UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN ON RAINFALL'S VIBRATION BASED POWER GENERATION MODULE FOR RURAL AREA IN MELAKA

This report submitted in accordance with requirement of the Univerisiti Teknikal Malaysia, Melaka (UTeM) for the Bachelor Degree of Engineering Technology Industrial Power with Honours

by

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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TAJUK: **DESIGN ON RAINFALL'S VIBRATION BASED POWER GENERATION MODULE FOR RURAL AREA IN MELAKA**

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Date : 9 DECEMBER 2016

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 Degree of Engineering Technology Industrial Power with Honours. The member of the supervisory is as follow:

…………………………………

(Encik Muhamad Faizal Bin Yaakub)

ABSTRACT

The project purpose is to design a power generation module that can harvest energy from the rainfall's vibration for rural area in Melaka. Malaysia has equatorial and tropical climate throughout the years with high temperatures in the earlier months and rainy season in the following months. According to Tenaga Nasional's Berhad website portal, the electrical tariffs in Malaysia start increasing since 2014. The objectives are to design a module for alternative power generation which generates electricity by harvesting the natural energy that produced from the raindrops, to analyse the kinetic energy conversion method and its efficiency that affects towards the module, and to verify the module performance which capable to collect data results. Some background research and Multisim simulations will be done. The designing hardware development will be conducted to make it suitable to apply in rural area of Melaka. The data results will be collected from the lab scale testing.

ABSTRAK

Projek ini direkabentuk untuk kegunaan tenaga semula jadi daripada getaran air hujan yang boleh menghasilkan elektrik untuk kegunaan pengguna elektrik di Melaka. Melaka mempunyai cuaca yang sesuai untuk projek ini iaitu cuaca panas di permulaan tahun dan cuaca hujan di bulan yang seterusnya. Mengikut sumber daripada laman web Tenaga Nasional Berhad, elektrik tariffs di Malaysia mula meningkat sejak tahun 2014. Objektif untuk menjalankan projek ini adalah untuk mereka bentuk projek modul dengan menggunakan tenaga semula jadi dalam penghasilan elektrik, meneliti effek tenaga kinetik kepada projek modul dan untuk mengenalpasti kualti projek modul ini. Latar belakang projek modul akan dilakukan serta simulasi daripada software Multisim akan dijalankan. Tujuan untuk merekabentuk projek modul ini supaya dapat diaplikasikan kepada pengguna di Melaka. Data eksperimentasi akan dicatat di dalam ruangan seterusnya.

DEDICATION

To my beloved parents

Kamarudin Bin Abu Hassan

Kamisah Binti Ali

To my supervisor:

Encik Muhamad Faizal Bin Yaakub

ACKNOWLEDGMENT

By the name of Allah, the Most Compassionate Most Merciful. I would wish to show my gratitude to Allah for providing me the blessings to complete this report. I represent my gratitude to Universiti Teknikal Malaysia Melaka (UTeM) for yielding me the opportunities to make this final year project report. I am grateful to my supportive and helpful supervisor, Encik Muhamad Faizal bin Yaakub for assisting and guiding me in the completion of this research. In all truthfulness, without him, the project would not have been a complete one. Encik Muhamad Faizal bin Yaakub has always been my source of motivation and direction. I am truly grateful for his continual support and cooperation in assisting me all the way through the semester

Last but not least, I would wish to give my thanks to my mother, my father, and all my family who has always been in that respect for me. Finally, I would like to express my appreciations to all my friends, colleagues, and everyone who has helped me in this journey. Without their support, I would not have been able to finish my project report.

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

The project's introduction, background, problem statement, objectives and project scope will be focused in this chapter. The process and development of the module will be explained more in details throughout the following chapters.

1.0 Introduction

Malaysia is a country that located in the Southeast Asia and has two regions that made up of Peninsular Malaysia and East Malaysia (the Malaysian Borneo). Malaysia is widely known as one the country with tropical climate because of the country is located near the equator of the world. It has equatorial climate with being hot and humid throughout the years. The average amount of rainfall in Peninsular Malaysia is around 2500mm while in East Malaysia is around 5080mm of the rain. The average temperature in Malaysia has range from 20ºC to 30ºC. In the early months of the year, the amount of rainfall is below average. When the rainy season appeared at the end of the year, it caused the amount of the rainfall to increase beyond the average.

