MODULE 2

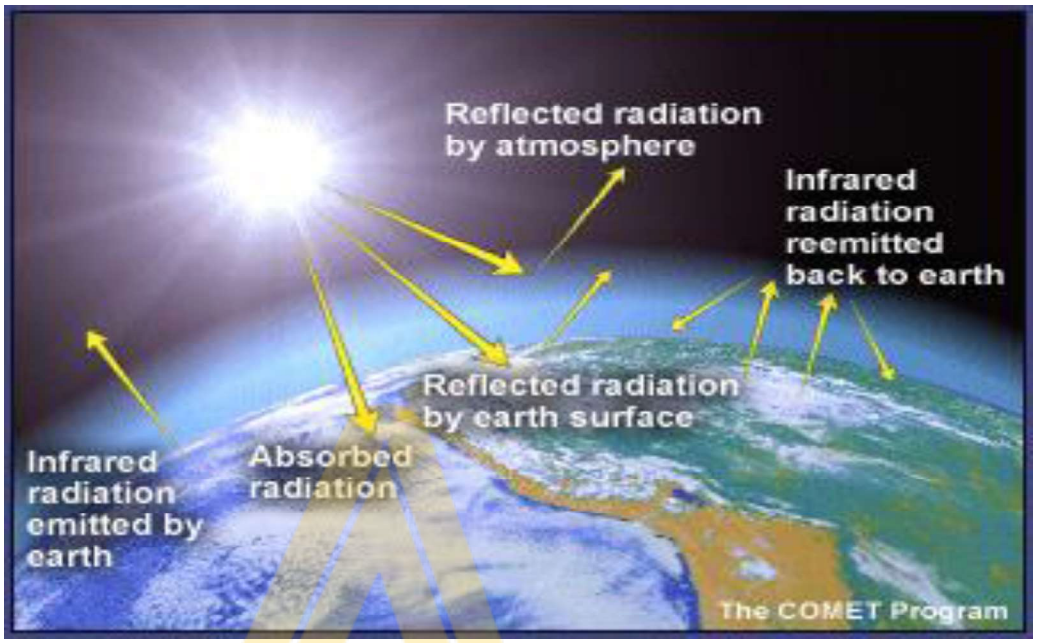
SOLAR THERMAL ENERGY COLLECTORS & Solar Cells

INTRODUCTION

1. "Drying is an excellent way to preserve food and solar food dryers are an appropriate food preservation technology for a sustainable world." Actually, solar food drying is one of the oldest agricultural techniques related to food preservation,

2. Drying of crops can change this trend and is useful in most areas of the world, especially those without a high humidity during the harvesting season. If drying of produce were widely implemented, significant savings to farmers would be achieved. These savings could help strengthen the economic situation of numerous developing governments as well as change the nutritional condition in these same countries. Unfortunately many of the areas that could benefit from solar drying technology lack adequate information related to how to employ this technology and which technology to use under specific conditions. Many of the latest developments in solar drying technology, as well as significant achievements through applying this body of knowledge are not available in libraries or the Universities of developing countries. However, modern science has provided a new resource that helps bridge this information void. The World Wide Web, commonly know as the INTERNET can provide the solution to rapidly spreading new information and applications of known information into areas of greatest need.

Physical principles of the conversion of solar radiation into heat:



1. Green houses are useful for growing and propagating plants because they both allow sunlight to enter and prevent heat from escaping.
2. The transparent covering of the greenhouse allows visible light to enter unhindered, where it warms the interior as it is absorbed by the material within. The transparent covering also prevents the heat from leaving by reflecting the energy back into the interior and preventing outside winds from carrying it away.
3. Like the greenhouse covering, our atmosphere also serves to retain heat at the surface of the earth. Much of the sun's energy reaches earth as visible light. Of the visible light that enters the atmosphere, about 30% is reflected back out into space by clouds, snow and ice-covered land, sea surfaces, and atmospheric dust. The rest is absorbed by the liquids, solids, and gases that constitute our planet.
4. The energy absorbed is eventually reemitted, but not as visible light (only very hot objects such as the sun can emit visible light). Instead, it's emitted as longer-wavelength light called infrared radiation. This is also called "heat" radiation, because although we cannot see in infrared, we can feel its presence as heat. This is what you feel when you put your hand near the surface of a hot skillet.

5. Certain gases in our atmosphere (known as "trace" gases because they make up only a tiny fraction of the atmosphere) can absorb this outgoing infrared radiation, in effect trapping the heat energy. This trapped heat energy makes the earth warmer than it would be without these trace gases.
6. The ability of certain trace gases to be relatively transparent to incoming visible light from the sun yet opaque to the energy radiated from earth is one of the best-understood processes in atmospheric science. This phenomenon has been called the "greenhouse effect" because the trace gases trap heat similar to the way that a greenhouse's transparent covering traps heat. Without our atmospheric greenhouse effect, earth's surface temperature would be far below freezing. On the other hand, an increase in atmospheric trace gases could result in increased trapped heat and rising global temperatures.

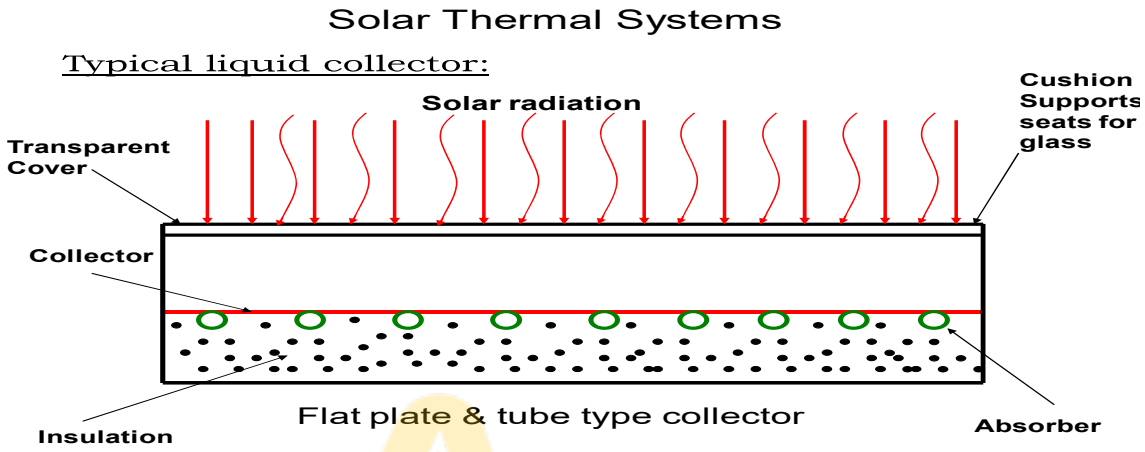
Flat plate Collectors:

