UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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A POTENTIAL STUDY OF WIND TURBINE GENERATOR FOR MOTORWAYS APPLICATION

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Power) with Honours

by

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APPROVAL

This report is submitted to the Faculty of Electrical and Electronic Engineering Technology of UTEM as one of the requirement for the award of Bachelor of Electrical Engineering Technology (Industrial Power) with Honours. The following are the members of the supervisory committee:

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(Ts.Dr. Muhammad Sharil Bin Yahaya)

ABSTRAK

Angin adalah salah satu tenaga yang boleh menghasilkan tenaga elektrik yang dibantu oleh turbin angin heliks. Project ini adalah untuk mereka dan membina sebuah model generator turbin angin heliks untuk digunakan diatas jalan raya. Disamping itu ia juga boleh mengukur potensi tenaga yang boleh dihasilkan oleh turbin angin heliks dalam keadaan yang makmal terkawal. Cabaran untuk menghasilkan tenaga elektrik dari tenaga angin ini ialah keadaan kelajuan angin yang tidak stabil di Malaysia. Diatas jalan raya menunjukkan potensi sumber tenaga angin yang boleh digunakan untuk uji kaji, oleh itu uji kaji julat angin yang berbeza di antara 2.5 m/s hingga 6.6 m/s mengikut ketinggian turbin angin daripada paras tanah iaitu 1 meter dan 1.5 meter. Rekaan turbin angin heliks ini boleh diaplikasikan pada tiang-tiang lampu yang berapa di atas jalan raya. Disamping itu, simulasi arus angin dilakukan menggunakan perisian solidwork untuk menunjukkan tali angin bagi tujuan membina model turbin angin heliks ini. Hasil uji kaji ini menunjukkan hasil keluaran voltan maksima, 22.2v pada kelajuan angin 6.66 m/s tanpa beban pada generator. Selain itu, bagi uji kaji dengan beban, 0.48 watt tenaga elektrik yang dihasilkan pada kelajuan angin 6.6 m/s. Akhir sekali, dari keseluruhan uji-kaji menunjukkan uji kaji 1 meter menunjukkan penghasilan tenaga tertinggi.

ABSTACT

Wind is one of the energy that can be use to generate electricity with the help of helical wind turbine. This project is to design and develop a model of helical wind turbine generator for motorways. From that it can be evaluate the potential energy harvesting via helical wind turbine based from lab environment scale. A major difficulty in the growth of wind energy is instability in the sources of wind in Malaysia. Motorways appear to be a sufficient source of potential wind energy whereby the experiment are test by different wind profile from 2.5 m/s until 6.6 m/s and different height at 1.0 meter and 1.5 meter from the ground. In the present work, design of helical wind turbine can be placed to the pole light on the motorways and appraise by using Flow simulation from solidworks software where it show the wind streamlines and wind profile and fabricate a model to be test for the lab environment scale to evaluate the output. As the test show up the maximum output voltage for no-load test is 22.2v at 6.66 m/s and for the fixed-load test is 0.48 watt at 6.6 m/s. lastly, from the overall experiment show that the 1.0 meter test show the highest output power.

DEDICATION

To beloved family

ACKNOWLEDGEMENT

In the name of Allah, the Most Gracious and the Most Merciful
Alhamdulillah, all praises to Allah for the strengths and His blessing in completing this final year project.

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LIST OF ABBREVATION, SYMBOL AND NOMENCLATURE

MW	-	MegaWatt
TWh/year	-	TeraWatt hour per year
GW	-	GigaWatt
PV	-	Photovoltaics
CO_2	-	Carbon Dioxide
$KWhm^{-2}$	-	kilowatt hour per (square meter)
GHG	-	Green House Emission
HAWT	-	Horizontal Axis Wind Turbine
AD	-	Anno Domini
VAWT	-	Vertical Axis Wind Turbine
KM	-	Kilometer per hour
RPM	-	Revolution per minutes
M/S	-	Meter per second
AC	-	Alternating current
DNA	-	Deoxyribonucleic acid
UV	-	Ultraviolet
PVC	-	Polyvinyl chloride
TSR	-	Tip speed ratio
λ	-	Tip Speed Ratio
Ω	-	Rotational velocity

r	-	Radius
V_w	-	Windspeed
3D	-	Three dimension
CAE	-	Computer-aided engineering
CAD	-	Computer-aided design
2D	-	Two dimension
S	-	Second
MIN	-	Minimum
MAX	-	Maximum
MM	-	Milimeter
ABS	-	Acrylonitrile Butadiene Styrene
PP	-	Polypropylene
KM/H	-	Kilometer per hours
m/s	-	meter per second
v	-	voltage
A	-	Ampere

