"I hereby declare that I have read through this report entitle '*Effect of Cloud On Solar Photovoltaic Module Output*' and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)".

Signature	:…….
Supervisor's Name	: Prof. Madya Dr. Gan Chin Kim
Date	:…….

EFFECT OF CLOUD ON SOLAR PHOTOVOLTAIC MODULE OUTPUT

TAUFIK HIDAYAT BIN DARMAWAN

A report submitted in partial fulfilment of the requirements for the degree of Bachelor of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2016

"I declare that this report entitle '*Effect of Cloud on Solar Photovoltaic Module Output*' is the result of my own research as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree".

Signature :……..

Student's Name : Taufik Hidayat Bin Darmawan

Date :……..

To my beloved mother and father

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ABSTRACT

Photovoltaic solar system is the technology that converts energy from sunlight into electrical energy. Generally, it consist several components including solar panel to absorb and convert the irradiance from sun light into electricity. The availability of the irradiance also depends on the weather condition that brings much variation and uncertainty. The irradiance at top of atmosphere was 1,367 W/m^2 and the radiation can easily absorbed, reflected and deflected by the cloud type. In other word, the solar irradiation will decrease because of the blocking and movement of the cloud. From that, this project had to emulate the cloud movement by replacing the cloud with tinted film. The percentage of the tinted film which is 50%, 65%, 80% and 95% to emulate the cloud that brings different effect on output PV module. The different output can be seen on the measurement of the solar such as voltage and current. Furthermore, to emulate the cloud, the panel had to create to hold the tinted film and make the panel moving slowly. The moving panel had to move with suitable gear so that it can emulate the cloud moving. From that, the required parameter can be taken with suitable equipment.

ABSTRAK

Solar sistem photovoltaic adalah teknologi yang menukarkan tenaga daripada matahari kepada tenaga elektrik. Secara umunya, ianya merangkumi beberapa komponen termasuk solar panel yang menyerap tenaga daripada matahari dan menukarkan sinaran cahaya matahari tersebut kepada tenaga elektrik. Ketersediaan sinaran matahari adalah bergantung kepada keadaan cuaca yang pastinya sentiasa berubah-berubah dan tidak dapat diramalkan. Radiasi matahari yang tertinggi di atas atmosfera adalah 1,367 W/m^2 dan radiasi tersebut amat mudah diserap, dipantulkan and dibias oleh beberapa jenis awan. Dalam erti kata lain, radiasi solar akan berkurang kerana faktor yang disebakan oleh halangan dan pergerakan awan tersebut. Daripada itu, projek ini akan mensimulasikan pergerakan awan dengan menggantikannya dengan penapis cahaya. Peratusan penapis cahaya iaitu 50%, 65%, 80% dan 95% yang bertindak sebagai awan yang memberi perubahan terhadap keluaran solar modul. Perbezaan keluaran daripada solar modul dapat dilihat dengan mengukur voltan dan arus. Tambahan lagi, untuk mensimulasikan penapis cahaya sebagai awan, sekeping panel lutsinar akan digunakan untuk memegang filem gelap tersebut dan akan digerakkan secara perlahan diatas solar panel. Penggerak panel penapis cahaya akan digerakkan menggunakan alat yang sesuai seperti roda. Seterusnya, parameter yang diperlukan akan diukur menggunakan alat pengukuran yang bersesuaian seperti solar meter dan clamp meter.

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CHAPTER 1

INTRODUCTION

1.1 Overview

Solar energy was the one of unlimited source of renewable energy in Malaysia that located South East Asia. With the increasing of energy demand in our country nowadays, the development of solar system significantly been increase. Comparing to the other source of energy such as fossil fuel that non-renewable energy, those energy will run out of source and solar system might be the best way to back up the demand of energy requirement. Moreover, solar system has the advantage of being friendly environment and do not pollute the surrounding area. From that, the solar irradiance being the main of input in term of electricity production. A photovoltaic systems basically depends on the solar irradiance level to operate.

