KEMENTERIAN PENDIDIKAN TINGGI

JOJAPS

eISSN 2504-8457

POLITEKNIK MALAYSIA PORT DICKSON

Journal Online Jaringan COT POLIPD (JOJAPS)

# A Study of Elevated Wind Speed Assessment at East Malaysia Using Extrapolation Method

Shaifatulna'im Shamsuddin[1] & Mohd Asyraf Md Junos[2]

*[1#]Mathematics, Science and Computer Department, Kuching Polytechnic,*
*Locked Bag 3094, KM 22, Matang Road, 93050 Kuching, Sarawak, Malaysia*
*[2#]Petrochemical Engineering Department, Kuching Polytechnic,*
*Locked Bag 3094, KM 22, Matang Road, 93050 Kuching, Sarawak, Malaysia*
*[1] shaitulnaim@poliku.edu.my*
*[2] asyraf@poliku.edu.my*

**Abstract**

Exploring the possibilities of utilizing renewable energy apart of hydro power are crucial due to high growth of demanding market plus the current rate of fossil fuel depletion. Hence, it is a need to analyze the potential of wind power in generating electrical energy. Being Equatorial country, Malaysia has seasonal wind and it differs according to topographic of the area. Wind speed data at 10 meter height from 9 reading station all over East Malaysia are collected. However, wind study demanding a further data at elevated height to suit the actual positioning of wind turbine. Thus, this study identified Kudat as a site with highest wind speed at 4.2ms$^{-1}$ and the most mean wind speed, hence it is selected for further consideration. Extrapolation process will be need to determine the projected wind speed at height of 20m,30m,40m,50m and 60m using both Power Law and Log Law method . Their mean wind speed data, yearly mean speed data and cumulative yearly wind speed data are identified and analyzed. The result showing the wind profile pattern for both graphs from Power Law and Log Law and it is showing the increment patents for Log Law are always greater than Power Law. Same results are obtained for wind power density and actual power. It is showing that Kudat wind power is classify as Class 1, which is having wind speed less than 5.6ms-1 while wind power density is less than 200Wm$^{-2}$. Nevertheless, with current development, wind class lower than Class 4 are possible for wind energy extraction using mid or small size wind turbine. Hence, to suit the seasonal wind, the hybrid system combining wind and solar shall be applied to compliment the low wind speed.

*Keyword:* - renewable energy, wind speed, wind power.

## 1. Introduction

Malaysia is located between 2 and 7 degrees north of the Equator. Peninsula Malaysia is separated from the states of Sabah and Sarawak by the South China Sea. Malaysia is situated right in the heart of South East Asia and is divided into two geographical sections: Peninsular Malaysia and the East Malaysian provinces of Sabah and Sarawak in North Borneo. The two parts are separated 650km apart by the South China Sea. Peninsular Malaysia's neighbors are Thailand and Singapore. Sabah and Sarawak border Kalimantan and Sarawak surrounds the tiny enclave of Brunei. The Andaman Sea is on the West Coast of the peninsula. The East Coast of the peninsula, Sabah and Sarawak all adjoin the South China Sea.

Peninsular Malaysia accounts for 40% of the country's landmass. There are several mountain ranges running north- south along the backbone of the peninsula. A wide, fertile plain trails the West Coast, while a narrow coastal plain runs along the east. Sabah and Sarawak are covered by dense jungles and have large river networks. These rivers are still the main means of transportation to the natives of these two states. Over 60% of the country is still rainforest, and there are 8000 species of flowering plants (in Peninsular Malaysia alone) which includes 2000 tree species, 800 different orchids and 200 types of palm, not forgetting a myriad of wildlife animals. There are also an abundance and variety of bird populations from all over the world that can be found in East Malaysia.

Due to Malaysia rapid development, there are high rate off energy demanding and kept increasing over the past years. These energy sources are oil, natural gas, coal and renewable energy. The examples of renewable energy other than hydro which currently being explored are solar power, wind energy and biomass. (*Abbas R, et al 2011*). The rapid development resulting our final energy consumption rate grew at the rate of 5.6% within 5 years' time. The projected ultimate consumptions are expected to reach 98.7.7Mtoe by 2030. (*Rahim N.A et al 2012*). Renewable energy can be defined as sources of energy that didn't depleted over time. Other definitions are "energy obtained from the continuous or repetitive currents of energy recurring in the natural environment" (*Azhar A.A 2011*)