CHAPTER 1

INTRODUCTION

1.0 Introduction

In the recent years, fuel fossil or another kind of fossil has become a high cost to produce and to manage. In the future, it may become a material that will be hard to have. China, united states, German and etc, they are one of the largest countries that consume energy fossil. (Feng, Niu and Cheng, 2019)

Other country has already taken a step ahead where they started to use, design and research a potential and suitable renewable energy for their country. Some of the countries already use renewable energy to preserve their fossil supply bank. The unintentional plan can preserve an earth fossil more than what we can see. (Tian *et al.*, 2017)

The renewable energy contains the sun, the wind and consecutively water that can be obtained from the sea and river in divergence to oil, gas and coal which depend on fossil fuel from gas and oil field or mines. Furthermore, geothermal, biomass, and hydropower can provide an indigenous energy service. The potential for renewable energy is massive in world demand energy. As the cost to build a solar farm or a wind turbine power system is continuing to drop rapidly but in vice versa for oil and gas supplies which the cost is increasing higher than expected.

In fact, renewable energy and fossil fuels prices, environmental cost and social and are heading in the opposite direction. Moreover, the economic and policy mechanism structure needed to support and widespread the information of renewable energy system to the sustainable market and rapidly involve spreading it until the world know that the sector of renewable energy is one step ahead to the future. The awakening of the future growth potential of renewable energy and other new energy technologies will beat the conventional technology when new energy is more efficient than the conventional. (Herzog, Lipman and Kammen, 2016)

Wind energy is a renewable energy that has developed swiftly since the end of the 1970s and wind turbine one of the solutions that produce clean energy and does not need a

fuel transport that can be hazardous to the environment. Our new era and our modern technologies already produce a reliable, efficient and reasonable cost to produce power.

The research development already created an energy policy for renewable energy to entering a sustainable market. Furthermore, the technology in wind turbine has changed in a few decades which the control system has become cheaper but more advanced than before, the new profile and design of the rotor blade can extract more wind to produce power and new power electronic circuit equipment design makes it more possible to blade self-finding variable speed for efficiency and to optimize the capacity of the turbine.

One of the big issue in Malaysia is to find a location and the speed of the wind that is not constantly high and sometimes differs depending on location and month consequence from this issue. (Farriz *et al.*, 2010; Daut *et al.*, 2012)

The high-speed vehicle can produce high energy of wind to move are a vertical axis wind turbine. In another side, if the vertical axis wind turbine is planted on the median of the motorways the energy from both sides can flow energy from the vehicle to move the vertical axis wind turbine. With this, it can produce electricity without endangering the environment also society.

Each vehicle on the motorways offer an infrequent and uncontrolled source of wind energy power to be extracted to the turbine and produce power and importantly it will give a less negative impact to the environment at the placement location as possible. With this, we can utilize the wind from vehicle to generate power (Champagnie, Altenor and Simonis, 2013; Tian *et al.*, 2017)

1.1 Project Background

This project is about a potential study of wind turbine generator for motorways application from the literature review. The energy is focusing on wind generation produce from the wake of wind which is vortex. Since the motorways are the most suitable place to study the vortex condition on certain vehicle then it will be the most priority place to develop a helical wind turbine before the vortex is already wasted.

The energy from the vehicle which is vortex are commonly waste, but we all know the vortex produce enough wind pressure to start the vertical axis wind turbine to spin and start to produce energy from the generator. The study is using 3D modelling Solidworks software, lab-scale test. Other than simulation, the turbine fabrication will be taking part by hollow steel, zinc, mild steel, wind generator and 12mm long nut. After that, the potential of vertical axis wind turbine will be analyzed from a different wind speed and height position in generating power.

