Solar Panel

A solar panel (also solar module, photovoltaic module or photovoltaic panel) is a packaged connected assembly of photovoltaic cells. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. Each panel is rated by its DC output power under standard test conditions, and typically ranges from 100 to 320 watts. The efficiency of a panel determines the area of a panel given the same rated output - an 8% efficient 230 watt panel will have twice the area of a 16% efficient 230 watt panel. Because a single solar panel can produce only a limited amount of power, most installations contain multiple panels. A photovoltaic system typically includes an array of solar panels, an inverter, and sometimes a battery and or solar tracker and interconnection wiring.

Theory and Construction: Solar panels use light energy (photons) from the sun to generate electricity through the photovoltaic effect. The majority of modules use wafer-based crystalline silicon cells or thin-film cells based on cadmium telluride or silicon. The structural (load carrying) member of a module can either be the top layer or the back layer. Cells must also be protected from mechanical damage and moisture. Most solar panels are rigid, but semi-flexible ones are available, based on thin-film cells. Electrical connections are made in series to achieve a desired output voltage and/or in parallel to provide a desired current capability. The conducting wires that take the current off the panels may contain silver, copper or other non-magnetic conductive transition metals. The cells must be connected electrically to one another and to the rest of the system. Externally, popular terrestrial usage photovoltaic panels use MC3 (older) or MC4 connectors to facilitate easy weatherproof connections to the rest of the system. Bypass diodes may be incorporated or used externally, in case of partial panel shading, to maximize the output of panel sections still illuminated. The p-n junctions of mono-crystalline silicon cells may have adequate reverse voltage characteristics to prevent damaging panel section reverse current. Reverse currents could lead to overheating of shaded cells. Solar cells become less efficient at higher temperatures and installers try to provide good ventilation behind solar panels. Some recent solar panel designs include concentrators in which light is focused by lenses or mirrors onto an array of smaller cells. This enables the use of cells with a high cost per unit area (such as gallium arsenide) in a cost-effective way.

Efficiency: Depending on construction, photovoltaic panels can produce electricity from a range of frequencies of light, but usually cannot cover the entire solar range (specifically, ultraviolet, infrared and low or diffused light). Hence much of the incident sunlight energy is wasted by solar panels, and they can give far higher efficiencies if illuminated with monochromatic light. Therefore, another design concept is to split the light into different wavelength ranges and

Fig 1 : Solar Panel

direct the beams onto different cells tuned to those ranges.[2] This has been projected to be capable of raising efficiency by 50%.

Currently the best achieved sunlight conversion rate (solar panel efficiency) is around 21% in commercial products, typically lower than the efficiencies of their cells in isolation. The energy density of a solar panel is the efficiency described in terms of peak power output per unit of surface area, commonly expressed in units of watts per square foot (W/ft2). The most efficient mass-produced solar panels have energy density values of greater than 13 W/ft2 (140 W/m^2).