In order to cope with the projections, Malaysians government has drafted a series of policy in order to boost other energy sources other than oil. The best examples are the national energy policies which had started as far back as 1997 and were revised in 1999, with the announcement of the Five-Fuel Diversification Policy (FDP), which defines that the energy mix is contributed by 5 main resources: gas, coal, oil, hydro and renewable energy in the Eighth Malaysian Plan (MP). Currently, the Malaysian Government is focusing on replacing 5.5% of electricity sources using renewable energy as the country progresses towards becoming a developed nation by 2020 (*Hashim H. 2011)* and (*Mekhilef S. 2010*)

At present we mainly rely on fossil fuels which resulting the quicker depletion of these natural minerals. According to a study, at present, the world coal reserves can last for about another 200 years, natural gas for about 60 years while oil approximately 40 years only. (*Kyairul A.B 2007*). Thus, it is a crucial challenge to sustain the energy supply by diversify the energy resources. Diversification is critical as to not too dependent on a single source of energy. Wind energy assessments are crucial as it help to strategically analyze the potential of harvesting electricity using renewable resources. The process of utilizing the wind energy is started by analyzing the data from Meteorological Department.

However, the data from the institute are not standardize amongst station as they are using two different method in taking reading, and it is taken at different height from ground. Initial data reading are using Cup Anemometer for data reading. April 2005 afterwards, data reading method at meteorological station are gradually changed to a modern Sonic Anemometer. This new wind reading mechanism is mounted at 10meter height above ground. Hence, it enable the wind speed detection precisely at 10m height above ground, thus it is a need to determine the wind speed at further height in order to identify the profile of wind speed. Two methods are used in this process and the result obtained will be compared and discussed

a) To identify the site with highest wind speed.
b) To analyze the Power Law and Log Law method and their impact in extrapolating the wind speed at best calculated site.

## 2. Methodology

2.1 Analyzing Data from Data from MetMalaysia.

Data for wind stations for Sabah and Sarawak are being analyzed to identify their mean speed. Those data are gathered at different height of the station, hence have got to refine to achieve projected wind speed at standardize height. The calculations also involved the considerations of nature at surface area. The projected wind speeds are based on extrapolation and interpolation method. The obtained value will be used for estimation of wind power and wind power density.

**Table 1 –** Details of Data Station.

| | STATION | LATITUDE | LONGITUDE | HEIGHT ABOVE GROUND | LOCATION DETAILS | FRICTION COEFFICIENT,α | SURFACE ROUGHNESS LENGTH $z_o$ |
|---|---|---|---|---|---|---|---|
| 1. | Kuching | 1° 29' N | 110° 20' E | Jan1998 – Mac 2005 : 12.2m<br>Apr 2005 – Dec 2013 : 10m | City | 0.40 | 0.4000 |
| 2. | Bintulu | 3° 07' N | 113° 1' E | Jan1998 – Mac 2005 : 12.5m<br>Apr 2005 – Dec 2013 : 10m | Mowed grass airport field | 0.20 | 0.0024 |
| 3. | Miri | 4° 20' N | 113° 59' E | Jan1998 – Mac 2005 : 12m<br>Apr 2005 – Dec 2013 : 10m | City | 0.40 | 0.4000 |
| 4. | Kota Kinabalu | 5° 56' N | 116° 03' E | Jan1998 – Mac 2005 : 12m<br>Apr 2005 – Dec 2013 : 10m | Airport | 0.10 | 0.0024 |
| 5. | Labuan | 5° 18' N | 115° 15' E | Jan1998 – Mac 2005 : 14.1m<br>Apr 2005 – Dec 2013 : 10m | Airport | 0.10 | 0.0024 |
| 6 | Kudat | 6° 55' N | 116° 50' E | Jan1998 – Mac 2005 : 12.2m<br>Apr 2005 – Dec 2013 : 10m | Airport | 0.10 | 0.0024 |
| 7. | Sandakan | 5° 54' N | 118° 04' E | Jan1998 – Mac 2005 : 12.2m<br>Apr 2005 – Dec 2013 : 10m | Airport | 0.10 | 0.0024 |
| 8. | Limbang | 4° 48' N | 115° 00' E | Jan2007 – Dec2013 : 10m | Mowed grass airport field | 0.15 | 0.0024 |
| 9. | Kapit | 2° 00' N | 112° 55' E | Jan2008 – Dec2013 : 10m | Bushy field | 0.20 | 0.0550 |

Wind Speed Data are calculated for their mean monthly and yearly value based on 3 extrapolated height, 10 meter (for certain period only), 20 meter and 30 meter. Using the appropriate Friction Coefficient and Surface Roughness Length, both monthly and yearly data shall then be calculated thus concluded into a table of mean data for monthly and yearly.