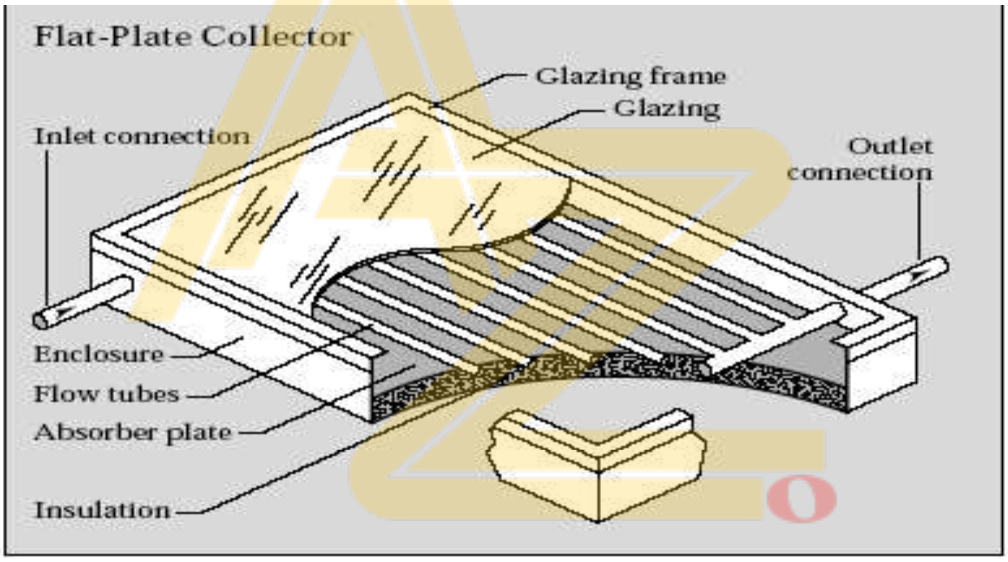
1. Made of rectangular panels (1.7 to 2.9 Sq.m)
2. Simple to construct and erect.
3. Can collect and absorb both direct and diffuse radiations
4. Flat plate solar collectors classified into two types based on the type of heat transfer fluid
    1. Liquid heating collectors are used for heating water and nonfreezing aqueous solutions (rarely Non aqueous solutions)
    2. Air or gas heating collectors are employed as solar air heaters.

Basic Components of Flat plate collectors:

1. A transparent cover which may be one or more sheets of glass or radiation transmitting plastic film or sheets.
2. Tubes, fins, passages or channels are integrate with the collector absorber plate or connected to it, which carry the water, air or other fluids.
3. The absorber plate, normally metallic or with a black surface although a wide variety of other materials can be used with air heaters.
4. Insulation, which should be provided at the back and sides to minimize the heat losses. (fiber glass or styro-foam)
5. The casing or container which encloses the other components and protects them from the weather.

Collectors





Advantages of Flat plate collector:

1. Of using both beam and diffuse solar radiations
2. They do not require orientation towards the sun
3. They require little maintenance.
4. Mechanically simpler than the concentrating reflectors, absorbing surfaces and orientation devices of focusing collectors

Drawbacks of using water as fluid:

1. Freezing in the collector tubes in the cold climates during cold nights. (ethyline glycol is added to prevent)
2. Corrosion of the metal tubes

Air collector or solar air heaters

Applications:

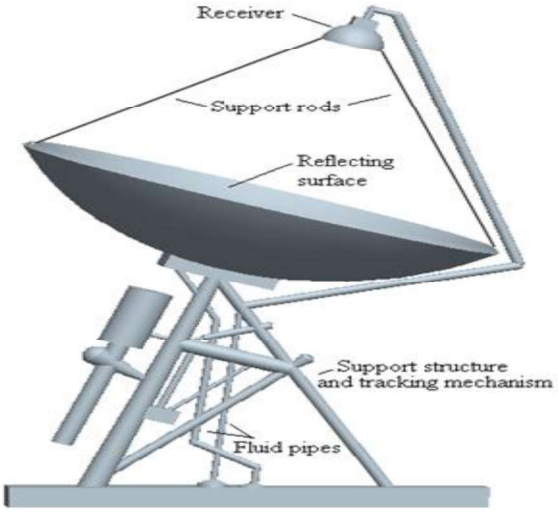
1. Heating buildings
2. Drying agricultural produce and lumber.
3. Heating green houses
4. Air conditioning (refrigeration process)
5. Heat sources for a heat engine

Concentrating Collector:

1. Focusing Collector is a device to collect solar energy with high intensity of solar radiation on the energy absorbing surface. Optical systems in the form of reflectors or refractors are used.
2. A focusing collector is a special form of flat plate collector modified by introducing a reflecting surface between the solar radiators and absorber.
3. Radiation increases from low value of 1.5-2 to high values of the order of 10,000.
4. Radiation falling on a relatively large area, is focused on to a receiver (or absorber) of considerably smaller area.
5. Fluid can be heated to temperature of 500^0C or more.

Types of Concentrating Collectors:

1. Depending on concentrating, collectors may classified as
    1. Line focusing and
    2. Point focusing



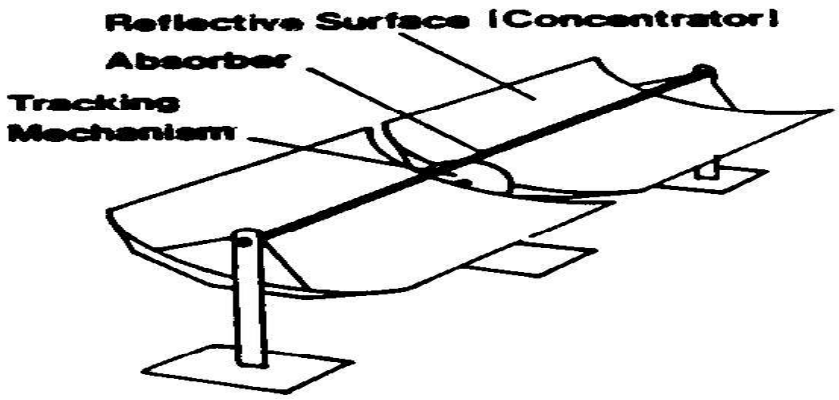
As per the no. of concentrating collector geometries, the main types of concentrating collector are

1. Parabolic through collector
2. Mirror strip reflector
3. Fresnel lens collector
4. Flat plate collector with adjustable mirrors
5. Compound parabolic concentrator (C.P.C)

Line focusing collectors (Parabolic through reflector)

1. Solar radiation coming from the particular direction is colleted over the area of the reflecting surface and is concentrated at the focus of the parabola, if the reflector is in the form of a through with parabolic cross-section, the solar radiation is focused along a line.
2. Mostly cylindrical parabolic concentrators are used, in which absorber is placed along focus axis.

