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Investigation the Efficiency of Horizontal and Vertical Axis Wind Turbine

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Abstract – *Today most researchers are follows and persuade that the increasing in the source of energy in the form of green or renewable energy is our demand. Therefore, the benefit from the gigantic of electricity production must be shifted towards carbon neutral sources such as wind power in order to mitigate the impacts of raising change regarding environment. This contribution work shows an investigation of the efficiency between horizontal and vertical axis for wind turbine systems that implemented to produce electricity by the wind. The investigation was conducted for the different scales scope wind innovation, as many systems are depend on horizontal axis wind turbine rather than vertical axis wind turbine. Tow types of turbine were selected based on its configuration and through providing sufficient amount of efficiency during operation. After analysis, the efficiency of horizontal axis wind turbine was recorded to be higher than the efficiency extracted from vertical axis wind turbine. The variation in efficiency was recorded to have high percentage about 80% compared with the 55% of the vertical wind turbine. Although, vertical axis wind turbines has more application if it compared with horizontal axis turbine, which the vertical axis turbine works at low speed and benefit from receiving the wind from all direction. Where as the horizontal axis turbine permits to work on different scales and has advantages for different projects.*

Keywords – Energy obtained by wind, horizontal and vertical axis, energy efficiency

I. Introduction

The kinetic energy of wind can be clearly observed since the dawn of time from sailing ships, grinding process of grain, lifting water by pump and powering to drive saw mill approaching to the most recent technology. A wind turbine is a device that directly transforms the kinetic energy of the wind into electrical energy. The windmill, on the other hand, converts the kinetic energy of the wind directly into mechanical energy [1]. In recent decades, the energy that obtained form wind has become more efficient in most electrical power systems around the world. So, the presence can be retrieved vital around the world while energy consumption levels are grow up due to climate change [1, 2]. 67% of the county's electricity is produced by carbon heavy fossil fuels and only 4.7% is generated from zero emission wind power [2]. To mitigate the effects of climate change, a shift towards sustainable forms of energy such as solar and wind power is necessary. Wind energy is the fastest growing energy source in the United States [2, 3]. Large-scale wind operations both on and offshore will generate significant amounts of energy, but with global energy demand expected to grow by 48% by 2050 from standards, it is necessary to investigate all avenues for energy generation [4]. Urban wind generation and the application of vertical axis wind turbines have recently gained attention because of their potential to harness wind power in new locations and reduce energy loss through transmission. Urban wind generation involves installing wind turbines in the urban environment. These can be mounted on freestanding poles such as a light post, or on a rooftop. Less attention has been given to wind generation in the built environment because wind patterns are more difficult to measure in urban areas [5]. Buildings obstruct and deflect the wind, leading to increased turbidity and decreased intensity of the wind. Turbines work best in environments with strong and consistent winds, such as over an open field or off-shore [6]. However, research demonstrates that turbines may have a place in the urban environment as well. Computational fluid dynamics (CFD) software has been used to expand the knowledge of wind patterns around buildings [7, 8, 9]. This information can help developers more accurately estimate wind resources and locate the most effective sites for wind generation Rooftop wind projects are advantageous because they bring energy production closer to the end user [10].

II. Horizontal and Vertical wind turbies

Two type of wind turbine are found. These are designed in such a way that their rotor blade is mechanically coupled to a horizontal generator shaft. Moreover, these types of wind turbines are normally made up of two, three or more rotor blades. Meanwhile, horizontal axis wind turbines are classified into Up-wind and Down-wind. For the up wind, this type is designed in such a way that the wind strikes the rotor blades first before it strikes the tower. This turbine must be inflexible and placed at some distance from the tower. The basic advantage of this turbine is that it can avoid the wind shade behind the tower. On the other hand, it incorporates a yaw system since its rotor faces the wind all the time [10]. The second type of turbine is also designed in down manner to allow the wind strikes the nacelle and tower first before it strikes the rotor blades. The rotors and nacelles are arranged so that the nacelles allow the wind to pass in a controlled way [11]. Figure 1 shows the comparison between up and down turbine turbines. In vertical axis wind turbine, the design of rotor blades are connected in such a manner using mechanical way to connected to the generator shaft that is previously set in vertical position. Regardless the type of turbine, the design of any turbine may require some factors and consideration and recommended for adding number of elements

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that are significantly selected in developing a model of wind turbine.

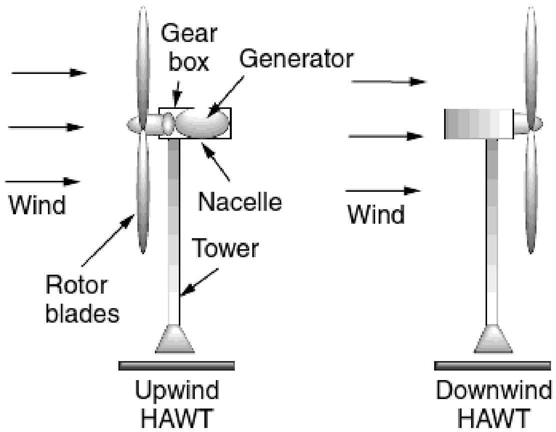

Figure 1 A pictorial of up and down wind turbine for the horizontal type [5]