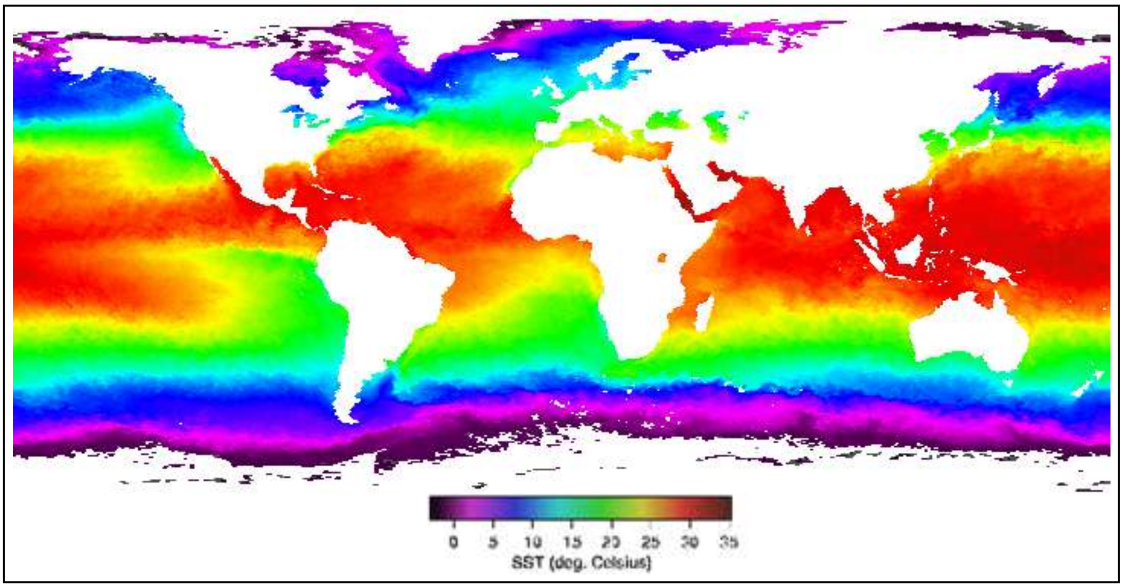


**Figure 1 -** AVHRR Sea Surface Temperature

These hot areas are indicated in the warm colours, red, orange and yellow in this infrared picture of sea surface temperatures. While magenta represents both very cold temperatures as well as high-altitude cloud tops. *(Cynthia O.C, 2012)*

2.2 Hellman Exponential Law.

It is also known as Power Law. The calculations are using the Hellman Exponential Law formula that correlates the wind speed readings at two different heights. This formula is expressed by an equation below

$$\frac{v}{v_o} = \left[\frac{H}{H_0}\right]^{\alpha}$$

υ is the speed at H height, υ0 is the speed at H0 height, and α is the friction coefficient. Further calculation involving calculates wind speed at three different height ranges. The friction coefficient is a function of the topography at a specific site, this study assess each of data reading station to ensure their correct physical properties.

The Monin-Obukhov method is the most widely used to depict the wind speed *v* at height *z b*y means of a log-linear profile clearly described by:

$$v(z) = \frac{v_f}{K}\left[ln\frac{z}{z_0} - \xi\left(\frac{z}{L}\right)\right]$$

Where; *z* is the height, $v_f$ is the friction velocity, *K* is the von Karman constant (normally assumed as 0.4), *z* is the surface roughness length, and *L* is a scale factor called the Monin-Obukhov length.

The function *ξ(z/L)* is determined by the solar radiation at the site under survey. This equation is valid for short periods of time, e.g. minutes and average wind speeds and not for monthly or annual average readings. This equation has proven satisfactory for detailed surveys at critical sites; however, this approach is difficult to use for general engineering studies. Thus the surveys must resort to simpler expressions and secure satisfactory results even when they are not theoretically accurate (*Johnson, 2001*). Hence, the Hellmann Exponential Law that correlates the wind speed readings at two different heights are selected.

