A Study on the Wind and Geothermal as a Potential of Renewable Energy Sources in Malaysia

M.F.M Basar, M.R. Sapiee, L.M.Hishamudin, N. Zakaria, N.M.Yusof, N. Wahid, W..A Ismail
Email: mfarriz@utem.edu.my, razali@utem.edu.my
Universiti Teknikal Malaysia Melaka (UTeM)

***Abstract*— This paper is studies about the potential of renewable energy sources in Malaysia. Energy is one of the most valuable and desired resources over. In general, almost all countries in the world suffer a negative impact from the increasing oil prices. A new source of renewable energy from wind and geothermal is a possible contributor to solve the energy crisis. Even though, this renewable energy had already established especially in the developed countries, but until now the mature application in harvesting both energy is still not commercialization applied in Malaysia. Besides of that, the relevant scientific literature about these both energy employed in Malaysia is not easily found. Hence, this paper is presenting the previous research in harvesting the wind and geothermal energy that have been employed in other countries in term of their advantages, drawbacks, costing and technologies. This is the preliminary effort intended in order to investigate the relevancy and suitability to be implemented in Malaysia. In addition, the studies have gives a meaningful indicator regarding the effort to create a wind and geothermal power plant in Malaysia. As a final point, the idea that has been proposed in this paper would provide an understanding of the principle in harvesting the wind and geothermal energy and furthermore give a significant contribution for further research.**

***Keywords* — energy sources, renewable enrgy, wind, geothermal, commercialization.**

I. INTRODUCTION

Renewable energy is energy that can be replenished once it has been used. Generally, the remaining oil reserves are left for only 50 more years proportional to the worldwide current usage consumption rate. Moreover, Malaysia was also affected by this issue. Consequence from this issue, the renewable energy which are from wind and geothermal is whispered to replace the existing fossil fuel reserves. Hence, this paper is studies and investigates the capability and the suitability for harvesting the wind and geothermal energy in Malaysia. In order to obtain an easier understanding, firstly, it is better to identify the principle of work for harnessing these both energy sources as preliminary effort. Then, investigate the potentiality of implementing both clean energy system in Malaysia according to the previous research works and literature studies.

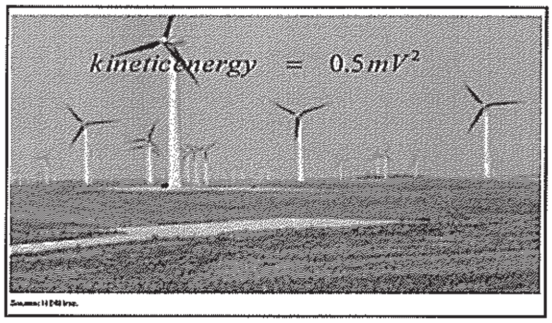
II. WIND TURBINE

In theory, solar energy is pertaining to wind energy. During day and night, diverse surfaces and different parts of the earth absorb and reflected the sun's rays heat at dissimilar rates As a result, it causes the atmosphere to temperate differently. Due to that, the hot air become increases, causing the atmospheric pressure at the earth's surface reduce and finally the cooler air is drawn to replace it [4-5]. This is how the wind is generated. Beside that, the kinetic energy is energy of the air mass motion.

Wind can be harnessing to gain an electrical power at almost all location. In order to gain a high return on outlay, wind turbines have to be located at the places, which have constantly high wind speed. Figure 1 shows a picture of wind turbines located at the places called wind farm.

Generally, a wind turbine is a revolving machine that adapts the kinetic energy of wind and converted into mechanical energy. The kinetic energy of moving air is equal to half the mass of the air, m times the square of its velocity, V as shown in equation 1, where m is in kilograms and V is in meters per second (ms^{-1})[1]. If the mechanical energy used straightly for grinding works, typically the machine is known as a windmill. Otherwise, the machine is called as a wind generator, wind turbine, wind power unit, wind energy converter or aerogenerator[6].