Melaka is one of the states that located at the Peninsular Malaysia. There is still villages existed which located in the rural area. Recently, Melaka had experienced flood due to the heavy rain on 7 June 2015. The purpose of this project is to design a power generation module that can harvest the energy from the rainfall's vibration and suitable to be implemented in the rural area of Melaka.

Figure 1.0.1: Peninsular Malaysia and East Malaysia

The energy sector in Malaysia is handled by the Tenaga Nasional Berhad (TNB) which is the largest electric utility company in the Southeast Asia. Recently, the demands in electricity are increasing especially in 2014 and broke a record with the highest electricity demand of history in 2016. The power generation module will be designed and developed. This project will generate electricity to help and support the community that lives in the rural area of Melaka by decreasing their electric bills.

1.1 Background

In this project module, the component of the hardware that will be used is the piezoelectric sensor. The first type of piezoelectric chosen is the Polyvinylidene DiFluoride (PVDF). The PVDF sensor will detect mechanical energy such as strain or vibration energy and convert it to electrical energy. The PVDF sensor is small, flexible and high sensitivity at low frequencies. The structure of the plate is a Polymer film with screen printed silver ink electrodes and laminated with polyester substrate. It also has 2 crimped contacts. The bending of the plate will create high strain and high voltages are generated. The output of the PVDF sensor is sufficient to trigger MOSFET or CMOS stages.

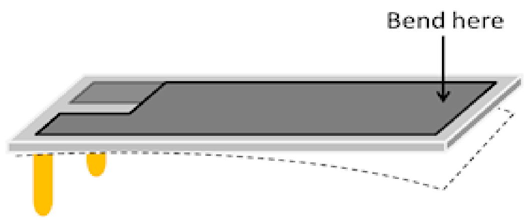

Figure 1.1.1: PVDF piezoelectric transducer

Besides that, the PVDF sensor can act as accelerometer or vibration sensor. The PVDF sensor has been used widely in the several applications such as vibration sensing in washing machine, low power wakeup switch, low cost vibration sensing, car alarms, body movement of machine or robot, and security systems. The PVDF sensor is tested as flexible switch and the results are written in a datasheet as below.

Tip deflection (mm)	Charge output (nC)	A/C Voltage Output (V)
2	3.4	7
5	7.2	15
10	10 - 12	20 - 25
Max (until 90º)	>30	>70