2.3 Logarithmic Wind Profile Law

Logarithmic Wind Profile Law also known as The Log Law. The calculations are using the formula as expressed by an equation below.

$$\frac{U(H)}{U(H_r)} = \frac{\ln\left(\frac{H}{z_o}\right)}{\ln\left(\frac{H_r}{z_o}\right)}$$

$U_H$ is a speed at *H* height, while $UH_r$ is speed at $H_r$ reference height. Surface roughness length indicated by $z_o$.

2.4 Possible of Harvested Wind Power Density.

Referred to the variation of height, the possible power generated for both Power Law and Log Law method are calculated. The formula for Wind Power Density is as follows;

$$P = \frac{1}{2}\rho v^3$$

While, next formula are used for identification of Actual Available Power ;

$$P = \frac{1}{2}\rho v^3 C_{P_{max}}$$

Details of the calculations are;

$\rho$ = air density , 1.225 $kgm^{-3}$
$v$ = wind speed, $ms^{-1}$
$C_P$ = Power Coefficient for wind turbine.
$C_{P_{max}} = 0.59$ , Maximum Theoretical Power Coefficient.

## 3. Result and Discussion.

**Table 2 –** Calculated Data at Station 1 – Kuching for year 1998-2013.

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | **Annual** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1998 | 1.1 | 1.1 | 1.1 | 0.9 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.6 | 0.5 | **0.7** |
| 1999 | 0.5 | 1.0 | 0.6 | 0.5 | 0.4 | 0.5 | 0.7 | 0.8 | 0.7 | 0.8 | 0.7 | 0.8 | **0.7** |
| 2000 | 0.7 | 0.7 | 0.5 | 0.7 | 1.4 | 1.7 | 1.7 | 1.7 | 1.6 | 1.6 | 1.4 | 1.4 | **1.3** |
| 2001 | 1.5 | 1.7 | 1.5 | 1.3 | 1.0 | 1.3 | 1.3 | 1.4 | 1.1 | 1.1 | 1.1 | 1.4 | **1.3** |
| 2002 | 1.4 | 1.3 | 1.1 | 1.2 | 1.2 | 1.1 | 1.4 | 1.4 | 1.2 | 1.1 | 1.1 | 1.1 | **1.2** |
| 2003 | 1.4 | 1.3 | 1.2 | 1.1 | 1.2 | 1.1 | 1.2 | 1.2 | 1.4 | 1.2 | 1.2 | 1.3 | **1.2** |
| 2004 | 1.2 | 1.4 | 1.2 | 1.2 | 1.1 | 1.2 | 1.4 | 1.4 | 1.3 | 1.2 | 1.2 | 1.3 | **1.3** |
| 2006 | 1.5 | 1.5 | 1.5 | 1.4 | 1.8 | 1.8 | 1.9 | 1.9 | 1.7 | 1.8 | 1.8 | 1.7 | **1.7** |
| 2007 | 2.0 | 2.0 | 1.8 | 1.6 | 1.7 | 1.8 | 1.9 | 1.9 | 1.7 | 1.7 | 1.7 | 1.8 | **1.8** |
| 2008 | 2.1 | 2.0 | 1.8 | 1.7 | 1.7 | 1.7 | 1.8 | 1.9 | 1.8 | 1.8 | 1.8 | 2.0 | **1.8** |
| 2009 | 1.8 | 2.0 | 1.6 | 1.7 | 1.7 | 1.7 | 1.9 | 1.8 | 1.8 | 1.7 | 1.7 | 1.8 | **1.8** |
| 2010 | 2.1 | 1.9 | 1.6 | 1.7 | 1.7 | 1.6 | 1.8 | 1.7 | 1.7 | 1.8 | 1.7 | 1.7 | **1.8** |
| 2011 | 1.8 | 1.9 | 1.9 | 1.7 | 1.7 | 1.8 | 1.9 | 1.8 | 1.7 | 1.8 | 1.8 | 1.7 | **1.8** |
| 2012 | 2.0 | 1.9 | 1.8 | 1.8 | 1.7 | 1.7 | 1.7 | 1.8 | 1.9 | 1.8 | 1.8 | 1.8 | **1.8** |
| 2013 | 2.0 | 1.7 | 1.8 | 1.7 | 1.6 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.7 | 1.8 | **1.8** |
| **Monthly Mean** | **2.1** | **1.9** | **2.0** | **1.8** | **1.7** | **1.6** | **2.0** | **2.1** | **1.9** | **1.8** | **1.8** | **1.7** | |

