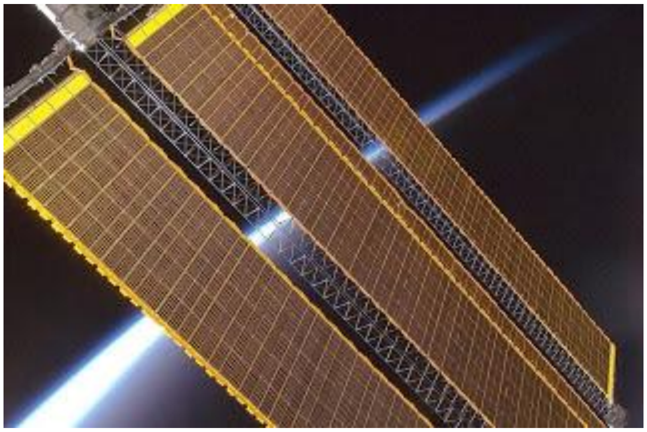
Solar Panel Basics

A solar panel (photovoltaic module or photovoltaic panel) is a packaged interconnected assembly of solar cells, also known as photovoltaic cells. The solar panel is used as a component in a larger photovoltaic system to offer electricity for commercial and residential applications.

A photovoltaic module is composed of individual PV cells. This crystalline-silicon module has an aluminium frame and glass on the front.

Because a single solar panel can only produce a limited amount of power, many installations contain several panels. This is known as a photovoltaic array. A photovoltaic installation typically includes an array of solar panels, an inverter, batteries and interconnection wiring.

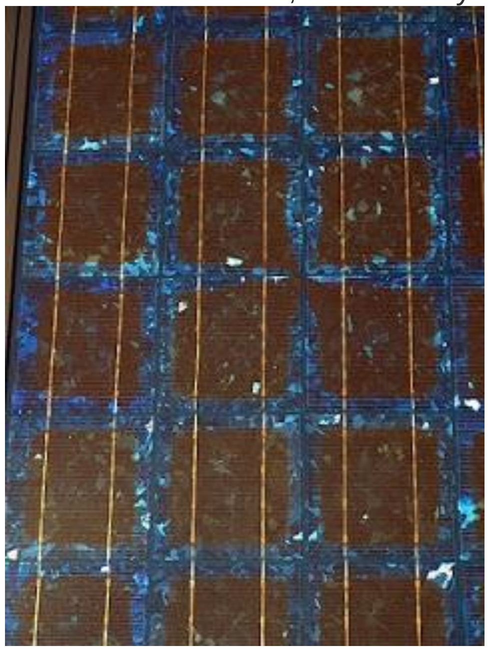
Photovoltaic systems are used for either on- or off-grid applications, and for solar panels on spacecraft.



A PV module on the ISS.

Theory and Construction

Solar panels use light energy (photons) from the sun to generate electricity through the photovoltaic effect (this is the photo-electric effect). The structural (load carrying) member of a module can either be the top layer (superstrate) or the back layer (substrate). The majority of modules use wafer-based crystalline silicon cells or a thin-film cell based on cadmium telluride or silicon. Crystalline silicon, which is commonly used in the wafer form in photovoltaic (PV) modules, is derived from silicon, a commonly used semi-conductor.



PV cells in a panel.

In order to use the cells in practical applications, they must be:

• connected electrically to one another and to the rest of the system.
• protected from mechanical damage during manufacture, transport, installation and use (in particular against hail impact, wind and snow loads). This is especially important for wafer-based silicon cells which are brittle.
• protected from moisture, which corrodes metal contacts and interconnects, (and for thin-film cells the transparent conductive oxide layer) thus decreasing performance and lifetime.Most modules are usually rigid, but there are some flexible modules 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 amount of current source capability.

Diodes are included to avoid overheating of cells in case of partial shading. Since cell heating reduces the operating efficiency it is desirable to minimize the heating. Very few modules incorporate any design features to decrease temperature, however installers try to provide good ventilation behind the module.

New designs of module include concentrator modules in which the light is concentrated by an array of lenses or mirrors onto an array of small cells. This allows the use of cells with a very high-cost per unit area (such as gallium arsenide) in a cost-competitive way.

Depending on construction, the photovoltaic can cover a range of frequencies of light and can produce electricity from them, but sometimes cannot cover the entire solar spectrum (specifically, ultraviolet, infrared and low or diffused light). Hence much of incident sunlight energy is wasted when used for solar panels, although they can give far higher efficiencies if illuminated with monochromatic light. Another design concept is to split the light into different wavelength ranges and direct the beams onto different cells tuned to the appropriate wavelength ranges. This is projected to raise efficiency by 50%. Also, the use of infrared photovoltaic cells can increase the efficiencies, producing power at night.