Table 1.1.1: PVDF piezoelectric as flexible switch

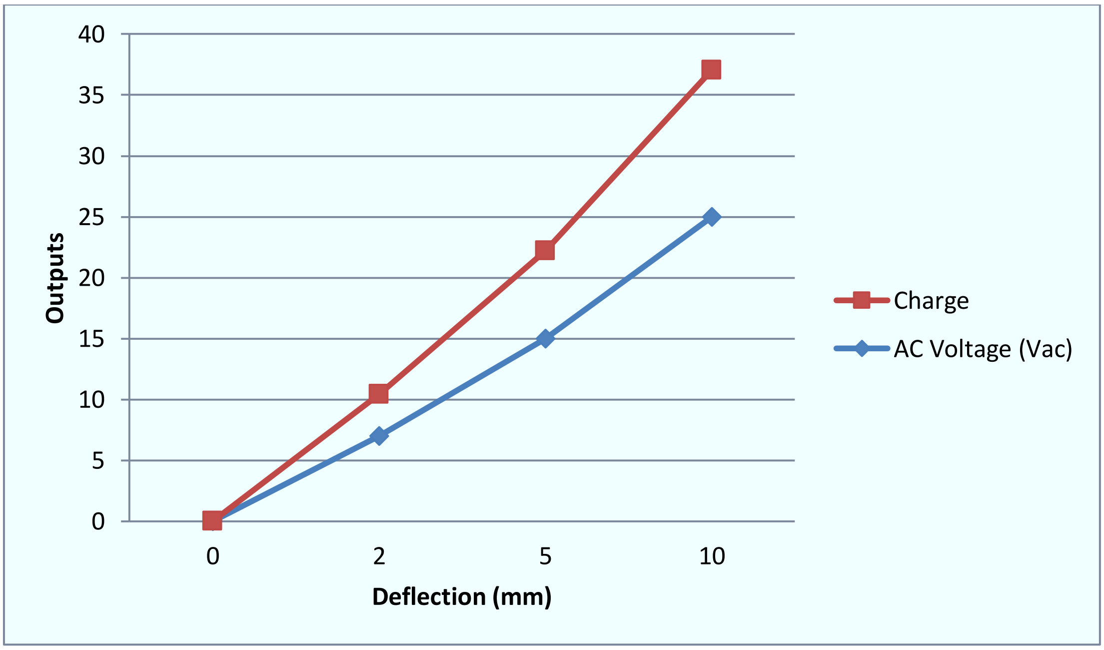

Figure 1.1.2: Graph of Voltage output vs Tip deflection

The second type of piezoelectric transducer chosen is the Lead Zirconate Titanate (PZT). This type of piezoelectric transducer is made from ceramic materials called ceramic perovskite hence when the compound changes its shape when an electrical field is applied. Besides, the PZT has constant sensitivity and inexpensive transducers compared to PVDF. This PZT is one of the piezo ceramics that can withstand any mass or vibration that applied but the PZT's high sensitivity will degrades over time. Most likely the degradation is related with increased temperature.

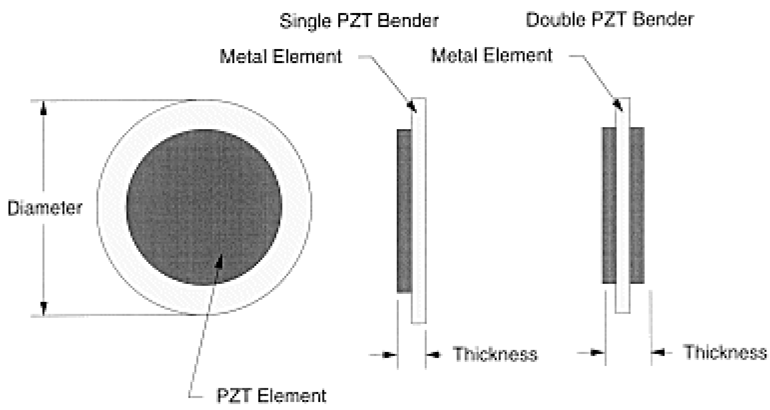

Figure 1.1.3: PZT piezoelectric transducer

The PZT is widely and commonly used as components of ultrasound transducers and ceramic capacitors, scanning tunnelling microscope actuator tubes and atomic-force microscopy actuator tubes. It also used in high value ceramic capacitors and also the FRAM chips. Furthermore, PZT is used in electronic circuits for reference timing as ceramic resonators.

1.2 Problem Statement

Recently, the interest in renewable energy sources and its reliable working is rapidly growing and giving much attention without using conventional thermal power or nuclear plants according to the demand for energy in developing countries by MET (2015a). Energy in the surrounding area can be capture and the latest energy that can be harvest is by converting mechanical energy from raindrop's vibration into electricity that can be used to power sensors or other device by Zyga (2008). Malaysia has equatorial and tropical climate with being hot and humid throughout the years. It will be high temperatures in earlier months and rainy season in the following months. The method of harvesting energy from rainfall is a good alternative as sustainable power system where it is installed in the tropical region with rain season by Wong et al. (2016a) especially in the rural area of Melaka.

The energy demands arise as the years pass on by Warude et al. (2015a). According to Tenaga Nasional Berhad (TNB), the electrical tariffs in Malaysia start increasing in 2014 due to the high demands. The TNB record stated that the demand in electricity start to increase on 28 May 2014 with 16,583MW. In the following years, the latest electrical tariff showed that the electrical bills are also increasing in 2016. According to TNB, the highest electricity demand in Malaysia's history with 17,175MW on 9 March 2016. This record had broken the previous record of 16,901MW in 6 June 2014. This means that the renewable energy sources are focused to avoid environmental and energy crisis by Warude et al. (2015b). The type of piezoelectric plates that will be use is the Polyvinylidene Fluoride (PVDF). Energy generations are done by binding the plates to make the structures vibrate and gain physical strain for generation of electricity by Dakua and Afzulpurkar (2015). When a single raindrop hitting the piezoelectric plates, it generates voltages less than a dozen of volts but no evaluation on power is proposed by Miceli et al. (2014).

