ELECTRICITY GENERATION FROM RAINWATER HARVESTING SYSTEM FOR URBAN AREA

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DECLARATION

I declare that this thesis entitled "ELECTRICITY GENERATION FROM RAINWATER HARVESTING SYSTEM FOR URBAN AREA is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

Name : WONG JIA XIN

Date : 30/6/2021

APPROVAL

I hereby declare that I have checked this report entitled "ELECTRICITY GENERATION FROM RAINWATER HARVESTING SYSTEM FOR URBAN AREA" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Electrical Engineering with Honours

Signature : .....

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Date : 4/7/2020

DEDICATIONS

To my beloved mother and father

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ABSTRACT

Electricity plays an important role in our modern daily lives on everywhere and every time. However, electricity access to the urban population was found to be insignificant reflecting that electricity is not always available when it is needed in the urban areas. Some of the urban citizens are even cannot afford the extreme electricity cost bill. The demand for electrical energy is also increasing rapidly in every country in the world and thus the increasing depletion of fossil fuel had led to a concern action for example replacement of renewable energy. Malaysia is a tropical country that enjoyed tropical weather year-round and somehow interspersed with tropical rain showers. Thus, our country is suitable on implemented hydro renewable energy to replace fossil fuels. This study aimed to develop a Rainwater Harvesting System (RHS) to generate electricity and analyze the performance of output power. The RHS used the principle of hydropower technology, which is more cost affordable and easy implemented for beginners than other renewable power technology. There are two main parts consisted in the RHS which are mechanical and electrical parts. The generator generates output energy using the flowing rainwater collected from the rooftop. The rainwater is then flowed through the pipe and the turbine is rotated to generate electricity. In this project, a micro-hydro generator is used to generate electricity and a water flow sensor meter is used to measure the flow rate of water. The performance of output power is analyzed by using different head meters and flow rates of water. The result of the project showed that the experimental output power is nearly the same as the calculated output power. However, the experimental result in high-speed water is more efficiency compared with low-speed water. This is due to the higher the head meter will increase the water pressure and thus the output generated power produced will become higher. RHS is very beneficial to us and has become increasingly popular to be used in every country to enhance the depletion problem of fossil fuel and the increasing cost of electricity.

ABSTRAK

Elektrik memainkan peranan penting dalam kehidupan seharian moden kita di mana-mana dan setiap masa. Walau bagaimanapun, akses elektrik ke penduduk bandar didapati tidak signifikan mencerminkan bahawa elektrik tidak selalu tersedia ketika diperlukan di kawasan bandar. Sebilangan warga kota bahkan tidak mampu membayar bil kos elektrik yang melampau. Permintaan untuk tenaga elektrik juga meningkat dengan pesat di setiap negara di dunia dan dengan demikian, penipisan bahan bakar fosil yang semakin meningkat telah menyebabkan tindakan yang membimbangkan misalnya penggantian tenaga yang dapat diperbaharui. Malaysia adalah negara tropika yang menikmati cuaca tropis sepanjang tahun dan entah bagaimana diselingi dengan hujan tropika. Oleh itu, negara kita sesuai dengan tenaga boleh diperbaharui hidro yang dilaksanakan untuk menggantikan bahan bakar fosil. Kajian ini bertujuan untuk mengembangkan Sistem Penuaian Air Hujan (RHS) untuk menjana elektrik dan menganalisis prestasi kuasa output. RHS menggunakan prinsip teknologi tenaga hidro, yang lebih berpatutan dan mudah dilaksanakan untuk pemula daripada teknologi tenaga boleh diperbaharui yang lain. Terdapat dua bahagian utama yang terdiri daripada RHS iaitu bahagian mekanikal dan elektrik. Penjana menghasilkan tenaga output menggunakan air hujan yang mengalir yang dikumpulkan dari atas bumbung. Air hujan kemudian dialirkan melalui paip dan turbin dipusingkan untuk menghasilkan elektrik. Dalam projek ini, penjana mikro-hidro digunakan untuk menjana elektrik dan meter sensor aliran air digunakan untuk mengukur kadar aliran air. Prestasi daya output dianalisis dengan menggunakan meter kepala dan kadar aliran air yang berbeza. Hasil projek menunjukkan bahawa daya output eksperimen hampir sama dengan daya output yang dikira. Walau bagaimanapun, hasil percubaan dalam air berkelajuan tinggi lebih kecekapan dibandingkan dengan air berkelajuan rendah. Ini kerana semakin tinggi head meter akan meningkatkan tekanan air dan dengan itu kuasa yang dihasilkan output akan menjadi lebih tinggi. RHS sangat bermanfaat bagi kami dan telah menjadi semakin popular untuk digunakan di setiap negara untuk meningkatkan masalah kekurangan bahan bakar fosil dan kenaikan kos elektrik.

