PHOTOVOLTAIC CELL USAGE IN SARAWAK

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Universiti Malaysia Sarawak
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PHOTOVOLTAIC CELL USAGE IN SARAWAK

by

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This project attached here to, entitle "Photovoltaic Cell Usage in Sarawak" prepared and submitted by Mr. Muhammed Nazri Bin Mustapha in partial fulfillment for the Bachelor Degree of Engineering with Honors (Mechanical and Manufacturing System Engineering) is hereby accepted.

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Date: 20 April 2000

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Dedicated especially to my beloved parents,

Mustapha Abdullah and Norzilah Abd Rahman

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ABSTRACT

Nowadays photovoltaic (PV) system have an importance usage at remote area away from national electricity grid. PV provides power for a wide range of application including water pumping, lighting, telecommunication and others electrical application.

This project is to study on the energy produce by a module of photovoltaic cell by acting with different angle between sunrays and solar module. This research is divided into two categories. The first category is the energy produce by solar module at different angle by each time. The second category is the energy produce by the module in a fix position (horizontal to the surface) for the range time between sunrise and sunset. The entire factor affecting the energy produce by the module was discussed thoroughly. From this study, It is known that the solar angle did effect the amount of solar energy could be harvested.

ABSTRAK

Pada masa kini, Sistem *Photovoltaic* (PV) merupakan suatu kepentingan kepada kawasan pendalaman yang kedudukannya agak jauh dari pusat janakuasa elektrik. PV memberikan kuasa kepada penggunaan yang agak meluas termasuk system pam air, lampu, telekomunikasi dan sebagainya.

Kajian projek ini adalah merujuk kepada kajian kesan perubahan sudut antara sinaran matahari dan sel photovoltaic kepada tenaga yang dihasilkan. Kajian ini dibahagikan kepada dua kategori. Kategori pertama merupakan tenaga yang terhasil pada sudut yang berbeza pada waktu yang tertentu. Manakala kategori kedua merupakan kajian terhadap tenaga yang terhasil pada setiap jam bermula matahari terbit hinggalah ia terbenam dalam kedudukan sel selari dengan permukaan bumi. Faktor-faktor yang mempengaruhi tenaga yang terhasil ketika kajian dijalankan dibincang seimbas lalu. Daripada kajian yang telah dijalankam, diketahui bahawa wujudnya kesan sudut matahari kepada tenaga yang terhasil.

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P	Power of energy measured in miliWatts [mW]
V	Voltage measured in volts [V]
I	Current measured in miliAmpere [mA]

Chapter 1

Introduction

1.1 Background

Photovoltaic cell is also familiarly known as Solar cell. It is a technology of converting sunlight into electricity. (The term photovoltaic is often abbreviated to PV). It converts energy from the sun, which is an alternative energy without adversely affecting the environment. The major purpose of photovoltaic cell usage is to reduce the usage of fuel and definitely the cost.

Sunlight is a type of energy, which is free, abundant, and expected to be infinitely renewable, [NRDC, 1997].

The major reason for photovoltaic cells usage is due to it criterion. The criterion for photovoltaic system usage advantages are as followed:

1. PV systems are economically viable. Although PV system are expensive at first but it is quite cheap in term of its usage.
2. PV systems have no moving part and produce power silently. Thus, PV system is easy to maintain.
3. They are non-polluting with no detectable emission or odors

4. PV systems are in term of operation. There is little degradation in performance over 15 years.
5. PV modules can withstand severe weather condition including snow and ice.
6. PV systems are modular. If power demand increase, photovoltaic cell just need to added. In another way, each PV system can be sized to meet the particular demand.

The major barrier to widespread adoption of photovoltaic equipment is its high cost. However, photovoltaic cell require with low maintenance, thus this make its very cheap.

1.2 Brief History

Photovoltaic (PV) effect was first discovery by Edmund Becquerel in 1839 while he was working in his father's laboratory in France.

