



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**DESIGN AND PERFORMANCE ANALYSIS OF SOLAR  
BICYCLE FOR A SUSTAINABLE LOCAL COMMUTE**

This report submitted in accordance with requirement of the Universiti Teknikal  
Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology  
(Industrial Power) (Hons.)

by

**MUHAMAD FAKRI HAKIM BIN KAMARUZAMAN**

**B071210021**

**911028-03-6003**

FACULTY OF ENGINEERING TECHNOLOGY  
2016

## BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **DESIGN AND PERFORMANCE ANALYSIS OF SOLAR BICYCLE FOR A SUSTAINABLE LOCAL COMMUTE**

SESI PENGAJIAN: **2015/16 Semester 2**

Saya **MUHAMAD FAKRI HAKIM BIN KAMARUZAMAN**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **\*\*Sila tandakan (✓)**

SULIT

(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

TERHAD

(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)

TIDAK TERHAD

Disahkan oleh:

(TANDATANGAN PENULIS)

(TANDATANGAN PENYELIA)

Alamat Tetap:

**NO.RPT Chenulang**

Cop Rasmi:

**18000 Kuala Krai,**

**Kelantan,**

\*\* Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

**FAKULTI TEKNOLOGI KEJURUTERAAN**

Tel : +606 234 6623 | Faks : +606 23406526

Rujukan Kami (Our Ref) :  
Rujukan Tuan (Your Ref) :

26 JAN 2016

Pustakawan  
Perpustakaan UTeM  
Universiti Teknikal Malaysia Melaka  
Hang Tuah Jaya,  
76100 Durian Tunggal,  
Melaka.

Tuan/Puan,

**PENKELASAN LAPORAN PSM SEBAGAI SULIT/TERHAD LAPORAN  
PROJEK SARJANA MUDA TEKNOLOGI KEJURUTERAAN EL EKTRIK  
(BETI)MUHAMAD FAKRI HAKIM BIN KAMARUZAMAN**

Sukacita dimaklumkan bahawa Laporan PSM yang tersebut di atas bertajuk  
**“DESIGN AND PERFORMANCE ANALYSIS OF SOLAR BICYCLE FOR  
A SUSTAINABLE LOCAL COMMUTE”** mohon dikelaskan sebagai \*SULIT /  
TERHAD untuk tempoh LIMA (5) tahun dari tarikh surat ini.

2. Hal ini adalah kerana IANYA MERUPAKAN PROJEK YANG DITAJA  
OLEH SYARIKAT LUAR DAN HASIL KAJIANNYA ADALAH SULIT.

Sekian dimaklumkan. Terima kasih.

Yang benar,

\_\_\_\_\_  
Tandatangan dan Cop Penyelia

\* Potong yang tidak berkenaan

**NOTA: BORANG INI HANYA DIISI JIKA DIKLASIFIKASIKAN SEBAGAI  
SULIT DAN TERHAD. JIKA LAPORAN DIKELASKAN SEBAGAI TIDAK  
TERHAD, MAKA BORANG INI TIDAK PERLU DISERTAKAN DALAM  
LAPORAN PSM.**

## **DECLARATION**

I hereby, declared this report entitled “Design and Performance Analysis of Solar Bicycle for a Sustainable Local Commute” is the results of my own research except as cited in references.

**Signature** :.....

**Name** : **MUHAMAD FAKRI HAKIM BIN KAMARUZAMAN**

**Date** : .....

## **APPROVAL**

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Power Industrial) (Hons.). The member of the supervisory is as follow:

.....  
(Emy Zairah Binti Ahmad)

## **ABSTRACT**

The solar powered transport offers potential advantages to replace the usage of fossil fuel transportation by the communities. It can reduce the dependency on the non-renewable energy such as petroleum, coal and diesel that will depletes soon. Solar power is type of renewable energy that will not last forever even if we keep using it day by day. It is derived from the sun radiation and can be collected and converted into electricity by the solar module such as crystalline and thin film type based on photovoltaic effect. The goal of this project is to design a model of solar powered bicycle for sustainable local commute in order to reduce the usage of fossil fuel. The design of the bicycle has been using PVGIS software and manually .The bicycle basically consist of 60 Watt Thin Film solar panel that directly connected to the 2 of 12 Volt of deep cycle lead acid battery with capacity of 13Ah each via the solar charge controller (SCC). The 250 Watt brushless DC motor is mounted on the bicycle and controlled by using motor controller and throttle. The performance of this solar bicycle analyzed in terms of its feasibility and economic aspects.