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LIST OF SYMBOLS AND ABBREVIATIONS

DC	-	Direct Current
FIS	-	Fuzzy Inference System
FLC	-	Fuzzy Logic Controller
GHGs	-	Greenhouse Gases
MHLG	-	Ministry of Housing and Local Government
NWRC	-	National Water Resources Council
RE	-	Renewable Energy
RES	-	Renewable Energy Source
RHS	-	Rainwater Harvesting System
SCORE	-	Sarawak Corridor of Renewable Energy
SHPS	-	Small Hydropower Systems

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CHAPTER 1

INTRODUCTION

1.1 Background

Malaysia is continuously exploring an alternative source of energy to become another form of an electrical source. The demands for utilization of natural renewable energy sources such as solar, water, biomass, wind, and geothermal are increasing to replace the use of fossil fuels. Hydropower technology is one of the examples of renewable energy sources to achieve the current power demand in Malaysia. In the context of hydropower technology, rainwater and river are also considered as a renewable energy and natural resources. The unfiltered water source from rainwater or river can also be used to generate energy by converting the energy in water to electrical energy. Thus, it is named as hydroelectric power or hydropower.

A typical hydropower plant consists of a dam or a mountain reservoir used to stores water and creates the head, penstocks used to carry water from the reservoir to turbines inside the powerhouse, a powerhouse and an electrical power substation used to produce electricity by driving the generators when the flowing water rotating the turbines [1].

Hydropower is based on the principle that flowing and falling water has a specify amount of kinetic energy potential associated with it [2]. The micro-hydropower plant consists of a turbine with a generator to transform the kinetic energy in the flowing water into electrical energy and usually generates output power in the range of 5 to 100kW of output electricity. Hydropower generation mainly depends on the amount of water flow rate and the head meter.

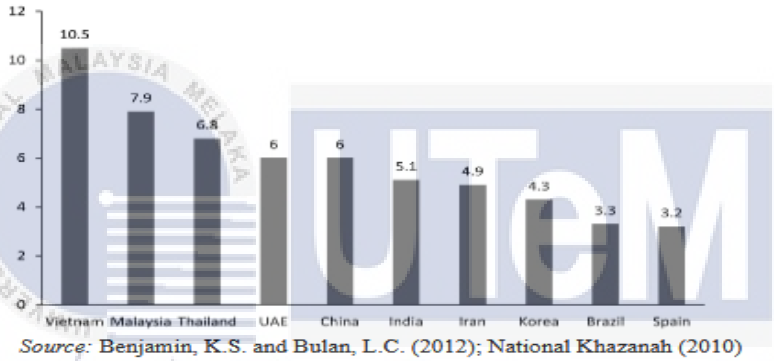
A certain head meter is calculated and the appropriate spot of installation is chosen so that the water flow from certain heights at sufficient quantity is necessary to drive the

turbine. It is possible to install without being affected by the flood during the rainy seasons. These areas have a variation of rainfall ranging up to 20cm which was found using rain-gauge estimation. The sufficient head for the turbine to rotate and run is made possible by stretching the penstock.

The rainwater harvesting system is based on the collection of rainwater and gravity flow pressure principles. The law of conservation energy is a law of physics that stated that energy cannot be created or destroyed but can be converted from one form to another form in energy. The kinetic energy in the moving rainwater falls from the rooftop and then hits and spins the rotating turbine. After that, it rotates the generator and thus produces output energy. The generator produces output power by converting mechanical energy to electrical energy. The rotation movement on the turbine is then affect the rotor and stator of the generator that automatically transform the kinetic energy to electrical energy. This transformation occurs due to the relationship between electricity and magnetism which were known as electromagnetism. The rainwater harvesting system is now becoming an increasingly popular technology in every country in the world due to the environmentally friendly initiative and financial benefits of its use.

1.2 Problem Statement

The most significant problem faced by the world is the demand for energy had increased frequently around the world years by years. The contribution to the declination of the resources due to the continuous relying on fossil fuel for energy by the world and thus a substitute is needed urgently to replace the fossil fuel resources. The increasing cost of electricity bill and declining fossil fuel resources had caused various negative effects to the people and the environment, especially in urban areas. Moreover, the consumption of the high amounts of fossil fuels had caused Malaysia to become the second-highest carbon dioxide emitter among the top ten countries with an annual rate of 7.9% between the years 1990 and 2006 as shown in Figure 1.1 [3].