Figure 1:Warm Mill



Refer to the Figure 2, wind turbine composes of four important parts [4]. First is a rotor or blades. This part is needed for converting the wind's energy into rotational shaft energy. Second is a nacelle which is containing a drive train and regularly together with a gearbox plus a generator. Third is a tower that is used to hold up the rotor and drive train. Fourth is electronic equipment such as controls, electric cables and ground support apparatus.

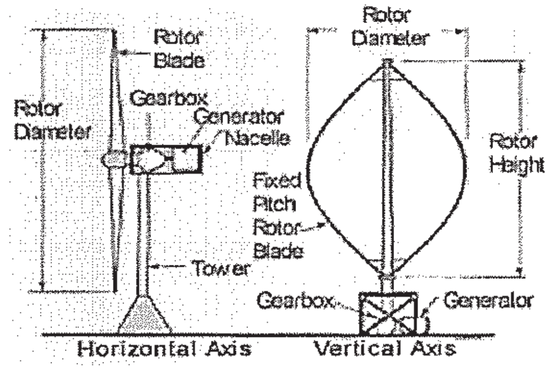


Figure 1. Wind Turbine Configurations [c]

Wind turbines have two basic designs, which are horizontal axis (propeller style) and vertical axis (eggbeater) [5]. In nowadays, horizontal axis is commonly used and almost all the wind turbines in the global market is employ this type. Table 1 shows the advantages and disadvantages for both rotation types [6].

TABLE I.
COMPARISON BETWEEN HAWT AND VAWT

	Horizontal Axis (HAWT)	Vertical Axis (VAWT)
Advantage	•For every ten meters Increasing the tall tower base, the power output increased 34% due to increasing of wind speed by 20%. •High efficiency because each rotation of blades move perpendicularly to the wind power. •Varying the degree of slope of a turbine blades causing to optimum angle of wind attack. •Lower vibration and audible noise compared to other machine similar power rating.	•Frequently mounted near to the ground with low bearing and huge tower arrangement is rarely used. •No need yaw mechanism once fix pitch rotor design is employ. •Easy to do the maintenance works because it is located near to the ground. •Start creating electricity at 10km/h. Thus, it has lower requirement startup wind speed compared to HAWT •Suitable to built at locations that prohibited taller structures.
Drawback	•Give a difficulty for convey especially when the blades and tower over than 90 meters. •Massive tower construction required to support the heavy blades, gearbox and generator. •The blades and shape of tower causing electro magnetic wave interference to the original signal. •Changing the visual appearance of the landscape. •Down wind type faces fatigue and structural failure by turbulence.	•At lower altitude, wind speed is low, so less wind energy obtained. •Reciprocating action occurred and hence creates lower effectiveness due to backtrack against the wind for the whole cycle blade. •Produce large torque ripple and cyclic stress on the tower hence contributed to poor reliability. •The reversal of the stress increases the probability of blade failure by fatigue. •Require super structures to hold top bearing.

According to the Table 1, both types of wind turbine have their own superiority and unfavorable condition. Nevertheless, referring to the previous research works, mostly the researcher mentioned that, it is more practical to use the HAWT type instead of VAWT type. For that reason, in this paper, it will discuss about harvesting the wind in Malaysia based on the HAWT type.

III. ENERGY AND POWER IN THE WIND

The electricity produced by wind turbines is dependently on the turbine's size and the wind speed through rotor. Presently, the manufactured of wind turbine has the power rating ranging from 250 watts to 5 megawatts, MW [4]. One megawatt of wind energy can produce around 3 million kWh a year. Thus, a megawatt of winds generates as much as 300 domestic electricity demands. However, the above statement is just theory and practically, the wind blow not continuously all the time, it needs a reliable storage system, once electricity is generated.

Wind turbine performance is dependable to the wind speed. Thus, it is better to obtain a wind speed profile at the place where the wind turbine needs to be employed. Based on the wind profile, the turbine performance can be optimization via wind's system construction. Commonly, small wind turbines is suitable for the place that have annual average wind speed approximately 14.5 kilometers per hour, km/h and it is suitable to use for water pumping activities. However, for utility usage, the wind power plants necessitate at least 22km/h or 13mph of the minimum average wind speed [1].

