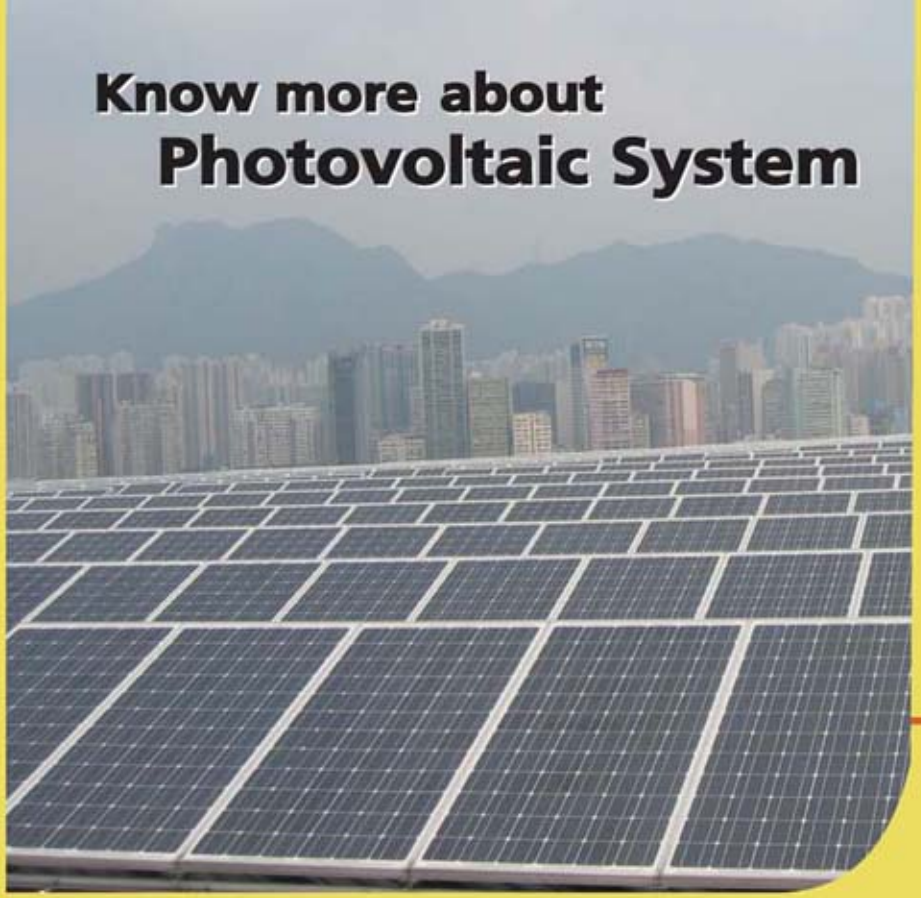
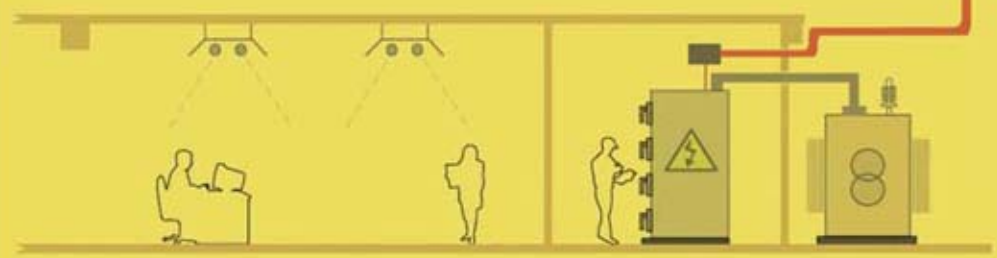
Know more about Photovoltaic System





Energy Efficiency EMSD

Electrical and Mechanical Services Department
3 Kai Shing Street, Kowloon, Hong Kong
Tel : 1823
Fax: 2890 6081
Homepage: http://www.emsd.gov.hk
Email: eepublic@emsd.gov.hk

Printed on recycled paper

EMSD

Contents

What is Photovoltaic Technology?