Then Russel Ohl of Bell Telephone Laboratories in the united Stated developed the first efficient silicon solar cell. Russel found that cut from recrystalized ingots had well defined natural barriers, which gave rise to a good photovoltaic response. One end of the rod developed a negative when illuminated or heated. It also had to be biased negatively to create low resistance to current flow across the barrier. This led to the terminology of "negative" or "n-type" and "positive" or "p-type" for the opposite of material. By carefully cutting cells from the cast ingot, Ohl was able to developed silicon PV devices that include the natural junction [Ohl, 1941].

In 1954, silicon solar cells (monocrystalline) were use for the first time in the space research programmed. The efficiency of these cells was only 5%. The production of solar cells is very energy-and-material intensive the purposed of their development for space applications was to provide the required resistance against high energy radiation. Inspite of the fact that this improvement in the efficiencies of solar cells was achieved very fast and that there was considerable development in the solar cell technology, the use of solar cells as energy generators came in discussion only after the oil crisis in 1973 [Bansal et al, 1990].

Therefore in 1973-1974 during the oil embargo, the U.S. Department of Energy funded the Federal Photovoltaic Utilization Program, the first large-scale program to test and demonstrate the value of photovoltaic systems for terrestrial applications. These systems helped to prove the reliability and competitiveness of photovoltaic power systems in practical field applications [Thomas et al, 1993].

As we know that some of this early systems are still used until today. There are such as pockets calculators, communication system, pumping stations, power array for isolated homes and others electric power application. In difference word there are now used all over the world. Nowadays there are useful in a big country to generate electricity on a small grid where is no electricity sources.

1.3 Photovoltaic Cell

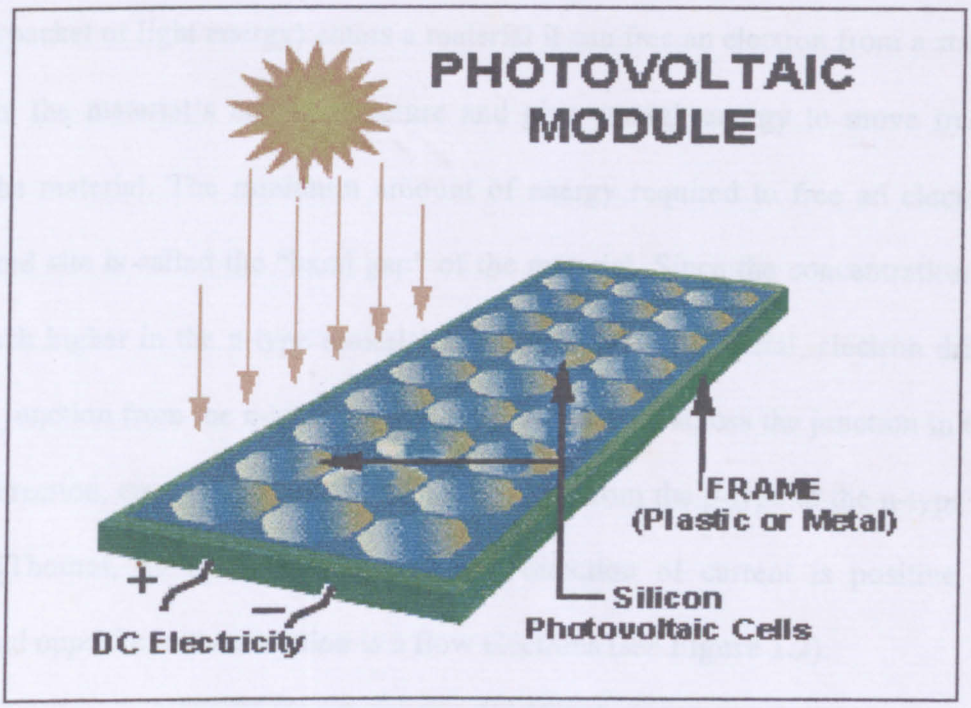

Figure 1.1: Photovoltaic Module [NRDC, 1997]

Figure 1.1 is photovoltaic module acting to the sun, which is generally used in this project. Photovoltaic cell work by converting energy of the sun directly into electricity (direct current, dc) by using devices made of silicon, the second most abundant element in the earth's crust, and the same semiconductor material used in computers. Other materials can be used to make solar cells but silicon has proved to be the most reliable and least expensive [Roberts, 1991]. This silicon is a hard material that is either dark blue or red in appearance. The blue cells are made as thin disc or squares which are quite fragile. This type is also called as crystalline silicon flat plate collectors. The red cell is coated on to glass that called as thin film.

