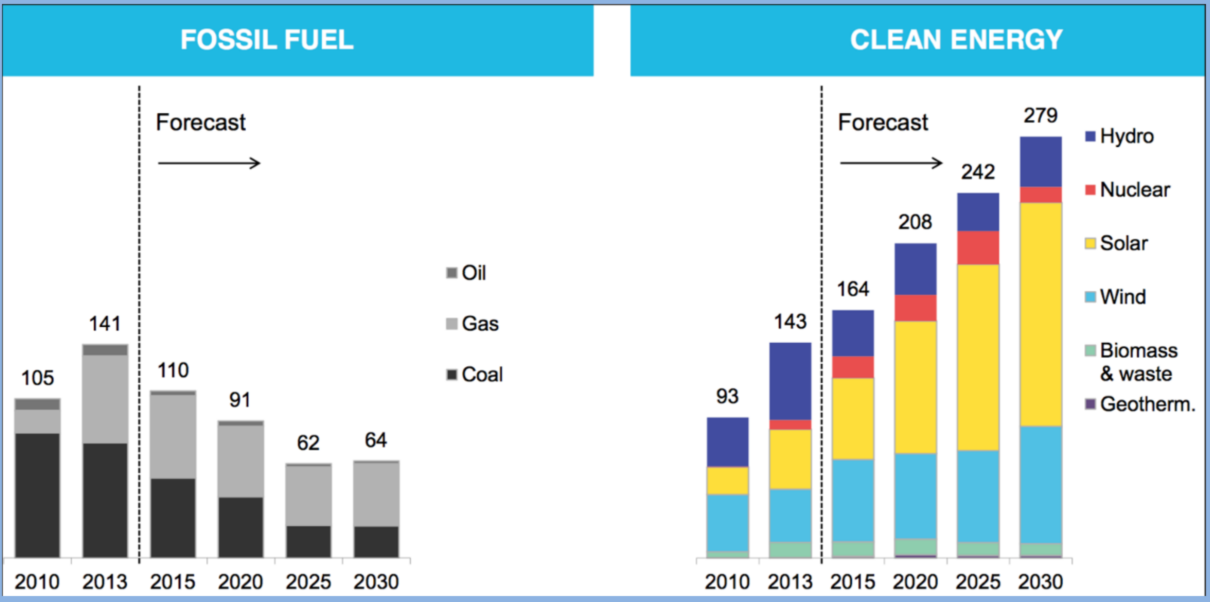
- Finding a reliable installer in your area is a problem. You have to find a reliable solar energy system installer to get your work done. That is a big problem. DIY Solar System is easy to assemble and connect to your house so you don't have to look for expensive solutions to install solar for your home.

# Conclusion

So we've discussed the solar power, its usage, its merits, and demerits in detail. And it's time for a verdict.

It is an undeniable fact that the world is moving towards solar energy gradually, one step at a time. It is time you get involved in the energy revolution before its too late.

Solar energy is the fastest-growing energy source. It is free. It is cheap. And it is clean and renewable. The amount of energy that reaches earth in one hour from the sun is enough to fulfill our yearly energy needs all over the world.




The above charts show the current distribution of energy from fossils fuels and different renewable energy sources. By 2025, almost half of the energy produced worldwide will be contributed by solar energy systems. The energy produced by burning oils will be mitigated in the upcoming years.

After weighing the merits against the demerits of solar energy. It is safe to say that solar energy is the way to move forward in the coming time.

Now, we've established that we need solar energy to sustain our energy needs, and getting it cheaper and cleaner let us talk about DIY Solar Dish System. If you are thinking about installing a solar energy system, you should go with DIY Solar Dish System. Your question would be, Why? Here's why:

It is easy to install and configure, you can install it yourself. It is way more efficient than any solar energy system on earth because of its robust design. It can work with any kind of system, whether grid-tie, off-grid, or hybrid system. Since you will install it yourself, you will know your way around different components and can perform maintenance on your own. When there is a fault you can fix it yourself as well.

The dish system can be made into any size depending upon the consumption of your power. From 50 watt to 10 kilowatts. You can employ multiple dish systems together to form a bigger dish system. Even if you're thinking to generate electricity and load it onto the public grid, it can work with that as well.

As a solar energy system installer, you can still work with the DIY Solar Dish system. All you would have to do is collect the parts, assemble them, and get paid.

The DIY Solar Dish System is designed to minimize your efforts towards getting your solar energy system. It is a complete gateway into the world of solar energy. Detailing every fact and piece of information there is to know about solar power, solar arrays, and installation of DIY Solar Dish System. It is a complete guideline into the solar energy world, detailing every kind of technology used currently and in the coming times. We hope you find this manual useful and productive and it may resolve the energy crisis at your home and clear your doubts about solar power.