Effect Of Temperature On SolarCell Due To Solar Radiation Concentrator

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By

Mohamed Mohmoud Sabry
B.Sc. of Science Physics Departement (1989)
Demonstrator in National Research Institute of Astronomy and Geophysics

To

Physics Department
Faculty Of Science
Ain Shams University

T. El Dessouki
M. Shaltout
A Agalal

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ABSTRACT

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The purpose of the study is to test the effectiveness of using radiation concentrators to increase the output of the solar cells in hot desert climate like Egypt. The work is divided into two main parts.

The first part concerns with soft concentration systems, which is called V-trough.

Typical systems of V-trough concentrator is installed in the roof top of the National Research Institute of Astronomy and Geophysics in Helwan. Two samples of Si solar cells of amorphous and polycrystalline types were fixed inside the concentrator cavity to test their reliability and validity to operate at hot desert climate. The collected energy of the V-trough concentrator is measured for both horizontal and full tracking modes; also the gains of both polycrystalline and amorphous Si solar cells were calculated.

The use of the V-trough concentrator along with the polycrystalline type is responsible for reducing the expected gain as the effective current response is in the IR which corresponds to the minimum reflectivity of the mirrors used in the V-trough.

In contrary, use of amorphous Si solar cell that has an effective part of the spectrum lies in the visible region that, fortunately, has the highest reflectivity by the V-trough mirrors.

The second part of the work is concerning with hard concentrator systems

The purpose of this chapter is to test the effectiveness and reliability of using commercial cells with three different cooling techniques and to get their behavior in these cases.

A hard concentrator system using glass lens and several commercial types of Si polycrystalline cell is also built in the same site.

Results of the system performance under several types of cooling and at different cell temperatures are measured and demonstrated.

Cooling systems that carried out are three types:

i) Water cooling *ii)* Air cooling *iii)* Heat sink

each one of these types is tested in real outdoor conditions.

Using the second and third types as cooling systems mean that no thermal energy could be derived from the system although they has high efficiency . Using the first type gives excess of thermal energy gain in addition to the electrical energy gain.

Key words: Solar Concentrators, Photovoltaics, Amorphous Si Solar Cells, Polycrystalline Si Solar Cells, V-trough.

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Summary in Arabic

CHAPTER 1

INTRODUCTION

Overview

In this chapter, sources and distribution of energy are presented especially solar radiation. Photovoltaic cells are discussed as efficient and clean devices for producing energy. Also, solar concentrators types, advantages and disadvantages of concentration are presented and discussed.

1.1 Energy: Sources And Distribution

1.1.1 Alternative Energy Sources

For all practical purposes energy supplies can be divided into two classes:

(1) Renewable energy: obtained from continuing or repetitive current of energy occurring in the natural environment such as solar energy.

(2) Nonrenewable energy: obtained from static stores of energy that remain boundunless released by human such as nuclear fuels and fossil fuels of coal, oil and natural gas.

There are five alternative sources of useful energy [1]:

i) The sun.

ii) The motion and gravitational potential of the sun, moon and earth.

iii) Geothermal energy from cooling, chemical reactions, and radioactive decay in the earth.

iv) Nuclear reactions on the earth.

v) Chemical reactions from mineral sources.

1.1.2 Solar Radiation And Energy Balance

It has been estimated that the earth receive energy from the sun at the rate of 1.73×10^{17} W some 20,000 times the world's current rate of energy consumption.
Since the temperature of the earth is comparatively stable, all the energy received must eventually be re-radiated. In fact about 30% of the energy received is directly reflected by the atmosphere, while a further 47% is converted into heat and radiated at much longer wavelengths during the night. Most of the remaining 23% is consumed in evaporating water, producing vapour which later condenses and releases the energy for subsequent radiation.
A small fraction, less than 0.2% sustains wind, wave and convection motion. An even smaller amount, about 0.025% is stored by photosynthesis in plants.
Apart from wind and water power, the main source of energy since the earliest times has been the 0.025% of solar energy stored in vegetation (wood) and in the form of the fossil fuels - coal and oil. However, since it has been estimated that six-months supply of coal requires 10^6 years to replace. Thus, hydroelectric power, fossil fuel replenishment, wind and wave power accounts for less than 2% of the total energy received from the sun [2].

