CHAPTER 1

INTRODUCTION & LITERATURE SURVEY

1.1 Introduction

Solar energy is an appealing alternative energy source for the future, with the special advantages of being non-polluting, renewable, widely distributed, and of delivering peak power at the times of peak loads. The Sun has been worshipped as a life-giver to our planet since ancient times; all the energy on earth is nearly a direct or indirect result of solar energy. The exceptions are attributable to moontides, radioactive materials, and the earth's residual internal heat (even these are present only because of the processes in the early solar system). Furthermore, the total energy reaching the earth amounts to 3 x 10^{24} J/year, which is about ten thousand times as much as the energy consumption of the mankind. For a conversion system of 10% efficiency, 2% area of the desert is enough to satisfy all the energy requirements (1).

When the solar radiation enters the Earth's atmosphere (Fig. 1.1), about 30% of the incident energy is removed by scattering or absorption by air molecules, clouds and particulate matter usually referred to as aerosols. The radiation that is not reflected or scattered and reaches the surface directly in line from the solar disc is called "direct" or "beam" radiation. The scattered radiation which reaches the ground is called "diffuse". Some of the radiation may reach a receiver after reflection from the ground or other appropriately positioned surfaces is called the "albedo". Accordingly, total solar radiation consists of the mentioned three components is called "global".

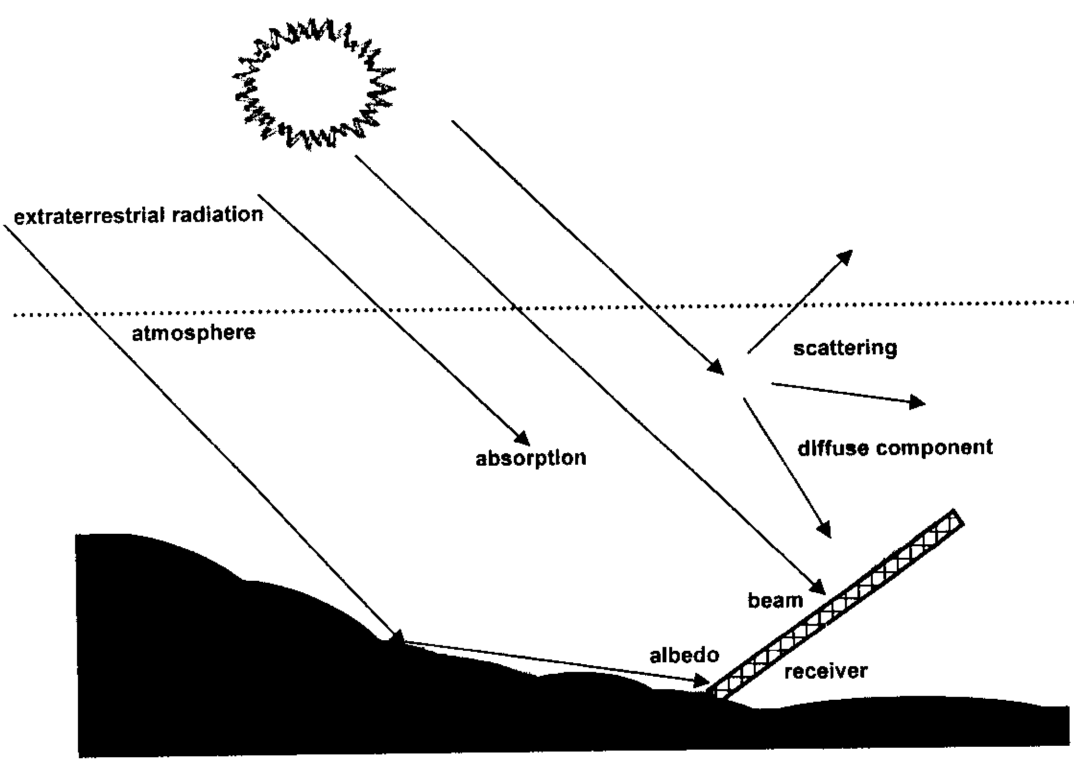

Fig.(1.1): Sunlight and the earth's atmosphere[1].

It is of primary importance to estimate the proportions of these components since they have irregular variations caused by the climatic conditions. The amount of radiation that reaches the ground is, of course, extremely variable. In addition to the regular daily and yearly variation due to the apparent motion of the sun, irrigular variations are caused by the climatic conditions (cloud cover), as well as by the general composition of the atmosphere[2]. For this reason, the design of a photovoltaic system relies on the input of the measured data close to the site of the installation.

