THE POTENTIAL OF WIND ENERGY IN KOTA KINABALU AND KUCHING, EAST MALAYSIA

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DECLARATION

I hereby declare that this dissertation is my own work and effort except for quotations, excerpts, equations, summaries and references, which have been duly acknowledged. It has not been submitted anywhere for any award.

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ABSTRACT

THE POTENTIAL OF WIND ENERGY IN KOTA KINABALU AND KUCHING, EAST MALAYSIA

The wind speed studies have been carried out to find the efficient utilization of wind energy as alternative resource in east Malaysia. The main objective of this thesis is to evaluate wind energy potential based on measured data obtained from the Malaysia Meteorological Service in Kuching, Sarawak and Kota Kinabalu, Sabah. The wind data from 1990 to 2009 was analysed to determine the mean wind speed and direction in Kota Kinabalu. The wind direction was presented using wind rose scale. The Weibull density function has been used to estimate the wind energy potential. The comparison of wind speed and direction between 2004 and 2009 was conducted to identify the potential of wind energy in Kuching and Kota Kinabalu. Two types of wind turbines were simulated and compared to identify their profitability for producing wind power. The results showed that 8.5 m/s was the highest mean wind speed in Kota Kinabalu and the annual prevalent wind blows from north-west direction. Furthermore, the winds in Kuching are generally characterized by larger mean values than in Kota Kinabalu. The highest mean wind speed in both areas is found in September which is the end of the southwest monsoon. The highest wind power densities found in September in both study areas with the values of 703 W/m^2 (Kota Kinabalu) and 668 W/m^2 (Kuching). The results of this study showed that Kuching and Kota Kinabalu are not feasible to use wind energy. This is due to high installation cost and requires large tracts of land. This study is important for further research on wind energy where more data is needed for comparison.

ABSTRAK

Kajian mengenai kelajuan angin telah dilakukan di Malaysia timur untuk mengetahui keberkesanan tenaga angin sebagai sumber tenaga alternatif. Objektif utama kajian ini adalah untuk menilai potensi tenaga angin berdasarkan data yang diperolehi daripada Jabatan Meteorologi Malaysia di Kuching, Sarawak dan Kota Kinabalu, Sabah. Data angin dari tahun 1990 sehingga 2009 telah dianalisikan untuk menentukan purata kelajuan dan arah angin di Kota Kinabalu. Arah angin telah ditunjukkan melalui diagram mawar angin. Fungsi kepadatan Weibull telah digunakan untuk menganggar potensi tenaga angin. Perbandingan antara Kuching dan Kota Kinabalu dari segi kelajuan dan arah angin dari 2004 sehingga 2009 telah dilakukan untuk mengenalpasti potensi tenaga angin. Dua jenis turbin angin disimulasikan dan dibandingkan untuk mengenalpasti keuntungan mereka dalam penghasilan tenaga angin. Keputusan kajian menunjukkan bahawa 8.5 m/s adalah purata kelajuan angin yang tertinggi di Kota Kinabalu dan arah angin tahunan utama adalah dari utara- barat. Selain itu, secara amnya, angin di Kuching didapati mempunyai nilai purata yang lebih besar daripada Kota Kinabalu. Nilai purata kelajuan angin yang tertinggi di Kuching and Kota Kinabalu didapati dalam bulan September di mana ia adalah akhir musim barat daya. Kepadatan daya angin yang tertinggi didapati dalam bulan September untuk kedua-dua tempat kajian dengan nilai 703 W/m^2 (Kota Kinabalu) dan 668 W/m^2 (Kuching). Keputusan kajian ini menunjukkan bahawa Kuching dan Kota Kinabalu tidak sesuai menggunakan tenaga angin. Ini disebabkan oleh kos pemasangan yang tinggi dan memerlukan tanah yang meluas. Kajian ini adalah penting untuk penyelidikan tenaga angin yang lebih lanjut di mana data-data yang lebih banyak diperlukan untuk perbandingan.

