FUNDAMENTALS OF SOLAR ENERGY

Introduction

Energy from the sun is available at every place on the earth. People do not realize that daily life would not be possible without the presence of the sun. In ancient cultures, such as those of the Egyptians in times of the **Pharaohs** and the culture of the **Mayas** in Mexico and Guatemala, **the sun played a very important role** in daily life. **The sun was recognized as the creator of seasons, rain and drought;** it was recognized as the **source of all life. The sun was worshipped;** people were even sacrificed to please the Sun God.

Today, it is not surprising to see human beings themselves cause **pollution to the environment** though industrial activities, **traffic and pollution from generating electricity from fossil fuels.** In order **to avoid drastic climatic changes,** which threatens life on earth, a reduction in this pollution is urgently needed. Fossil fuels are limited and not **evenly shared.** Both the **energy crisis** and increasing **environmental degradation,** due to the production and consumption of energy, have made people and governments aware that we cannot go on like we do. People have to be more conscious about the state of the world they live in and which they share with so many other living creatures. It is expected that the demand for energy due to the **rapid increase in the population and the economic growth** is growing dramatically.

In order to meet this growing demand for energy and, at the same time, beat the environmental degradation due the growing energy consumption and production, use of alternative energy sources, which are not threat to the environment, has to be encouraged. **The time has come to worship the Sun in a modem way,** by profiting from the benefits of its radiation.

The source of all renewable forms of energy such as **direct solar energy, biomass energy, wind energy and hydropower is the sun.** Energy from the sun can reduce the **consumption of fossil fuels, thus reducing pollution of the atmosphere.** The offer of renewable energies is nearly unlimited and could cover the world's energy demand. So the question arises why not only renewable energies are used to produce electricity, as their advantages are obvious? The advantages of renewable energy sources are many but just to mention a few;

1) Big **potential**
2) **Environmental friendliness** (as compared to fossil/nuclear energy)
3) Good chances to supply even **remote areas** with energy
4) High degree of **decentralization**

Renewable energy sources also have some disadvantages. The important ones are:

1) Not for all kinds of renewable energies **have an appropriate technology**
2) Not **economically competitive** yet
3) The supply of **energy is not constant (Intermittent Supply)**

In the long-term perspective, renewable energies can replace the conventional modes of energy production. Such energy sources could be used to a great extent to replace fossil energy. **Hydro plants** are common since a long time. **Wind generators** and **geothermal power** plants are increasingly being used. **Tidal power** application has also reached a **stage of commercialization.** However, wind, hydro, tidal and geothermal energies are not available at all places and at all times.

SOLAR ENERGY RESOURCE

Energy potential is the amount of energy which a source of energy can provide within a given time period. Estimations regarding the yearly amount of energy show that the amount of energy by **solar radiation on the earth** is equivalent to **2×10^{14} ton** coal units per second, **tidal energy** is estimated to be **3×10^{9} ton** coal units per year and **geothermal energy** to be **3×10^{10} ton** coal units per year. The only amount of solar radiation incident to the earth surface is about **15,000 times** the yearly energy need worldwide.

Many people believe that the **energy from the sun is indefinite.** This **belief is far from truth** mainly because of its **vast amount** of radiation compared to the amount of energy which we use on the earth. **The loss of mass of the sun per second by nuclear fusion of hydrogen to form helium is 4 million tons. Solar radiation** is a result of **nuclear fusion reaction** of hydrogen to form helium. In equation form it is represented as;

$$H + H \rightarrow He + Energy$$

The **amount of hydrogen** is finite; the **solar energy is also finite.** It is estimated that solar energy will last for **five billion years.** It is known that, at present the sun has already passed its **half-life** time. The sun is a **black body,** radiating at 6000ºC. Although we have seen that solar energy is strictly not renewable, we refer to as renewable because of the **large time scale for its exhaustion.**

Solar energy is considered to be a renewable source of energy because the **supply does not exceed the rate of its consumptions.** Two general methods are used for the direct use of solar energy:

1) **The solar-thermal use:** a solar collector transforms the solar radiation into heat energy. This energy can be used direct, to warm water, room heating or for generation of electricity by turbines.
2) **The photovoltaic use:** the solar radiation energy is directly transformed into electricity.

