
**FACULTY OF ELECTRICAL ENGINEERING**
**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**FINAL YEAR REPORT**

# SYSTEM PERFORMANCE EVALUATION OF UTeM SOLAR PV SYSTEM

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**May 2014**

" I hereby declare that I have read through this report entitle "System Performance Evaluation of UTeM Solar PV System" and found that it has comply the partially fulfilment for awarding the degree of *Bachelor of Electrical Engineering (Industrial Power).* "

Signature : _____

Supervisor's Name : _____

Date : _____

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**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**

**2014**

I declare that this report entitle “System Performance Evaluation of UTeM Solar PV System” is the result of my own research except 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 : _____

Name : _____

Date : _____

To my beloved mother and father

## ACKNOWLEDGEMENT

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Last but not least, I would like to say a word thanks to my family members, especially my parents for their constant supports and encouragement throughout the years.

Below is the published work as a result of my Final Year Project.

[1] H. S. Lew, C. K. Gan, and P. H. Tan, “The Performances of UTeM Solar PV Systems: An Evaluation,” in *The 2nd Power and Energy Conversion Symposium (PECS 2014)*, 2014, pp. 129–134.

## ABSTRACT

Renewable clean solar energy can be utilized by using a photovoltaic (PV) system to convert solar energy into electrical energy. This helps to reduce global warming and save the environment as it enables the user to reduce the amount of energy utilization from electricity grid, and it can also supply back the additional energy into the grid. This project presents the performances of the systems concerning mono crystalline silicon (Mono), thin film (TF), and heterojunction with intrinsic thin layer (HIT) grid-connected solar photovoltaic (PV) system, which are installed in the Faculty of Electrical Engineering of Universiti Teknikal Malaysia Melaka. The research was carried out based on the climatic condition in Malaysia. The performances of the solar photovoltaic (PV) inverters were also taken into consideration. The research was conducted at every 5 minutes interval, whereby the data were recorded and analysed to determine the system with the production of the highest energy yield. Several factors, such as inverter losses, cable losses, mismatch, and cloudy weather that influenced the solar photovoltaic (PV) system performance were also considered in this paper. After the data were analysed and the evaluation was done, it was found that the thin film (TF) system performed better than the heterojunction with intrinsic thin layer (HIT) and mono crystalline silicon (Mono) for the highest energy yield and system performance.

# ABSTRAK

Tenaga solar yang boleh dikatakan sebagai sumber tenaga bersih yang boleh diperbaharui boleh ditukar kepada tenaga elektrik dengan menggunakan sistem photovoltaic (PV). Penggunaan teknologi ini boleh membantu mengurangkan masalah pemanasan global dan secara tidak langsung dapat menyelamatkan alam sekitar. Hal ini demikian kerana penggunaan sistem ini dapat mengurangkan penggunaan tenaga daripada grid elektrik dan juga dapat menyalur kembali tenaga tambahan ke dalam grid elektrik. Projek ini membentangkan prestasi sistem yang menggunakan teknologi mono kristal silicon (Mono), filem nipis (TF) dan "heterojunction" dengan lapisan nipis intrinsic (HIT). Semua photovoltaic (PV) sistem ini telah dibina di Fakulti Kejuruteraan Elektrik Universiti Teknikal Malaysia Melaka. Kajian ini dijalankan berdasarkan keadaan cuaca di Malaysia dengan mengambil kira prestasi daripada penyongsang photovoltaic (PV) solar. Kajian ini dijalankan dengan merekodkan data pada setiap 5 minit dan data tersebut akan dikaji untuk menentukan sistem mana yang akan menghasilkan pengeluaran tenaga yang paling tinggi. Beberapa faktor yang akan mempengaruhi prestasi sistem solar photovoltaic (PV) juga akan dipertimbangkan seperti kerugian inverter, kerugian kabel, tidak sepadan, dan cuaca mendung dalam kajian ini. Selepas data diproses dan dikaji, kesimpulannya, penggunaan teknologi filem nipis telah menunjukkan prestasi yang lebih baik daripada teknologi "Heterojunction" dengan lapisan nipis intrinsik (HIT) dan mono kristal silikon (Mono) dalam penghasilan tenaga yang paling tinggi dan prestasi sistem.