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LIST OF ABBREVIATION

GW	Gigawatt
KK	Kota Kinabalu
km	Kilometre
km^2	Square kilometre
kW	Kilowatt
$kWh/m^2/yr$	Kilowatt-hour per square meter per year
m/s	Metre per second
MBIPV	Malaysian Building Integrated Photovoltaic Technology Application Project
MMS	Malaysian Meteorological Service
MW	Megawatt
MWh/yr	Megawatt-hour per year
MWh	Megawatt- hour
SCORE	Sarawak Corridor of Renewable Energy
SESCO	Sarawak Electricity Supply Corporation
SREP	Small Renewable Power Programme
TW	Terawatt
TWh/yr	Terawatt-hour per year
W/m^2	Watt per square meter
WAsP	Wind Atlas Analysis and Application Program

LIST OF SYMBOLS

%	Percent
~	Tilde
≥	Greater than or equal to
$\bar{v}_m$	Average wind speed
$\bar{v}_w$	Weibull average wind speed
°	Degree
A	Cross-sectional area
c	Weibull scale parameter
k	Weibull shape parameter
Γ	Gamma function
ρ	Air density
σ	Standard deviation

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CHAPTER 1

INTRODUCTION

1.1 Background

The energy sector is an essential sector in the country. In our daily life, we can't live without using electricity such as air conditional, light and others appliances. Public should be aware on the energy issues such as energy efficiency and the use of renewable energy. The product of burning fossil fuel will damage environment and the health of millions of the people in the world. Renewable energy is a clean energy and can be replenished rapidly by natural processes. It can reduce the emission of greenhouse gases and hence continuously generate the power. For the whole Sarawak, the power is supplied by the Sarawak Electricity Supply Corporation (SESCO). There are thirty six power stations in Sarawak with a total installed capacity of 1315 MW (Wikipedia, 2010f). These stations comprise 64% gas turbines, 18% thermal generators and 18% hydro turbines. Most of the power stations generate electricity from thermal plants and diesel-electric plants which produce greenhouse gases and other pollutants. Compare the electricity in Malaysia and Brunei, there is a significant regional price differences. Not only the public, need to pay such a high electrical bill, but Local District Council of Kuching and Sabah as well. They are responsible to maintain the electricity which has been used on the streetlights, building lights like indoor stadium multifunctional hall, outdoor stadium and swimming pool. The only solution to this problem is to rely on the renewable energies.

There are two types of energy existing in the world which are renewable energy and non-renewable energy. Renewable energy resource is a resource of natural energy which is replenished rapidly by natural processes and does not have a limited supply. Some examples of energy resources are sunlight, waves, wind, tides, geothermal heat and biomass such as wood burning. The Sun provides an incredible supply of solar energy to the earth. The water in the river is continually replenished by rainfall. If we chop down a tree and burn its wood to gain heat, it takes short duration for the forest to grow enough to replace that wood. Generally, renewable energy can be used again and again, and will never run out of resource. In the nineteenth century, a scientist who named Svante Arrhenius firstly introduced the concept of the greenhouse effect (Wikipedia, 2010e; NASA Earth Observatory, 2010). Hence, the global environmental concerns created the essential of using clean energy. Renewable energy will produce clean and healthy environment. Hence renewable energy also is known as "green" energy or "clean" energy. Most of the pollutant is produced by the non-renewable energy.

Fossil fuels are non-renewable resources that are formed very slowly than they are consumed. The uses of the fuels include gasoline, diesel fuel, jet fuel, lubricants for transportation; heating oil, residual oil and kerosene for heat and heavy residuals for building development. In order to provide heat and electricity, fossil fuels have to be burned. This burning has caused a host of environmental effects. Pollutants in the form of carbon dioxide and sulphur emitted into the air are responsible for acid rain, smog, global warming and climate change. These pollutants have reached a level that will threat to vegetation, wild life and human health. Global warming is the phenomena which average temperature across the globe will increase as greenhouse gases trap the solar heat in the atmosphere and warm it. Malaysia was one of the important petroleum exporters after the collapse of the tin market in the early 1980s (Wikipedia, 2010a). Indirectly, Malaysia has become the contributor of the global warming and climate change. Besides, since petroleum is non convection source, it will be depleted in the future. Due to these reasons, renewable energy will be best alternative energy sources to fulfil the modern needs.