The combinations of mechanical and electrical are together performed to get electrical energy which is extracted by wind energy. But this has such limit in using a number of variety factors with the future economic viability requirements. Producing power need more cost effective in designing turbine to overcome other sources of energy such as fossil products, extruding gas and fuels. This result to attribute that both cost and annual production of fuel are considered to be important factors. Further more, adding the cost of installation, set up and start operation as another source of cost. Light weight of components will attribute to reduce the cost to such a reasonable value and in contrast lower the rate of need it for regular maintenance [12]. The area of swept can be defined as the area of the circle formed by the rotor blades of the wind turbine as they sweep through the air. The area is known after knowing the amount of total power in wind that hits the rotor blades of wind turbine. Calculating power in turbine is follows as mentioned below in equation (1).

$$P = \left(\frac{1}{2}\right).\rho.AV \qquad (1)$$

Where P denoted by power having unit Watt, ρ referred by air density, A referred by area of blade under swept condition and V is a velocity of wind. The area of blade under swept condition can be determined as follows:

$$A = \pi r^2 \qquad (2)$$

Where π =3.14, r is radius of circle. This equivalent to the length of rotor blade, Figure 2 shows the swept area of the wind turbine.

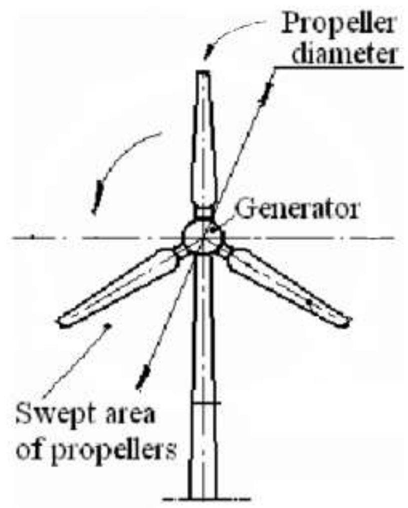

Figure 2 Wind turbine configurations with swept area of propellers [5]

III. Results

Due to collecting data of January commenced in 27th and ended in 30th, the energy generation were recorded in Watt per hours and their analysis were carried out to complete the test. Within this period, the turbines produced a total of 1.4556.36 Whr of electricity. These calculations represent an estimation of the energy produced because power is a 16 rate, not a quantity. Each data point was multiplied by 60 seconds to represent the energy produced if the turbine generated the same amount of power for the minute between measurements. The breakdown along several days can be tabulated in Table 1.

Table 1 Measurements of HAWT , VAWT and total energy

Day	HAWT	VAWT	TOT. Energy
Jan	**Whr**	**Whr**	**Whr**
27	3.22	9.84	10.5
28	4.95	4.52	8.99
29	4.04	6.03	10.22
30	120.3	60.98	188.16
Feb			
1	25.15	20.3	45.61
2	25.90	23.58	50.36
3	5.05	9.86	12.06
4	18.38	16.45	32.56

Although this represents a combined daily average of 69 Wh, it is apparent that some days produce nearly nothing while others are very productive. The HAWT had a daily production range of 157.68 Wh to 0.00 Wh. The VAWT's range was 66.43 Wh to 0.26 Wh. Data collection for this project is ongoing and commenced on January 27th. The power generation fluctuation

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curves (Figure 3) was depicted from two turbines over a range days on February 9th 2023

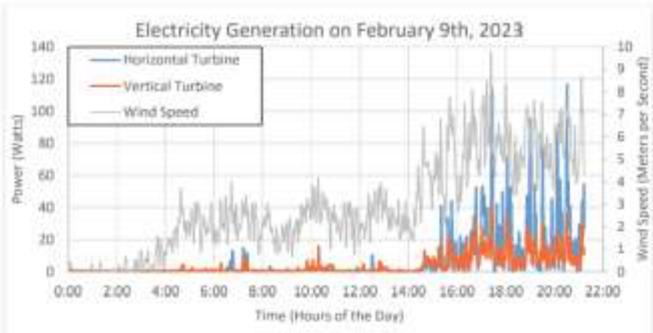

Figure 3 Power generation curves over the course of February 9th, 2023

Both turbines are closely followed the changes in wind speed. The HAWT generated more energy than the VAWT at nearly every wind speed. Which the efficiency was recorded to be 80% by HAWT compared with 50% belongs to VAWT. This can also be seen in the power curves for the two turbines, where power production is measured at varying wind speeds.

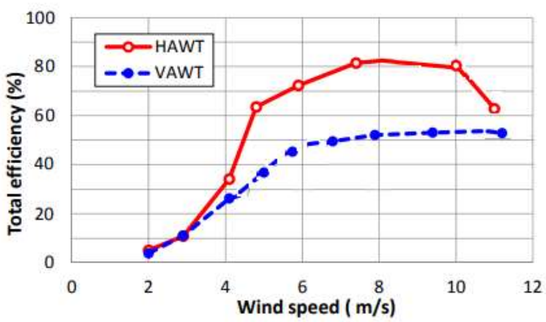

Figure 4 Investigation of efficiency for the two types of wind turbine

The percentage of efficiency for the two types of wind turbines were investigated successfully and their trends are carried out as seen in Figure 4 which confirms high total efficiency was drawn by HAWT compared with VAWT.

IV. CONCLUSIONS

Investigation the efficiency of wind turbine for the two types of horizontal and vertical axis of turbine system was successfully carried out. The proper design based on the assumption, configurations and including of factors results to obtain good comparison between the turbines regarding the suggest factors such as efficiency. The high amount of efficiency put the turbine to be used in versatile application and in different locations. Analysis of power were correctly carried out for both types of turbine (HAWT and VAWT) which the former one proved to be the best through showing high rate compared to the second type. This investigation aided by the requirement of using HAWT in many fields and for both large and small projects. While VAWT stay useful in urban areas, high buildings and also entered in the line of long rails.

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