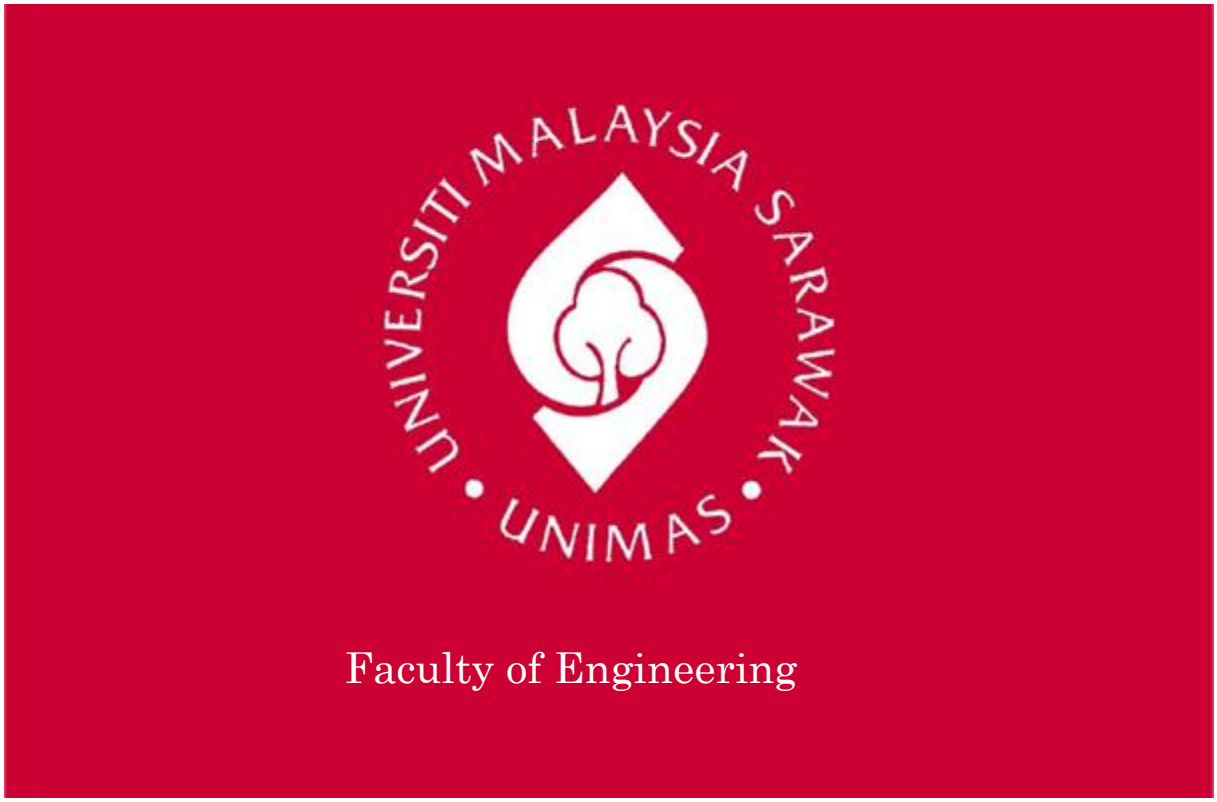

DESIGN OF ROOFTOP PV IN FACULTY OF ENGINEERING, UNIMAS BUILDING

Anatassia Lampai Anak Abut

Bachelor of Engineering

Electrical and Electronics Engineering

with Honours

2022

UNIVERSITI MALAYSIA SARAWAK

Grade: _____

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Final Year Project Report ☒

Masters ☐

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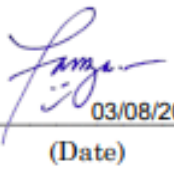
Supervisor signature:  03/08/2022 (Date)