Parabolic through reflectors have been made of highly polished aluminum, of silvered glass or of a thin film of aluminized plastic on firm base

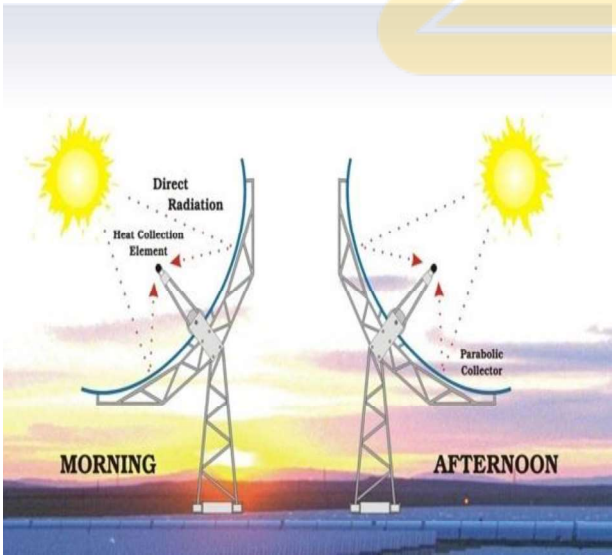


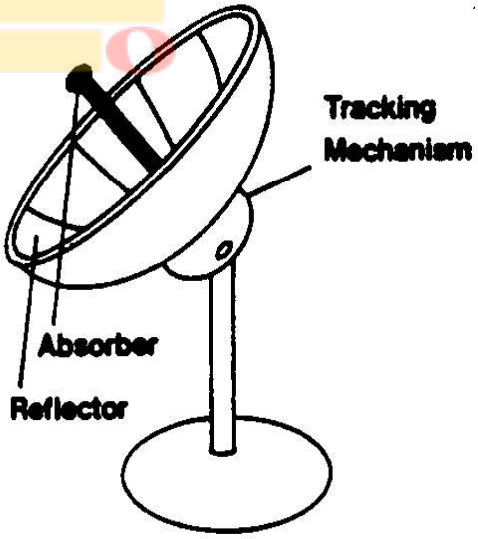
Mirror strip Reflector:

1. Slightly curved mirror strips are mounted on a flat base.
2. The angles of the individual mirrors are such that they reflect solar radiation from a specific direction on to the same focal line.
3. Angles of the mirrors must be adjusted to allow for changes in the sun's elevation, while the focal line remains in a fixed position.

Pointed Focusing collector (Paraboloidal type)

1. Absorber located at the focus is a cavity made of zirconium-copper alloy with black chrome selective coating.
2. The heat transport fluid flows into and out of the absorber cavity through pipe bonded to the interior.





Advantages and Disadvantages of concentrating collectors over flat Plate type collectors:

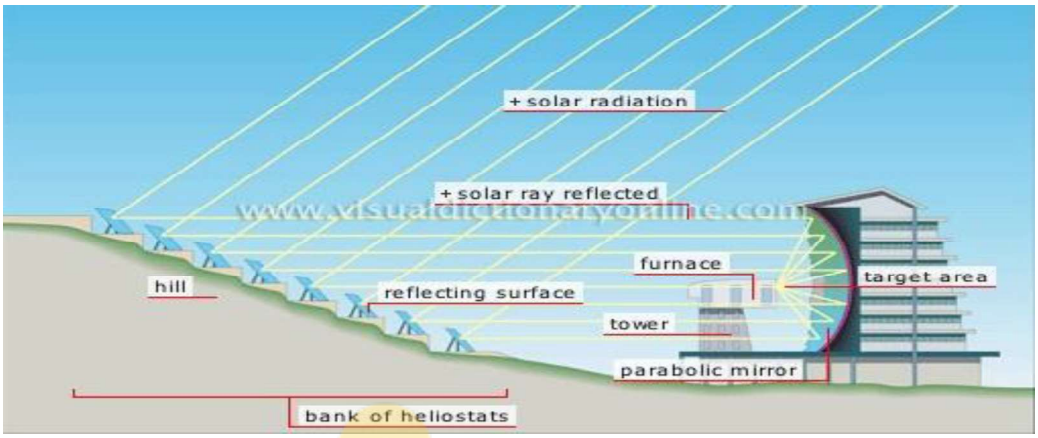
Advantages:

1. Reflecting surfaces require less material and are structurally simpler than flat plate collectors. (less cost)
2. The absorber area of a concentrating system is smaller than that of a flat plate system for same solar energy collection.
3. Loss of energy after collecting is less than FPC, because of large absorber area in FPC, working fluid can attain higher temperature.
4. Owing to the small area of absorber per unit of solar energy collecting area, selective surface treatment and/or vacuum insulation to reduce heat losses and improve collector efficiency are economically feasible.
5. Can be used for electricity power generation.
6. Heat storage costs are less
7. Little or no anti-freeze is required to protect the absorber.
8. It is possible to get higher efficiencies.

Disadvantages:

1. Only beam component is collected.
2. Costly oriented systems
3. An additional requirement of maintenance is required.
4. Non uniform flux on the absorber.
5. Additional optical losses such as reflectance loss and the intercept loss, so they introduce additional factors in energy balances.
6. High Initial cost.

Solar furnace cookers:

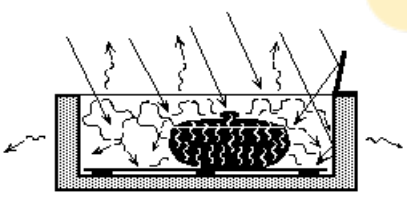


Solar Thermal Systems

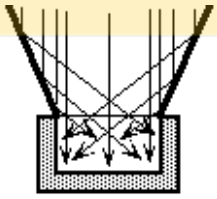
Solar cooking:

Basically there are three designs of solar cooker

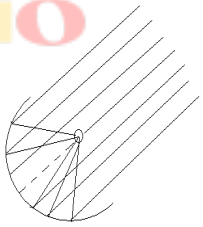
1. Flat plate box type
2. Multi reflector type solar oven and
3. Parabolic disc concentrator type solar cooker



Flat plate box type



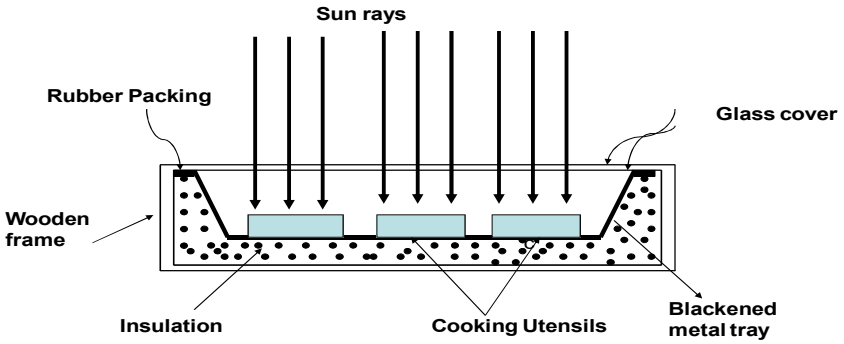
Multi reflector type



concentrator type

Solar Thermal Systems

Box type Cooker:



Solar Cooker:

1. The solar rays penetrate through the glass covers and absorbed by a blackened metal tray kept inside the solar box.
2. The solar radiations entering the box are of short wave length.
3. The higher wave length radiation is not able to pass through the glass cover i.e reradiation from absorber plate to outside the box is minimized to gain minimize the heat loss.
4. Rubber strips are used to reduce the loss.
5. Insulation material like glass wool, paddy husk, saw dust are used.
6. A solar box cooks because the interior of the box is heated by the energy of the sun.
7. Sunlight, both direct and reflected, enters the solar box through the glass or plastic top. It turns to heat energy when it is absorbed by the dark absorber plate and cooking pots. This heat input causes the temperature inside of the solar box cooker to rise until the heat loss of the cooker is equal to the solar heat gain.
8. Temperatures sufficient for cooking food and pasteurizing water are easily achieved.