Malaysian Government has taken several measures to explore and promote the use of renewable energy as alternative fuel source. These measures include in the Ninth Malaysian Plan, the Kyoto Protocol, Copenhagen Protocol, the Small Renewable Power Programme (SREP), the Malaysian Building Integrated Photovoltaic Technology Application Project (MBIPV) and Biomass. Government is strengthening the role of renewable energy with an emphasis toward Energy Efficiency both on production and utilisation. There is a corridor which known as the Sarawak Corridor of Renewable Energy (SCORE), was established in 2008 (Sarawak

Corridor of Renewable Energy, 2010). It is one of regional development corridors being developed throughout the country in order to accelerate the state's economic growth and development as well as improving life quality of Sarawakian.

Kuching and Kota Kinabalu were chosen as the study areas due to economic, environmental and location reasons. Firstly, these two cities have the highest population and hence the demand for electricity is higher compare to other places within the states respectively. Secondly, the location of both areas can reduce the transmission cost of electricity to Peninsular Malaysia and Brunei if wind resources have a significant contribution to the long term supply and meet the local demand for electricity.

The purpose of this study is to make an assessment of the local wind energy potential at which the wind data is currently available. The result may provide some practical recommendations for the coastlines of East Malaysia that face toward South China Sea.

1.2 Study Areas

Sarawak and Sabah are the Malaysian states on the island of Borneo. Sarawak is the largest states while Sabah is the second largest states in Malaysia (Figure 1.1). Both of them share a border with the province of East Kalimantan of Indonesia in the south.

Kuching is the capital of Eastern Malaysian state of Land of the Hornbills – Sarawak. It has the highest population (approximately 579,900) compared to other cities in Sarawak like Sibu, Miri and Bintulu (Wikipedia, 2010d). It has an area of 431.01 km^2 (The Commission of The City of Kuching North, 2010). Since the population is high, the energy consumption of the State proportionally increases as well.

Kota Kinabalu is the capital of Sabah, the land below the wind as well as the capital of West Coast Division of Sabah. Previously, it is named as Jesselton by Sir Charles Jessel and affectionately known as Kota Kinabalu (KK) in 1967 or Api-Api by the locals. It is a major tourist destination and popular tourism gateway into Borneo Island. It has a population of 617,972 in 2009 (Wikipedia, 2010c). Besides being the capital, it is also one of the major industrial and commercial centres of East Malaysia which make it to be one of the fastest growing cities in Malaysia. Therefore, this city consumes more electricity than other divisions.

The location of Kuching is more than 10 km from the coastline while Kota Kinabalu is just only located a few km from the coastline. Furthermore, the terrain of Kuching is surrounding with urban district and forest with many windbreaks. On the other hands, Kota Kinabalu's terrain exposes with a few windbreaks.