## ABSTRAK

Kenderaan berkuasa solar menawarkan pelbagai kelebihan yang berpotensi untuk menggantikan penggunaan pengangkutan yang menggunakan bahan api fosil oleh masyarakat untuk perjalanan yang sederhana. Keadaan ini secara tidak langsung dapat mengurangkan pergantungan kepada tenaga yang tidak boleh diperbaharui seperti petroleum, arang batu dan diesel yang kita semua maklum akan kehabisan tidak lama lagi. Kuasa solar adalah jenis tenaga boleh diperbaharui yang tidak akan habis selama-lamanya walaupun kita terus menerus menggunakannya hari demi hari. Ianya berasal dari sinaran matahari dan boleh dikumpul dan ditukar menjadi tenaga elektrik oleh modul solar seperti jenis kristal dan thin film dengan menggunakan kesan fotovolta. Projek ini akan mereka bentuk sebuah model basikal berkuasa solar untuk tujuan berulang-alik tempatan yang mampan untuk mengurangkan penggunaan bahan api fosil dalam pengangkutan. Perisian PVGIS digunakan dalam projek ini untuk mereka bentuk sistem basikal. Basikal ini pada dasarnya terdiri daripada 60 Watt panel solar thin film yang disambungkan terus kepada 2 x 12 Volt asid plumbum bateri dengan kapasiti 13Ah setiap satu melalui pengawal caj Suria (SCC). 250 Watt brushless motor DC akan dipasang pada basikal dan akan dikawal menggunakan alat kawalan motor dan pendikit. Prestasi basikal solar ini akan dianalisis dari segi daya maju dan aspek ekonomi.

## **DEDICATIONS**

Specially dedicated to my family and friends,  
For all the love and support, comes hell or high water



## ACKNOWLEDGMENTS

I would like to express my gratitude to Universiti Teknikal Malaysia Melaka (UteM) for giving me opportunities to pursue my studies in Degree in Electrical Engineering Technology. First of all, I want to thank Allah S.W.T. the Almighty God. With His blessings, I am able to complete this research of my Final Year Project. I would like to thank my project's supervisor, Mrs Emy Zairah Binti Ahmad for her supervision, encouragement and suggestion upon completing my research project. She guides, motivates and helps me in order to accomplish my project and not to forget my panels Mrs Halyani and Mr Syahrul Hisham ,for their support and guidance.

I would like to thank other lecturers as they give me a helping hand by teaching me the theories and explaining the fundamental of my research project.

Last but not least, thank you to my parents and friends. They give me support and ideas to complete my research project. I am really grateful with their help. Thank you.

# TABLE OF CONTENTS

DECLARATION .....	iv
APPROVAL.....	v
ABSTRACT.....	vi
ABSTRAK .....	vii
DEDICATIONS.....	viii
ACKNOWLEDGMENTS .....	ix
TABLE OF CONTENTS.....	x
LIST OF FIGURES .....	xv
LIST OF TABLE .....	xvi
LIST OF SYMBOLS AND ABBREVIATIONS .....	xvii
CHAPTER 1 .....	1
1.0 Introduction .....	1
1.1 Background .....	1
1.2 Problem Statement .....	2
1.3 Objectives of Research .....	2
1.4 Scope of Research .....	3
CHAPTER 2 .....	4
2.0 Introduction .....	4
2.1 Renewable Energy.....	4
2.1.1 Solar Energy.....	5

2.1.2	Wind Energy .....	5
2.1.3	Hydroelectric Power.....	5
2.1.4	Biomass .....	6
2.2	Solar Power System.....	6
2.2.1	Stand-Alone Power System.....	6
2.3	Solar Panel.....	7
2.3.1	Crystalline Silicon (c-Si).....	8
2.3.1.1	Monocrystalline .....	8
2.3.1.2	Polycrystalline .....	8
2.3.2	Organic Solar Panel.....	9
2.3.3	Thin Film Solar panel .....	10
2.4	Comparison between Crystalline and Thin Film.....	11
2.4.1	Cost .....	11
2.4.2	Efficiency .....	12
2.4.3	Temperature and Shaded Tolerant .....	12
2.4.4	Flexibility .....	12
2.5	Solar Charge Controller (SCC) .....	13
2.6	Electric vehicle .....	13
2.6.1	Electric Powered Bicycle .....	14
2.6.2	Solar Powered Bicycle .....	14
2.7	Motor .....	14
2.7.1	AC Motor .....	15
2.7.1.1	Induction Motor .....	15