Source: Benjamin, K.S. and Bulan, L.C. (2012); National Khazanah (2010)

Figure 1.1: Growth rate of carbon dioxide emissions from 1990-2006 (%).

Electrical energy has been an integral part of the economic and growth economic development of a country [5,6]. Electrical energy is generated in power plants through the conversion of primary fuel resources for example natural gas, coal, and fuel oil which are also the three major fossil fuel resources that mainly used by the power generation in Malaysia [7–9]. Burning of the fossil fuels will produce greenhouse gases (GHGs) and resulting in environmental degradation and climate changes [10]. Power generation from fossil fuels also caused the depletion and exhaustion of fuel reserves and consequently hampers independence in energy supply and security [11].

The current pattern of power generation cannot be maintained in future times due to the environmental impacts and the depletion of fossil fuel reserves [9]. Based from Figure

1.2 below showed the final electricity demand in Malaysia from the year 2000 until year 2012 [12, 13]. In general, the total residents population increases consistently every year and because of this rapid population growth, eventually, the final energy demand in the form of electricity is also increasing. This country also set to be a high-income nation by 2020 that consequently increases electricity demands. This required a lot of conversion of primary fuel resources into electricity in order to achieve the rapid growing demands.

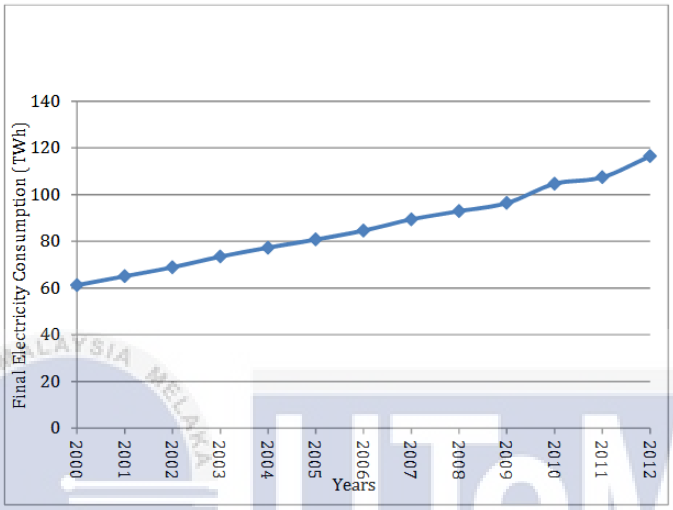


Figure 1.2: Electricity demand in Malaysia between year 2000 and 2012.

Based on Figure 1.3 below, it appeared that the greenhouse gas emission was increased over the past few years [14]. Increasing of greenhouse gas emission from the combustion of fossil fuel are influenced by many factors, including economic growth, population growth, changing energy prices, introduction of new technologies, and changing human behavior. The greenhouse gas emissions had contributed to the global warming problem such as increasing in Earth's temperature, and lead to climate changes that causing disasters for example flood, storm, soil erosion, biodiversity effects, and landscape changing [15].

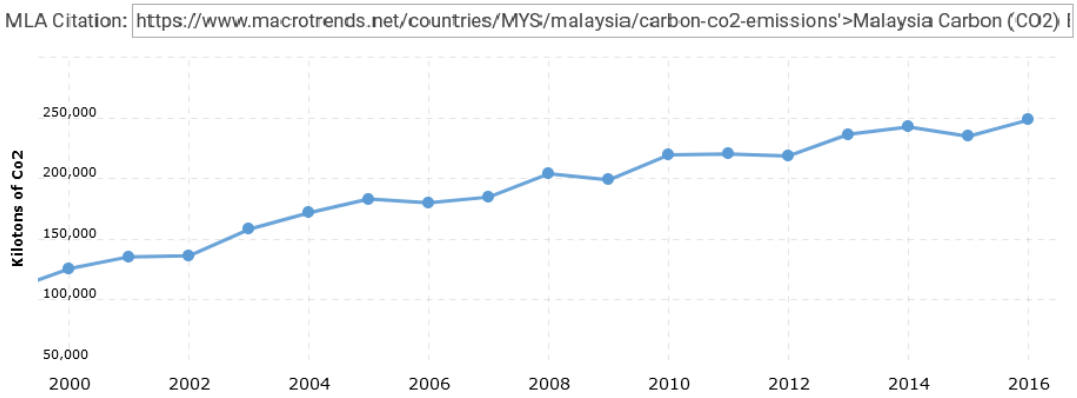


Figure 1.3: Greenhouse gases emission in Malaysia between year 2000 and 2016.