**Table 3 –** Monthly Mean Data (2006-2013) For 9 Station

| | Kuching | Bintulu | Miri | K.K | Labuan | Kudat | Sandakan | Limbang | Kapit |
|---|---|---|---|---|---|---|---|---|---|
| Jan | 1.99 | 1.74 | 2.19 | 1.86 | 2.48 | 2.59 | 2.78 | 1.54 | 0.97 |
| Feb | 1.91 | 1.83 | 2.19 | 1.81 | 2.66 | 2.84 | 2.85 | 1.57 | 0.98 |
| Mar | 1.79 | 1.76 | 2.09 | 1.86 | 2.19 | 2.40 | 2.53 | 1.50 | 1.07 |
| Apr | 1.71 | 1.78 | 2.03 | 1.99 | 1.81 | 2.23 | 2.24 | 1.46 | 0.98 |
| May | 1.85 | 1.71 | 2.01 | 2.10 | 1.68 | 2.13 | 2.14 | 1.37 | 0.92 |
| Jun | 1.71 | 1.66 | 2.05 | 2.18 | 1.70 | 2.15 | 2.00 | 1.40 | 1.00 |
| Jul | 1.85 | 1.71 | 2.13 | 2.24 | 1.66 | 2.31 | 1.99 | 1.46 | 1.03 |
| Aug | 1.85 | 1.75 | 2.19 | 2.30 | 1.73 | 2.40 | 2.14 | 1.47 | 1.10 |
| Sep | 1.79 | 1.75 | 2.23 | 2.35 | 1.83 | 2.61 | 2.03 | 1.47 | 1.07 |
| Oct | 1.78 | 1.73 | 2.16 | 2.25 | 1.85 | 2.51 | 2.08 | 1.47 | 1.05 |
| Nov | 1.75 | 1.70 | 2.18 | 2.10 | 1.85 | 2.11 | 2.08 | 1.40 | 1.05 |
| Dec | 1.79 | 1.71 | 2.13 | 1.98 | 2.09 | 2.34 | 2.45 | 1.50 | 1.02 |
| **Mean Value** | 1.81 | 1.74 | 2.13 | 2.08 | 1.96 | 2.38 | 2.27 | 1.47 | 1.02 |

Calculated results are summarized in the next table comprising both methods;

**Table 4 –** Projected Wind Speed at Escalated Height Using Both Method.

| MONTH | METHOD | HEIGHT | | | | | |
|---|---|---|---|---|---|---|---|
| | | 10m | 20m | 30m | 40m | 50m | 60m |
| Jan | Power Law | 2.59 | 2.77 | 2.89 | 2.97 | 3.04 | 3.10 |
| | Log law | 2.59 | 2.80 | 2.93 | 3.02 | 3.09 | 3.14 |
| Feb | Power Law | 2.84 | 3.04 | 3.17 | 3.26 | 3.33 | 3.39 |
| | Log law | 2.84 | 3.07 | 3.21 | 3.31 | 3.39 | 3.45 |
| Mar | Power Law | 2.40 | 2.57 | 2.68 | 2.76 | 2.82 | 2.87 |
| | Log law | 2.40 | 2.60 | 2.72 | 2.80 | 2.86 | 2.92 |
| Apr | Power Law | 1.81 | 1.94 | 2.02 | 2.08 | 2.13 | 2.17 |
| | Log law | 1.1 | 1.96 | 2.05 | 2.11 | 2.16 | 2.20 |
| May | Power Law | 2.13 | 2.28 | 2.37 | 2.44 | 2.50 | 2.54 |
| | Log law | 2.13 | 2.30 | 2.41 | 2.48 | 2.54 | 2.58 |
| Jun | Power Law | 2.10 | 2.30 | 2.40 | 2.47 | 2.53 | 2.57 |
| | Log law | 2.10 | 2.33 | 2.43 | 2.51 | 2.57 | 2.61 |
| Jul | Power Law | 2.31 | 2.48 | 2.58 | 2.66 | 2.72 | 2.77 |
| | Log law | 2.31 | 2.50 | 2.62 | 2.70 | 2.76 | 2.81 |
| Aug | Power Law | 2.40 | 2.57 | 2.68 | 2.70 | 2.76 | 2.81 |
| | Log law | 2.40 | 2.60 | 2.72 | 2.80 | 2.86 | 2.92 |
| Sep | Power Law | 2.61 | 2.80 | 2.92 | 3.00 | 3.07 | 3.17 |
| | Log law | 2.61 | 2.83 | 2.96 | 3.05 | 3.12 | 3.17 |
| Oct | Power Law | 2.51 | 2.69 | 2.80 | 2.89 | 2.95 | 3.01 |
| | Log law | 2.51 | 2.72 | 2.84 | 2.93 | 3.00 | 3.05 |
| Nov | Power Law | 2.11 | 2.26 | 2.36 | 2.43 | 2.48 | 2.53 |
| | Log law | 2.11 | 2.29 | 2.39 | 2.46 | 2.52 | 2.57 |
| Dec | Power Law | 2.34 | 2.51 | 2.61 | 2.69 | 2.75 | 2.80 |
| | Log Law | 2.34 | 2.53 | 2.65 | 2.73 | 2.79 | 2.84 |