2.7.1.2	Synchronous motor .....	15
2.7.2	DC Motor .....	16
2.7.2.1	Brushless type DC Motor.....	16
2.7.2.2	Brushless type DC Motor .....	17
2.7.3	Advantages of Brushless DC Motor .....	17
2.8	Rechargeable Batteries .....	17
2.8.1	Lithium-ion Battery.....	18
2.8.2	Lead Acid Battery .....	18
2.8.3	The Advantages of Lead Acid Battery.....	18
CHAPTER 3	.....	20
3.0	Introduction .....	20
3.1	Project design and development.....	20
3.1.1	Sizing the System.....	22
3.1.1.1	Load Estimation.....	22
3.1.1.2	Solar Array Sizing .....	23
3.1.1.3	Battery Sizing .....	23
3.1.2	List Out the Materials and Component .....	24
3.1.3	Design of Hardware .....	24
3.2	Project implementation and development .....	25
3.2.1	Construct the hardware of the project .....	26
3.2.2	Hardware materials and component.....	26
3.2.3	Hardware testing .....	27
3.2.4	Identify and troubleshooting the problem.....	27

3.3	Project evaluation and completion .....	28
3.3.1	Data collection .....	29
3.3.2	Performance evaluation.....	29
CHAPTER 4 .....		30
4.0	Introduction .....	30
4.1	Stand-alone PV Estimation .....	30
4.2	Data for PV panel .....	31
4.2.1	PV panel testing.....	33
4.3	Data collecting.....	34
4.3.1	Data of output of Voltage and current testing.....	35
4.3.1.1	Voltage output testing.....	35
4.3.1.2	Output current testing .....	37
4.4	Test drive results .....	38
4.4.1	Travel range performance and power utilization performance .....	38
4.5	Cost analysis.....	39
4.6	Discussion .....	40
4.7	Limitations.....	41
CHAPTER 5 .....		42
5.0	Introduction .....	42
5.1	Conclusion.....	42
5.2	Recommendations for further research .....	43
APPENDIX A .....		45
APPENDIX B .....		46

APPENDIX C .....	51
APPENDIX D .....	52
REFERENCES.....	55

## LIST OF FIGURES

Figure 2.1: Monocrystalline Solar panel.....	5
Figure 2.2: Polycrystalline Solar Panel.....	6
Figure 1.3: Organic Solar Panel .....	7
Figure 2.1: Thin-film Solar Panel .....	9
Figure 2.4: DC Motor Construction .....	15
Figure 3.1: Phase 1 Design and Development.....	21
Figure 4.2: Flow Chart For Phase 2 .....	21
Figure 4.2: Flow Chart For Phase 3.....	21
Figure 4.4: Map and stand-alone PV estimation.....	31

## LIST OF TABLE

Table 2.4	: Comparison between crystalline and thin film.....	11
Table 3.1	: load estimation for the project.....	26
Table 3.3 (a)	: data of average energy production per day .....	28
Tabel 3.3 (b)	: monthly energy output.....	28
Tabel 3.3 (b)	: data of average energy per day.....	28
Tabel 4.3	: cost analysis.....	38





# CHAPTER 1

## INTRODUCTION

### 1.0 Introduction

This chapter will provide the details about the background, problem statements that lead to this study, the objectives and the scopes of this study.

### 1.1 Background

Transportation in nowadays era is one of the important medium for daily usage of human. Each of the transport are differentiate from each other by its characteristic in term of size, speed, capacity and other aspects. In this project, the type of transportation is bicycle specifically. Nowadays, the main type of transportation that used over the world is fossil fuel transportation that used non-renewable energy like petroleum and diesel. As we have known, this type of energy is decreasing and will be depleted soon. Since , the bicycle with combination use of renewable energy has potential to replace the fossil fuel transportation in local commute area , the performance of the bicycle is important for the sustainable local commute.