The piezoelectric materials are used as mechanisms to transfer ambient motion which is vibration, into electrical energy and stored or used to power devices by Sodano and Inman (2004). In real rainfall, the raindrops' impact has different position of the piezoelectric by Wong et al. (2016b). The powering devices require a size that is suitable with the application, sufficient power and extended lifetime using permanent and ubiquitous energy sources by Park (2010). To solve the problems this module is require to build and to apply in the rural area of Melaka for community usage. Based on the problems, there is a need to design, to configure and to verify this module that will harvest the energy from the rainfall. The most suitable solutions for the low power supply are by using the piezoelectric materials to be use in this project module.

1.3 Project Objectives

This project is the design of rainfall's vibration based power generation module for rural area in Melaka was developed to give more convenience to the user. There are several objectives as follows:

1. To design a module for alternative power generation which generates electricity by harvesting the natural energy that produce from the raindrops. The designated module has to be suitable to use and apply in the rural area.

2. To analyze the output parameters that relates with kinetic energy conversion method and its efficiency that affects towards the module. The effect from the kinetic energy of the raindrops is the impact of the raindrops on the module surface which produce vibration energy.

3. To verify the module performance and efficiency between two types of piezoelectric transducers. The data results are from the field study and lab scale testing. The data parameters involve voltage, current, calculated output power that applied during the rain time.

1.4 Project Scope

According to the Malaysian Meteorological Department, there will be rainy season which means the quantity of the rain in this season is above the average of the amount of rain for every end of the year in Malaysia. This project will focus on the alternative power generation which can harvest the natural energy from the raindrops to produce electricity. The project will be applied in the rural area of Melaka. In 7th June 2015, Melaka was one of the states in Malaysia that experienced flood due to the heavy rain. The simulation that will be used is Multisim software to present the signal output. The hardware of the module will be design using the PVDF (Polyvinylidene Fluoride) piezoelectric.

Field study and field data collection will be taken in the working area only. The instruments that will be use to obtain the data results are parameters of multimeter and calculated power. The multimeter will show the output of voltage and current while the calculated power will present the output power. The cost due to this module will be examined for the community usage. This project has some limitation. The test and measurement are limited to a certain rainy days. The field test will be conduct in Ayer Keroh, Melaka, Malaysia. The project will focus on the development of the module.

CHAPTER 2

LITERATURE REVIEW

2.0 Conditions and weather changes in Malaysia

Malaysia is known as an Asian country that located at the east side of the world which has equatorial and tropical climate throughout the years with high temperatures in several months at the beginning of every year and rainy season in the following months. The sky is always cloudy and the wind is lightly even though the country is located near to the equator of the world. The country has climate with uniformly temperature, high humidity and greater amount of rainfall throughout the years. As the following years passed by, Malaysia is a country whereby the amount of rainfall increases which has proven during year 1975 to 2010 by Syafrina et al. (2014a). Hourly rainfall data between the years 1975 and 2010 across the Peninsular Malaysia were analysed for trends in hourly extreme rainfall events. The analyses were conducted on rainfall occurrences during the northeast monsoon (November–February) known as NEM, the southwest monsoon (May–August) known as SWM, and the two inter-monsoon seasons, March–April (MA) and September–October (SO) by Syafrina et al. (2014b). Malaysia has never run out from direct sunlight except during the northeast monsoon. According to the Meteorology Malaysia (MET) (2015b), the amount of rainfall in Malaysia shows from January 2015 to March 2016.