Photovoltaic (PV), as the name given, means generate electricity (voltaic) by light (photo). Photovoltaic technology can convert solar energy directly into electricity.

How does it work?

Photovoltaic cell is composed of a thin wafer consisting of an ultra-thin layer of phosphorus-doped (N-type) silicon on top of a thicker layer of boron-doped (P-type) silicon. An electrical field is created near the top surface of the cell where these two materials are in contact, called the P-N junction. When sunlight strikes the surface of a photovoltaic cell, this electrical field provides momentum and direction to light stimulated electrons, resulting in a flow of current when the solar cell is connected to an electrical load. Electricity is produced in the form of Direct Current (DC). DC electricity can be converted into Alternating Current (AC) through an inverter to meet the power characteristics of the load.

Benefits of Photovoltaic System

The electricity generated from the photovoltaic system is clean. The generaration process does not generate pollutants and contribute to the avoidance of greenhouse gas emissions from power stations.

Graphic source: National Renewable Energy Laboratory
Credit: Sandia National Laboratories

Photovoltaic Applicaions

Photovoltaic technology originally developed for the space mission. It was applied as an energy source for satellites and orbital stations in space. Due to the technology advancement, photovoltaic systems are becoming less expensive to produce, which has widen their applications.

Nowadays, photovoltaic system can be used in many ways. Simple photovoltaic systems provide power for many small consumer items, such as calculators and watches etc. More sophisticated systems provide power for communication satellites or buildings.

Photovoltaic systems are often integrated into the building envelope providing novel and aesthetically pleasing architectural alternatives. In addition, the electricity generated will help to meet part of the building electrical power demand.

Innovative applications for photovoltaic are being developed all the time. For example, a high concentration type photovoltaic system is being developed which uses plastic lenses to focus sunlight onto small photovoltaic cells so as to increase the cell efficiency.

Solar street light

Solar Garden Lamp

High concentration photovoltaic system

Photovoltaic boat

Types of Photovoltaic Cell

Common types of photovoltaic cells are below:

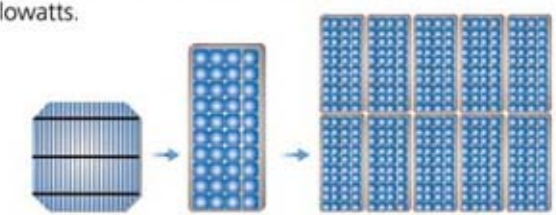
Photovoltaic Type	Manufacturing Method	Advantages	Disadvantages
Mono-crystalline silicon	Made from a single, continuous crystal lattice structure	High efficiencies (around 14%-16%)	Complicated and relatively expensive to manufacture
Poly-crystalline silicon	Silicon wafers are produced by casting and sawing or by forming thin ribbons directly from the silicon melt	*Cheaper than mono-crystalline cells *Simpler and less energy intensive to manufacture than mono-crystalline	Less efficient than mono-crystalline cells (around 13%-15%)
Amorphous silicon	Use a homogeneous layer of silicon rather than a crystal structure	*Cheaper than crystalline cells *Can use on curved and flexible surfaces	Less efficient than crystalline technologies at (around 5%-7%)

Mono-crystalline silicon

Poly-crystalline silicon

Amorphous silicon

Photovoltaic cells come in many sizes and shapes. A photovoltaic cell produces only a small amount of power. To produce more power, cells can be interconnected to form modules, which can be in turn be connected into arrays to produce more power. Its inherent modularity allows systems to be installed in smaller capacity increments from just a few hundred watts to several kilowatts.