Merits of Solar cooker:

1. No attention is needed during cooking
2. No fuel is required.
3. Negligible maintenance cost
4. No pollution
5. Vitamins of the food are not destroyed
6. No problem of charring of food and no over flowing

Limitations:

1. One has to cook according to the sun shine, menu has to be preplanned.
2. One cannot cook at short notice and food cannot be cooked in the night or during cloudy days.
3. It takes comparatively more time.
4. Chapattis are not cooked because high temperature is required and also needs manipulation at the time of baking

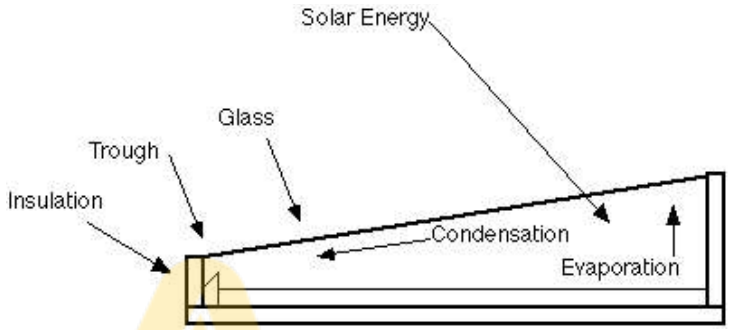
SOLAR ELECTRIC SYSTEMS

Solar Still:

1. The basic principles of solar water distillation are simple yet effective, as distillation replicates the way nature makes rain.
2. The sun's energy heats water to the point of evaporation. As the water evaporates, water vapor rises, condensing on the glass surface for collection.
3. This process removes impurities such as salts and heavy metals as well as eliminates microbiological organisms. The end result is water cleaner than the purest rainwater.
4. The Sol Aqua still is a passive solar distiller that only needs sunshine to operate. There are no moving parts to wear out.
5. Solar stills use natural evaporation and condensation, which is the rainwater process. This allows for natural pH buffering that produces excellent taste as compared to steam distillation.
6. Solar stills can easily provide enough water for family drinking and cooking needs.
7. Solar distillers can be used to effectively remove many impurities ranging from salts to microorganisms and are even used to make drinking water from seawater.
8. Sol Aqua stills have been well received by many users, both rural and urban, from around the globe. Sol Aqua solar distillers can be successfully used anywhere the sun shines.
9. The Sol Aqua solar stills are simple and have no moving parts. They are made of quality materials designed to stand-up to the harsh conditions produced by water and sunlight.
10. Operation is simple: water should be added (either manually or automatically) once a day through the still's supply fill port. Excess water will drain out of the overflow port and this will keep salts from building up in the basin.
11. Purified drinking water is collected from the output collection port.

Solar Thermal Systems

Solar Distillation: (solar still)



SOLAR DRYING

Drying preserves foods by removing enough moisture from food to prevent decay and spoilage. Water content of properly dried food varies from 5 to 25 percent depending on the food. Successful drying depends on:

• Enough heat to draw out moisture, without cooking the food;

• Dry air to absorb the released moisture; and

• Adequate air circulation to carry off the moisture.

When drying foods, the key is to remove moisture as quickly as possible at a temperature that does not seriously affect the flavor, texture and color of the food. If the temperature is too low in the beginning, microorganisms may grow before the food is adequately dried. If the temperature is too high and the humidity too low, the food may harden on the surface. This makes it more difficult for moisture to escape and the food does not dry properly. Although drying is a relatively simple method of food preservation, the procedure is not exact.

Solar Driers:

1. In many countries of the world, the use of solar thermal systems in the agricultural area to conserve vegetables, fruits, coffee and other crops has shown to be practical, economical and the responsible approach environmentally.

2. Solar heating systems to dry food and other crops can improve the quality of the product, while reducing wasted produce and traditional fuels - thus improving the quality of life, however the availability of good information is lacking in many of the countries where solar food processing systems are most needed.

Solar green houses

Greenhouses are used extensively by botanists, commercial plant growers, and dedicated gardeners. Particularly in cool climates, greenhouses are useful for growing and propagating plants because they both allow sunlight to enter and prevent heat from escaping. The transparent covering of the greenhouse allows visible light to enter unhindered, where it warms the interior as it is absorbed by the material within. The transparent covering also prevents the heat from leaving by reflecting the energy back into the interior and preventing outside winds from carrying it away.

Like the greenhouse covering, our atmosphere also serves to retain heat at the surface of the earth. Much of the sun's energy reaches earth as visible light. Of the visible light that enters the atmosphere, about 30% is reflected back out into space by clouds, snow and ice-covered land, sea surfaces, and atmospheric dust. The rest is absorbed by the liquids, solids, and gases that constitute our planet. The energy absorbed is eventually reemitted, but not as visible light (only very hot objects such as the sun can emit visible light). Instead, it's emitted as longer-wavelength light called infrared radiation. This is also called "heat" radiation, because although we cannot see in infrared, we can feel its presence as heat. This is what you feel when you put your hand near the surface of a hot skillet. Certain gases in our atmosphere (known as "trace" gases because they make up only a tiny fraction of the atmosphere) can absorb this outgoing infrared radiation, in effect trapping the heat energy. This trapped heat energy makes the earth warmer than it would be without these trace gases.

The ability of certain trace gases to be relatively transparent to incoming visible light from the sun yet opaque to the energy radiated from earth is one of the best-understood processes in atmospheric science. This phenomenon has been called the "greenhouse effect" because the trace gases trap heat similar to the way that a greenhouse's transparent covering traps heat. Without our atmospheric greenhouse effect, earth's surface temperature would be far below freezing. On the other

hand, an increase in atmospheric trace gases could result in increased trapped heat and rising global temperatures.

Solar Photovoltaic:

Photovoltaics (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect. Photovoltaic power generation employs solar panels composed of a number of solar cells containing a photovoltaic material. Materials presently used for photovoltaics include monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium gallium selenide/sulfide. Due to the growing demand for renewable energy sources, the manufacturing of solar cells and photovoltaic arrays has advanced considerably in recent years.