**Table 5 –** Actual Monthly Mean Available Power.

| | | Actual Available Power, $kWm^{-2}$ | | | | | |
|---|---|---|---|---|---|---|---|
| | | **10m** | **20m** | **30m** | **40m** | **50m** | **60m** |
| Jan | Power Law | 6.27 | 7.68 | 8.72 | 9.47 | 10.15 | 10.77 |
| | Log Law | 6.27 | 7.93 | 9.09 | 9.95 | 10.66 | 11.19 |
| Feb | Power Law | 8.26 | 10.16 | 11.18 | 12.52 | 13.38 | 14.13 |
| | Log Law | 8.26 | 10.49 | 11.97 | 13.10 | 14.02 | 14.81 |
| Mac | Power Law | 4.99 | 6.13 | 6.96 | 7.60 | 8.10 | 8.54 |
| | Log Law | 4.99 | 6.35 | 7.27 | 7..93 | 8.45 | 9.00 |
| Apr | Power Law | 2.14 | 2.64 | 2.98 | 3.25 | 3.49 | 3.69 |
| | Log Law | 2.14 | 2.72 | 3.11 | 3.40 | 3.64 | 3.85 |
| May | Power Law | 3.49 | 4.28 | 4.81 | 5.25 | 5.65 | 5.92 |
| | Log Law | 3.49 | 4.40 | 5.06 | 5.51 | 5.92 | 6.21 |
| Jun | Power Law | 3.35 | 4.40 | 5.00 | 5.45 | 5.85 | 6.13 |
| | Log Law | 3.35 | 4.57 | 5.19 | 5.71 | 6.13 | 6.43 |
| Jul | Power Law | 4.45 | 5.51 | 6.21 | 6.82 | 7.27 | 7.68 |
| | Log Law | 4.45 | 5.65 | 6.50 | 7.11 | 7.60 | 8.02 |
| Aug | Power Law | 4.99 | 6.13 | 6.96 | 7.60 | 8.10 | 8.54 |
| | Log Law | 4.99 | 6.35 | 7.7 | 7.93 | 8.46 | 9.00 |
| Sept | Power Law | 6.45 | 7.93 | 9.00 | 9.76 | 10.45 | 11.08 |
| | Log Law | 6.45 | 8.19 | 9.37 | 10.25 | 10.98 | 11.51 |
| Oct | Power Law | 5.71 | 7.03 | 7.93 | 8.72 | 9.28 | 9.86 |
| | Log Law | 5.71 | 7.27 | 8.28 | 9.09 | 9.28 | 9.86 |
| Nov | Power Law | 3.39 | 4.17 | 4.75 | 5.19 | 5.51 | 5.85 |
| | Log Law | 3.39 | 4.33 | 4.93 | 5.38 | 5.78 | 6.13 |
| Dec | Power Law | 4.63 | 5.71 | 6.43 | 1.03 | 7.51 | 7.92 |
| | Log Law | 4.63 | 5.85 | 6.72 | 7.35 | 7.84 | 8.28 |

Meanwhile, **Table 5** showing the Actual Monthly Mean Power which already have put in the maximum theoretical power coefficient. Hence, for actual application, less power are expected as more considerations on losses have got to put into account. Value for actual power are directly rely on the wind power density as it simply a net value of energy after considering the possible losses. Hence, January, February and September are still the month with highest energy output. Note that, overall differences between Power Law and Log Law are ranging between 3% - 5% as the calculations are rounding to 2 decimal points. Though a 5% differs is small, it will be slightly affecting the projection of harvested power, thus involving the cost effective considerations.