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DESIGN OF ROOFTOP PV IN FACULTY OF ENGINEERING, UNIMAS BUILDING

Design Of Rooftop Pv In Faculty Of Engineering, Unimas Building

ANATASSIA LAMPAI ANAK ABUT

A dissertation submitted in partial fulfilment
of the requirement for the degree of

Faculty of Engineering

Universiti Malaysia Sarawak

2022

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ABSTRACT

Renewable energy is widely used to replace conventional energy as conventional energy has negative impact on environment. A few common renewable energy are solar energy, wind energy, biomass energy, geothermal energy, etc. Solar energy has been extensively used in Malaysia as this country has climate of hot and humid throughout the year. In this few years, it can be seen an increase in installation of solar farms and rooftop solar system in Malaysia. Rooftop solar system is more suitable for urban area as it is installed on buildings' rooftop and does not required additional area. Thus, this project was conducted to design rooftop solar system in Faculty of Engineering, UNIMAS buildings. PVSyst 7.2 software was used to simulate and evaluate the design of grid -connected PV system while Meteonorm 8.0 for climate data collection. Apart from that, power demand was determined using Fluke 435 as sizing of PV system was based on power demand. In the simulation, types of solar panels were varied to investigate which gives best performance of PV system. Specifications of inverter were remained the same throughout the simulation. Results show that to meet power demand of the building, 105kW of PV system with 525 of Si-Mono 200Wp 24V and nine 9.0kW inverters gives the highest Performance Ratio and thus, such design was chosen for this project.

ABSTRAK

Tenaga boleh diperbaharui telah digunakan secara meluas untuk menggantikan tenaga konvensional kerana tenaga konvensional memberi impak negatif kepada alam sekitar. Contoh tenaga boleh diperbahurui ialah tenaga solar, tenaga angin, tenaga biomas, tenaga geothermal dan lain-lain. Tenaga solar banyak digunakan di Malaysia kerana negara ini mempunyai cuaca panas dan lembap sepanjang tahun. Beberapa tahun ini, terdapat peningkatan dalam jumlah ladang solar serta pemasangan solar atas bumbung bangunan di Malaysia. Pemasangan solar di atas bumbung bangunan adalah lebih sesuai untuk kawasan bandar kerana tidak memerlukan kawasan tambahan. Oleh sebab itu, projek ini dilaksanakan untuk mereka bentuk pemasangan solar di atas bumbung bangunan Fakulti Kejuruteraan, UNIMAS. Perisian PVSyst 7.2 digunakan untuk simulasi serta evaluasi reka bentuk sistem PV yang bersambung ke grid manakala Meteonorm 8.0 digunakan untuk pengumpulan data cuaca. Selain itu, permintaan kuasa yang diperlukan bangunan ini telah dikenalpasti menggunakan Fluke 435 kerana penentuan saiz sistem PV adalah berdasarkan permintaan tersebut. Dalam simulasi, jenis solar panel telah divariasikan untuk menyiasat yang boleh memberikan kualiti yang terbaik untuk sistem PV tersebut. Spesifikasi untuk inverter adalah sama sepanjang simulasi. Hasil simulasi menunjukkan bahawa untuk mencapai permintaan kuasa bangunan, 105kW sistem PV dengan 525 Si-Mono 200Wp 24V dan sembilan 9.0kW inverter menghasilkan Performance Ratio yang tertinggi. Oleh sebab itu, konfigurasi ini telah dipilih untuk projek ini.

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LIST OF ABBREVIATIONS

PV	-	Photovoltaic
MIDA	-	Malaysia Investment Development Authority
DC	-	Direct Current
AC	-	Alternating Current
TNB	-	Tenaga Nasional Berhad
SEB	-	Sarawak Energy Berhad
FYP	-	Final Year Project
PPE	-	Personal Protection Equipment
Si-Mono	-	Silicone Monocrystalline
Si-Poly	-	Silicone Polycrystalline
FENG	-	Faculty of Engineering
PR	-	Performance Ratio
Ls	-	System Loss
Lc	-	Collection loss

Chapter 1

INTRODUCTION

1.1 Background

Renewable energy is very common to human and has been studied for a long time. Generally, renewable energy is known as energy that produced from sources that can be continuously replenished. Examples of the sources are solar, hydropower, wind, geothermal and biomass. Renewable energy is expected to replace conventional energy, for example crude oil, natural gas and coal in the future to ensure better life for mankind and environment. This is because conventional energy brings more negative than positive impacts especially to the environment.