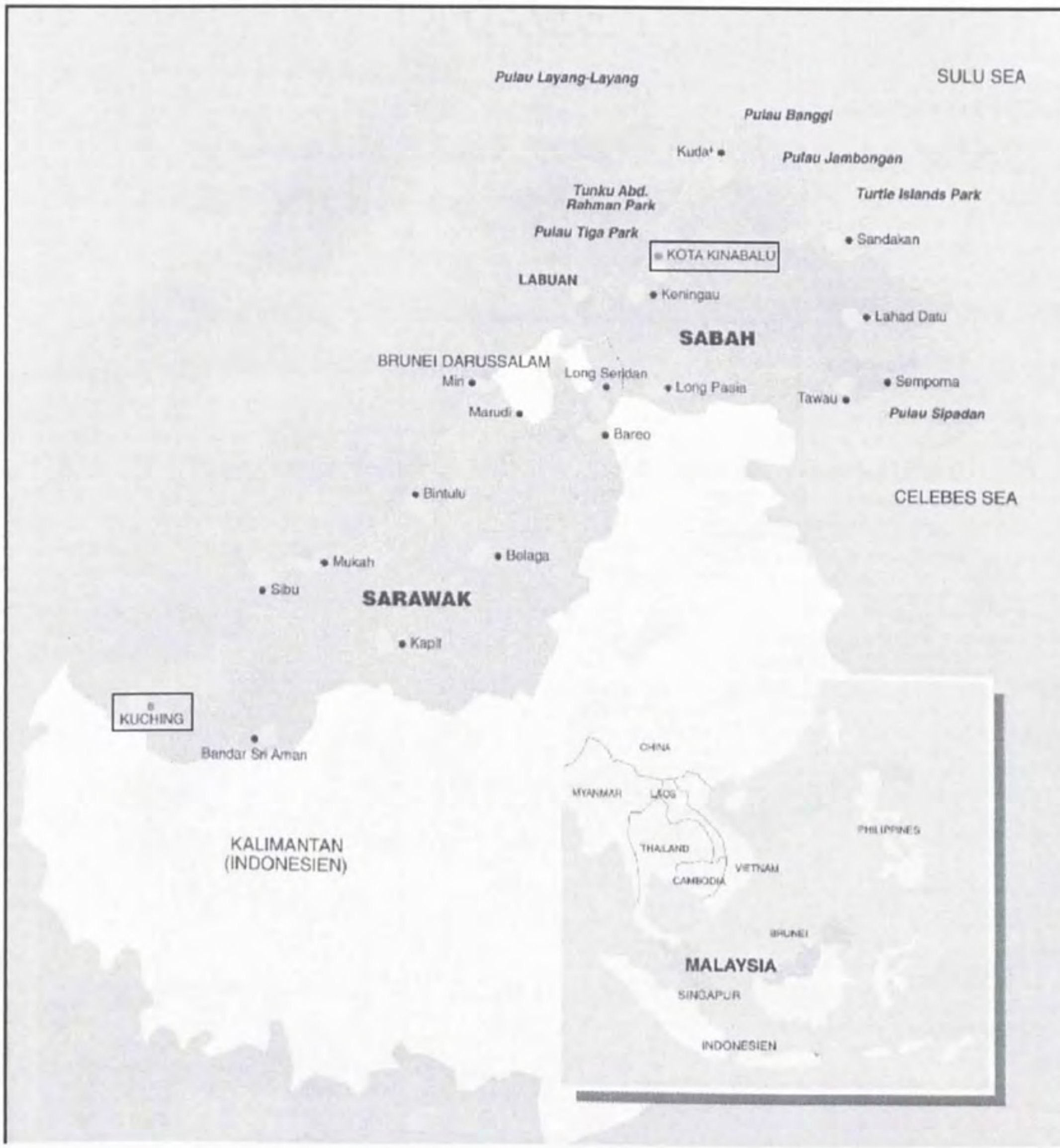

Figure 1.1: Location of Meteorological Stations in Sarawak and Sabah.

1.3 Aims

The aims of this study are as below:

1. To evaluate wind energy in Kuching, Sarawak and Kota Kinabalu, Sabah at different seasonal monsoon.

2. To compare the wind power between Kuching, Sarawak and Kota Kinabalu, Sabah.

3. To estimate the wind power by using different wind turbines.

CHAPTER 2

LITERATURE REVIEW

2.1 Background

Malaysia possesses vast renewable resource potential for electricity. These include sunlight, biomass, hydropower and wind. The location of Malaysia that being near to the Equator and the clearance of the sky dominate a good solar potential in the state. Sarawak receives abundant rainfall and the topography that characterized by numerous rivers flowing between steep, narrow, interconnected ridges up to a high level of height contributing to have the largest hydropower in Malaysia. However, the installation cost of these two renewable resources is higher compare to wind energy. Furthermore, an investment in wind power produces more amount of the electricity as the same investment in hydropower and solar energy. Due to these reasons, it is better option to choose wind energy as renewable energy in Sarawak.