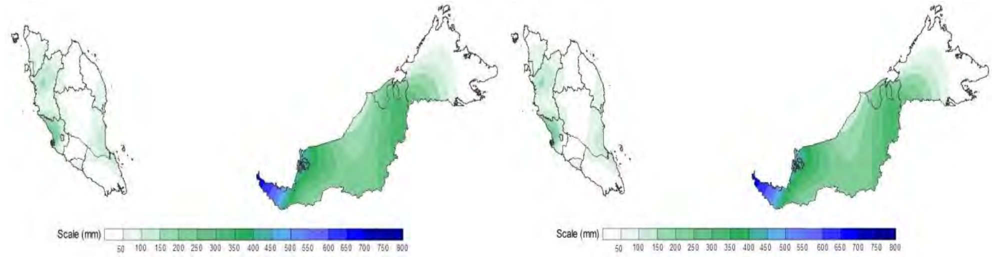

Figure 2.0.1: Northeast Monsoon (NEM) on January 2015 and February 2015

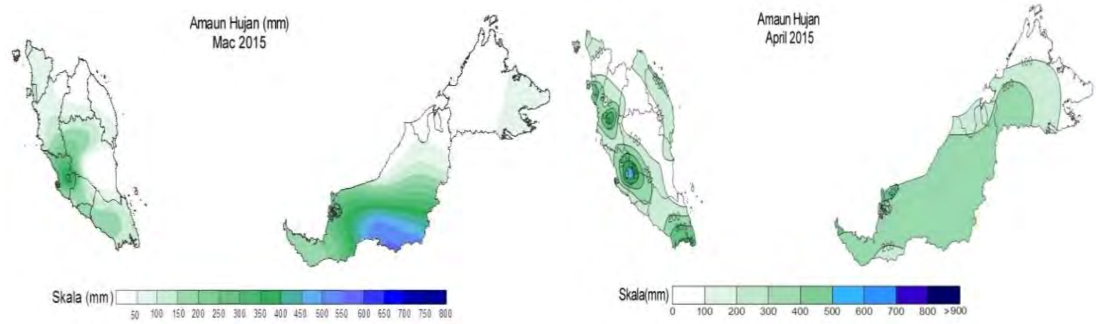

Figure 2.0.2: Two Inter-Monsoon (MA) on March 2015 and April 2015

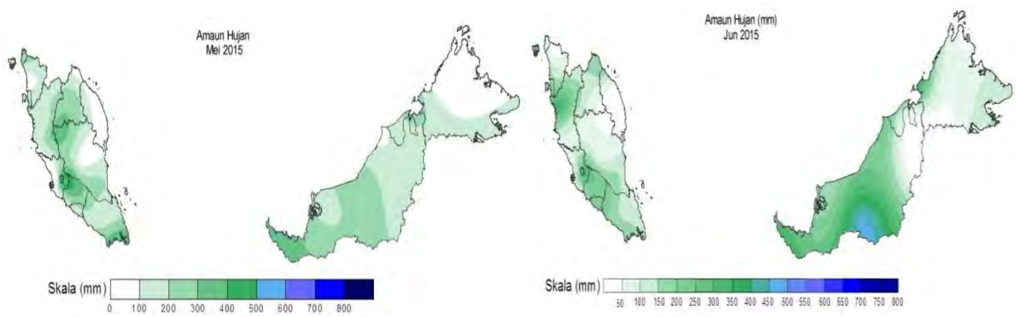

Figure 2.0.3: Southwestern Monsoon (SMM) on March 2015 and Jun 2015

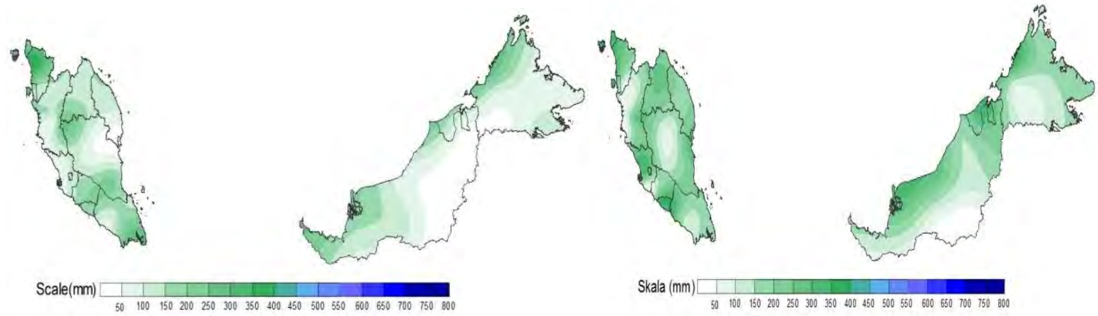

Figure 2.0.4: Southwestern Monsoon on July 2015 and August 2015

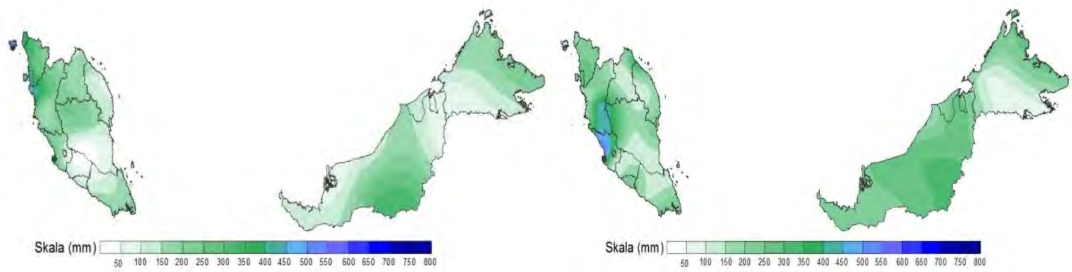

Figure 2.0.5: September 2015 and October 2015 (SO)

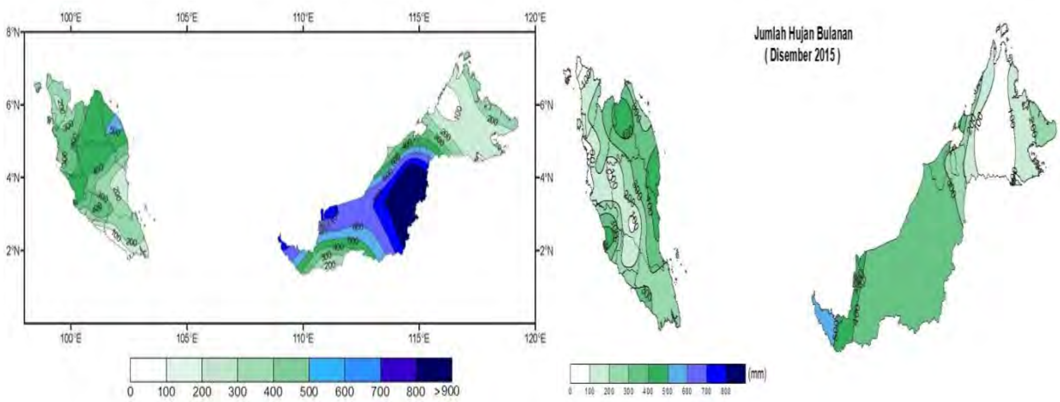

Figure 2.0.6: Northeast Monsoon on November 2015 and December 2015

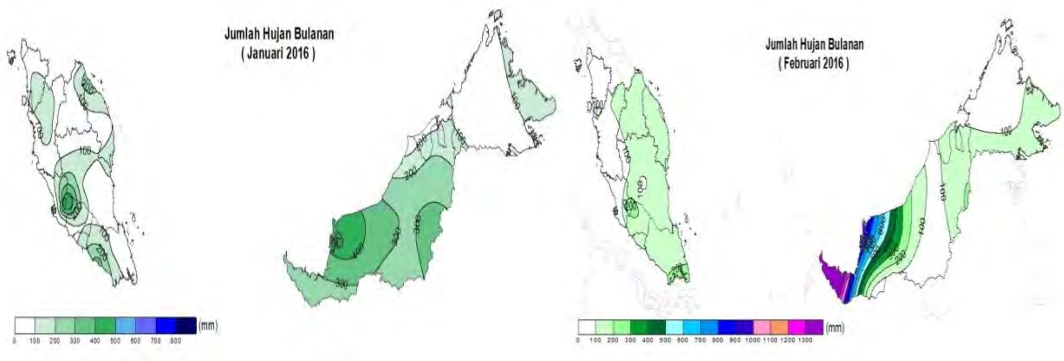

Figure 2.0.7: Northeast Monsoon on January 2016 and February 2016

Melaka is one of the states that achieved status as a developing country in 2010 and starting to achieve the country's vision towards 2020. According to the Melaka Green Technology policies, the state government has set three objectives such as to increase the process of developing in the state, to strengthen the state status of the city, and to improve the state status through the use of sustainable technologies and practically apply the Green Technology. Melaka has goals to achieve the title of "State Urban Green Technology" and 7 major sectors of UN-UAE framework focusses are in power, time reduction, urban design, urban environment, transportation, environmental health and air. In order to achieve one of these goals the study will be focused and conducted in Melaka.