Many countries had their focus on developing renewable energy and outline aim in reaching 100% renewable energy in future. Iceland and Norway are the examples of countries that use renewable energy to generate their electricity. Renewable energy currently provides around 85% of all primary energy in Iceland [1] and Norway had generated 147TWh electricity which 143.6TWh came from renewable energy by 2018 [2]. Malaysia is also one of the countries that had invested in renewable energy. According to MIDA, power generation strategy by Malaysia target to increase the share of renewable energy in installed capacity to 31% within 2025 and 40% within 2035 [3]. Datuk Seri Dr Shamsul Anuar Nasarah who is Minister of Energy and Natural Resources, said that in order to expand renewable energy in the power capacity mix, the government would concentrate on Peninsular Malaysia, which contributes 80% of the country's energy consumption [3].

Malaysia has a climate of hot and humid throughout the year which makes solar energy has high potential in this country. The country has been focused on installing more solar farms especially in Peninsular Malaysia. The largest solar farms that has been constructed in Malaysia is located in Sepang, Selangor which 230,000 of solar panels has been installed on land with area of 98 hectares in Mukim Tanjung 12, Sepang. This solar farm has the capacity of 50MWac

and said to increase renewable energy capacity of TNB to national grid up to 73.2MW [4]. Figure 1.1 illustrates the above view of the largest solar farm.

Figure 1.1: Malaysia's largest solar farm which located in Sepang, Selangor [4].

In Sarawak, only 25% of Sarawak's energy demand is met by solar energy, with the remaining 75% met by other energy sources [5]. The installation of solar power by SEB in Sarawak is focused on rural area such as Lubok Antu. Sarawak Energy's CSR Solar projects have benefited nine longhouses in the Batang Ai region since 2014. In 2019, SEB has successfully supplied electricity to 31 households of Rumah Bada, Nanga Talong at Batang Ai, Lubok Antu using solar power. The RM1.45 million project began in June 2018 and ended in May 2019 [6]. Figure 1.2 shows the aerial view Rumah Bada longhouse and its solar powerhouse.

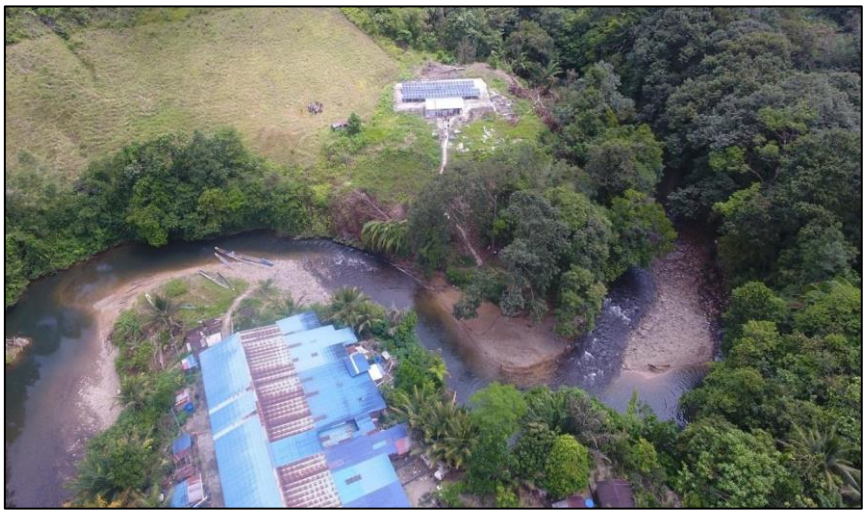

Figure 1.2: Aerial view of Rumah Bada longhouse and its solar powerhouse [6].