1.2 Problem Statement

A major difficulty in the growth of wind energy is instability in the sources of wind in Malaysia.(Farriz *et al.*, 2010). Motorways appear to be a sufficient source of potential wind energy. Furthermore, analysis of the wind flow due to traffic on motorways must be performed to acquire the limit boundary for the wind turbine design. The turbine must be able to capture the wind when there is go and stop traffic. The design model must be environmentally friendly and sustainable The analysis of the height of the turbine blade to make sure the turbine is on the right height position to be able to capture the wind from different size of vehicle and speed.

1.3 Objectives

1. To design helical wind turbine generator application for motorways
2. To develop helical wind turbine generator prototype.
3. To evaluate the potential energy harvesting via helical wind turbine based on lab environment scale

1.4 Working Scope

In order to archive the state objectives, several work scopes have been identified to complete the project. The work scopes for this project are listed below:

1. Design a model of helical wind turbine that suitable for motorways using SolidWorks software.
2. Fabrication of Helical Axis Wind Turbine using aluminium bar, hollow steel bar, zinc and etc.
3. Construct an experiment for variable type of height and different wind speed.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

The potential of renewable energy is enormous as they can meet many times the world energy demand. The renewable energy sources can provide sustainable energy services such as wind, solar, biomass, hydropower and lastly geothermal. Renewable energy system is increasingly looking like as the cost of wind and solar power have dropped.(Herzog, Lipman and Kammen, 2016) . Renewable energy sources currently supply between 15% and 20% of the total energy demand in the world. The supply is dominated by traditional biomass, mostly fuel wood used for cooking and heating, especially in African, Asian and Latin American developing countries

2.1 Renewable energy

The potential of renewable energy source is massive because it can meet global energy demand at any time. Renewable energy source such as wind, solar, biomass, hydropower and geothermal can provide continuous energy service because of renewable energy is in-exhausted resource, which also called as green sources that can replace consumption of fossil fuel like gas and oil that are higher in price while the renewable energy is lower in price cost but the system is in high demand. Other than that, renewable energy is not only for our future, but it is something that can be used in daily life. Globally renewable energy is already used in daily life and for some big company already use it to run the daily building power source. In the past 30 years solar and wind system had an experience of rapid sales growth, declined the cost of electricity generated and capital cost and continue to improve their performance characteristic.

According to (Prol-ledesma and Morán-zenteno, 2019) geothermal is defined based on its thermal, hydrogeologic and geologic condition. The steam or hot water will be used in geothermal power plant from high temperature to create high pressure of steam and flow

to the turbine with high pressure to generate and to produce electricity. According to (Tesfaye & Khader, 2015), Ethiopia has a total power of geothermal power resources that is estimated at about 5 GW which includes the thermal and electrical. But, the resources of that available for the electric power generation is only about 700 MW.

In another hand, based on (Rahman, 2013) about 10.715 MW of geothermal energy is generated from 25 countries worldwide and the next countries who will develop a power plant for geothermal are Bangladesh and make it as 26 countries who a using a geothermal as renewable energy resources. The use of geothermal energy worldwide is about 70 TWh/year of electricity are produced in 2012 and it keeps increasing

Based on (Shahsavari and Akbari, 2018) the use of solar PV system can reduce 69 million to 100 million tons CO_2 by 2030. Solar PV energy is available for the most country because of irradiation of the sun received globally. Some country with the most irradiation will produce higher production of electricity

Based on (Kannan and Vakeesan, 2016). Even though solar energy can be easy to use but solar PV is expensive, complex and required an advanced technology to manufacture and also required experience for installation. In addition, the performance of PV panel is highly depended on environment such as cloudiness, humidity, wind speed and sunshine intensity. Either one came during electricity production it will effect to productivity efficiency so the productivity will not constant. Furthermore, solar power plant required large scale of ground to place all the solar PV panel and it required more cost to maintenance. Other than that, a large amount of water is used to clean up the PV panel from dirt or dust and also to clean up the turbine in solar thermal case. Nevertheless, wastage of water contributes to water pollution

Reported by (Feng, Niu and Cheng, 2019) The world of hydropower is dominated by China because of the gross of total hydropower installed capacity is 332 GW and the total is actually equivalent of summation of other top 4 country which is United state, Brazil, Canada, and Russian. Hydropower is known as one of the most stable and reliable renewable energy all because of its unique advantages in high flexibility, ease of maintenance and low in pollution. Based on (Penghao, Pingkuo and Hua, 2019) The challenges hydropower have to archive is the technology of the construction, design of the power plant and instrument technology that have to be used. This is because every hydropower plant has its own challenges like they're geological of the soil and the flow of the water. Every obstacle will

need a new calculation, simulation and another circumference to make sure the hydropower plant is following a country provider condition for example in China is "Law of the People's Republic of China on Environmental Protection".

