FEASIBILITY STUDY OF USING OPTICAL FIBERS AS A LIGHT GUIDE FOR INDOOR SOLAR PANEL WITH ANALYSIS OF OUTPUT EFFICIENCY

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DEDICATION

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time. I also dedicated this thesis to my husband, my family, lecturers and fellow friends for their continuous support throughout my journey.

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ABSTRACT

Solar energy is now a reasonable alternative to reduce our dependency on fossil fuel. However, the photovoltaic (PV) cell performance may degrade with high temperature. The PV panel will perform at its best as it gets more sunlight, but excessive heat exposure can reduce their efficiency in turning photons to electricity and optimum operating period. Sunlight consists of light and heat. Thus in this study, an extensive review of indoor solar panel is to be conducted, whereby an analysis of using optical fibre as a light guide will be experimented. Parameters of concern would be the amount of photons guided to the panel against the length of the fibres itself. It can be measured through the value of power output of DC load compared to conventional outdoor PV panel. The heat that comes along is also a concern thus simultaneous temperature measurements has been implemented. At the end of this study, the use of optical fibre as a light guide for indoor solar panel is optimized.

ABSTRAK

Pada masa kini, tenaga suria menjadi satu alternatif yang munasabah untuk mengurangkan kebergantungan terhadap bahan api fosil. Walaubagaimanapun, prestasi sel fotovoltaik (PV) boleh berkurang disebabkan suhu yang tinggi. Panel PV akan beroperasi pada tahap yang terbaik apabila mendapat cahaya matahari yang banyak, akan tetapi pendedahan haba yang berlebihan akan mengurangkan tahap kecekapan dalam menukar foton-foton kepada elektrik dan tempoh operasi yang optimum. Cahaya matahari terdiri daripada cahaya dan haba. Oleh hal yang demikian, satu kajian yang menyeluruh tentang panel suria dalaman akan dijalankan, di mana satu analisis tentang penggunaan fiber optik sebagai panduan cahaya akan dikaji. Parameter yang diambil kira adalah jumlah foton yang dipandu ke arah panel melalui panjang fiber itu sendiri. Ianya boleh diukur melalui nilai kuasa yang dikeluarkan oleh beban arus terus (DC) dengan perbandingan terhadap panel PV luaran konvensional. Jumah haba yang terhasil juga diambil perhatian. Oleh itu, pengukuran suhu secara serentak telah dijalankan. Di akhir kajian ini, penggunaan optik fiber sebagai panduan cahaya untuk panel suria dalaman adalah dapat dioptimumkan

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LIST OF ABBREVIATIONS

ANN	-	Artificial Neural Network
CO_2	-	Carbon dioxide
CO	-	Carbon monoxide
I-V	-	Current vs Voltage
DC	-	Direct Current
DTC	-	Direct Flux and Torque Control
HC	-	Hydro-carbon
MCO	-	Movement Controlled Order
MPPT	-	Maximum Power Point Tracking
NA	-	Numerical Aperture
NiMH	-	Nickel Metal Hydride
O_3	-	Ozone -
PV	-	Photovoltaic
P-V	-	Power vs Voltage
RE	-	Renewable Energy
SOC	-	State of Charge
STC	-	Standard Test Condition
SSB	-	Sunda Strait Bridge
SDGs	-	Sustainable Development Goals
TCSEvOF	-	Transmission of Concentrated Solar Energy via Optical Fibers
UV	-	Ultra-violet

CHAPTER 1

INTRODUCTION

1.1 Overview

Sustainable development is the main topic discussed throughout the world, as declared in the Sustainable Development Goals (SDGs), that adopted by all United Nations Member States in 2015. It is a designated blueprint for peace and prosperity for people and the planet with 17 SDGs (shown in Figure 1.1) and 169 targets to be achieved [1]. The aim of this agenda is to build "sustainable cities and communities" with targets such as ensuring healthy lives at all ages, the availability access to affordable and sustainable of all energy and urgent actions to conserve and preserve the climate changes over the world. In order to achieve SDGs by 2030, vigorous actions need to be done in terms of generating clean, safe and reliable energy to communities.

Figure 1.1: 17 SDGs agreed by all countries in the United Nations on 2015 [1]

According to statistics, more than 50% of the population in developing countries, live in rural areas, with highly cost of delivered electricity. Consequently, the price is expensive and unaffordable to the rural poor giving rise to reduced standard of living and social inequity. In India, more than 70% of the population lives in rural regions and around 40% of the total population lives without any access to modern energy services [2]. In fact, in China, there are more than 50 million people living without electricity, which has a total rural population of 900 million. In fact, in 21st century, the energy industry in China is expected to face the double pressure from both economic growth and environmental protection [3]. The high cost of delivered electricity increases the operation on centralized energy systems which mostly uses fossil fuels for establishing transmission and distribution grids that can cater remote areas. As a result, the emission of hazardous gases might increase soon. Due to these problems, the development of renewable and alternative energy including solar energy is very important.

In [4], it is believed that solar energy is one of the best solutions to solve a decentralized energy supply. Solar energy is also one type of clean resource of energy which is not harmful to the environment. The high usage of fossil fuels has caused the global shifting towards renewable energy source like solar energy. Based on [5], almost 24% of the total energy used by buildings and 35% of energy used by buildings is contributed from lighting systems. Thus, the usage of solar panels can reduce the dependency on the conventional energy used for lighting systems with good management of energy.