Solar energy is a renewable energy that converts sunlight into electricity. Two important elements in implementing this energy are solar panel and dc-ac inverter. Multiple solar panels are placed in array position on a rooftop while the inverter is preferably placed away from direct sunlight with proper air ventilation. A solar panel consists of multiple photovoltaic cells which are made from materials such as monocrystalline or polycrystalline that has different efficiency of absorbing the sunlight. Each photovoltaic cell consists of two layers of silicon that makes a thin semiconductor wafer. These layers form an electric field as one layer has protons (p-type silicon) while another has electrons (n-type silicon) [7]. During sunny day, these PV cells absorbed the light energy from the sun which later get energize and makes the electrons to "come loose" from atoms within the semiconductor wafer [8]. The electric field that surrounds the wafer causes the electron to move which leads to the formation of direct current. The direct current is converted into alternating current using the solar inverter and later is distributed within the home. Figure 1.3 shows the illustration of this process.

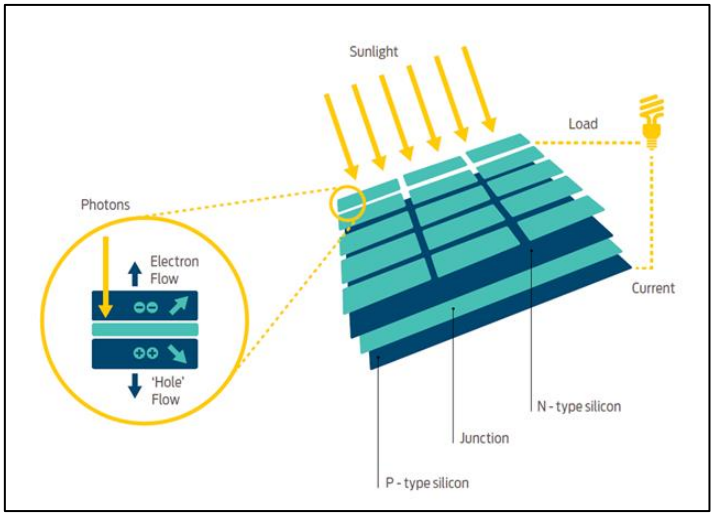

Figure 1.3: Two layers of silicon in PV cells [9].

In recent years, there has been a lot of interest in estimating rooftop solar potential in metropolitan areas [10]. Rooftop solar PV is an alternative for solar farms in urban areas. Solar farm needs large land area for the solar panel to be placed while rooftop solar requires none of it. The excellent financial returns had caused solar farms as a popular choice among investor. However, their negative consequences are frequently overlooked. Solar farms threaten vast agricultural landscapes and compete with other renewable energy sources for restricted land, such as bioenergy feedstock systems [11]. Rooftop solar pv is practical in urban area as no

additional land needed to place the solar panel. Figure 1.4 and 1.5 show the example of rooftop solar PV in an urban area.

Figure 1.4: Rooftop solar PV in TNB building [12].

Figure 1.5: Rooftop solar PV at Mölnlycke in Malaysia [13].

1.2 Problem Statement

Although conventional energy is the main resources for energy production throughout all countries including Malaysia, it is undeniable that the use of conventional energy did affect the environment and mankind negatively. This is due to the fact that non-renewable energy emits greenhouse gases which is fairly known as one of the causes of global warming. According to study by Mirhosseini, Mirani and Miri [14], greenhouse gases emission is measured in CO2E/kWh and combustion of natural gas produces between 0.6 and 2 pounds of CO2E/kWh and coal burning releases between 1.4 and 3.6 pounds of CO2E/kWh. Contrarily, they found out that wind energy only emits 0.02 to 0.04 pounds of CO2E/kWh on a life-cycle basis, solar energy produces 0.07 to 0.2, geothermal 0.1 to 0.2 and hydroelectric between 0.1 and 0.5. An article written by Nunez [15] also supports that conventional energy emits more greenhouse gases compared to renewable energy where she stated that 44% of carbon dioxide emissions worldwide total are from coal combustion which makes it the most significant factor of global warming above pre-industrials level. These comparisons have shown that conventional energy is more harmful to the nature compared to the renewable energy.