SOLAR RADIATION AND PRINCIPLES

For all practical purposes the sun can be assumed to be a hot gas with a surface temperature of 6000 °C. This temperature is maintained by nuclear fusion reactions in which hydrogen fuses into helium. The sun **radiates in all directions** and a **small part of the radiation reaches the earth.** When designing and sizing a solar energy system, **reliable solar data is required.** The most relevant data is the average daily radiation (i.e. the total solar energy received per day per square meter) on a horizontal surface. Global radiation consists of the **direct sun radiation** and **diffuse radiation** of the sky. The strength of the radiation of the sun **depends highly on the location of the earth** and is directly dependent on the **hour of the day.** The global radiation or the total radiation is the sum of three components, namely **direct radiation, diffuse radiation and reflected radiation:**

Direct Radiation

This component **propagates in a straight line** from the sun and **casts shadows.** Direct radiation comes in a straight beam and can be focused with a lens or mirrors. On a sunny day, most of the radiation is direct.

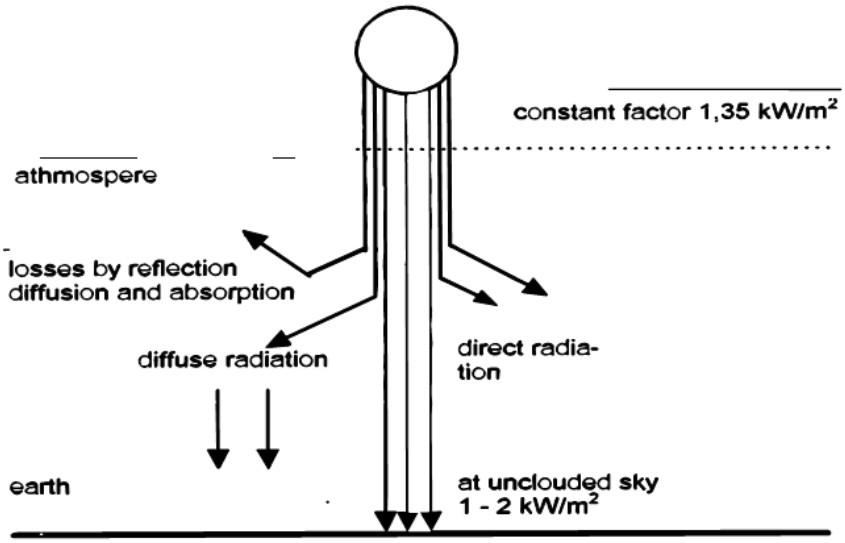
Diffuse Radiation

This is the radiation that has been **scattered by clouds** or **dust particles** in the atmosphere. **Clouds and dust absorb and scatter radiation, reducing the amount** that reaches the ground. On a cloudy day, up to 100% of the radiation is diffuse. Together, direct and diffuse radiations are known as global radiation.

Reflected Radiation

This is the radiation reflected by the **ground** and **other physical surroundings.** This distinction is very important, since some solar energy systems make use of all incoming light (e.g. PV panels), while others only use direct radiation (e.g. a solar heater with a parabolic dish). Apart from **climate** and the **cloud cover,** important factors determining global radiation are the **latitude** of the site, the **time** of the year and **time of the day.**

The time of the year and the time of the day influence the length of the sun path through the atmosphere and thus the intensity of the direct sunlight. The intensity is highest when the sun is **perpendicular** above the solar collector. Knowledge of the sun path from day to day and season to season is also required to **optimise orientation** and **tilting** of the device.



Flow of Energy From the Sun

SOLAR ENERGY DATA

Solar Irradiance

Solar irradiance refers to the solar radiation actually striking a surface, or the **power received per unit area** from the sun. This is measured in watts or kilowatts per square metre.