The concept which characterizes the effect of a clear atmosphere on sunlight is the air mass (Fig. 1.2), which is a measure of how far sunlight travels through the earth's atmosphere. On a clear summer day at the sea level, the radiation from the sun at zenith, corresponds to air mass 1 (abbreviated to AM1). At other times, the air mass is approximately equal to $1/\cos\theta_z$, where θ_z is the zeinth angle whose complement to 90^o is the angle

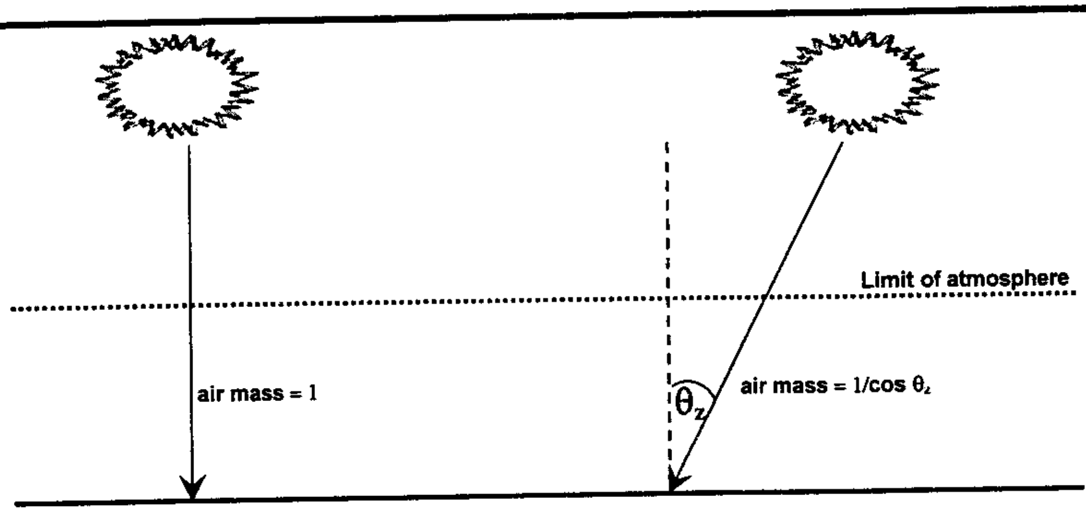

Fig.(1.2): The relationship between the zenith angle and the air mass[1].

between the sun's direction and the horizon (elevation angle). The effect of the atmosphere (as expressed by the air mass) on the solar spectrum is shown in Fig.(1.3). Air mass zero (denoted by AM0), describes the solar irradiance in space just above the earth's atmosphere, also called extraterrestrial global irradiance and is very important for satellite applications of solar cells. AM1.5 is a typical solar spectrum on the earth's