Most solar cells are made of silicon semiconductor material treated with special additives. When the sunlight strikes the cells, a flow of electrons is generated proportional to the intensity of the sunlight and the area of the cell. The process how photovoltaic work is a same as p-n junction same like a diode works out. When a photon (a packet of light energy) enters a material it can free an electron from a stable position in the material's crystal structure and give enough energy to move freely through the material. The minimum amount of energy required to free an electron from a fixed site is called the "band gap" of the material. Since the concentration of free is much higher in the n-type material than in the p-type material, electron drifts across the junction from the n-type to the p-type. Holes drift across the junction in the opposite direction, creates a net electrical current (Id) from the p-type to the n-type of material, [Thomas, 1993]. As conclusion, the direction of current is positive to negative and opposite to the direction is a flow electrons (see **Figure 1.2**).

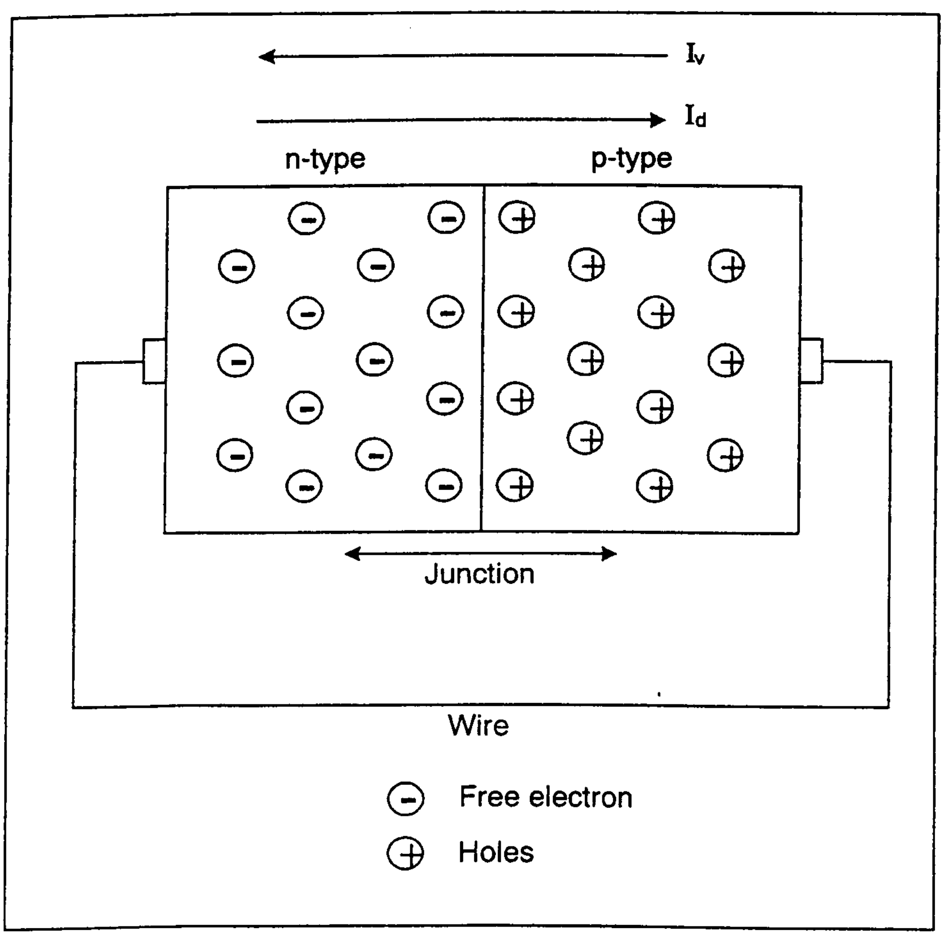

FIGURE 1.2: n-type and p-type insulated from each others [Thomas, 1993]

A solar cell with 10 centimeter a side will produce about 3.5 amperes in full sunlight. Each solar cell produces approximately one-half volt. Higher voltages are obtained by connecting the solar cells in series. The typical photovoltaic module used for terrestrial applications contains 36 silicon solar cells, connected in series to provide enough voltage to charge a 12-volt battery [Thomas, 1993].