Besides, there is more greenhouse gases emission in urban area compared to rural area. According to study by Shahidan and Shafie [16], carbon dioxide is mainly emitted in cities due to the urbanisation and transportation industry. Urban areas have high human population which means massive used of resources such as fossil energy to meet the needs for human activities. For example, the needs of transportation increased inside the city to meet the growing population and allowed people's movement to anywhere. The issue emerges when the transportation industries increased to meet people's mobility demand that causes rising in emission of carbon dioxide in the city [17]. Apart from that, as human population grows in urban areas, more electricity needs to be generated to meet the needs of the humans. Resource management may be much more difficult in highly urbanised areas where peak electrical demand exceeds average consumption [18].

Malaysia is one of the countries that actively involved in developing the renewable energy where it is strategized to increase the installation of renewable energy to 31% by 2025 [3]. Furthermore, UNIMAS is one of the educational institutions that actively conducting research on the application of renewable energy in Sarawak which is done by Faculty of Engineering. Thus, all above discussions show that it is a good opportunity to implement

rooftop solar PV system in Faculty of Engineering building in order for better investigation and validation by the lecturers and students of this faculty.

1.3 Objectives

i. To design rooftop solar PV system at Faculty of Engineering Building, UNIMAS

ii. To investigate suitable parameters for the solar PV including quantity and specifications of solar panel and inverter.

iii. To validate the performance of energy generation by solar PV system using PVSyst software.

1.4 Research Significance

In Malaysia, most of the solar PV projects that have been conducted were the implementation of solar farm/ powerhouse. Although rooftop solar PV system is quite popular in urban areas, most of the installed systems were in small scale and only involved individual's residents. Thus, this study will contribute in rooftop solar PV system in Sarawak and advantageous to UNIMAS engineering student as the implementation of this system is at Faculty of Engineering, UNIMAS which can be a study medium on solar system.

1.5 Scope of Research

The scope for this project involves the software development only. This project will be carried out with the following steps:

i. Calculate energy demand
    - Energy demand of Faculty of Engineering building will be calculated using power analyser.

ii. Collection of climate data
    - Climate data will be collected using *Meteonorm 8.0* software.

iii. Design and evaluation of the developed system.
    - To design, simulate and evaluate the performance of proposed system using *PVSyst 7.2* software.

1.6 Report Structure

This written report includes five chapters where each chapter discusses the different aspect of the study. Chapter 1 is the introduction of the report. The purpose of this chapter is to introduce the study as a whole. Chapter 2 is the literature review. This chapter consists of subtopics that are written based on scholarly books, journals and articled which provide overview of current knowledge and identify relevant understandings. Next chapter is Chapter 3: Methodology. Chapter 3 explains the methodology that are executed in this study. Chapter 4: Discussion follows after Chapter 3. This chapter discusses all results and findings throughout this project. The last chapter is Chapter 5: Conclusions whereas to conclude the whole report and provide recommendations. This report also attached with appendix as additional documents that provide extra information on this project.

1.7 Summary

To summarise this chapter, the design of rooftop solar PV system in Faculty of Engineering Building, UNIMAS will be developed with a purpose to increase the usage of renewable energy in Sarawak. This is due to the fact that the reduction use of conventional energy can help to lessen the negative impact to the environment and mankind. The climate data will be collected using *Meteonorm 8.0* software and solar PV system will be designed using *PVSyst 7.2* software as well as its performance will be evaluated and validated. All the findings will be documentated in a full report with a total of five chapters.