

Introduction to Solar PV System
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Introduction to Photovoltaic Power System



The solar power system, also known as photovoltaic (PV) power system has become a popular source of electrical power since 1990s. The PV power system uses semiconductors (cells, panels, modules, arrays) to collect and convert sunlight into direct current (DC). The DC power is then converted into alternating current (AC) for various load requirements.

The solar power system may be “off-grid” or “grid-connected.” Off-grid or stand alone systems are not connected to existing power system run by utilities companies. They can be used to solely power homes, schools, hospitals/clinics and can be designed with or without batteries. Grid connected systems are designed to supplement existing electric service from a utility company.

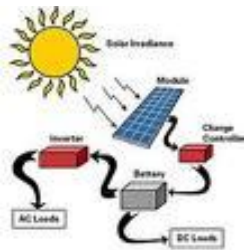
Figure 1. Image to the left is a sample of a PV module. A solar PV module is made up of many PV cells and can be mounted as ground mount, track racks, side of pole (tower), and top of pole. Other mounting techniques are possible depending on their safety, effectiveness and feasibility.

Advantages of the PV Power System

- PV installation is static that does not need strong and tall towers leading to longer life with little maintenance.
- It does not produce vibration or noise and does not need active cooling.
- PV power systems have short lead times to design, install and start a new plant.
- PV power systems are highly modular and the power output can easily match the peak-load demands.
- PV power systems are highly mobile and portable due to their light weight.

The PV Power System Components

Figure 2. Image illustrates the key components of the solar PV system.



- **PV Cells, Modules and Arrays** – the PV cells are the basic components or the building blocks of a PV power system. Solar PV cells make a module and several modules make an array. Extensive research projects have been undertaken to improve its conversion efficiency that leads to reduction of its unit cost.

Sun Trackers (not shown in the illustration) – Sun trackers are devices attached to the PV modules to capture sunlight as much as possible. They can be a one-axis trackers (they follow the sun from east to west during the day) or two-axis trackers (they follow the sun east to west during the day and from north to south during the seasons of the year). Effective sun trackers can increase the energy yield up to 40% compared to a fixed array design.

- **Energy Storage (Battery)** – Because solar or PV power is intermittent, the use of energy storage has become integral to the system to ensure the load availability. The primary type of energy storage used by the PV power system is the electrochemical battery. The primary electrochemical battery converts chemical energy into electrical energy. Once fully discharged, it is discarded and therefore, not reusable.

The secondary electrochemical battery is also known as rechargeable battery. It is rechargeable because its chemical reaction is reversible. In the charge mode, it converts electrical energy into chemical energy while at the discharge mode, it converts chemical energy into electrical energy. The round-trip conversion efficiency is between 70 – 80%. The batteries in modern system are managed by computer software to prevent from overcharging.

- **Charge and Discharge Controller** – The Controller is a multi-function component of the PV system. It is primarily used for detecting the working status of the system and the charging/discharging of the batteries. It protects the batteries from being overcharged or over-discharged. The controller is the central controller of the entire PV system .

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Solar Photovoltaic (PV) Power System

- **Inverters** – Inverters are devices that convert direct current (DC) to alternating current (AC) and control the voltage and power frequency. Inverters are utilized both for stand alone and grid-connected systems. The inverter is a key component of the grid-connected PV system. Efficient inverters result to high efficiency in DC – AC conversion and peak-power tracking. They also have low harmonic distortion, low electromagnetic interference (EMI) and high power factor. Inverters are available in a wide range of power ratings with efficiencies ranging from 85 – 95%.

Application of the PV Power System



At present, PV power is extensively used in stand-alone power systems, however, they are often used in grid-connected power systems as well. Remote villages around the world are the usual target areas for implementation. They are also used in hybrid systems with diesel power generators.

The applications or utilizations of solar PV power systems are almost boundless as the present way of living and doing business highly demands extensive energy supply. These applications include:

- **Residential/Commercial Applications**– depending on the design and capacity of the system, it can supply fully or partially the power demand of a residential or commercial center. For instance, a home PV system of 200w capacity would partially or amply supply the power demand for 10 – 15 20w bulbs, 2 electric fans and a small air-conditioning system. Large homes may need a PV system with 1,200 watt capacity to fully or partially supply for its power needs.

Related to residential and commercial applications, a PV system can support the power needs of the garden sprinkler system, aquarium aerators, lighted signages, water heating system, greenhouses, and many other residential/commercial utilization.

- **Agricultural Applications** – depending on the design and capacity, solar PV systems can support partially or amply the power demand of an irrigation system, fish farm aeration system, poultry/pig farms lighting and water pump system, greenhouses/nursery/seedling banks' lighting system, solar grains dryers, and many other agricultural applications.
- **Industrial Applications** – depending on the design and capacity, solar PV systems can support partially or amply the power demand of manufacturing companies for their lighting, cooling, heating, water treatment, solid waste management and many other requirements. For larger power needs and critical energy requirements, the system design is important so that it would deliver the capacity that meets the load requirements.
- **General Applications** – solar PV street and garden lights using light emitting diode (LED) and energy savings bulbs (ESBs) are fast replacing regular electric bulbs. These PV lights can normally replace the regular bulbs used in parks, parking areas, golf courses, military bases, ports, cemeteries/memorial parks and many other areas that need to be lighted during the wee hours.
- **Custom Applications** – schools, hospitals, rural clinics, multi-purpose halls and centers may use solar PV system to supply its power needs. Specially designed PV systems can be used for almost any applications that meet the cost-benefit consideration of the system provider and the end-user.

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Solar Photovoltaic (PV) Power System

Economics and Trends for PV Power Systems

The cost of producing PV cells has been declining since 1980s. Also, the cost of energy has been declining which is at present rate equivalent to USD 0.15 per kWh (by 2010; source: Patel, Wind and Power Solar Systems). In the US, installed capacity exceeded 1GW in 2004. According to the European Industry Association, the total global PV cell production in 2002 was over 560MW and has been growing at an annual rate of 30%.

Estimating the PV System Size and Cost. There are basically two (2) steps in determining the PV system size and cost. The first step focuses on determining the load requirement whether it is for a stand-alone or grid connected systems. Once the load requirement is known, then an existing solar PV system product or a customized system is used to meet the requirement. The load requirements of equipments are normally available, however, for building load requirements, a consulting service from a qualified electrical engineer or technician may be availed.

The second step focuses on calculating the PV system costs. The unit cost of power generation is normally expressed in \$/watt. If the cost of generating power from solar PV system exceeds that which is provided by the utility company, then it would not make sense to use the solar PV system unless the need is very important and there is no service from the utility company in a given locale. This is the reason why using solar PV system has become popular for remote villages where the costs of installing cables/grids is not commercially viable.

Author's Note. Mr. Makund Patel's book on Wind and Solar Power Systems: Design, Analysis and Operation has been used as the primary reference for the Introduction to Photovoltaic Power System. R Cueto does not claim IP or copyright ownership of the information presented. This information has been provided for general understanding of the PV power system only.

Other sources used come from general information from the internet. The information provided is not meant to be a comprehensive guideline for installing the solar PV system. The reader agrees that it is for informational used only.

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