2.2 Wind power generation

2.2.1 Introduction of wind power

Wind power generation is considerable potential as a global energy clean resource that being used widely since centuries. Since the early beginning of civilization, wind power energy has been used for their primary energy. Wind is one of the energy to transporting goods, pumping water, milling grain for several millennia. Based on (Herzog, Lipman and Kammen, 2016) The wind turbine starts been use onshore when windmill has been created and been used for about 200 years ago in Persia, China, India and has been evolution until early 20^{th} century to generate electricity. In addition, power generation are being declined for some period because of petroleum and coal are cheaper and more reliable to transport especially in a remote and rural area. For industrial, cheaper the price will be the first choice for their development of production until the oil crisis in the 70's triggered some renewed interest in wind energy to develop more technology in grid connectivity, pumping water, and power supply in a rural and remote area this action are the reason wind energy to rebirth.

Since that wind energy is one of the fastest rapid growing green energy in the world. Based on (Stathopoulos *et al.*, 2018) Since wind easily gets anywhere, macro wind power generation can use to be as their supply power to some rural or remote area. Furthermore, reported by (Allouhi *et al.*, 2017) there's no pollution or greenhouse emission during operation which means wind energy is clean energy whenever electricity is produced it also produce zero pollution to the world compared to traditional operation of fossil fuel that contributes to global warming and GHG emission. Wind turbine contributes to the core of wind power generation plant. The concept has been using is to use wind to drive the turbine, blade that connected to the generator. From that, kinetic energy that been produce will be converted into mechanical energy and next converted into electrical energy. Recently, various technology emerge to improve the efficiency, reliability and most importantly is reducing the construction cost and maintenance.

Reported by (Ritter *et al.*, 2015) The cumulative installed capacity in global of wind energy has increased from 6 GW in 1996 to 318 GW in 2013 and expected to reach more than 596 GW in 2018. In addition, wind power generation also on offshore because there is more wind energy potential that has been wasted. In offshore regions have lower roughness in term of drag of the wind to the surface and resulting in higher wind speed and wind power density. Based on (Argin *et al.*, 2019) In turkey, they estimated that around 1.629 MW of wind power energy potential on their specific site of the offshore. The offshore wind energy becomes foremost because of restriction of land availability on onshore installation. Annual cumulative of offshore wind power has been increasing triple times in the last 5 year and it makes the result accumulated capacity reaching to 14.384 GW.

On the other hand, a new application in wind power generation is on the highway, and train tunnel. Train in the tunnel will product high mass flow that is unsteady and highly turbulent. Based on (Bethi *et al.*, 2018) flow of high velocity generated around the train is the source of wind energy that being absorb by wind power generation to generate electricity. Based of , the micro wind turbine is placed both of the sides of the train which whenever train come the wind turbine will absorb the high-velocity flow from the train to driven it until the wind energy is loss.

2.3 Environment Advantages and Disadvantages of wind power

2.3.1 Advantages of wind power

There are diversified advantages on environment that are use to wind turbine generation to generate electricity. Amidst of them the wind energy creates no harmful emission like carbon, hence the carbon footprint can be reduce during power generation. For example a staggering 7000 tons of CO2 emissions could be avoided if 15 TWh / year is generated from wind energy (Faizal, Chelvan and Amirah, 2017). Another advantages of wind power is that the cost of wind energy will be lower than that of coal if we consider the cost of trying to offset CO_2 and SO_2 emissions among other substances(Zhao *et al.*, 2017). Another viable option is the use of low-speed off-grid wind turbines in rural areas, as linking small rural villages to the national power grid is too costly and difficult (Izadyar *et al.*, 2016). Not only does this improve the lives of our rural counterparts, it does so without having a major impact on the environment.