Hence, in order to overcome and provide the solution for this problem, the project focal point is to design and analysis the performance of solar bicycle for a sustainable local commute area was initiated. This projects aim to provide a bicycle powered by solar energy and gets its supply from the solar photovoltaic (PV) panels and drive by an DC electric motor to replace the usage of fossil fuel transportation like car, motorcycle and others that's always used in the local commute area such as the playground, campus and residential areas. The PV must be installed at the bicycle without affected the comfortability during riding. The PV that act as solar collector will be connecting to the Solar Charge Controller (SCC) for the purpose of collecting solar radiation and converting the energy into usable electrical power that

is stored in the deep cycle rechargeable batteries . The battery is connected to the motor for supplying the electrical power to drive the DC motor.

## **1.2 Problem Statement**

Nowadays, communities around us use transportation that relies heavily on fossil fuel as the main energy sources. They depend on the use of non-renewable energy such as petroleum and diesel that decreasing day by day and will be depletes soon. This situation also will give impacts to the environment by increasing the environmental pollution like carbon dioxide emission and thinning of the ozone layer.

Other than that, they always use small vehicle like bicycle to go to the groceries store, playground and others. It is not much suitable if the place is situated a little far away because the more distance they travel the more energy they need to ride the bicycle.

## **1.3 Objectives of Research**

The main objectives of this project are:

- To design a model of solar powered bicycle for a sustainable local commute in order to reduce the usage of fossil fuel in transportation.
- To analyse the performance of the solar bicycle in terms of its feasibility and economic aspects.

## 1.4 Scope of Research

The scope of this research is limited to the following items so that the research could be focused to achieve the stated objectives. These scopes include:

- The types of the transport for the projects: bicycle. This is because the bicycle is always used by the society in order to travel nearby.
- The types of the energy source : solar power (generated from thin film solar PV)
- Types of solar panel that will be used in this project is thin film
- Areas of implementation for this project is local commute area such as playground, campus and residential area. This is because the community always use the chosen transport in their daily usage.

# **CHAPTER 2**

## **LITERITURE REVIEW**

### **2.0 Introduction**

This chapter will be stressed on the literature review of related system. The main purpose of this chapter is to analysed, identify and make conclusion based on the previous research. According to (Strauss and Corbin 1990), a literature review means a collecting related data, analysed business process, identify underlying patterns and create the conclusion. Another description of the literature review is a systematic, clear and repeated ways to identifying, judging and synthesizing the existing body of full and recorded work proposed by the researcher. In order to develop a successful project, the current systems will be identified. The system of conventional electric powered bicycle, solar system and its connection have been analyzed. Studies of these systems are significant to develop a valid, reliable and efficient upgrade project. The Literature Review part acts as a mean to discover which methodology should be chosen in developing this system.

### **2.1 Renewable Energy**

(Reuters, 2011) states that renewable energy is the energy sources that can be replenished naturally in a short period of time. This energy will not last forever even if we keep using it. This type of energy comes from natural resources. Renewable energy flows involve the natural phenomena such as sunlight, wind, tides, plant growth, and geothermal heat . In its various forms, it derives directly from the sun, or from heat generated deep within the earth. Renewable energy resources may be used directly, or used to create other more convenient forms of energy. Currently we are relies heavily on non-renewable energy such as coal, oil, and natural gas for our energy. According to (Danielson, 2013), the world's energy could be deducted to

one quartle by 2050 if individuals and corporation being together to save energy from now on and begin to depending on renewable energy sources provided by the the power companies and privated consumption.

### **2.1.1 Solar Energy**

This form of energy obtained from the sun through the form of solar radiation and relies on the nuclear fusion power from the core of the sun. This energy can be collected and converted in a few different ways. International Energy Agency (2011) , said that the growth of fair, inexhaustible and fresh solar energy technologies will give long-term advantages. It will add the countries' energy security through dependence on a pure, not run out and mostly important source, improve sustainability, decreased the number of pollution, reduce the costs of mitigating global warming, and keep fossil fuel prices lower than otherwise.

### **2.1.2 Wind Energy**

Wind is simply air in motion. It is caused by the uneven heating of the Earth's surface by the sun will generate clean energy. Because the Earth's surface is made of very different types of land and water, it will absorb the sun's heat at different rates. The turbine is used to generate the electricity without creating pollutants. The example of this uneven heating can be found in the daily wind cycle.