1.2 Motivation

The main purpose of this project was to analyse the effect of cloud on solar photovoltaic module output. To verify the effectiveness of the proposed method, comparative studies are conducted in one system with encouraging result. A combined of four different tinted layer has been used to predict or represent the effect of passing clouds on a photovoltaic (PV) systems. The PV panel relies on the sunlight irradiance which may change naturally over the time and the weather conditions. Using the irradiance as input signal, the networks model the effects of four tinted movement on the PV systems. Generally, there are tens types of cloud patterns severely affect the PV output when they

shadow on the PV arrays. Each pattern allows a certain percentage of the irradiance to reach the earth's surface during a specific period of time. At the input, the combined neutral network receives the irradiance randomized by cloud movement. At the output, the same network generates simultaneously current and voltage.

1.3 Problem Statement

Generally, the irradiance totally depending form the weather condition which is often bring much of variations and uncertainty. Solar irradiance is very much affected by changes in weather. A warm, sunny day produces large solar irradiance values, while cold, cloudy days limit the available solar irradiance. Hence, clouds have a large impact on the solar irradiance received by a solar panel array. In other to understand the effect of cloud on PV module, the cloud had been replaced with tinted film which is almost all vehicle use it to reduce the heat. Hence, the tinted film that use in this project was to reduce the solar irradiance to the solar panel. For different solar irradiance transmittance condition from the tinted film which is 50%, 65%, 80% and 95%. The irradiance of solar changes over time to time provides useful information of solar irradiance record for better comprehending how quickly PV power would drop if exposed to such solar irradiance changes.

1.4 Objectives

The objectives of this project are:

i. To study the effect of the tinted film (simulating cloud) on the photovoltaic module system
ii. To analyse the performance of the film tinted under various percentage of irradiance levels

1.5 Scope of Work

This research is focused on the effect of cloud on photovoltaic module. The solar irradiance increase and drop throughout the day by day. From that, the development of the tinted film represent as the cloud movement to measure the V_{oc} and I_{sc} by moving the film slowly on the solar panel. There are four different film which is 50%, 65%, 80% and 95% that attach on the panel by using roller. Each of the layer diffuse the irradiance to the solar panel, then generate voltage and current from solar radiation. So, the measurement was conducted by using Seaward Meter and Clamp Meter.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, an overview of the information and an example of related project had been involved in the development corresponding to the project. Generally describe general information regarding to the effect of the photovoltaic (PV) module system. A great interest to utilize renewable energy such as solar development had been increased in the recent years due to demanding industry and exhaustion of fossil fuel. A solar cell basically made by a p-n junction and when exposed to the sun radiation, a direct current will produce by the solar panel. Hence, the findings from other information supports the theoretically regarding the implementation of the project.

Figure 2.1: Solar radiation to the solar PV

2.2 Theory and basic Principle

Photovoltaic (PV) is the technical term for solar electric. Photo means "light" and voltaic means "electric". Besides that, solar cells are semiconductor devices that convert sunlight into direct current (DC) electricity. The materials solar panel that used in this project was mono-crystalline silicon and polycrystalline silicon.

A number of solar cells electrically connected to each other and mounted in a support structure frame is called a photovoltaic module. Basically one single cell can produces about 0.5 volt and then form modules after connected together [1]. The combination connected of modules can form a larger unit called arrays as shown in Figure 2.2 below.