In order to know the probability ρ, where the wind speeds exceeds a certain value V, the Rayleigh distribution as shown in equation 2 provides a sensible approximation to the wind velocity over flat terrain in the world [1]. V_m is the annual average wind speed. From this equation, it can be expected that 46 percent of wind speeds will exceed the value of V_m in a year [1].

$$p(V) = \exp\left[-\frac{\pi}{4}\left(\frac{V}{V_m}\right)^2\right] \quad (2)$$

$$P(watts) = 0.5\rho\ A\ V^3 \quad (3)$$

$$Turbines swept\ Area(m^2) = \pi\left(\frac{rotor\ diameter}{2}\right)^2 \quad (4)$$

$$Average\ power\ in\ a\ year = 0.95\rho\ A\ V^3 \quad (5)$$

Equation 3 is the density power in the wind, P in watts per unit area and it is equal to the kinetic energy in the wind per second. ρ is the density of air (which at sea level is 1.2256 kgm^{-3}), A is the turbine swept area or the area passing by air (m^2) and V is the wind velocity (ms^{-1}). In addition, equation 4 shows how to determine the turbine swept area in meter square, m^2 [5]. Moreover, equation 5 used to calculate average power in the whole year.

According to the equation 3, the power in wind is proportional to the density of air, the cube of wind velocity and the area passing by air. It means that, if the wind speed is double, the power generated approximately eight times greater [4-5]. In theory, a turbine operating on a site with an average wind speed 20km/h could produce about 33 percent more electricity compare at 18.5km/h. From the above statement, the important thing to be realize is even though the wind speed is slightly difference, it still can give a large difference in term of energy and electricity produced. In addition, it also gives a large difference in the rate of electricity generated.

IV. Concerning of Wind Turbine in Malaysia

In Malaysia, it is expected that the energy demand increased align to the increment of population. Moreover, the energy issue has given an anxiety circumstances since it becomes an imperative part for the countries development. Due to that, Malaysia Governments have allocated a funding through the IRPA (Intensification of Research in Priority Areas) in order to support the research and developments activities in the public sector. The R&D developments that the Government encourages are closed to the need of Malaysia industry for raising the socio-economic.

It is good to bear in mind that even though Malaysia has a low wind speed in general, it still has the potential to backup the electricity to the places where not have adequate power generated such as at the island and inland area. In addition, after 7th Malaysia Plan, it can see that, the Government have been increased the funding for renewable energy research and development in 8th Malaysia Plan (2001-2005) and 9th Malaysia Plan (2006-2010) [3]. According to the report by the Renewable energy Policy Network, REN(2007), it mentioned that the potential of wind energy in term of generating capacity had increased by 28 percent.

In year 2005, the researchers from Universiti Kebangsaan Malaysia studied the employment of the 150kW wind turbine at Terumbu Layang-Layang, in the South China Sea, 306km northwest of Sabah's capital, Kota Kinabalu [3]. This is the first project installed in the island off the East Malaysia and this project has been demonstrated with some achievement. However, this research has faces a difficulties due to the wind resources obtained is not consistent.

Alert to the potential of harnessing this green energy, in 2007, the Malaysia government, State Government of Terengganu and National Electric Board has work together in conducting a renewable energy venture. The purpose of this project is to integrate the power supply at Pulau Perhentian (Perhentian Island). This project consists of installing two wind turbine, solar panel, generator and battery. The joint venture research work demonstrated that, the energy produced by the two wind turbine was able to fulfill about 50 percent of load required in that island. It is believed that, if the number of wind turbine hired is increased, the electricity required in the island can be supplied mostly from this source. However, to make the proposed system more sensible, the reliable energy storage and power conversion technique is required in order to deliver continuously electricity power.

It must know that, to yield an optimum generated power output, the wind speed distribution must be determined at the first place [5]. The wind speed is measured in meters per second, m/s or knots. The effort to collect the wind speed data is needed as a consideration in employing the wind turbine. As mentioned by previous researchers, understanding the wind resource is a critical step in planning the wind energy project.