Sunlight is the main source of all alternative energy. It is also widely known as solar radiation which refers to the incoming light coming from the Sun to the earth. It represents some portion of electromagnetic spectrum which are visible light, infrared light and ultraviolet light [6]. Due to this condition, heat is also produced from the radiation of sun. Thus, in order to capture and collect the sunlight, various methods have been used by the researchers. Two major methods are simply known as photovoltaic (PV) cells and solar thermal collectors. PV cells is an energy harvesting technology that make use a semiconducting material to convert sunlight directly into electrical energy. Meanwhile, solar thermal collectors are electricity generation plants that undergoes a few processes through concentrators to produce steam in order to generate electricity [6, 7].

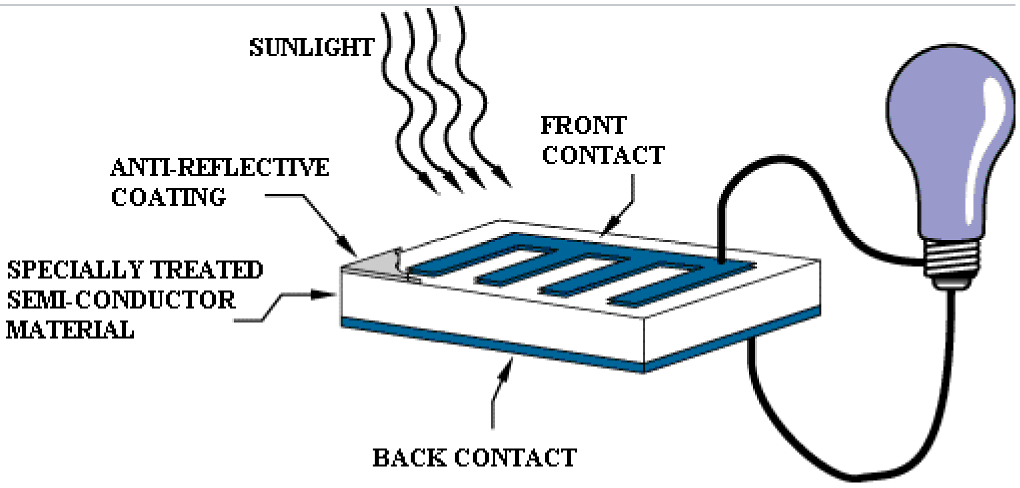

Figure 1.2: PV cells structure [6].

The anatomy of PV cells is shown in Figure 1.2 above. The most important part of PV cells is the built-in semi-conducting layer which consists of two layers; p-type and n-type. Here the photovoltaic effect will occur whereby the process of changing sunlight energy to electricity takes place. On both sides (front and back contact) of semiconductor is a layer of conducting material that able to collect any electricity produced. Backside of the cell is made up of conductor while front or illuminated side is made up from conductors sparingly to prevent a huge blocking of the Sun’s radiation from reaching the semiconductor layers. The anti-reflective coating is being used in the construction of PV cells to reduce the reflection of solar radiation on the surface of the cell (some solar radiation might reflect off the surface of the cell).

As per mentioned earlier, sunlight consists of light and heat. Most PV cells are placed outdoor in order to maximize the output efficiency of electricity. However, PV cells will degrade exponentially as the temperature increases. One of the most effective ways of increasing its output efficiency is reducing PV cell temperature. As for this project, indoor solar panel is proposed. The installation of indoor solar panel is possible as long as the amount of sunlight is directly travelled through a medium. Amount of photon guided through the panel is a concern so that the output efficiency produced can be compared together with the output efficiency produced by the outdoor solar panel. Fiber optics is a type of medium chosen in this project to be used by a light guide for indoor solar panel as it has an internal reflection property of light.

1.2 Problem Statement

Solar energy has become one of reasonable alternative nowadays to reduce the depletion of natural resources. However, the PV cells may deteriorate as temperature increases. Mostly the installation of PV cells is outside the building. The PV panel performs better as it gets sunlight, but excessive heat absorption by PV panel may reduce their output efficiency in converting sunlight to electrical power. The solar radiation itself carries heat energy as it penetrates on outdoor PV panel. The heat that comes along also ages the PV. Hence, there is a need to increase the PV performance as temperature increases and overcome the fast ageing of PV panel by installing PV panel from indoors.

1.3 Research Goal

The overall goal for the research is to optimize the usage of fiber optic as a light guide for indoor solar panel as well as increasing the life of PV cells. In order to achieve the goal, a few objectives have been identified as per discussed on the next section.

1.3.1 Research Objectives

The objectives of this research are:

(a) To conduct an extensive review of indoor solar panel and the use of optical fibers as a light guide.

(b) To conduct an experiment of Indoor Solar Panel by measuring the surrounding temperature, and output efficiency.

(c) To determine the effects of optical fibers presence as a light guide as well as analysing the measurement data which comprises of current, voltage and power output from the solar panel.

1.4 Scope of Works

The scope of works for the project are as shown below:

- The load type used is a DC load only since no inverter is involved in this study
- The Maximum Power Point Tracking (MPPT) obtained from the PV cells in this project is neglected by ensuring whole solar panel is illuminated
- The properties of fiber optics as a telecommunication medium which transmits the communication signals with specific standards is omitted since the length of fiber optic is only 1 meter.
- The irradiation of natural sunlight is not measured
- The luminosity of irradiation will be not be measured.

1.5 Report Structure

The report of the project consists of 5 chapters:

- Chapter 1: It explains about the introduction of the reports that reviews about the overall view of the project, problem statement, objectives, and scope of works.
- Chapter 2: It covers the previous research done by researchers related to this project. Various design and concepts of PV cells will be discussed further in this chapter.
- Chapter 3: It includes the proposed research methods and project flow before running the project. This chapter also discusses about the apparatus and tools used during the experiment
- Chapter 4: It presents the result obtained from the experiment. A few discussions and analysis are also been conducted in this chapter.
- Chapter 5: This chapter concludes the overall results from this project as well as some recommendations for future improvement.

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