Sabah also has few renewable energy potential for electricity. It is one of the best spot to capture most solar energy in Malaysia (Daily Express, 2009). In the capital of Sabah, Kota Kinabalu has more than 30% of electricity produced by solar energy than in Kuala Lumpur. That means Kota Kinabalu can get 1800 kWh/ m^2/yr compared to 1500 in the Klang Valley (Daily Express, 2009). However, as we mention before, the installation of solar grid system is quite expensive, approximately RM 26, 0000 per kW for a typical house. According to Head of the Renewable Energy Unit, Ahmad Hadri Haris, if household electricity bill is RM 100 per month, this mean that it need a 3kW system (RM78,000) (Daily Express, 2009). So, solar energy cost will be first issue that we need to consider before we install. Other than solar energy, biomass is another renewable energy that available in Sabah. There are over 120 oil palm mills located in the east coast of Sabah (Business Times, 2010). Every year, these mills will produce millions of tonnes of biomass, especially empty fruit bunches.

2.2 Wind Energy

All the renewable energy sources origin from the Sun, except tidal and geothermal power. In others word, wind energy or hydropower can be described as a by-product or secondary form of solar energy. Earth receives 1.74×10^{17} W h or 174,432,000,000,000 kW h from the sun (Neil and Jayne, 2006). Solar energy holds more than 99.9% of all the energy converted on earth (Martin *et al.*, 2007). A massive amount of this energy is absorbed by the ocean and land masses; the remaining energy is absorbed by the atmosphere, approximately 2.5% of the total solar radiation. This contributes to 4.3×10^{15} W of wind power (Martin *et al.*, 2007). Wind results from uneven heating of the atmosphere, the earth's rotation and the irregularities of the earth's surface. Differential heating of sea and land, nature of terrain, ranging from mountains and valleys to local obstacles such as buildings, and tree, weather patterns are the factors that strongly affect the origin of the wind.

The ancestor of the windmill that used to generate electricity was built in 1888 by Charles Francis Brush (1849 to 1929) in Cleveland, Ohio (Neil and Jayne, 2006). Windmill refers to the operation of a machine that found within a building for grinding grain and this machine is driven by wind power. Electrification from the wind is getting important nowadays due to several reasons. First of all there is a need. The depletion of conventional energy sources and their rising cost have caused people to look for alternatives. Second, wind energy is considered to be a "green" and "renewable" energy because of its minor impacts on the environment and can be replenished rapidly. Third, there is the technology capacity. When applied to wind turbines, development could revolutionize the way they could be used. Politics is another factor to promote the use of wind energy. Due to consideration of the future generation, Malaysia government would like to carry out research, development and testing of the wind power technology.

Human has been using wind energy in daily activities for more than thousand years. The use of this energy is not a new idea. Before the invention of steam engine, wind energy is the important sources to sail the ships. Ancient Egyptians used wind energy to pump water got irrigating agricultural lands and to grind grains. The conversion of the kinetic energy in wind into others forms of energy such as electrical energy and mechanical energy is known as wind power. This power is a clean and renewable energy because it produces no air pollutant or greenhouse gases during operation. But, there are some emissions of carbon dioxide during manufacture and installation of wind turbines which are about 130 times lower than from coal-fired generation (AWEA, 2008).

At the end of 2009, worldwide wind power capacity was 157.9 gigawatts (GW) which grew by 31 percent from existing capacity (Global Wind Energy Council, 2010). According to (World Wind Energy Association, 2008), the wind power produces more than 1.5 percent of the global electricity consumption, approximately 260 TWh per yr. United States and China took the lead in the world and Asia respectively. In Asia, China took over the place of number one position from India in terms of total capacity installations - 24'439 MW. China has doubled its installations in 2008 and continuous their best in occupying global wind turbine market. In the following year, China lead the way in installation of new wind energy capacity, more than doubling from 12.1 GW in 2008 to 25.1 GW at the end of 2009 with new capacity additions of 13 GW (Global Wind Energy Council, 2010). A great deal of information about the global wind energy generating capacity has been obtained from Global Wind Energy Council report (Table 2.1).

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