In Malaysia, the information about the wind speed profile can be achieved from The Malaysian Meteorologically Department. The organization is responsible to observe Malaysia's climate continuously. According to the observation from 36 meteorology stations in Malaysia, the data gathered from 1951 to 2006 shows that this country only has a light wind speed [2]. The wind speed in Malaysia is low and varies from season to season in the range of 2m/s to 13m/s [2-3]. The highest of the maximum wind speed is recorded at Kuching, Sarawak on 15 September 1992. The wind speed at that time is 41.7m/s. In addition, the highest reading of the average daily wind speed is 3.1m/s where it was happened at Mersing, Johor.

V. Potential of Wind Turbine in Malaysia

Even though the wind over the Malaysia is generally light, however, there has some homogeneous periodic changes in the wind flow patterns. Based on these changes, four seasons can be notable, which is the southwest monsoon, northeast monsoon and two shorter intermonsoon seasons. The southwest monsoon is usually established in the middle of May or early June and ends in September. The existing wind flow is normally southwesterly and light that is less than 15 knots.

The northeast monsoon usually begin in early November and ends in March. During this period, steady easterly or northeasterly winds of 10 to 20 knots exist. The affected areas are the east coast states of Peninsular Malaysia where the wind may reach 30 knots or more during periods of intense surges of cold air from the north (cold surges). The winds during the two intermonsoon seasons are generally light and variable. During these seasons, the equatorial trough lies over Malaysia [2].

It is worth mentioning that during the months of April to November, when typhoons frequently develop over the west Pacific and move westwards across the Philippines, southwesterly winds over the northwest coast of Sabah and Sarawak region may strengthen reaching 20 knots or more. As Malaysia is mainly a maritime country, the effect of land and sea breezes on the general wind flow pattern is very marked especially over days with clear skies. On bright sunny afternoons, sea breezes of 10 to 15 knots very often develop and reach up to several tens of kilometer inland. On clear nights, the reverse process takes place and land breezes of weaker strength can also develop over the coastal areas.

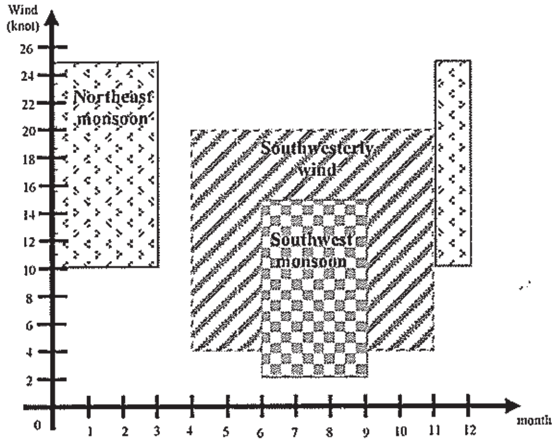


Figure 2. Wind Speed Recorded from January to December

Refer to Figure 3, it shows the wind speed from January until December in Malaysia. Generally, the wind speed is low, but at certain locations and at certain month, the wind speed is sufficient to contribute power electricity and integrate to electricity network. Moreover, the information in Figure 3 gives an inspiration and guidelines about when is the appropriate time and place to harnessing the wind energy. Due to that, Table II shown the data analysis based on wind speed in Figure 3. All the calculations are using the equation 2, 3 and 4 as discussed in chapter III.

TABLE II.
POWER DENSITY IN THE WIND

	Wind Speed (m/s)	Average Wind Speed, V_m	Expected Wind speed, V	Probability, p	Power in the wind, P (watts/m^2)	Average Power (W/m^2)
Jan – Mac	10 –25	10	10	45.6%	612.8	1,164
			15	17.1%	2,068.2	
			20	4.3%	4902.4	
Apr – Nov	4 – 20	5	5	45.6%	76.6	146
			11	2.2%	815.6	
			19	0.0%	4,203.2	
Jun – Sept	2 – 15	5	3	75.4%	16.55	146
			6	32.3%	132.4	
			13	0.5%	1,346.3	
Nov – Dec	10 -25	10	12	32.3%	1,058.9	1,164
			18	7.8%	3,573.9	
			25	0.7%	9,575.0	