Solar photovoltaics have long been argued to be a sustainable energy source.[1] By the end of 2011, a total of 67.4 GW had been installed, sufficient to generate 85 TWh/year.[2] Solar photovoltaics is now, after hydro and wind power, the third most important renewable energy source in terms of globally installed capacity. More than 100 countries use solar PV. Installations may be ground-mounted (and sometimes integrated with farming and grazing) or built into the roof or walls of a building (either building-integrated photovoltaics or simply rooftop).

Solar cells:

Photovoltaics are best known as a method for generating electric power by using solar cells to convert energy from the sun into a flow of electrons. The photovoltaic effect refers to photons of light exciting electrons into a higher state of energy, allowing them to act as charge carriers for an electric current. The photovoltaic effect was first observed by Alexandre-Edmond Becquerel in 1839.[7][8] The term photovoltaic denotes the unbiased operating mode of a photodiode in which current through the device is entirely due to the transduced light energy. Virtually all photovoltaic devices are some type of photodiode.

Solar cells produce direct current electricity from sun light, which can be used to power equipment or to recharge a battery. The first practical application of photovoltaics was to power orbiting satellites and other spacecraft, but today the majority of photovoltaic modules are used for grid connected power generation. In this case an inverter is required to convert the DC to AC. There is a smaller market for

off-grid power for remote dwellings, boats, recreational vehicles, electric cars, roadside emergency telephones, remote sensing, and cathodic protection of pipelines.

Photovoltaic power generation employs solar panels composed of a number of solar cells containing a photovoltaic material. Materials presently used for photovoltaics include monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium gallium selenide/sulfide. [9] Due to the growing demand for renewable energy sources, the manufacturing of solar cells and photovoltaic arrays has advanced considerably in recent year. Cells require protection from the environment and are usually packaged tightly behind a glass sheet. When more power is required than a single cell can deliver, cells are electrically connected together to form photovoltaic modules, or solar panels. A single module is enough to power an emergency telephone, but for a house or a power plant the modules must be arranged in multiples as arrays

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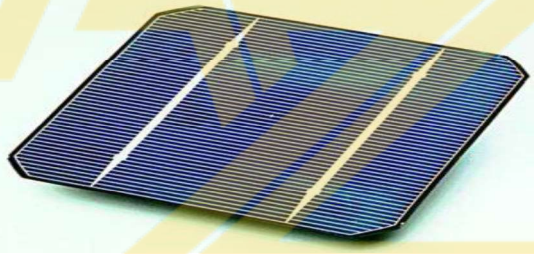


Classification of solar cell:

The sun in one year can produce 3.8 × 1023-kilowatt solar energy, is now equivalent to the entire mankind on earth, the total energy used in the 6 × 105 billion times. Of these, about 1 / 22 billion to the solar radiation on Earth, the Earth is now equivalent to the total energy used by 30,000 times. Solar cells is a human use of solar energy devices, it is the use of solar photovoltaic effect should be directly converted into electrical energy, and only when the sunlight power generation only, therefore, must have a battery to store electricity. At present, the photo pool used for a silicon cell, the photoelectric conversion efficiency up to 11% to 14%. In addition, there is CdS battery, battery gallium arsenide, cadmium telluride, such as batteries. The use of solar equipment is also increasing, such as electronic calculators, watches, telephones, radios, tape recorders and so on; the price of commercial solar cells has dropped to below 4 U.S. dollars per watt. Solar cells more and more applications, more and more

promising prospects. Solar cars, solar power, solar spacecraft, space solar power station, such as the use of solar energy research by the world's attention in general, are a number of countries in the field of energy in the future the focus of development. Some experts predict that solar cells will become the 21st century, one of the major sources of electricity.

Monocrystalline silicon solar cells:

Series silicon solar cells, silicon cells can convert Dayang the most efficient, most mature technology. High-performance single crystal silicon cell is built on high-quality single crystal silicon and related materials into the thermal processing technology based on. Now the power to single crystal silicon technology has matured in recent in battery production, is generally used on the surface texture, firing passive zone, area, such as doping technology, the development of batteries are flat silicon cells and groove Monocrystalline silicon gate electrode buried in the battery. To improve the efficiency of conversion depends mainly on the surface of silicon micro-structure to deal with doping and zoning process. In this respect, Germany Fu Langhuo fee falaj Fort Solar System Research Institute maintains a leading position in the world. The technique photo-lithography technology to cell surface texture made of inverted pyramid structure. And on the surface of a 13nm. Thickness of the oxide layer passivation and two-reflection coating by the combination. By improving the process of electroplating the gate to increase the ratio of width and height: more than battery system conversion efficiency over 23%, the largest value of up to 23.3 percent. Kyocera Corporation prepared a large area (225cm2) single-crystal solar cell power conversion efficiency of 19.44 percent for domestic Beijing Solar Energy Research Institute is also active high-performance crystalline silicon solar cell research and development, the development of high-performance single crystal silicon flat battery (2cm X 2cm) reached 19.79 percent conversion efficiency, the groove gate electrode buried in crystalline silicon cells (5cm X 5cm) up 8.6 percent conversion efficiency.

Monocrystalline silicon solar cell conversion efficiency is the highest in the large-scale application and industrial production is still dominant, but because of the single crystal silicon material prices and the cumbersome process of the batteries affected, resulting in high cost single crystal silicon At least, to a significant reduction in the cost is very difficult. In order to save high-quality materials, single crystal silicon cells to find alternative products, the development of the thin film solar cells, polysilicon thin film solar cells and thin film amorphous silicon solar cells is a typical representative.

Polysilicon thin film solar cells:

The normally crystal silicon solar cells in the 350-450μm thickness of high-quality silicon made on this silicon or pulling from the casting of silicon ingots from the Juge. Therefore, the actual consumption of silicon material more. In order to save materials, from the mid-70 began in the low-cost polysilicon thin film deposited on the substrate, but because of the growth of silicon film grain size, not made of valuable solar cells. In order to obtain large-size grain of the film, people have never stopped, and a lot of ways. At present, preparation of polycrystalline silicon thin film batteries use chemical vapor deposition, including the low-pressure chemical vapor deposition (LPCVD) and plasma enhanced chemical vapor deposition (PECVD) process. In addition, the liquid phase epitaxy (LPPE) and the sputtering deposition could be made available for preparation of polycrystalline silicon thin film batteries.

Chemical vapor deposition is the main SiH2Cl2, SiHCl3, Sicl4 or SiH4, as the reaction gas, a certain degree of protection in an atmosphere of silicon atoms to form and deposited on the substrate heating, the choice of substrate materials in general Si, SiO2, Si3N4, and so on. But the study found that in non-silicon substrates is difficult to form a larger grain, and easily form a gap between grains. To solve this problem is first in LPCVD substrate Shen Chi-thin layer of amorphous silicon layer, and then this layer of amorphous silicon layer annealing, the greater the grain, and then in this layer on the seed Thick polysilicon thin film deposition, recrystallization technology is a very important aspect of the current technology are solid-phase crystallization of the law and the Central re-melt crystallization. In addition to the polysilicon thin film batteries using the re-crystallization process, also used almost all of the preparation of single crystal silicon solar cell technology, such a system, the conversion efficiency of solar cells has increased remarkably. Germany falaj Fort Hall area using solar energy research institute recrystallization technology in the FZ Si substrate on a silicon-cell conversion efficiency of 19%, Japan's Mitsubishi with the preparation of the battery, the effective rate was 16.42 percent.