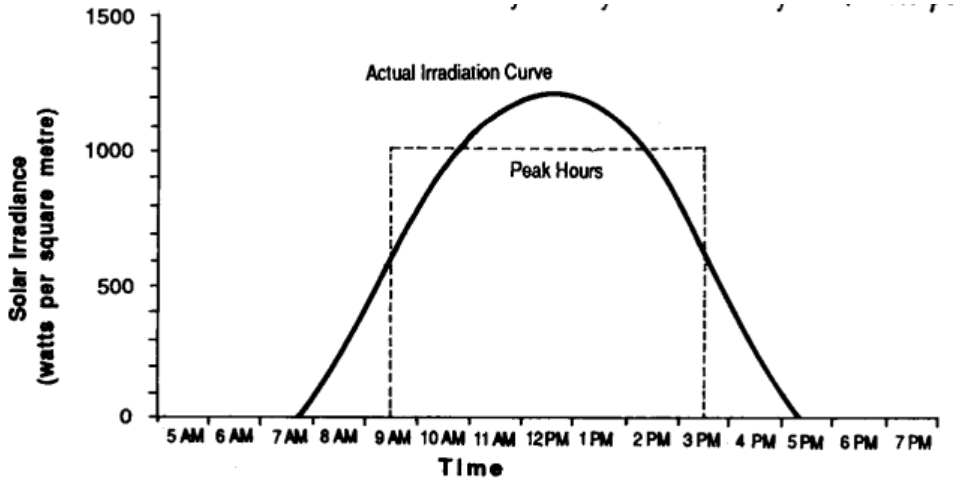
Insolation

Insolation (incident solar radiation) is a measure of the **solar energy received on a specific area over a specific period,** normally an hour or a day. It is measured in **kWh/m^2/day or MJ/m^2/day.** By knowing the insolation levels of a particular region we can determine the size of solar collector that is required. An area with poor insolation levels will need a larger collector than an area with high insolation levels.

MEASUREMENT OF SOLAR RADIATION

Solarimeter is a general term used to describe solar radiation measuring devices. Instruments, which measures global radiation, are called **pyranometers** and

pyrheliometer is used for measuring direct radiation. **Sunshine recorders** are used to record the sunshine hours.



Solar Irradiance and Peak Hours

SOLAR PHOTOVOLTAIC

Photovoltaic (PV) is a technology that **converts sunlight directly into electricity.** It was first observed in 1839 by the French scientist Becquerel who detected that when **light was directed onto one side of a simple battery cell, the current generated could be increased.** In the late 1950s, the space programme provided the impetus for the development of crystalline silicon solar cells; the first commercial production of PV modules for terrestrial applications began in 1953.

Today, PV systems have huge value use in areas remote from an electricity grid where they can provide power for **water pumping, lighting, vaccine refrigeration, electrified livestock fencing, telecommunications** and many other applications. With the global demand to reduce carbon dioxide emissions, PV technology is also gaining popularity as a mainstream form of electricity generation.

Photovoltaic modules provide an **independent, reliable electrical power source** at the point of use, making PV particularly suited to **remote locations.** However, solar PV is increasingly being used in **homes and offices for electricity to replace or supplement grid power,** often in the form of solar PV roof tiles. The daylight needed is **free,** but the cost of equipment can take many years to achieve payback. However, **in remote areas** where grid connection is expensive, PV can be the **most cost effective power** source.

Apart from SHS, other applications of PV in developing countries include **1) PV-powered remote telecommunications equipment; 2) rural health clinic refrigerators; 3) rural water pumping; solar lanterns and 4) PV battery-charging programmes,** which allow rural residents to purchase or rent batteries to provide electricity to their homes, and then recharge them at PV-powered charging stations. A few attempts have been made to establish PV-powered village power grids in developing countries.