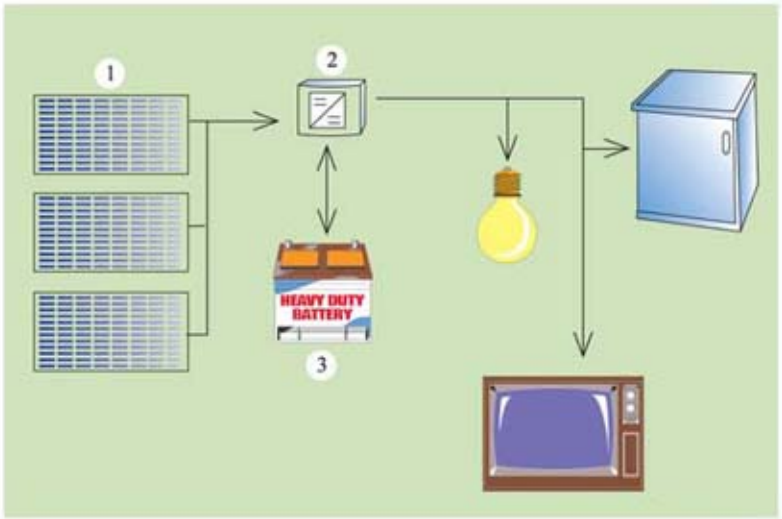
Cell → Module → Array

Types of Photovoltaic System

Photovoltaic systems are generally classified according to their functional and operational requirements, their component configurations, and how the equipment is connected to other power sources and electrical loads. There are two common types:

Stand-alone photovoltaic system

Stand-alone photovoltaic systems are designed to operate independent of the grid supply. Since PV panels do not generate power continuously, the stand-alone sysytem generally needs to include an energy storage device such as batteries to store the output power to cater for the intermittent supply characteristic. An inverter is required if alternating current (AC) loads are to be supplied and a charge regulator is needed to prevent overcharging and excessive discharging of batteries

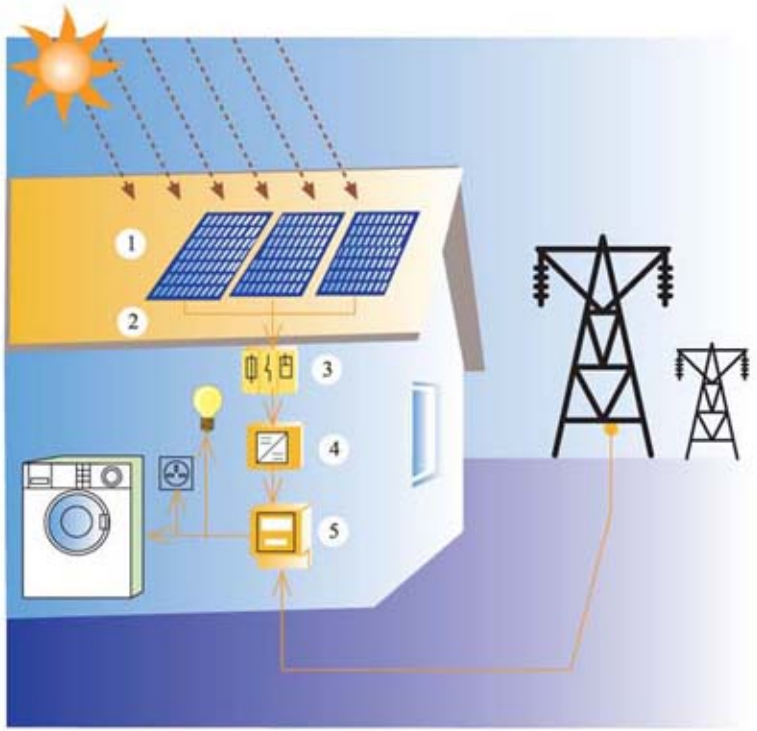


Principle of a stand-alone photovoltaic system

1. PV generator
2. Charge controller
3. Battery

Grid-connected photovoltaic system

The photovoltaic system can be connected to the grid supply which allows electricity to be drawn from the grid supply to back up the system. Grid-connected photovoltaic systems effectively use the mains power to secure a continuous electrical supply. An essential component of a grid-connected system is a grid-compatible inverter which converts the PV array's direct current (DC) output to alternating current (AC) at the same voltage and frequency as the grid supply.



Principle of a grid connected photovoltaic system

1. PV arrays
2. DC cabling
3. DC switch disconnector
4. Inverter
5. AC switch disconnector

How can the Photovoltaic Arrays be installed?