From Table II, the highest annual average power is 1,164 W/m^2 and it is occurred from November to March. Moreover, this is the best time to harnessing this alternative energy in Malaysia. In addition, there has a situation where the probability for the expected wind speed to occur with respect to the average wind speed for a certain month is less than one percent. If the expected wind is equally to the average wind speed, the probability, p to occur is 45.6%. As a result, the information given in Table II will support the planner to evaluate whether it is suitable or not to implement the wind turbine in Malaysia.

$$Gross\ wind\ power = power\ density \times turbines\ swept\ area \quad (5)$$

$$Electric\ power\ produced = 0.2 \times gross\ wind\ power \quad (6)$$

$$Energy(Joules) = Electric\ power\ produced \times seconds \quad (7)$$

$$Energy(kWh) = Electric\ power\ produced\ in\ kW \times seconds \quad (8)$$

As shown in equation 5, 6, 7 and 8, the equation is used for calculate the gross wind power, electrical power produces, energy in joules and energy in kWh respectively. Table III is the energy generated from wind turbine in a month with using equation 5-8. In addition, the result in Table III is base on the average wind speed 10m/s with power density 1,164 W/m^2.

TABLE III.
ENERGY GENERATED FROM WIND TURBINE

Rotor diameter (m)	Turbine swept area (m^2)	Gross wind power (kW)	Electric power produced (kW)	Energy in a month	
				Joules	kWh
5	19.63	22.85	4.57	1.48 x 10^6	411
10	78.54	91.42	18.28	5.92 x 10^6	1,645
20	314.16	365.68	73.14	23.7 x 10^6	6,583
30	706.86	822.79	164.56	53.3 x 10^6	14,810
40	1,256.64	1,462.73	292.55	94.8 x 10^6	26,330
50	1,963.50	2,285.51	457.10	148.1 x 10^6	41,139

The energy calculated in Table III is based on the assumption that the wind turbine is operated only for 3 hours every day in a month. In addition, the number 0.2 as shown in equation 6 is a capacity factor and it indicates the productivity of the wind turbine system.

The calculated energy shown in Table III proves that the energy produced in kWh is high. As example, when the rotor with five meter diameter is employed, the energy produced in a month is 411 kWh. Generally, one house in Malaysia consumed approximately 350kWh power month and compared to energy produced by 5 meter rotor diameter, it is sufficient to fulfill the household load requirement.

VI. GEOTHERMAL ENERGY

Geothermal energy is a power taken from heat energy originated from the inside of the earth, such as hot springs. It contained in the rock and fluid in the earth's crust. It is highly reliable and can supply base electricity load to the grid, which is same as coal, natural gas and other fuels. Hydrothermal reservoirs, earth energy, geopressured brines, hot dry rock and magma are a few of potential sources of geothermal. The hydrothermal reservoirs and earth energy are available and widespread use while the geopressured brines, hot dry rock and magma could only be accessed by advanced technologies and engineering techniques.

For generate the electricity power, the resources from earth heat such hot water or steam flows up through wells and molten rocks are used as shown in Figure 4. Geothermal energy are friendly to environment compared to others power especially in the aspect of air emission [12].

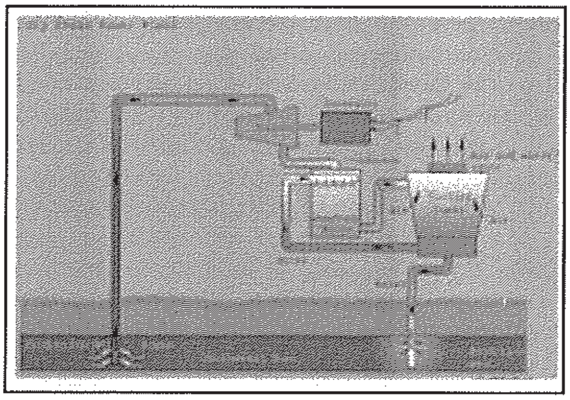


Figure 3. Geothermal Plant

VII. POTENTIAL ELECTRICITY IN GEOTHERMAL ENERGY

The geothermal energy can be divided into two parts in term of the use of this energy. First, the geothermal used for electricity generation and the other one is for heating purposes. The reviews of the electricity generation have been made by Huttrer and the other one is reviewed the direct use of geothermal energy by Lund and Freestone [9].