Liquid phase epitaxy (LPE) is a principle of law by molten silicon in its mother's body, the lower the temperature of precipitation silicon membrane. Astropower U.S. companies LPE Preparation of the battery efficiency of 12.2%. China photovoltaic technology development center Chen Zheliang LPE method used in the metallurgical grade silicon on a silicon crystal growth, and a design similar to the crystalline silicon thin film solar cells a new type of solar cells, known as the "silicon tablets of" solar energy Battery, but the performance has not yet seen the report.

As the polysilicon thin film batteries used in the silicon single crystal silicon than the less efficient and no recession, and there may be low-cost substrate material on the preparation, the cost much lower than the single crystal silicon cells, and more efficient than amorphous Silicon thin film battery, polysilicon thin film solar cells will soon be in power to dominate the market.

Amorphous silicon thin film solar cells:

The development of solar cells on two key issues: the conversion to increase efficiency and reduce costs. As the amorphous silicon thin film solar cells, low cost, ease of large-scale production, generally people's attention and rapid development, in fact, as early as in the early 1970s, Carlson, and so began the development of amorphous silicon cells, during the past few In its development has been rapid development of the world's been many companies in the production of this type of battery products.

Although the material as amorphous silicon solar battery is a good material, but because of its optical band gap is 1.7eV, making their own materials on the long-wave solar radiation spectrum of the region is not sensitive, so restrictions on the amorphous silicon solar cells The conversion efficiency. In addition, the efficiency of the photoelectric light as an extension of time and decay, the so-called photo-induced recession of the S-W effect, makes the battery performance of instability. To address these issues in this track is prepared laminated solar cells, solar cells are stacked in the preparation of p, i, n single-junction solar cell layer and then deposited on one or more sub-Pin of a battery system. Tandem solar cells increase the conversion efficiency of single-junction cells do not resolve the key to the stability of the problem is:

① It to a different band gap of Materials group with Taiwan, in response to the increased scope of the spectrum;

② Top of the i-thin battery, The light produced by small changes in the electric field strength to ensure that i layer of photo-induced carriers out;

③ Generated at the end of the battery carrier is about one-half of the battery, reducing the effect of photo-induced recession;

④ Tandem solar cells each child Battery is a series together.

Amorphous silicon thin film solar cells have a lot of preparation, response, including sputtering, PECVD method, LPCVD law, the response of raw materials for gas H2 diluted SiH4, and the glass substrate for the main piece of stainless steel, made of amorphous silicon Thin film battery technology through a different process can be a single-node tandem solar cells and batteries. At present,

amorphous silicon solar cells made major progress in the study: First, the laminated structure of the three amorphous silicon solar cell conversion efficiency of 13%, setting a new record; in the second. Laminated three annual production capacities of solar cells up to 5MW. United Solar Energy Company (VSSC) obtained the highest single-junction solar cell conversion efficiency of 9.3 percent for the third band gap cell stack three highest conversion efficiency of 13%.Above the highest conversion efficiency in a small area (0.25cm2) to get the battery. Had reported single-node amorphous silicon solar cell conversion efficiency of more than 12.5%, Academia Sinica, Japan adopted a series of new measures, a system of amorphous silicon cells for the conversion efficiency of 13.2 percent. With regard to domestic battery in particular, amorphous silicon thin film tandem solar cell research, Xinhua Geng's Nankai University, and other industrial materials used to back Al electrode prepared for the area 20X20cm2, to 8.28 percent conversion efficiency of a - Si / a-Si tandem solar cells. As the amorphous silicon solar cells with high conversion efficiency and low cost and light weight, and other features, has a great potential. At the same time, but because of its stability is not high, a direct impact on its practical application. If you can solve problems and improve the stability of the conversion rate, then the sun can be amorphous silicon cell is the main development of solar products. Solar photovoltaic cells (referred to as photovoltaic cells) used to direct the sun's light energy into electrical energy. At present, a large number of terrestrial photovoltaic systems is based on the use of the silicon substrate for silicon solar cells can be divided into single crystal silicon, polycrystalline silicon, amorphous silicon solar cells. In the energy conversion efficiency and performance, and other aspects of life, better than the single crystal silicon and amorphous silicon cell battery. Polysilicon conversion efficiency is slightly lower than silicon, but the cheaper price.

In accordance with application requirements, solar cells go through a combination of up to the required output power and the rated output voltage of a group of photovoltaic cells, called photovoltaic components. According to the size and scale photovoltaic power plant, photovoltaic components can be composed of a variety of different size of the array.

The advent of the first single crystal silicon solar cells are solar cells. Silicon is the Earth is a great deal of elements of a nearly everywhere silicon have a presence could be said to be inexhaustible. Used to manufacture silicon solar cells, has no shortage of raw materials. However, refining it is not easy, so people in the production of single crystal silicon solar cells at the same time, the polysilicon solar cell research and amorphous silicon solar cells, since commercial-scale production of solar cells, not yet out of a series of silicon. In fact, for the manufacture of solar cells, many semiconductor materials,

with the materials industry, the solar cell will be more and more species. Has been At present, research & development of solar cells, with the exception of silicon series, there are CdS, gallium arsenide, copper indium selenium and many other types of list goes on, this election only a few of the more common solar cells for presentation.

Monocrystalline silicon solar cell:

Monocrystalline silicon solar cell is the fastest development of a solar cell, its structure and production technology have stereotypes, the products have been widely used in space and on the ground. This high purity of the single crystal silicon solar cells to stick to raw materials, the purity of 99.999 percent requirement. In order to reduce production costs, ground applications such as solar cells using solar-grade silicon rods, materials performance has been relaxed. Some also use semiconductor materials and processing of waste at the beginning and end silicon materials, rehabilitation and Latin America through the exclusive use of single crystal silicon solar cells made of sticks.

The single crystal silicon solar cell Tablets monomers made after a random test, according to the specifications required for assembly into a solar cell components (solar panels), serial and parallel with the method in some parts of the output voltage and current.

Polycrystalline silicon solar cells:

At present, the use of polysilicon solar cell materials, most of the particles contain a large number of single-crystal aggregates, or waste time silicon materials and metallurgical grade silicon material from melting casting, and then into the graphite mold, to be gradually cooling solidification , That is, a polycrystalline silicon ingots. This can make a cube of silicon ingots, in order to slice processed into a square film solar cell, improve material utilization and to facilitate assembly. Polycrystalline silicon solar cell production process and almost single crystal silicon solar cell, its photoelectric conversion efficiency of about 12%, slightly lower than the single crystal silicon solar cells, but the material is simple, to save power consumption, with a total production costs than Low, it has been a large number of development.\

Amorphous silicon solar cell:

Amorphous silicon solar cells in 1976 is the emergence of a new type of thin film solar cell type, with single crystal silicon and polycrystalline silicon solar cell production method is completely different, very little silicon material consumption, lower power consumption, is very attractive.