1.4 Photovoltaic Cells Type

PV cell can be divided into two categories that is crystalline or thin film. These cells can operate with the lens or mirror concentrator.

1.4.1 Mono-crystalline and polycrystalline silicon cells

Most of photovoltaic cells are made of silicon called single crystal or mono-crystalline. Single crystal silicon than can be cut into several shapes. Two common shapes of cells are square with rounded corners (maximum length of 100 mm or 4 in) and circular (maximum diameter of 125 mm or 5 inch). Another type of silicon used to make solar cells is called polycrystalline, multicrystalline, or semicrystalline silicon. The surface of these cells looks slightly different from the single-crystal type. Compared to the single-crystal type, these cells are slightly less expensive to make but are less efficient in converting light into electricity [Roberts, 1991].

Crystalline and polycrystalline silicon cells have served as the photovoltaic workhorse for outdoor power applications for the past two decades and are likely to continue in this role in this role throughout the coming decade. Production of crystalline and polycrystalline silicon cells would well increase from levels of about 30 megawatts per year globally in 1990 to at least 10 times that amount by the end of the decade [Thomas, 1993]. However, because the cell approach is ultimately limited by its material intensiveness, it may well be superseded by a thin film approach in the next century.

Particularly exciting is the silicon-cell technology that may spawn a thin film silicon alternative, which maintains the high efficiency and reliability characteristic of the present cell technology. This would reduce photovoltaic costs to levels where they would be more than competitive with even large scale in the next century.

1.4.2 Thin Film

Most thin films are made from semiconductors that absorb sunlight about 100 times more effectively than crystalline silicon. This is a strategy for producing flat plates, and one that could lead to module costs much lower than for crystalline cells, uses thin (1 micron) films of materials such as amorphous (glassy) silicon (a-Si), copper indium disulfide (CIS) and cadmium telluride (CdTe) instead crystalline material. However, with this small amount of thin film (1 micron) it will absorb 90 percent of sunlight, which is same amount absorbed with 50 to 100 microns crystalline silicon. This efficiency leads to lower manufacturing costs. Deposition of thin films can also be much more rapid, much less energy intensive, and done on a larger scale than the manufacture of thick crystalline silicon. In addition, thin films require less handling to assemble into workable units because they are formed into modules (large-area devices) rather than individual cells [Thomas, 1993].

1.5 Photovoltaic Conversion

In photovoltaic conversion, the solar radiation falls on devices called solar cells, which convert the sunlight directly into electricity. The principal advantages associated with solar cells are that they have no moving parts, require little maintenance, and work quite satisfactorily with beam or diffuse radiation. In the future, as costs of production are reduced, it is possible that they may become one of the principal sources of electrical power for localized use. [Bansal et al, 1990]

1.5.1 Description and Principle of Working

The first solar cells were made of silicon and were developed in the U.S.A. in 1954. Even at present, silicon cells are the only cells that have attained commercial status. Conventional silicon cells are thin wafers about 300μm in thickness and 3 to 6 cm in diameter sliced from a single crystal of n-type or p-type doped silicon (Fig. 1.3). A shallow junction is formed at one end by diffusion of the other type of impurity. Metal electrodes made from a Ti-Ag solder are attached to the front and backside of the cell. On the front side, the electrode is in the form of a metal grid with fingers, which permit the sunlight to go through, while on the backside, the electrode completely covers the surface. An antireflection coating of SiO having a thickness of about 0.1 μm is also put on the top surface.

When radiation falls on a cell, it is absorbed and pairs of positive and negative charges, called electron-hole pairs are created. Then the mechanism will be same as p-n junction as describe on **Figure 1.3**.