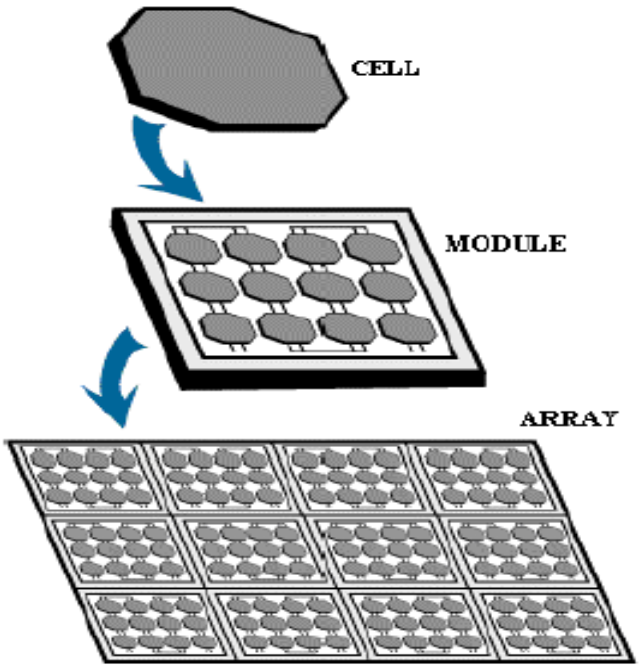

Figure 2.2: Part of PV cell, module and array

2.2.1 Solar Cell Principle

Solar cells are made of semiconductor materials such as silicon. For solar cells, when the sunlight strikes the cell, electrons are knocked loose. Then they move toward the treated front surface. An electron imbalance is created between the front and back. When two surfaces are joined by a connector, the current of electricity occurs between the negative and positives sides. Figure 2.3 below shows the electron and current flow in solar cells basically.

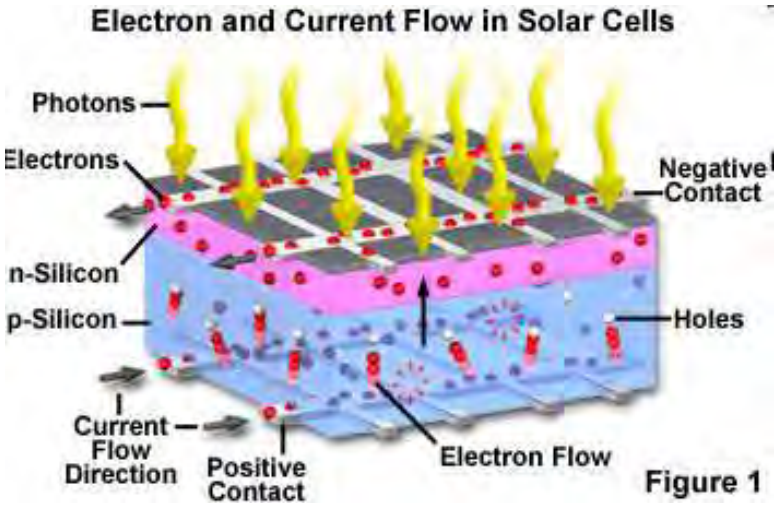

Figure 2.3: Electron and current flow in solar cells

The electron was flow in one direction and then generated electricity (DC). The input of the solar cells to generate electricity was the irradiance from the sunlight. Solar irradiance is measured in W/m^2 and is the amount of solar radiation power over a given surface area in square meters.

2.2.2 Solar Cell Structure

Solar cell are structured in layers with different functions. The working principle is the same as in semiconductors. The main part of silicon (Si) solar cell generating solar power is formed by two differently doped (n- and p-) silicon layers. A physical barrier is created between them along the p-/n- junction, with electrons and holes diffusing into regions of lower concentration. To be able to channel electrons and holes and generate electric power, metal contacts need to be printed onto the front and rear side. To reduce light reflection, a thin film of silicon nitride or titanium dioxide is coated onto the surface. Figure 2.4 below show the part of inside the solar panel which consists of P-doped silicon, P-n junction, glass, N-doped silicon, metal backing.