## 4. Conclusions

Kudat station, which located at the most northern tip of Sabah, and standing 3.5m above the sea level is not the highest land Borneo. But, among other station, the highest wind speed pass through it. Though Kudat station recorded the highest available wind speed, it was not consistent throughout the year as it maximum speed only avails during monsoon season only. Kudat experienced Northeast Monsoon which usually begins in in October and ends in February. This explained the maximum wind speed recorded on January and February at $4.2ms^{-1}$ and $4.0ms^{-1}$ respectively. Next, Kudat received South West Monsoon from March to September, thus a speed at $3.0ms^{-1}$ and $3.2ms^{-1}$ recorded at August and September.

This harvested wind power are rely on the 3 crucial factors; volume, velocity and density. Amount of air as well as the air speed will reflect the most as the swept area of turbine are kept constant. While mass of air and air density varies in direct proportion to air pressure. The study focused on the use of scientific findings and predefined coefficients for calculating the wind speed at different height level. Moreover, these findings must be pondered carefully because as demonstrates by the results, these coefficients are heavily dependent on the relevant land features. Since the wind speed undergoes repeated changes and the roughness and friction coefficients also change in line with the landscape features, the time of the day, the temperature, height, wind direction, etc. it follows that the reading results should be pondered carefully.

The calculated power at elevated height did not promising same output in real applications. Though the calculations already consider the maximum efficiency limit for turbine, the real world limit is well below the Betz Limit. Their values are between 0.35 and 0.45. This is because in real life, we need to take into account another factors in transmitting the mechanical power into electrical power such as gearbox, bearing, generator etc. Wind speed obtained using Power Law and Log Law showing a certain pattern at elevated height. It is noticeable that value of wind speed from Log Law is larger than Power Law method. Even though the formula for both methods is resulting slight differences, but yet it still proportionate to the height.

These formulas are used as initial estimates of the wind potential at the elevated altitudes. Such estimations from formula will lead us to query the precision and consistency of both methods. Hence, in real life, there is no better substitute to actual site measurements. Classifications of wind speed are based on wind speed frequency distributions and air density. These classes ranged from Class 1 (the lowest) to Class 7 (the highest). In general, at a 50-m height, wind power Class 4 or higher could have been useful for generating wind power with turbines in the 250-kW to 750-kW rating. Given the advances in technology, resources below Class 4 may now be suitable for the new midsize or small size wind turbines. Thus, with further studies, there should a little hope for Kudat to extract its wind energy potential and make use of it by integrating both wind and solar power.

It should be noted that information provided on this studies describes general wind power distribution and can be used as initial guidance in selecting regions for wind power projects. Additional information, such as design and specification of wind turbine, should be taken into account when executing wind energy applications. This sort of studies and analytical work are the initial steps prior to mounting the masts and towers fitted with either precision measuring instruments or wind generators. Indeed an analysis of this kind would help to save money and time that otherwise will be a waste in the absence of the appropriate methodology.

## References

Abbas, R., M. F. Kamarudin, A. B. A. Nurdin, and M. A. Simeh. (2011). "A Study on The Malaysian Biomass Sector- Supply and Perception of Palm Oil Millers." Oil Palm Industry Economic Journal 11(1): 28-41.

Azhar Abdul Aziz, (Feb 2011) Feasibility Study on Development of A Wind Turbine Energy Generation System for Community requirements of Pulau Banggi Sabah,Azhar Abd Azizi, Faculty of mech Eng, UTM,.

Baharuddin Ali, Kamaruzzaman Sopian, Chan Hoy Yen, Sohif Mat & Azami Zaharim. (2008). "Key success factors in implementing renewable energy programme". 4th IASME/WSEAS International Conference on Energy, Environment, Ecosystems and Sustainable Development (EEESD'08). June 11-13, 2008. Algarve, Portugal.

Bernama, "Hydropower to propel Sarawak to become regional power house", 17 April, 2008.