Sunlight conversion rates (module efficiencies) can vary from 5-18% in commercial production (solar panels), that can be lower than cell conversion.
The current market leader in efficient solar energy modules is SunPower, whose solar panels have a conversion ratio of 19.3%, with Sanyo having the most efficient modules at 20.4%. However, a whole range of other companies (Holo Sun, Gamma Solar, Nano Horizons) are emerging which are also offering new innovations in photovoltaic modules, with a conversion ratio of around 18%. These new innovations include power generation on the front and back sides and increased outputs; however, most of these companies have not yet produced working systems from their design plans, and are mostly still actively improving the technology.

Crystalline Silicon modules

Most solar module are currently produced from silicon PV cells. These are typically categorized into either monocrystalline or multicrystalline modules.

Thin-film modules

Third generation solar cells are advanced thin-film cells. They produce high-efficiency conversion at low cost.

Rigid thin-film modules

In rigid thin film modules, the cell and the module are manufactured in the same production line.
The cell is created on a glass substrate or superstrate, and the electrical connections are created in situ, a so called "monolithic integration". The substrate or superstrate is laminated with an encapsulant to a front or back sheet, usually another sheet of glass.
The main cell technologies in this category are CdTe, or a-Si, or a-Si+uc-Si tandem, or CIGS (or variant). Amorphous silicon has a sunlight conversion rate of 6-12%.

Flexible thin-film modules

Flexible thin film cells and modules are created on the same production line by depositing the photoactive layer and other necessary layers on a flexible substrate.
If the substrate is an insulator (e.g. polyester or polyimide film) then monolithic integration

can be used.

If it is a conductor then another technique for electrical connection must be used.
The cells are assembled into modules by laminating them to a transparent colourless fluoropolymer on the front side (typically ETFE or FEP) and a polymer suitable for bonding to the final substrate on the other side. The only commercially available (in MW quantities) flexible module uses amorphous silicon triple junction (from Unisolar).
So-called inverted metamorphic (IMM) multijunction solar cells made on compound-semiconductor technology are just becoming commercialized in July 2008. The University of Michigan's solar car that won the North American Solar challenge in July 2008 used IMM thin-film flexible solar cells.

The requirements for residential and commercial are different in that the residential needs are simple and can be packaged so that as technology at the solar cell progress, the other base line equipment such as the battery, inverter and voltage sensing transfer switch still need to be compacted and unitized for residential use. Commercial use, depending on the size of the service will be limited in the photovoltaic cell arena, and more complex parabolic reflectors and solar concentrators are becoming the dominant technology.
The global flexible and thin-film photovoltaic (PV) market, despite caution in the overall PV industry, is expected to experience a CAGR of over 35% to 2019, surpassing 32GW according to a major new study by IntertechPira.

Module embedded electronics

Several companies have begun embedding electronics into PV modules. This enables performing Maximum Power Point Tracking (MPPT) for each module individually, and the measurement of performance data for monitoring and fault detection at module level. Some of these solutions make use of Power Optimizers, a DC to DC converter technology developed to maximize the power harvest from solar photovoltaic systems.

Module performance and lifetime

Module performance is generally rated under Standard Test Conditions (STC) : irradiance of 1,000 W/m², 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) and module efficiency (%).

In kWp, kW is kilowatt and the p means “peak” as peak performance. The “p” however does not show the peak performance, but rather the maximum output according to STC.
Solar panels must withstand heat, cold, rain and hail for many years. Many Crystalline silicon module manufacturers offer warranties that guarantee electrical production for 10 years at 90% of rated power output and 25 years at 80%.

Production
7.5 GW of installations were completed and connected in 2009. IMS Research estimates that shipments of PV modules were far higher. Shipments exceeded installations due to the record amount of modules shipped in the final quarter of the year to serve installations completed in the first quarter of 2010 in booming European markets such as Germany, Italy, France and Czech Republic.

Top ten
Leading thin film manufacturer, First Solar topped the rankings list for PV module suppliers in 2009, surpassing all of its crystalline rivals to ship more than a GW of modules and become the industry's largest supplier.
Top ten suppliers in 2009 are:
- First Solar
- Suntech
- Sharp
- Yingli
- Trina Solar
- Sunpower Corporation
- Kyocera Corporation
- Canadian Solar Inc.
- SolarWorld AG
- Sanyo Electric

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.

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.

Mounting Systems

Trackers

Solar Trackers increase the amount of energy produced per panel.

Fixed Racks
Fixed racks hold panels in a single location 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 is common.

Standards

Standards generally used in photovoltaic panels:
IEC 61215 (crystalline silicon performance), 61646 (thin film performance) and 61730 (all modules, safety)
ISO 9488 Solar energy—Vocabulary.
UL 1703
CE mark
Electrical Safety Tester (EST) Series (EST-460, EST-22V, EST-22H, EST-110).

Source: http://electrical-all.blogspot.in/2010/07/solar-panel-basics.html