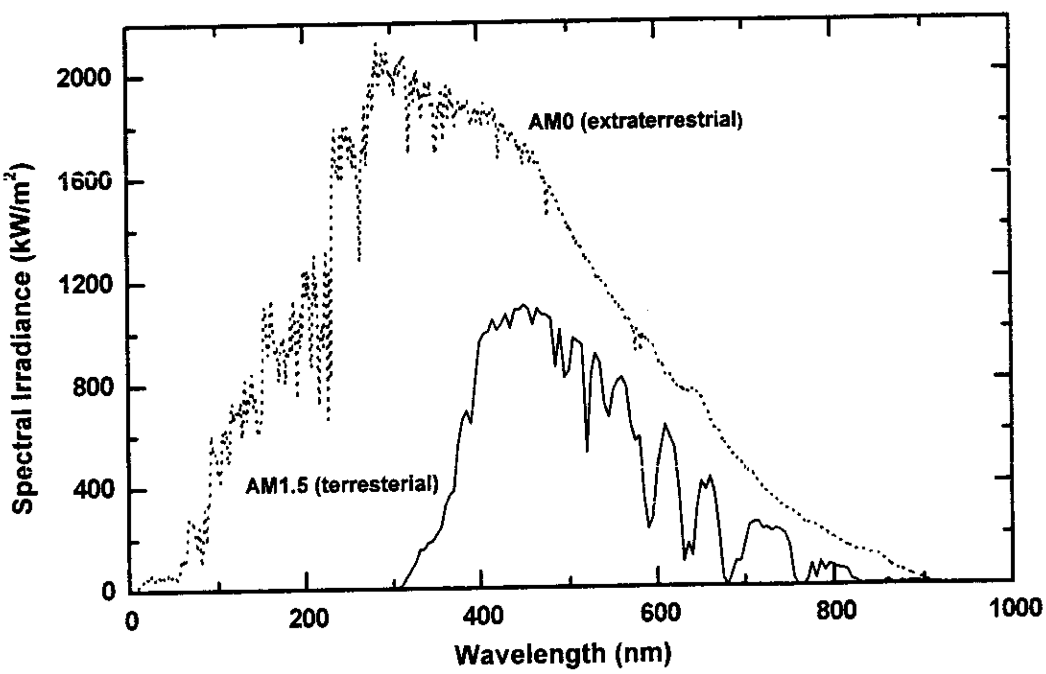

Fig.(1.3): The effect of air mass on the spectral distribution of solar energy [3].

surface on a clear day with a total irradiance of about 1 kW/m^2 called the terrestrial global irradiance and used for the calibration of solar cells and modules [3].

The solar energy is more than just sunshine; it is considered the parent of most of other renewable means of power generation. Hydroelectric power is made possible by evaporation- condensation due to solar radiant heat; the winds caused by the sun's irregular heating of the earth's atmosphere; fossil fuels which are remnants of organic life previously nourished by the sun[1-4]. It is also to be noted that the photosynthesis process in green plants which is supporting all the life activities consumes, only about 0.1% of the global solar energy reaching the earth, the trick is to get more energy more directly and efficiently from the sun. Therefore, the photophysical processes which occur through the excellent photoconversion systems in the nature can give important information to construct artificial photoconversion systems [5].

To convert solar energy, a heterogeneous reaction system is needed to prevent energy-consuming back reactions. From that reason the development of conversion systems composed of molecular assemblies, or polymers has become an active center of research on the solar energy conversion [6]. The cost of converting solar energy to other forms is the principle barrier to its use, especially in photovoltaic (PV) applications. Two main approaches must be pursued to decrease the cost of solar electric energy. The first is to reduce the cost of PV cells whose production is still very expensive [7]. The second is to concentrate as much light as possible on the photovoltaic cells [8].

Fluorescent solar concentrators (FSCs) had attracted a lot of attention as a possible means of reducing the cost of PV conversion, since the first proposal by Weber and Lamb [9]. The operation of the FSC, is illustrated in Fig.(1.4), it is based on the following principles, one or more kind of fluorescent species (e.g. organic laser dyes) are dissolved in a rigid highly transparent medium of high refractive index (e.g. polymethylmethacrylate (PMMA)). Solar photons entering the plate are absorbed by the fluorescent species and reemitted in random directions. Following Snell's law, a large fraction of the emitted photons will be trapped within the plate and transported by total internal reflections to the edge of the plate where they will be converted by appropriate PV cells facing the FSC edge.

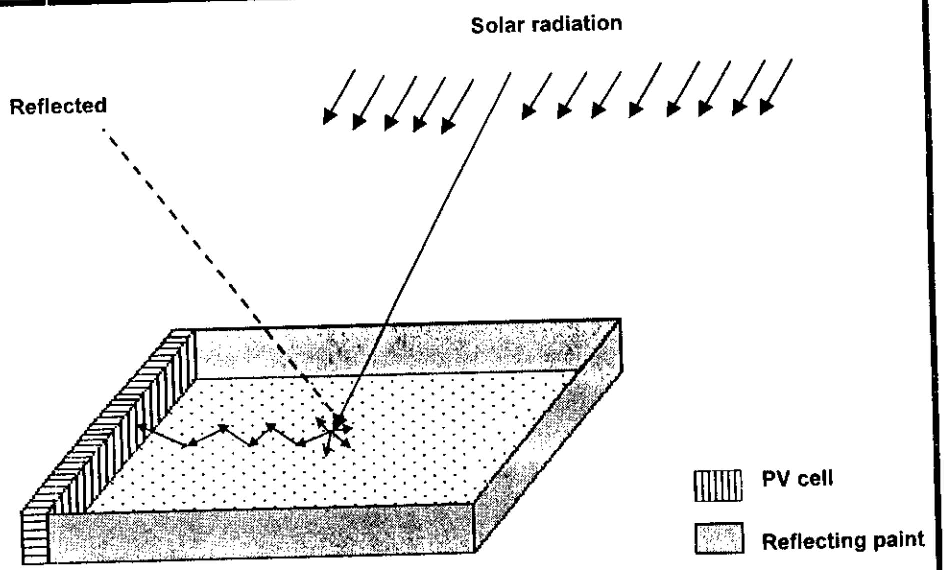

Fig.(1.4): The fluorescent solar concentrator, (FSC)[10].