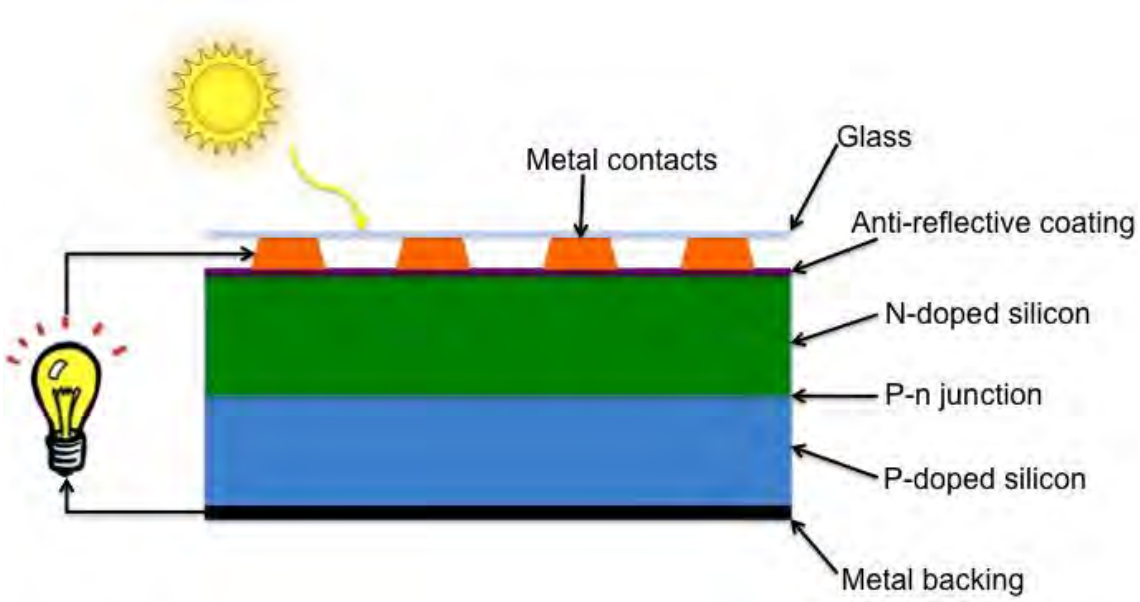

Figure 2.4: Solar cell structure

2.2.3 Solar Radiation

Solar radiation basically is the light and energy from the sun and there are many different forms. Besides that, the irradiance integrated over time is called solar irradiance and solar insolation. As shown in Figure 2.5, it show the solar radiation spectrum from at sea level to the top of the atmosphere.

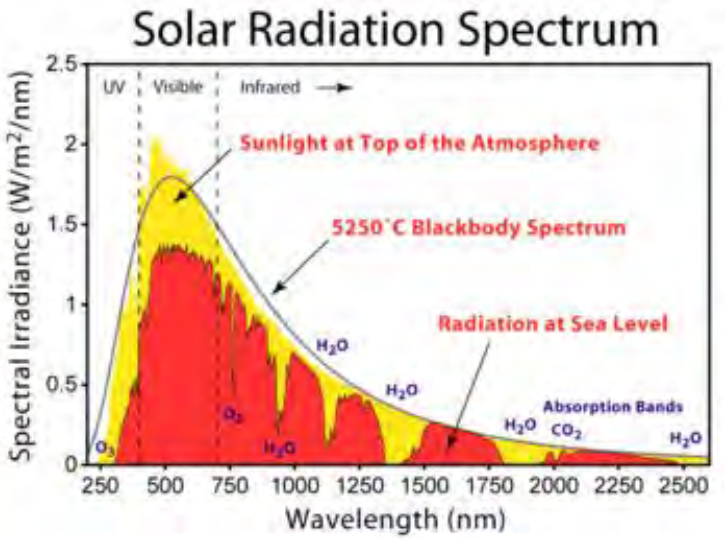

Figure 2.5: Solar radiation spectrum [17]

From Figure 2.6, it show the basic connection of solar system. The solar cells can generate more electricity during clear days with abundant sunlight. The amount of the voltage solar cells produce was depending on the clouds type and may vary by the type of solar panel. Good solar panels are better to use to receive the diffuse light that cause from the cloud.