The simplest mounting arrangement is to mount photovoltaic modules in fixed position. The modules are usually tilted at approximately the latitude angle to maximise annual power production.

In Hong Kong, photovoltaic arrays are more often placed on buildings because of the unique features of the land use pattern in Hong Kong with high rise buildings almost everywhere. Photovoltaic array integrates into the roofs, facades and walls of the buildings as such the previously alienated space can be utilised for electricity generation.

Incorporating with a sun tracking system the photovoltaic arrays can be made to rotate about one or two axes following the path of the sun throughout the day to maximise possible electricity generation. However, this type of system cost more than fixed arrays and require regular maintenance to the tracking mechanism.

Sun Tracking photovoltalic system

Power Output of the Photovoltaic System

The power output of a photovoltaic system is expressed by its kilowatt peak (kWp) potential, which is an indication of how much electricity the system could generate at standard test conditions(STC). STC stands for the conditions which are used to measure the nominal output power of photovoltaic cells or modules, when the irradiance level is 1,000 W/m², the reference air mass of 1.5 and cell or module junction temperature is 25°C.

The power output of a photovoltaic system depends on several factors, including the location, orientation hence the solar resource, the efficiency of the photovoltaic cell and the way the system is designed and installed.

The annual power output for crystalline modules to be mounted at fully exposed location in Hong Kong and installed from horizontal to tilting angle of 22° towards South is estimated to be around 120 kWh/m². If the modules to be mounted vertically at South facing wall in Hong Kong, the annual power output could reduce to be around 70 kWh/m².

Life Expectancy and Maintenance Requirement of the Photovoltaic System

Since the photovoltaic modules have no moving parts, the maintenance requirement is expected to be minimal and the expected lifetime is exceeding 20 years. The output of the panels should be monitored so that if the output is much lower than expected, the panels and the system should be inspected and cleaned, where necessary.

Issues to be considered when installing the Photovoltaic System

- Photovoltic system should be in locations that will be unshaded at all times of day, if possible. TV aerials, plants and other buildings in the vicinity should be identified as potentially shardings of the modules, particularly in the early

morning or early afternoon.

- Since the efficiency of the photovoltaic panels will decrease as their temperature rise, adequate space between the roof and the modules are required for ventilation purpose.

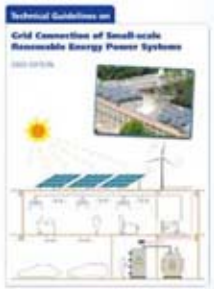
- If retrofitting photovoltaic system to the existing building, the system must be carefully positioned on the roof to take account of the loading capacity of the roof and wind effects.

- The potential for vandalism should be assessed if the PV system can be seen from the ground or if it is accessible to the general public.

- The building owner/occupant is advised to make reference to approved plans of the parent building and to consult building professionals to ensure that the existing building is structurally safe to support additional system components, and that prescribed windows as well as the means of escape including any roof designated as refuge floor thereof are not obstructed. Where alterations and addition works to the existing building structure are involved to support the additional system components, prior approval and consent from the Building Authority under the Buildings Ordinance are required. An Authorised Person (AP) (Architect, Engineer or Surveyor registered under the Buildings Ordinance) should be consulted in case of doubt.

- If the photovoltaic system is to be grid connected, prior approval has to be obtained from the Utility Company.

- For installation of a grid connected photovoltaic system, reference can be made to the "Technical Guidelines on Grid Connection of Small-scale Renewable Energy Power Systems" published by the Electrical and Mechanica Services Department. This set of guidelines provides guidance on technical issues relating to the connection of renewable energy systems to the electricity grid, such as safety, equipment protection, reliability and power quality.



- The design and installation of a photovoltaic system should be carried out by qualified professionals to ensure the installation is safe and energy efficient.

Where Can I Get More Information

For further information,please contact the Energy Efficiency Office,
Electrical and Mechanical Services Department
Contacts details are:

Add : 3 Kai Shing Street, Kowloon, Hong Kong
Tel : 1823
Fax : 2890 6081
Email : eepublic@emsd.gov.hk
Website : http://www.emsd.gov.hk