Borja M.A, Gonzalez R, Meija F, Hacuz J.M, Medrano M.C, Saldana R., (1998), "Estado del Arte y Tendencias de la Tecnologia Eoloelectrica " (In Spanish), Instituto de Investigaciones Electricas, IIE/UNAM, ISBN 968-36-7433-X, Mexico.
Burton T, David Sharpe, Nick Jenkins, Ervin Bossanyi, (2011), "Wind Energy Handbook", John Wiley & Sons, 2nd edition, ISBN 978-0-470-69975-1
Cheremisinoff N.P. (1979), "Fundamentals of Wind Energy", 2nd Ed. Ann Arbor, MI, Ann Arbor, Science Publisher Inc
Cynthia O.C, (2012), "Global Climate Change" Retrieved Dis 2014 from http://climate.nasa.gov/news/678/
Darrell D, (1996), Illustrated History Of Wind Power Development", retrieved Dec 2014 from http://ww.telosnet.com/wind/early.html
David D. (2013), "Wind Power Density", retrieved Dec 2014 from http://www.daviddarling.info/encyclopedia/W/AE_wind_power_density.html
De Renzo D.J, (1979), "Wind Power: Recent Developments", Noyes Data Corporation.
Donald Routledge Hill, (1991) "Mechanical Engineering in the Medieval Near East", Scientific American, May, p. 64-69. (cf. Donald Routledge Hill, Mechanical Engineering)
Francisco B.R, César A.C, Sebastian R.M, (2011), "Methodologies Used in the Extrapolation of Wind Speed Data at Different Heights and Its Impact in the Wind Energy Resource Assessment in a Region - Wind Farm - Technical Regulations, Potential Estimation and Siting Assessment", retrieved Dis 2014 from http://www.intechopen.com/books/wind-farm-technical-regulations-potential-estimation-and-sitingassessment/methodologies-used-in-the-extrapolation-of-wind-speed-data-at-different-heights-and-its-impactin-th
Hashim, H., and W. S. Ho. (2011) . "Renewable Energy Policies and Initiatives For A Sustainable Energy Future In Malaysia." Renewable and Sustainable Energy Reviews 15: 4780– 4787.
Ibrahim M.Z, Albani A, Hamzah M.H.M, (2013), "Assesment of Wind Energy Potential Using METAR Data In Malaysia", International Journal Of Renewable Energy Research, Vol 3, No 4.
Islam M.R, Saidur R, Rahim N.A , (2011), "Assessment of Wind Energy Potentiality At Kudat and Labuan, Malaysia Using Weibull Distribution Function", retrieved Dec 2014, from http://www.sciencedirect.com/science/article/pii/ S0360544210007012
Pacheco B.M, Rosaria N.E, Aquino R.E.R, Leo Garciano, 2007, ""Historical review of wind speed maps in the Philippines for various purposes: toward further development and use as typhoon hazard maps". Proceeding 4th Civil Engineering Conference in the Asian Region (CECAR4), Taipei, Taiwan.
Kyairul A.B (2007), "Analysis Of Renewable Energy Potential In Malaysia."
Manwell, J. F, Mcgowan J.G, Rogers A.L, ( 2009), "Wind Energy Explained, 2nd Edition", Wiley Ltd Publication.
Mekhilef, S. (2010). "Renewable Energy Resources and Technologies Practice in Malaysia." 5th International Symposium on Hydrocarbons & Chemistry (ISHC5), Sidi Fredj, Algiers, May the 23rd to 25th, 1-9.
Price T.J, (2004), Oxford Dictionary of National Biography (online ed.). Oxford University Press. doi:10.1093/ref:odnb/100957.
Rahim N.A, K.H. Solangi, and R. Saidur. (2012). "Assessing Wind Energy Potentiality for Selected Sites in Malaysia." Energy Education Science and Technology Part A: Energy Science and Research 29(1): 611-626.
Sen Z. Sahin AD, (1998) " Regional Wind Energy Evaluation In Some Parts Of Turkey", Journal Of Engineering Ind Aerodynam 1998, 74-76, 345-53
Siti Khadijah Najid, Azami Zaharim, Ahmad Mahir Razali, Mohd Said Zainol, Kamarulzaman Ibrahim & Kamaruzzaman Sopian (2009), "Analyzing the East Coast Malaysia Wind Speed Data". Retrieved Dec 2014 from http://www.academia.edu/792454/Analyzing_the_East_Coast_Malaysia_Wind_Speed_Data
Sopian K., Othman M.Y, Wirsat A. (1995), " The Wind Energy Potential Of Malaysia", Renewable Energy, Vol 6(8) pp 1005-1016.
Soren K. (2000), "Wind Energy", retrieved Dec 2014, from http://www.windpower.org/tour/wres.geostro.html
Timothy A.C, Kevin R.K, (2009), Factors Affecting Surface Wind Speeds in Gravity Waves and Wake Lows. Wea. Forecasting, 24, 1664–1679, retrieved Dis 2014 from http://journals.ametsoc.org/doi/abs/10.1175/2009WAF2222248.1