Renewable energy (RE) is one of the best options to consider for replacing the fossil fuel energy. This renewable energy is safe to use and has minimized effect on the environment. It is not just a sustainable energy but had also turn out to be an alternative energy for major transformation technology. Some of the developing countries are taking initiatives to exchange energy from fossil fuels to alternative and renewable resources to help on reducing the emissions of carbon and sustainable energy uses [4].

1.3 Motivation

According to the International Hydropower Association, hydropower plant is playing an important role in reaching Malaysia's energy and climate goals. Hydroelectric power is considered as a major electricity source and the portion of hydropower electricity generation is around 11% which means 11% of electricity in Malaysia was generated by using hydroelectric power. This electricity is typically generated by large-scale dam projects which block the rivers and pass water over turbines and rotate it.

Renewable energy had provided benefits to the community and increased socioeconomic wellbeing, especially in urban areas. The high cost of living in urban areas especially in terms of energy uses or electricity cost bills, making renewable energy as the best option to put into consideration. Socioeconomic wellbeing could be measure based on job opportunities, income, and lifestyle [16]. The relationship between socioeconomic wellbeing and renewable energy in terms of its benefits, make the life easier and the dependency on grid electricity will be decreased.

Urban development in Malaysia is a deep idea to build and develop at the urban areas in a more efficient and effective way towards achieving sustainable urban growth and development. The growing of population and economic growth from the expansion of urban areas will causing the global and local climates due to increased energy uses and emissions [17]. By using the renewable energy, it will become one of the solutions for this problem [18]. The urban area is a strategic location for renewable energy to be implemented.

The urban area has become an attraction or the center for people to live in and the human population in the urban cities is in increasing value over the time period. This is mostly because of the increasing in jobs opportunity and economic activities taking place compared to rural areas. With a lot of building expand in the urban area, it has provided a suitable surface for the implementation of renewable energy [19]. This had proved that by using hydropower which is one of the renewable energy sources, living towards urban sustainability will be achieved.

Thus, our country has the potential to apply the rainwater harvesting system on which this system able to generate electricity on a small scale. A rainwater harvesting system is designed in which the rainwater is collected and stored in a tank and the rainwater is released in a small pipe to drive a rotating road wheel which acts as the turbine to generate electricity. The electricity is then produced from the generator by converting mechanical energy to electrical energy. By using this technique, any disrupted electrical supply is hoped to be resolved and the electricity cost bill will be reduced.

Hydropower development is important to the Malaysia government's efforts in reducing the greenhouse gas emissions intensity. As demand for electricity is increasing over the years, the technology to generate electricity at home or working place has now become a necessary thing. Rainwater harvesting system is the technology in which the rainwater is collected from the rooftop drainage system and stored it for later use. By using the rainwater harvesting system, the electricity source will be generated by rotating the turbine with the moving rainwater.

1.4 Objectives

The objectives of this project are as follows:

i. To develop a rainwater harvesting system for generating electricity on sustainable urban development.
ii. To analyze the performance of power generated in the rainwater harvesting system on different height and rainwater flow rate condition.
iii. To investigate the efficiency of renewable energy in rainwater harvesting system.

1.5 Scope

Rainwater harvested from the rooftop was flowing over and the turbine connected with a generator is rotated by the rainwater flow. The energy transformation on the generator is converted to electrical energy from mechanical energy. Thus, the electricity is produced by the rainwater harvesting system by rotating the turbine. In this project, a micro-hydrogenerator is used to generate electricity and a water flow sensor meter is used to measure the flow rate of water.

The performance of power generated in the rainwater harvesting system is analyzed throughout the project. The performance of output power generated by the rainwater harvesting system was analyzed based on the different head meters and flow rates of water. The different values of the head meter and water flow rate have affected the performance of output generated power. The higher the head meter increased the water pressure and thus the maximum or highest output electrical energy generated is produced. Besides, the efficiency of the measured output power generated by the rainwater harvesting system is then compared with the estimated calculated output power to validate the measured result.

The limitation of this project is due to the Movement Control Order (MCO) period in Malaysia, the suitable place for implementation of the rainwater harvesting system is limited and very hard to find and thus there is also no chance for the prototype of rainwater harvesting system to be placed in a certain higher place. Thus, the different value of head meter for the rainwater harvesting system is allocated at 0.5m, 1.0m, and 1.5m only.