There is monsoon season occurrence at Malaysia. The monsoon season is divided into four types of occurrence such as Northeast Monsoon (NEM) which occurred between November to February, two inter-monsoon season which occurred in March and April (MA), Southeast Monsoon (SWM) which occurred during May until August, and occurred in September and October (SO) by Syafrina et al. (2014c). The total amount of rainfall in the eastern region of Peninsular Malaysia has the higher indices during the Northeast monsoon by Syafrina et al. (2014d). That explained the flash floods that happened in the eastern states of Peninsular Malaysia such as Kelantan, Terengganu and Pahang. The NEM occurrence affects Sarawak too as show in the map figures which taken from the MET portal website. Furthermore, the Northeast Monsoon occurrence has indices for the highest number of very wet hours and extreme hours compared to others by Syafrina et al. (2014e).

According to the bar chart 1 below which is taken from World Weather and Climate Information website (2015), the amount of rainfall in Melaka when the NEM occurred between November until February 2015 shows a decreasing trend. However, it shows that the amount of rainfalls in Melaka has the highest value in November 2015 because it is the earlier of NEM season. During two inter-monsoon seasons (MA), the western region of Peninsular Malaysia represents the higher indices of the amount of rainfall by Syafrina et al. (2014f). These affect the Melaka area and it is proven by the bar chart figure 2.0.8 below that shows an increasing trend from March to April. The average amount of rainfall in Melaka is maintained from May to August when the SWM season happened by Syafrina et al. (2014g).

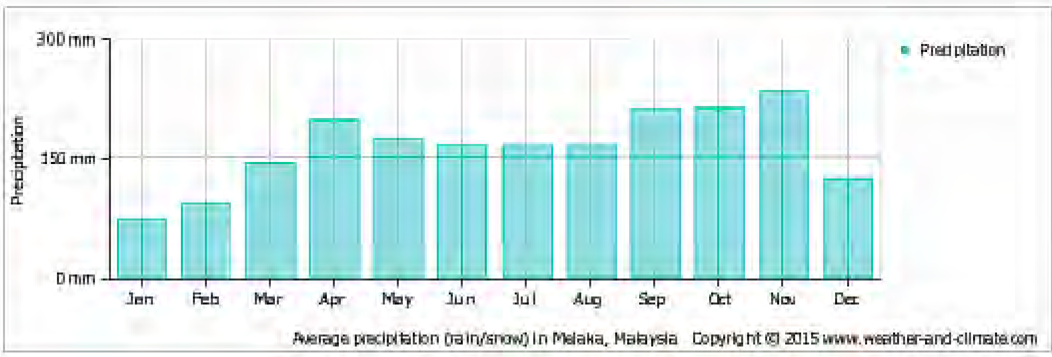

Figure 2.0.8: Average precipitation (rain/snow) in Melaka, Malaysia by by Syafrina et al. (2014h).

2.1 Power generation from the rain source

Alternative energy harvesting has many ways in this engineering field. One of the energy harvesting is from the water source which is the rain. A micro hydro generator is installed in a household for the usage of water consumption that can generate electricity by Yan et al. (2011a). This generator is built and developed by a concept from hydropower systems which the types are conventional and pumped storage. The selection of generator and the size of the turbine are important which depends on the results. In this previous study by Yan et al. (2011b), the permanent magnet generator and the turbine are set up in a small scale according to the turbine design in the market. After the prototype is completed, several tests were conducted which are turbine test, open circuit test and system test to determine the how much power can be generated. The prototype of Micro Hydro Generator has been built which consists of turbine and generator. This project is able to generate approximate 7 V and 17 mA. With the help of circuitry part, this generated power is able to charge up hand phone by Yan et al. (2011c).

Throughout another previous study by Martin and Shrivastava (2013a), a domestic power generation using rooftop rain water harvesting method is used. The harvested rain water is stored in a tall building and the underground storage tank is for collecting the rain water for other uses by Martin and Shrivastava (2013b). In this Rooftop Hydroelectric Generation, the rain water in the storage above flows through the channels from the roof and runs down to the turbines that connected to a generator. The excess storage of rain water on the underground will be used for other uses such as plants and gardens. The designing of the micro hydroelectric power generation is upgraded by adding the vacuum to pump the water from the underground storage flowing back to the above storage during non-rainy days. The designing involves storage tanks, pipe network, and flow control valves for this Rooftop Rain Water Harvesting system. The wettest place generates power of 5kW throughout this power generation by Martin and Shrivastava (2013c). The data of average power is taken and shown in the table 1.