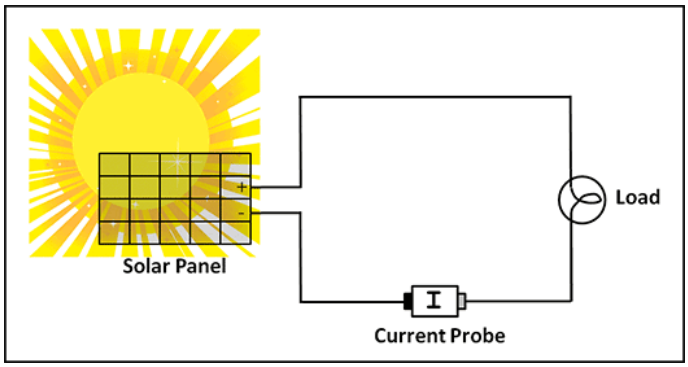

Figure 2.6: Basic connection of solar

As shown in figure 2.7, the current produce is directly dependent on the irradiance of the sunlight. In other words, during full sunlight, the solar cells will receive the maximum levels of panel capacity to form electricity. But, when the solar cells are covered, the amount of the irradiance from sunlight to the solar panel was reduced. The decreasing of the irradiance may disturb the production but the solar cells operate at about minimum capacity.

Malaysia located in the equatorial region and exposed to ample and constant sunshine generally and it is suitable for an ideal environment for solar PV power generation. About of 17 Mega Joules per square meter (MJ/m^2) average Malaysia receive the irradiance of solar per day. All around Malaysia mostly have the availability of land for the PV installation except for Kuala Lumpur where the solar PV capacity is limited to 5 GW due to the limited area and locations for solar PV installations.