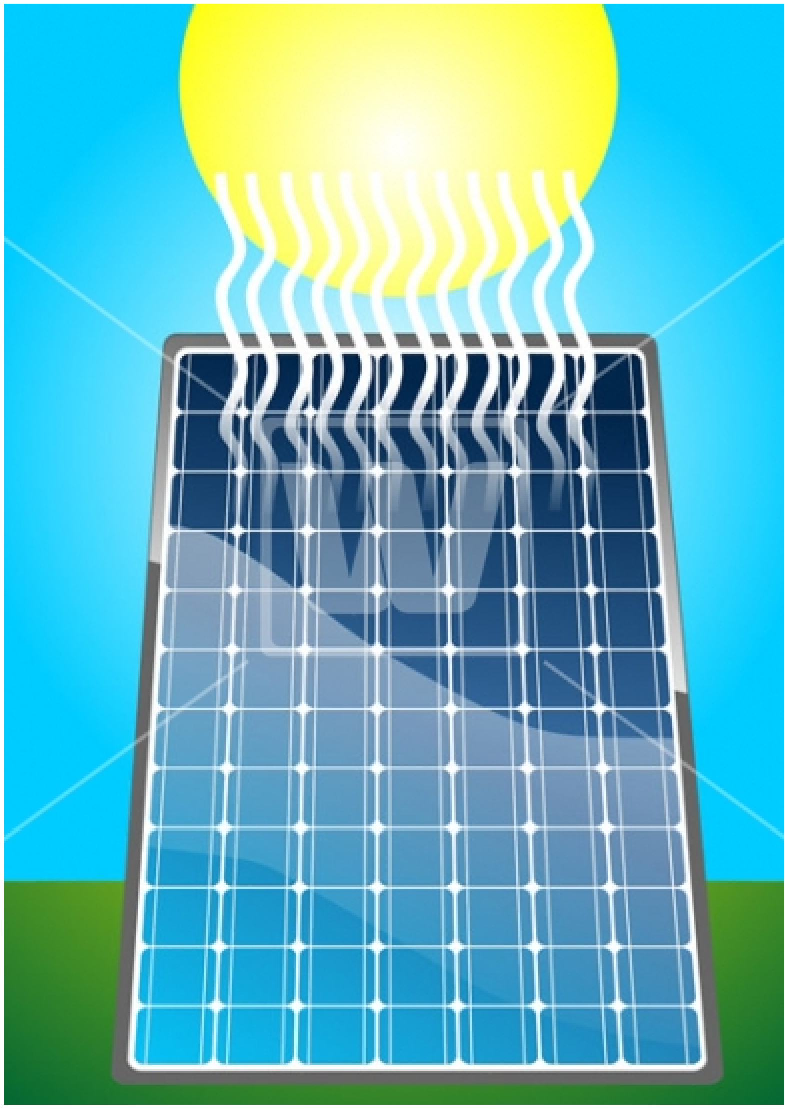

Fig 2 : Solar Panel

Performance : Module performance is generally rated under standard test conditions (STC): irradiance of 1,000 W/m^2, solar spectrum of AM 1.5 and module temperature at 25°C.Electrical characteristics include nominal power (PMAX, measured in W), open circuit voltage (VOC), short circuit current (ISC, measured in amperes), maximum power voltage (VMPP), maximum power current (IMPP), peak power, Wp, and module efficiency (%). Nominal voltage refers to the voltage of the battery that the module is best suited to charge; this is a leftover term from the days when solar panels were only used to charge batteries. The actual voltage output of the panel changes as lighting, temperature and load conditions change, so there is never one specific voltage at which the panel operates. Nominal voltage allows users, at a glance, to make sure the panel is compatible with a given system. Open circuit voltage or VOC is the maximum voltage that the panel can produce when not connected to an electrical circuit or system. VOC can be measured with a meter directly on an illuminated panel's terminals or on its disconnected cable.[5] The peak power rating, Wp, is the maximum output according under standard test conditions (not the maximum possible output). Typical panels, which could measure approximately 1x2 meters or 2x4 feet, will be rated from as low as 75 Watts to as high as 350 Watts, depending on their efficiency. At test panels are binned by their test results, and a typical manufacturer might rate their panels in 5 Watt increments, and either rate them at +/- 3%, +/-5%, +3/-0% or +5/-0%. Solar panels must withstand rain, hail, and cycles of heat and cold for many years. Many crystalline silicon module manufacturers offer a warranty that guarantees electrical production for 10 years at 90% of rated power output and 25 years at 80%.[10] The output power of many panels slowly degrades at about 0.5%/year.