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## LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| AC | - | Alternating current |
| CSP | - | Concentrated solar thermal |
| DC | - | Direct current |
| FiT | - | Feed-in Tariff |
| FKE | - | Fakulti Kejuruteraan Elektrik |
| FYP | - | Final Year Project |
| HIT | - | Heterojunction with intrinsic thin layer |
| MBIPV | - | Malaysia Building Integrated Photovoltaic |
| Mono | - | Mono crystalline silicon |
| Poly | - | Poly crystalline silicon |
| PV | - | Photovoltaic |
| STC | - | Standard test condition |
| TF | - | Thin Film |
| UTeM | - | Universiti Teknikal Malaysia Melaka |

## LIST OF SYMBOLS

| | | |
|---|---|---|
| A | - | Current |
| Hz | - | Frequency |
| kWh | - | Energy generation |
| kWh/kWp | - | Energy yield |
| m | - | Length |
| V | - | Voltage |
| W | - | Power |
| $Wh/m^2$ | - | Solar irradiance |
| Ω | - | Resistance |
| ℃ | - | Temperature |

# LIST OF APPENDICES

# CHAPTER 1

# INTRODUCTION

## 1.1 Research Background

The world global warming is in a critical stage. Scientists have estimated that the world's temperature will rise to another six degree Celsius if the emission of greenhouse gasses are not controlled [1]. This is will have a detrimental effect towards our environment and also causes climate changes to a country. One of the factors that affect global climate change is due to various human activity that changes the atmospheric composition [2].

Beside this, the carbon dioxide content in the atmosphere is steadily increasing which had climbed above 310 parts per million (ppm) and now it has almost reached 400 ppm.

The emission of the carbon dioxide gas that enters into the atmosphere has reached up to 90 million tons a day, and this increases the greenhouse properties that will lead to global warming [3]. Burning of forests and fossil fuels are some of the factors that cause global warming where it will lead to climate change. Hence, in order to reduce the emissions of these harmful gases into the atmosphere, the governments around the world need to support the development of clean energy sources, such as solar energy [4], for it is efficient and considered as cleaner fuels with multiple beneficial effects [5].

In Malaysia, the solar photovoltaic (PV) system has been implemented for a few years now, but they are still at the beginning stage due to the high initial cost of the PV system with the low solar electricity tariff rate [6]. This is because of the lack knowledge and information

about the solar PV system. The important of the system performance is to determine the highest energy yield of different type of solar PV technology. This can assists the investors to improve the high quality systems. There are natural factors such as solar irradiance and temperature that can affect the system performance[7]. Besides that, the importance of reducing the loss factor from solar equipment also need to be considered. This project is to evaluate on the system performance of solar PV systems connected in grid in Malaysia.

## 1.2 Problem Statement

There are many factors need to be considered in evaluating the performance of solar PV system. Factors that affect the system performance are the temperature losses, dust, cable losses, inverter losses, mismatch, fluctuation losses, transformer and shadow [8]. A good solar PV performance will produce the highest energy yields. For European, they do much research on solar PV performance on their own country but it is not necessarily applicable to tropical countries due to different climate conditions, temperature, ordinances, clouds and etc.

In Malaysia, PV systems or green technology development still lack of awareness among the citizen. Even though PV system is still new, there is lot of research have been conduct but all the relevant research or articles is more focus on solar cell than the solar system [9]. In general, there is no information regarding which solar PV systems is suitable to be installed as there is lack of professional in this field. Furthermore, there is study on the performance of the PV system technology which may affect the energy yields and make it hard to predict the performance level of PV system in Malaysia.

However, the performance of solar PV systems are not fully evaluated yet. Therefore, this study is carried out for determine which solar technology give the best system performance. This study is based on actual system according to tropical country weather conditions. In Universiti Teknikal Malaysia Melaka (UTeM), there are four different types of solar PV systems installed around the area of Fakulti Kejuruteraan Elektrik (FKE) which are the poly crystalline silicon (Poly), mono crystalline silicon (Mono), thin film (TF), and heterojunction with intrinsic thin layer (HIT). This project is to study and find out the details

of each PV system to conclude which system produces higher energy yield and this conclusion will help investors to have a better idea on which is a system is to be chosen.