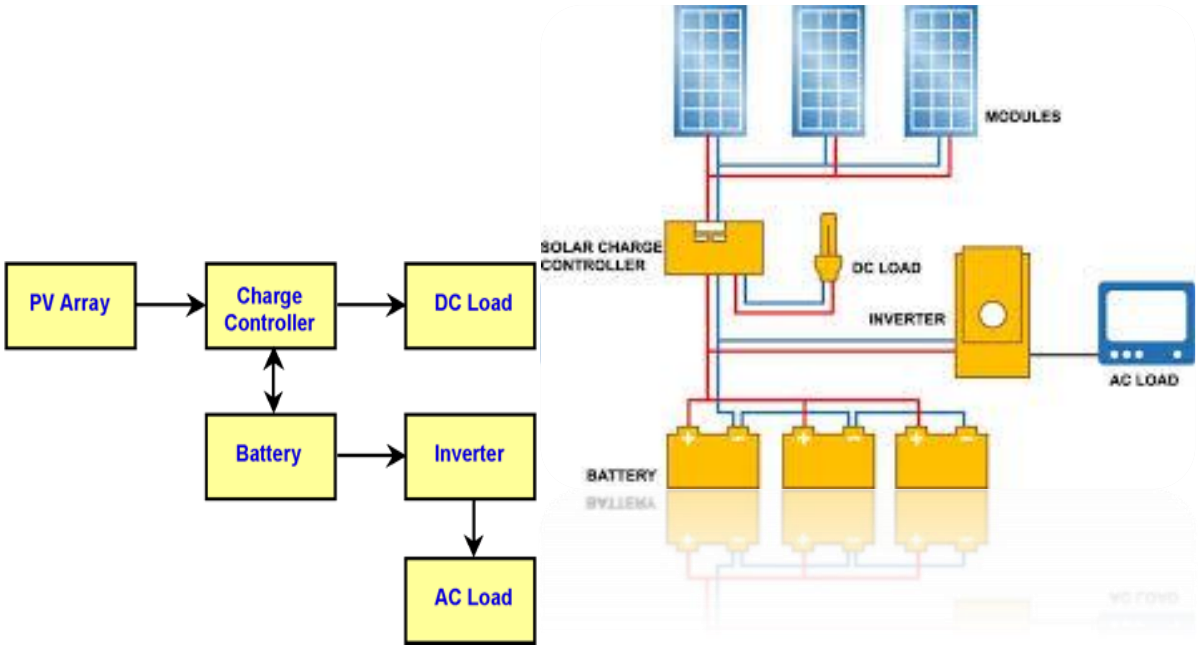
HOW SOLAR CELLS CREATE SOLAR POWER

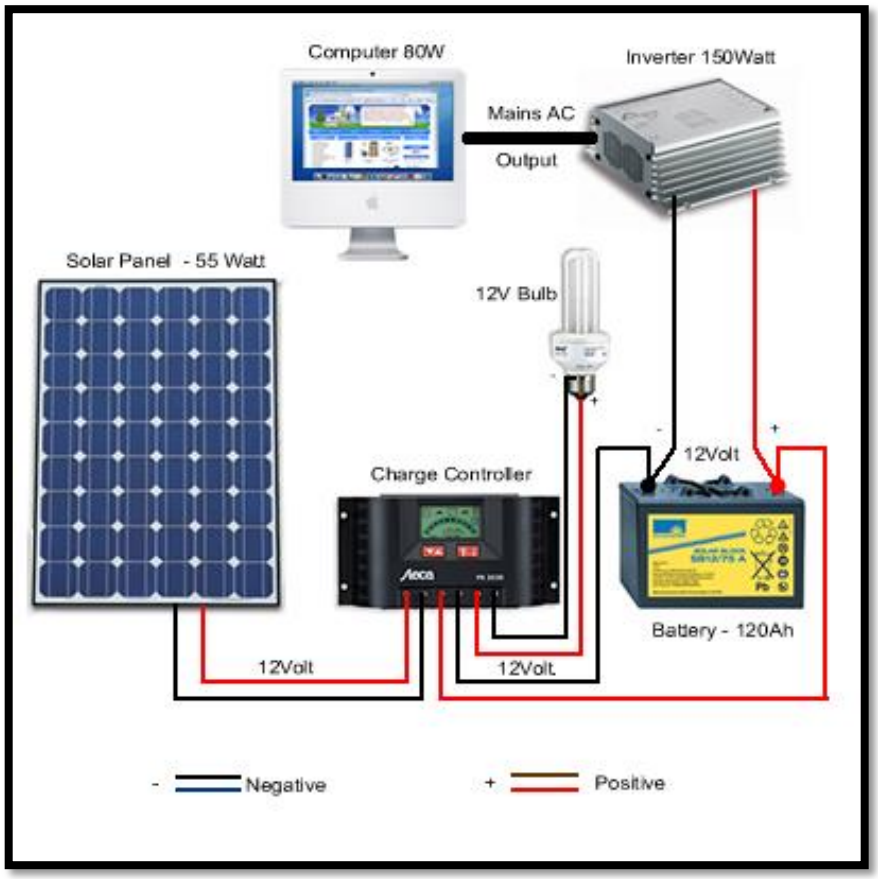
Solar cells are also called **photovoltaic cells,** which is why the panels that they create are generally called **photovoltaics.** Each solar cell is responsible for turning sunlight into electricity, and at the most basic level it happens like this:

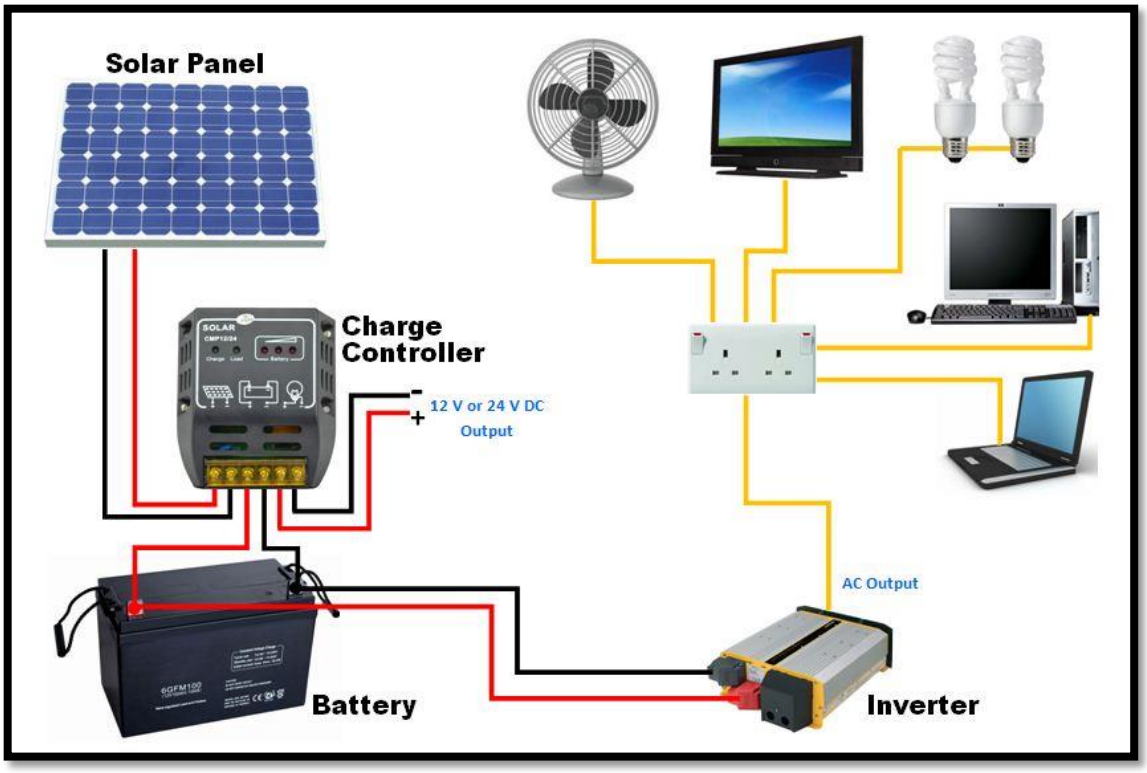
*Sunlight hits the solar cell… The **photons** in sunlight knock loose electrons in the solar cell, which causes them to move… The solar cell only allows electrons to move in one direction, which causes electric current…*

That is called photovoltaic effect

SOLAR PV CONFIGURATION/CONNECTION




Computer 80W
Inverter 150Watt
Mains AC
Output
Solar Panel - 55 Watt
12V Bulb
12Volt
Charge Controller
Battery - 120Ah
12Volt
12Volt
- Negative
+ Positive


Solar Panel
Charge Controller
12 V or 24 V DC Output
AC Output
Battery
Inverter