Recycling : Most parts of a solar module can be recycled including up to 95% of certain semiconductor materials or the glass as well as large amounts of ferrous and non-ferrous metals. Some private companies and non-profit organisations are currently engaged in take-back and recycling operations for end-of-life modules.Recycling possibilities depend on the kind of technology used in the modules: Silicon based modules: aluminium frames and junction boxes are dismantled manually at the beginning of the process. The module is then crushed in a mill and the different fractions are separated - glass, plastics and metals.[14] It is possible to recover more than 80% of the incoming weight.[15] This process can be performed by flat glass recyclers since morphology and composition of a PV module is similar to those flat glasses used in the building and automotive industry. The recovered glass for example is readily accepted by the glass foam and glass insulation industry. Non-silicon based modules: they require specific recycling technologies such as the use of chemical baths in order to separate the different semiconductor materials.[16] For cadmium telluride panels, the recycling process begins by crushing the module and subsequently separating the different fractions. This recycling process is designed to recover up to 90% of the glass and 95% of the semiconductor materials contained. Some commercial-scale recycling facilities have been created in recent years by private companies. Since 2010, there is an annual European conference bringing together manufacturers, recyclers and researchers to look at the future of PV module recycling.

Production : In 2010, 15.9 GW of solar PV system installations were completed, with solar PV pricing survey and market research company PVinsights reporting growth of 117.8% in solar PV installation on a year-on-year basis. With over 100% year-on-year growth in PV system installation, PV module makers dramatically increased their shipments of solar panels in 2010. They actively expanded their capacity and turned themselves into gigawatt GW players. According to PVinsights, five of the top ten PV module companies in 2010 are GW players. Suntech, First Solar, Sharp, Yingli and Trina Solar are GW producers now, and most of them doubled their shipments in 2010.

Price: Average pricing information divides in three pricing categories: those buying small quantities (modules of all sizes in the kilowatt range annually), mid-range buyers (typically up to 10 MWp annually), and large quantity buyers (self-explanatory—and with access to the lowest prices). Over the long term—and only in the long-term—there is clearly a systematic reduction in the price of cells and modules. For example in 1998 it was estimated that the quantity cost per watt was about $4.50, which was 33 times lower than the cost in 1970 of $150.In the real world, prices depend a great deal on local weather conditions. In a cloudy country such as the United Kingdom, price per installed kW is higher than in sunnier countries like Spain. Following to RMI, Balance-of-System (BoS) elements, this is, non-module cost of non-microinverter solar panels (as wiring, converters, racking systems and various components) make up about half of the total costs of installations. Also, standardizing technologies could encourage greater adoption of solar panels and, in turn, economies of scale.[citation needed] Despite the cost of solar panels, one of the main selling points of them is their return on investment, which can be as high as 6.8% in some areas of the United Kingdom, where a typical 4 kWp panel would take about 15 years to be paid off.

Mounting systems :

Trackers

Solar trackers increase the amount of energy produced per panel at a cost of mechanical complexity and need for maintenance. They sense the direction of the Sun and tilt the panels as needed for maximum exposure to the light.

Fixed racks

Fixed racks hold panels stationary as the sun moves across the sky. The fixed rack sets the angle at which the panel is held. Tilt angles equivalent to an installation's latitude are common.

Ground mounted

Ground mounted solar power systems consist of solar panels held in place by racks or frames that are attached to ground based mounting supports. Ground based mounting supports include:

Pole mounts, which are driven directly into the ground or embedded in concrete.

Foundation mounts, such as concrete slabs or poured footings

Ballasted footing mounts, such as concrete or steel bases that use weight to secure the solar panel system in position and do not require ground penetration. This type of mounting system is well suited for sites where excavation is not possible such as capped landfills and simplifies decommissioning or relocation of solar panel systems.

Roof mounted

Roof mounted solar power systems consist of solar panels held in place by racks or frames attached to roof based mounting supports. Roof based mounting supports include:

Pole mounts, which are attached directly to the roof structure and may use additional rails for attaching the panel racking or frames. Ballasted footing mounts, such as concrete or steel bases that use weight to secure the panel system in position and do not require through penetration. This mounting method allows for decommissioning or relocation of solar panel systems with no adverse effect on the roof structure.