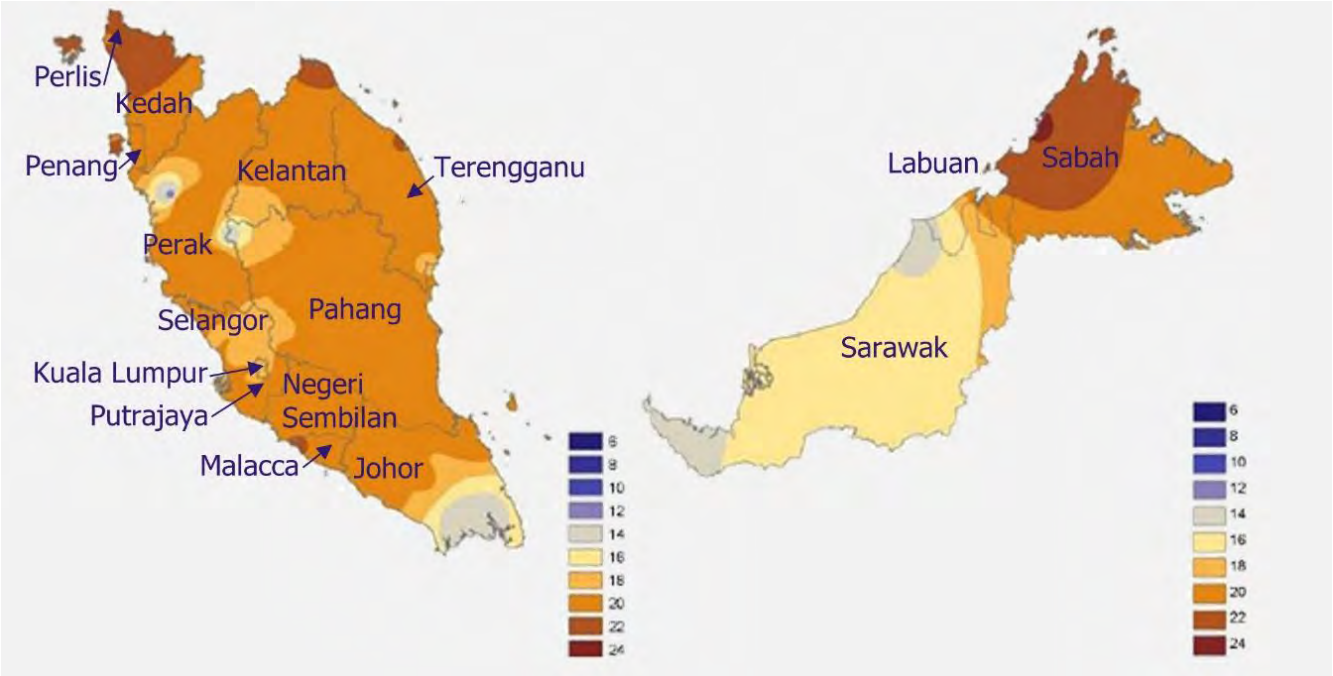

Figure 2.7: Malaysia average daily solar radiation (MJ/m^2)

Table 2.1: Solar radiation yearly for selected locations in Malaysia [16]

Cities in Malaysia	DNI [kWh/m^2]
Georgetown	1246
Kota Kinabalu	1192
Kota Bharu	1107
Senai	1045
Kuantan	1013
Durian Tunggal	973
Tawau	969
Sitiawan	949
Subang	932
Kuching	834

From Table 2.1 above, it show the solar radiation yearly for selected location in Malaysia. The Direct Solar Irradiance (DNI) show the highest value of 1246 and the lowest value is 834 for Georgetown and Kuching respectively. Meanwhile in Durian Tunggal which is location of Universiti Teknikal Malaysia Melaka show the value of DNI was 973 kWh/m^2.

2.2.4 Effect of the Colour Filter on the Solar Panel

An analysis of colour shaded to the solar panel had been done to see the effect of voltage and current as sown in Figure 2.8. Basically, the efficiency of the solar cells obtained with no colour filter due to the directly receiving irradiance. With use of colour filter, it may diffuse the irradiance to the solar cells.

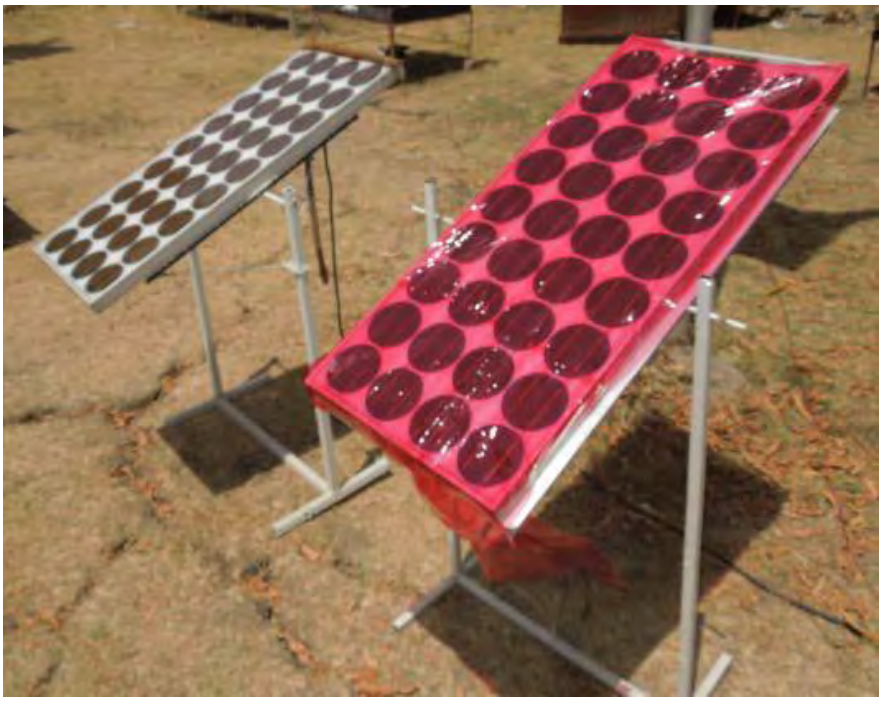

Figure 2.8: Experiment setup [19]

The results for the experiment for output power and the efficiency of the solar cells had been compared with and without colour filter in Table 2.1 below.