## 1.3 Objective

The objectives of this project are:

- To investigate the system energy performance of PV system according to Malaysia climate conditions
- To evaluate the PV system component losses installed in UTeM FKE

## 1.4 Scope

This project is expected to evaluate the systems performance of the solar PV system and obtain the suitable PV technology of the system at UTeM FKE. There are four different types of solar PV system that are installed in UTeM FKE. The different types of solar panels have different levels of performances under different local climate conditions. The PV technology can be affected by the climate changes and this causes variation in the performance of the whole system. This will indirectly affect the investment of the investors as they are unable to obtain the best performance from the system they have invested due to these factors. Several factors that affect the performance of the system are considered in this project such as dust, cable losses, inverter losses and so on. These data were recorded at a five minute interval. To determine which system produces the best performance in energy yields, it can be done by collecting the data in the laboratory by daily, weekly and monthly. Based on the analysis, the energy yield of each system can be determined. Besides, the importance of reducing the loss factor from the solar equipment also needs to be considered. Therefore, this project was carried out to evaluate the overall performance of Mono, TF and HIT solar PV systems based on UTeM's climate conditions. This will help investors have a better idea on which is the best system that is to be chosen.

## 1.5 Project Outline

This project consists of five chapters. The first chapter is about the research background, problem statement, objectives, scope and expected outcome. Chapter 2 focus on the theory, basic principles and the review of previous work that have been done. In this chapter includes the basic theory about solar energy, solar cells and solar PV. In Chapter 3, the principles of the methods or techniques used in the previous work, case study, description of the work to be undertaken, project gantt chart and key milestones are discussed. Chapter 4 will be the discussion and analyzes the performances of the Mono, HIT, and TF PV systems. The results present the energy yield, performance ratio, and losses analysis based on spreadsheet data at Standard Test Condition (STC) of irradiance of 1000 $W/m^2$ at 25 ℃ for the systems. Chapter 5 concludes this project and prove the objectives of the project are achieved.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

This chapter provides an overview of solar PV system. It includes published materials on the study and research such as journals, case studies, books, technical documents and internet sources that has been selected relevant to this review. This chapter also describe about the theory and basic principles about solar energy, solar cells and solar PV system. Furthermore, summary and discussion of the review were included in this chapter.

## 2.2 Theory and Basic Principles

### 2.2.1 Solar Energy

Energy plays an important role in people's daily lives, their social activities and economical advancement in every nation. There are many different types of renewable energy in this world that can be used to generate electricity such as solar, wind, ocean, hydropower, biomass and so on. Solar energy is one of the best secondary sources of energy due to the fact that it has many benefits compared to other resources. Solar energy is the radiant energy provided by the sun [10]. It is a simply energy which is naturally available and a clean energy source. This energy is harvested in the form of solar radiation that can be used

directly to generate electricity [11]. Solar energy have several advantages and disadvantages and they are as shown in Table 2.1. The two main types of solar power conversion of sunlight into electricity are the concentrated solar thermal plant (CSP) and photovoltaic plant. This project focus on photovoltaic plant which is a solar PV system.

Table 2.1: Advantages and disadvantages of solar energy [6,9]

| **Advantage** | **Disadvantage** |
|---|---|
| No pollutant | Doesn't work at night |
| Low maintenance | Low efficiency in generation of electricity using solar energy |
| High reliability | Solar energy storage has not reached its potential yet. |
| Life span expectation up to 20-30 years | High cost of installing solar panels |
| Ongoing free energy | |
| Save eco-systems and livelihoods | |

### 2.2.2 Solar Cells

Solar cells is a device that converts sunlight into electricity as shown in Figure 2.1 below. Solar PV cell does not produce heat to generate electricity but it can generate electricity directly from the interaction of electrons from the radiant energy with the semiconductor materials in the PV cells. The PV cells are made of different material but the most common material is silicon. This is because the atomic structure of silicon makes it one of the ideal elements in making the cells. The amount of electricity that PV cells are able to generate depends on the size of cells, conversion efficiency and the intensity of light source. There are various types of PV technology such as mono crystalline silicon (Mono), poly crystalline (Poly), thin film (TF) and heterojunction with intrinsic layer (HIT). Each of solar PV technologies has its own performance. The characteristics of the four different types of solar technology are shown in Table 2.2. Figure 2.2 shows the process of solar PV cell to module and lastly become array.