Amorphous silicon solar cells have different structures, of which there is a better structure called PiN battery, which is in the first substrate layer deposition of N-P-doped amorphous silicon and then a layer of sediment is not doped i Layer, and then deposited a layer of boron-doped amorphous silicon-based P, with the final electron beam evaporation by a layer of reflective film, and electrode silver evaporation. Such production process, a series of deposition chamber can be used in the production process constitutes a row in order to achieve high-volume production. At the same time, thin amorphous silicon solar cells can be made of laminated type, or integrated circuits produced in a plane, with the appropriate mask technology, the production of a number of batteries in series to achieve a higher voltage. Japan is now in series production of amorphous silicon solar cells up to 2.4 volts. Amorphous silicon solar cell problems in photoelectric conversion rate is low and unstable, so a lot yet to be used for large-scale solar power, for most, such as pocket-sized electronic calculators, electronic watches and clocks, and copiers, and so on.

Multi-compound solar cells:

Multiple compounds refers to the solar cell is not a single element semiconductor materials made of solar cells. Now a wide variety of national studies, though not yet the majority of industrial production, but indicates that the photoelectric conversion Spring garden. There are CdS solar cells, gallium arsenide solar cells, solar cells are several copper indium selenium.

Solar cells Condenser:

Solar concentrator solar cells are to reduce the use of a measure of the total cost. By condenser result of larger-sun together in a small, to form the "focal" or "focal zone" and will put solar cells "focal" or "focal zone" in order to Increase in light intensity, solar radiation to overcome the shortcomings of low density and thus more power output. Concentrator is usually greater than the rate of a few dozen of its structure may or lens-reflex. Condenser's optical tracking with automatic tracking in general. Can be a way of cooling water or air, water heater and some combination of both accesses to electricity, hot water to be.

For condenser of monomer solar cells, solar cells and ordinary slightly different, because to be resistant to high-rate of solar radiation, particularly in the higher temperature of photovoltaic conversion performance to be assured that it is in the choice of semiconductor materials, batteries And the structure of the grid lines have to design some special consideration. The best material is gallium arsenide, followed by single crystal silicon material. In the cell structure, the general structure of the plane to make more use of solar cells, solar cells and condenser regular vertical structure in order to

reduce the series resistance. At the same time, the condenser battery grid lines are more dense, typical of the condenser battery grid lines account for about 10% of the cell area to meet the high current density.

Solar cells have the type of single-crystal silicon and amorphous silicon, multi-crystalline silicon three categories, and most of the applications currently on the market for single-crystal silicon and amorphous silicon.

1. Single-crystal silicon solar cell

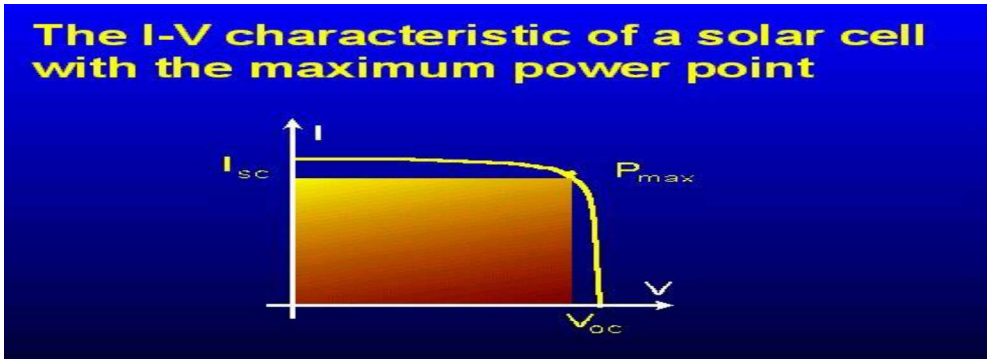
The most common single-crystal silicon cells are used for power plants, charging systems, lighting and traffic signals, and so on, the electricity voltage and a wide range of high-efficiency, long service life, the world's leading manufacturers, such as Siemens of Germany, United Kingdom Oil and Japan's Sharp are the production of such single-crystal silicon-based solar cells, as the market share of about five, single-crystal silicon cell efficiency from 11% to 24% of the space level (-evaporation) chip from 16% to 24% efficiency, of course, the higher the price of its more expensive.

2. Multi-crystalline silicon solar cell:

Polysilicon cell efficiency than the low-single-crystal silicon, but the process step is relatively simple, low-cost, single-crystal silicon cell less than 20%, so some of the power of low-power applications using polysilicon solar cells

Solar characteristic:

In solar cell applications this characteristic is usually drawn inverted about the voltage axis, as shown below. The cell generates no power in short-circuit (when current Isc is produced) or open-circuit (when cell generates voltage Voc). The cell delivers maximum power Pmax when operating at a point on the characteristic where the product IV is maximum. This is shown graphically below where the position of the maximum power point represents the largest area of the rectangle shown.



The efficiency (n) of a solar cell is defined as the power Pmax supplied by the cell at the maximum power point under standard test conditions, divided by the power of the radiation incident upon it. Most frequent conditions are: irradiance 100 mW/cm2 , standard reference spectrum, and temperature 25 0 C. The use of this standard irradiance value is particularly convenient since the cell efficiency in percent is then numerically equal to the power output from the cell in mW/cm2.

solar panel, module and array :

Assemblies of photovoltaic cells are used to make solar modules which generate electrical power from sunlight. Multiple cells in an integrated group, all oriented in one plane, constitute a solar photovoltaic panel or "solar photovoltaic module," as distinguished from a "solar thermal module" or "solar hot water panel." The electrical energy generated from solar modules, referred to as solar power, is an example of solar energy. A group of connected solar modules (such as prior to installation on a pole-mounted tracker system) is called an "array."

Solar panel Solar module and array

Solar Photovoltaic Systems:

Solar Photovoltaic System uses solar cells to convert light into electricity. A PV system consists of PV modules and balance of systems (BOS). Balance of systems includes module support structure, storage, wiring, power electronics, etc.

DC (direct current) electricity is generated when solar radiation strikes the PV module. Power can be used in any DC load directly during this generation. But the generation exists during daytime. So, some storage device is needed to run the system at night or in low sunshine hour. Again this power cannot be used to run any AC (alternate current) load. Inverter has to be used to convert DC into AC.