Table 2.2: The output with and without filter

Colour (Filter)	Current,(A)	Voltage,(V)	Power,(W)	Efficiency,(%)
No Filter	1.9	17	34.3	9.2
Violet	1.35	17	22.9	6.17
Blue	1.2	17	20.4	5.49
Green	1.5	17	25.5	6.86
Yellow	1.4	18	25.2	6.78
Orange	1.3	18	23.4	6.30
Red	1.6	18	28.8	7.75

2.2.5 Solar Irradiance Effect on PV Performance

Basically, the output power of solar cell/module directly depends on the amount of solar irradiance which is receives from the sunlight. Also it is known that the irradiance values not constant at any specific time interval. As shown in Figure 2.9, it show the changes in position of the sun with respect to earth are one of the main reasons causing the variations in the amount of incoming sunlight and its energy to the earth's surface on photovoltaic module.

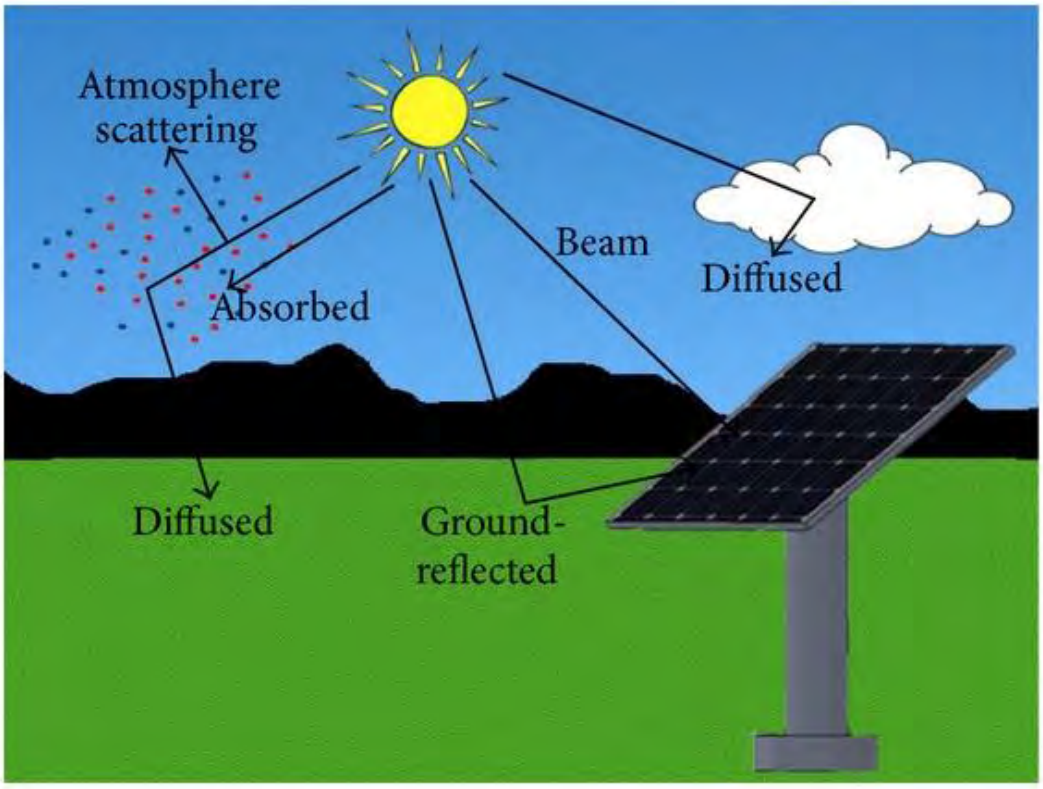

Figure 2.9: Flow of solar radiation on PV [1]