### **2.1.3 Hydroelectric Power**

Hydropower or water power is power obtained from the energy of falling water, which may be used for good purposes. Since a long time ago, the hydropower has been used for watering and the operation of variety mechanical devices, such as watermills, textile mills, sawmills, and domestic lifts. Hydropower relies on the water cycle. Since water is about 800 times denser than air, even a slow flowing stream of water, or moderate sea swell, can yield considerable amounts of energy.

#### **2.1.4 Biomass**

Biomass can be described as organic material that made up from plants and animals. Biomass contains stored energy from the sun. Green plants will absorb the sun energy via a process called photosynthesis and then the chemical energy in plants gets passed on to animals and people that eat them. Biomass can be grouped into renewable energy resources because we can always grow more trees and waste will always be exist. Some examples of biomass fuels are wood, crops, and some garbage. When they are burned, the chemical energy in the biomass will release as heat. Wood waste or garbage can be burn to produce steam and generated electricity, or to provide heat to the industries and homes.

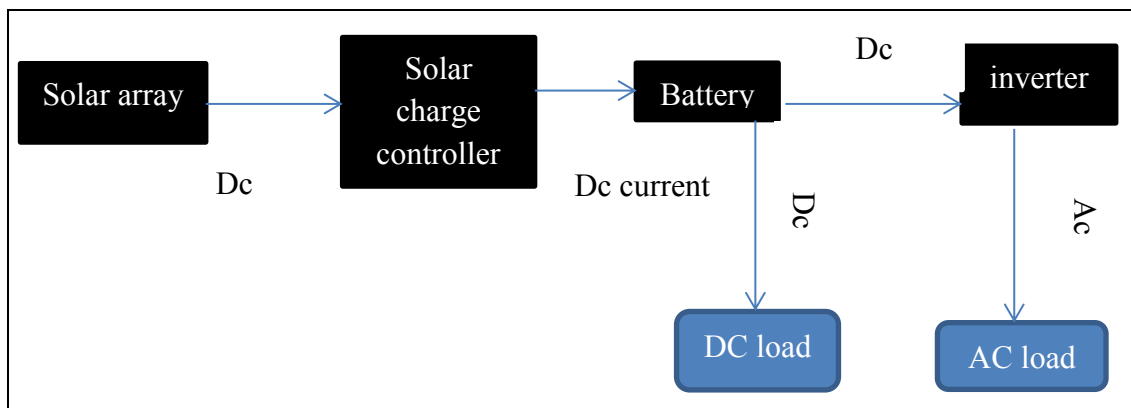
### **2.2 Solar Power System**

Solar power or solar energy are come from the sun that situated around 90 million miles from the earth. According to (Ciosek, 2014), it takes just only 9 minutes for the sun to reach the earth. For every hour, the sun gives more than enough power to satisfy global energy needs for an entire year that needs by the earth. It has produced the energy to this earth for the billions of year and it is become the most important form of energy for living thing to survive. It is used by the plant in the photosynthesis process by convert the solar energy by the green plant into the chemical energy. The radiation of the sunlight is converted to the electricity by the solar cells. The solar system can be divided into two that is On-Grid system and Off - Grid system that sometimes be called Grid connected and stand-alone solar system.

#### **2.2.1 Stand-Alone Power System**

A stand-alone power system (SAPS) or also known as remote area power supply (RAPS) is an of Off-Grid power system that is independent and do not

connected to the electricity grid in order to supply electricity to the load or consumer. It is most often used in remote rural area where the electricity grid does not reach to them. The DC power generated from the system will be stored in the batteries and be converted to AC power by the inverter for the uses of AC appliances. This system is most preferred and best suited to the remote village or to the rural electrification project.



Figures 2.5: Stand- alone solar system block diagram

### 2.3 Solar Panel

Solar panel or usually refers as a photovoltaic (PV) module, is the main component in the solar energy system that convert the sun radiation directly into usable electricity. It is comprised from several individual solar cells.(Mifflin, 2011) defines solar cells as a type of photoelectric semiconductor device that converts the solar energy into electrical energy. Solar cells utilize large area of p-n junction diode and when it is exposed to the sun radiation or light it will convert the energy into a usable of electrical energy. Photovoltaic effect is refer to photons of light exciting electrons into a higher state of energy, it will allow them to act as a charge carriers for an electric current as viewed in Mrsolar website. There are 3 basic types of solar panel module. They are differentiated based on their construction and the efficiency. Each of the type has advantages and disadvantages itself.