1.2. Solar Radiation Spectrum And Components

1.2.1 Sun And The Solar Spectrum

The sun is a sphere of intensely hot gaseous matter with a diameter of 1.39×10^9 m and is, on the average 1.5×10^{11} m apart from the earth. As seen from the earth, the sun rotates on its axis about once every four weeks. However, it does not rotate as a solid body; the equator takes about 27 days and the polar regions take about 30 days for each rotation.

The sun has an effective blackbody temperature of 5777K, and the density is estimated to be about 100 times that of water.

The sun is a continuous fusion reactor with its constituent gases as the "containing vessel" retained by gravitational forces. Several fusion reactions have been suggested to supply the energy radiated by the sun. The one considered the most important is a process in which hydrogen (i.e. four protons) combine together to form one helium (i.e. one helium nucleus); the mass of the helium nucleus is less than that of the four protons, mass having been lost in the reaction and converted to energy [3].

Solar radiation at normal incidence received at the surface of the earth is subjected to variations due to change in the extraterrestrial radiation (radiation received out of the earth's atmosphere) and to two additional and more significant phenomena, (1) atmospheric scattering by air molecules, water vapour, and dust, and (2) atmospheric absorption by O_3, H_2O and CO_2. Figure 1-1 shows the effect of Rayleigh scattering by air molecules and absorption by O_3, H_2O and CO_2 on the spectral distribution of beam irradiance.

1.2.2 The Solar Constant

Figure 1-2 shows schematically the geometry of the sun-earth relationship. The eccentricity of the earth's orbit is such that the distance between the sun and the earth varies by 1.7%. At a distance of one astronomical unit, 1.495×10^{11} m, the mean earth-sun distance, the sun subtends an angle of 32^o.

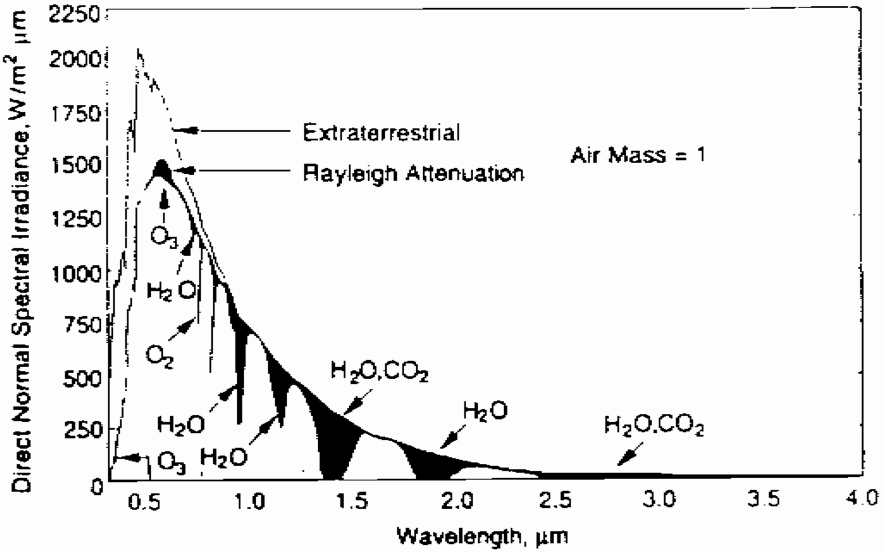

Fig. 1-1: Effect of Rayleigh scattering by air molecules and absorption by O3, H2O and CO2 on the spectral distribution of beam irradiance.

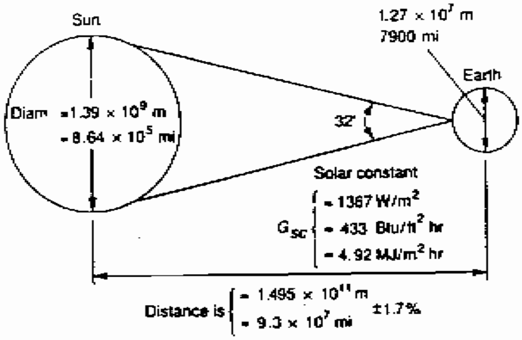

Fig. 1-2: The geometry of the sun-earth relationship.