The FSCs have the following advantages over the conventional solar energy concentrators (focusing concentrators) [10]:

1. They collect and concentrate both direct and diffuse light, therefore tracking the sun is unnecessary.
2. Materials used in manufacturing the FSCs are low cost so the price of the PV cell is less important in the cost of the total system.
3. They have a high power to weight ratio, making them suitable for roofs.

4. There is a good heat dissipation of non utilized energy by the large area of the FSC in contact with air, so that "cold light" reaches the PV cells.
5. A stack of sheets doped with different dyes can separate the wavelengths of solar light, and PV cells can be chosen to match different fluorescence wavelengths as shown in Fig.(1.5) [11].

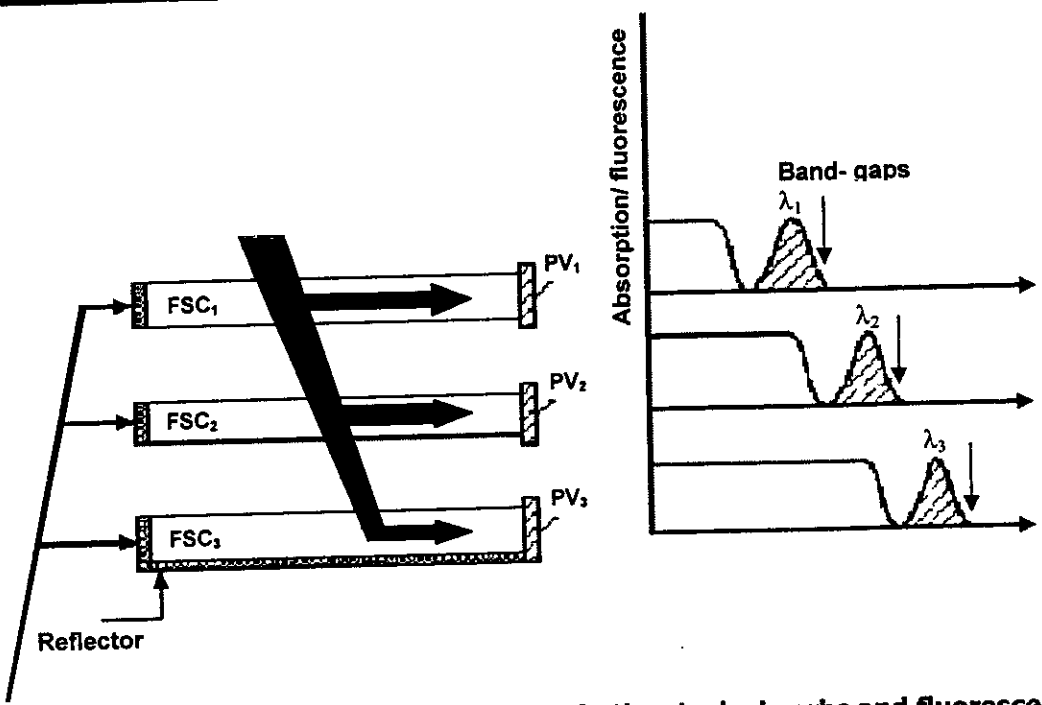

Fig.(1.5): A three-stack FSC. Each layer in the stack absorbs and fluoresces light of longer wavelength with ideal absorption coefficient of the next plate. The FSC plates fluoresces light at the absorption edge of PV cells[11].

6. The fluorescent dyes could also be dissolved in a liquid solvent and the solution could be contained in the space between two plates of a transparent materials. This has the practical advantage of renewing the degraded sample more easily than the using of solid plates.
7. FSC can serve as a second cover of a thermal flat plate concentrator for providing the electric energy for the water circulation pump.
8. The main advantage of FSCs is the reduction of the large area to be covered by PV cells to only the area of the edges.