The temperature increases with an average of 25°C per kilometer of the earth depth. If the average surface temperature is 30°C, the temperature at 5km is 155 °C. For direct use application of geothermal energy, temperature as low as 35°C can be utilized. However, the minimum temperature suitable for electrical generation is about 125 °C.

In 2003, about 21 countries in the world generate electricity using a geothermal steam. The largest installed capacities are in the United States, which is 2228MW. In addition, it is motivating to look to the Malaysia's neighbor countries in South East Asia. Philippines, Indonesia and Thailand had installed 1909MW, 589MW and 0.3MW respectively. The ratio of electricity generated from geothermal resources in Philippines is about 22% and Indonesia is 5% [9].

VIII. GEOTHERMAL ENERGY IN MALAYSIA

It was reported that there are 79 localities hot springs in Malaysia. It was located in Peninsular Malaysia along the eastern part of the main range granite batholiths. Besides that, the hot springs in Sabah originate within young volcanic area. While in Sarawak, thermal springs were located at the most westernmost area of that state. Currently, the thermal areas used for the recreational activities purposes only. In Malaysia, there are a few of famous hot springs. There are Ulu Lenggong Hot Springs in Kedah, Air Hangat Village in Pulau Langkawi, Gadek Hot Spring in Melaka, Pedas Hot Spring in Negeri Sembilan, Sungai Klah in Perak, Tambun Hot Spring in Perak, and Poring Hot Spring in Sabah.

There is a place called Apas which is 40km from Tawau has a potential to generate electricity from geothermal sources. According to the studied by the Deputy Natural Resources and Environment of Malaysia, the geothermal site in Apas has a potential to generate up to 67MW of electricity a day. Moreover, the electricity generated is able to meet the energy demands of Tawau.

Started at year 2007, the researcher found that this place had a potential to generate electricity according to the magnetotelluric study on the 50km^2 site. The study also found a reservoir about 3km below the earth's surface with the water temperatures near to 235°C. This temperature was more than enough to heat and at the same time generate electricity. However, to implement a large-scale system for harvesting this alternative energy, it would take time. It is due to the several matters to resolve where the land was under the Sabah's jurisdiction and was located within the Sabah Parks, a protected area.

TABLE IV.
ENERGY COST COMPARISON

Resources Type	Average cost (cent / KW)
Hydroelectric	2 – 5
Nuclear	3 - 4
Coal	4 – 5
Natural Gas	4 - 5
Wind	4 - 10
Geothermal	5 – 8
Biomass	8 – 12
Hydrogen fuel cells	10 – 15
Solar	15 – 32

Besides that, under the Ninth Malaysia Plan, the Government had allocated RM1.5 million for research on the site and it was hoped that drilling could start under the 10th Malaysia Plan. The cost of geothermal is competitive with other energy whereas it is almost equally to the wind power as shown in Table IV.

III. CONCLUSION

It is good to understand that, sufficient information about both energy is necessary before employing a large scale and mature system. Besides that, the constraint in harvesting this two energy is regarding the cost. The high cost is the main reasons why it is not develop seriously in Malaysia. Realize with the reducing of fossil fuel in the world, Malaysia needs to find other potential of energy sources. The studies on wind and geothermal energy are basically not to replace the fuels generator. However, it is believed that, this both energy sources can be integrate with the ordinary electricity network. In this paper, it concludes that, Malaysia could produce electricity by using the wind energy about 50% of requirement for one household. On the other side, Malaysia also has a potential to develop more electricity by using geothermal energy. As a final point, the wind energy and geothermal energy can be a potential of energy sources in Malaysia as long as the equipments and technologies suitable to used in this country.

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