Solar PV systems are categories into

Stand-alone PV systems (also called off-grid systems)

Grid connected PV systems (also called on-grid systems)

Hybrid systems

Stand-alone PV systems

Stand-alone systems are not connected with utility power lines and these are self-sufficient systems. These systems could either be used to charge the batteries that serve as an energy storage device or could work directly using the solar energy available in the daytimes. These systems consist of the following:

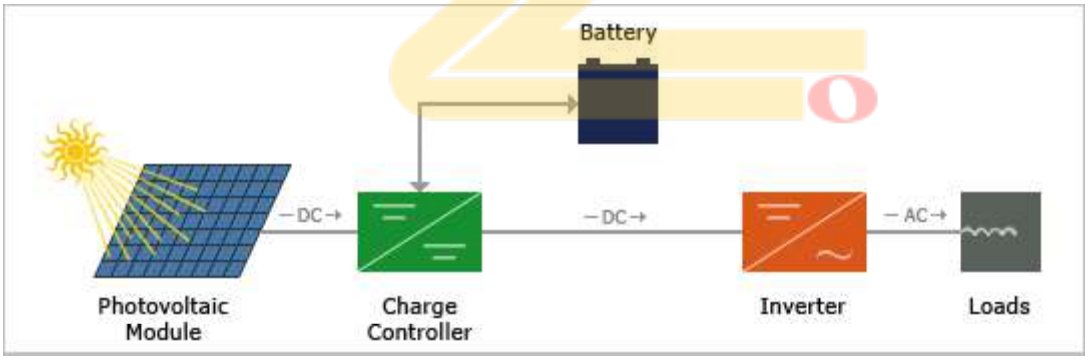
Solar panels mounted on the roof or in open spaces. Photovoltaic modules produce direct current (DC) electrical power.

Batteries to store DC energy generated by the solar panels.

Charge controller to prevent overcharging the battery.

Inverter to convert electricity produced by the system from DC to AC power.

The following diagram shows PV system powering AC loads with battery bank. DC loads can also be connected directly to the battery bank. It is also possible to power the AC load without battery, but in that case it would be confined only to daytime when solar radiation is sufficient to generate required electricity.



Grid connected PV systems

A grid connected photovoltaic system will be interacted with utility grid. The main advantage of this system is that power can be drawn from the utility grid and when power is not available from grid, PV system can supplement that power. These grid connected systems are designed with battery or without battery storage. These systems consist of the following:

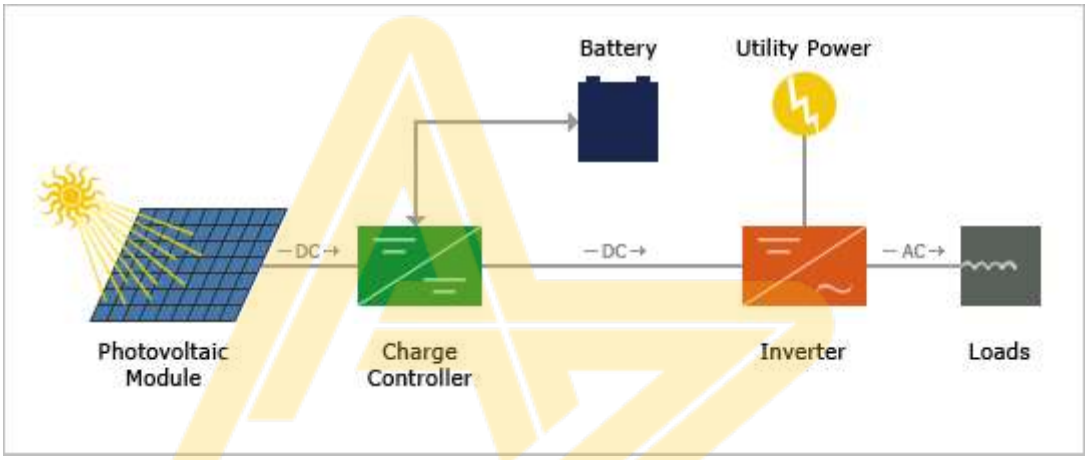
Solar panels mounted on the roof or in open spaces. Photovoltaic modules produce direct current (DC) electrical power.

Batteries to store DC energy generated by the solar panels.

Charge controller to prevent overcharging the battery.

Specially designed inverter to transform the PV generated DC electricity to the grid electricity (which is of AC) at the grid voltage.

The following diagram shows PV system powering AC loads. This system is connected to utility power supply and having battery storage for backup



Applications:

Solar Lighting

A Solar lantern is a simple application of solar photovoltaic technology, which has found good acceptance in rural regions where the power supply is irregular and scarce. Even in the urban areas people prefer a solar lantern as an alternative during power cuts because of its simple mechanism. Home lighting System is powered by solar energy using solar cells that convert solar energy (sunlight) directly to electricity. The electricity is stored in batteries and used for the purpose of lighting whenever required. These systems are useful in non-electrified rural areas and as reliable emergency lighting system for important domestic, commercial and industrial applications. The SPV systems have found important application in the dairy industry for lighting milk collection/ chilling centers mostly located in rural areas.

Solar Street Light system is designed for outdoor application in un-electrified remote rural areas. This system is an ideal application for campus and village street lighting. The system is provided with battery storage backup sufficient to operate the light for 10-11 hours daily. The system is provided with automatic ON/OFF time switch for dusk to down operation and overcharge / deep discharge prevention cut-off with LED indicators.

Energy Storage

Introduction:

A type of thermodynamically force that is used to derive the system equally to do work is called as energy. There are different forms of in energy in different field of science such as physics and chemistry both have different forms of energy in their relevant fields which are used to derive their phenomena's separately. As we know that there are different Laws which explain that energy is neither created nor destroyed. As it is cleared that it is difficult to create energy for different appliances independently so, a method was used to reduce such condition of created the energy again that is called as energy storage.

Types of Energy Storage:

There are lots of types which are used to store energy but there are three main types which are used to store energy for the long term use, these types are as follows

Hydrogen cells

Batteries

Fuel tanks

Hydrogen Cells:

An energy storing type that is used to store the energy in the form of hydrogen ions and then generate the power that is really free of environmental hazards to derive the working of different applications is called as hydrogen cell. This type can do the work more effectively as compared to other energy storing devices.

Batteries:

A second type of energy storing device is called as battery, it is that type of device which can generate the power with the help different cells arrangement in a specific manner is called as battery. The cells which are arranged in the battery for working are of two types that is primary cells and secondary cells.

Fuel Tanks:

A special type of energy storing device that stores energy in the form of liquid, it is look like box that is filled with the flammable liquid i.e. mostly gasoline that is used by the engine to generate the energy and start the working, such device is called as fuel tank.

Methods of Energy Storage:

There are many methods or ways to store energy, these methods really help us to store energy which is useful in our future to run different kind of systems. Energy storage methods are different in different fields of science such as chemistry, bio or physics etc. we can store energy by different types of methods which are chemically in nature such as energy storage by hydrogen, nitrogen in the liquid form etc. Energy can also store through the different kinds of mechanical methods such as hydraulic accumulator, fly wheel energy storage etc. sometimes energy storage can also done thermally such as ice storage, molten salts, hot bricks etc.

Importance of Energy Storage:

There are lots of aspects which made the energy storage valuable or important for the mankind. Some of them are as follows

It plays an important part in power leveling.

It can increase the efficiency of the engine and increase the output.

It can change the low duty cycles into important ones.