Mobile Power Bank Using Small Vertical Axis Wind (VAWT) Generator

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Abstract — **This paper propose a study of mobile power bank using small wind turbine attached to vehicle or used free wind at windy area somewhere in Malaysia. The objective of this study are to develop power bank by using small verticals axis wind turbine (VAWT) and the circuit of power bank was created by Ni-MH rechargeable batteries which is attached to VAWT small generator. The scope of study is to develop small power bank using VAWT using wind energy and to verify the performant of small VAWT in term at its capability to produce electricity. The simple circuit obtained the input source from wind energy using small VAWT. The wind energy was transformed to electrical energy then stored in the batteries. The storage energy used when the output being connected to simple circuit of power bank. It was expected that VAWT can produced power that can be stored inside the rechargeable batteries. The result showed that VAWT can produced power.**

Index Terms- **Renewable Energy, Vertical Axis Wind Turbine (VAWT), Mobile Power Bank, Ni-MH Battery**

I. INTRODUCTION

Nowadays, electrical energy demand was rapidly growing from time to time, the levels of pollution also increase and the limitation on fossil fuel reserves and supply have led to a rising interest in researching and utilization of renewable energy sources and technologies. [1] Renewable energy as known as energy derived from natural process such as sunlight or wind that replenished, which is can be used again and again at a faster rate and can be consumed effectively . Solar, wind geothermal, hydro and some form of biomass are common sources of renewable energy available nowadays.

One potential renewable energy source is wind power that has been developed rapidly since the late 1970s. Wind power produce clean energy with no air or water pollution, no needs any fuels that are harmful to the environment with toxic or hazardous substances and poses no threat to public safety. This is in contrast to coal, oil and gas, which rely on fossil fuels from mines or oil and gas fields that will one day run out of supply.

Wind power generated through the creation of wind turbines. Wind turbine systems are used to convert the energy available from the kinetic motion of air particles into electricity. Small wind turbine is suitable for location where average wind speed is more than 2.5 m/s. The higher wind speed, the batter is the output. In Malaysia, research study of potential wind power stated that good potential for farms based on the East Coast of Peninsular Malaysia that face the South China Sea., good potential during the monsoon season (November - February) and during the monsoon season, the average wind speed for East Coast states can reach up to 30 knots. 30 knots is equivalent to about 15.4 meters per second, which is about 55 km per hour [2]. However, in order to create a constant power source of wind energy, instead of relying on Malaysia weather, an alternative to it is by producing the wind itself. This can be achieved by using placing a wind generator at a moving vehicles such as car or motorbike to gained more the speed of wind.

In recent time, the study to create power bank using small VAWT to be attached to vehicle or using at windy area is new implemented technology in Malaysia. Since the government had built many high way and have a good road, which is an advantage to all vehicles to use this power bank that attach small wind turbine on rooftop of vehicle. This power bank system can fixed at their vehicle and the high speed wind will generate electricity through the small wind turbine system.

There are two type of wind turbine available. There are VAWT and horizontal axis wind turbine (HAWT). However, these study about VAWT. The design of VAWT have some of advantage which is ability to capturing the wind in any direction and does not always come from a general area. A prime example of this would be if it were decided to put the wind turbine on a rooftop, the direction of the wind blowing up and over the vehicle might be highly variable and hard to predict to and capture efficiently, where a vertical axis turbine would be ideal for such a scenario. The wind blades are positioned to capture wind coming from any direction they cannot harness much of the energy from the wind that they encounter.

This study also concerning on the energy storage element. In this study, power bank refer to this storage element. According to the evolution of advance technology, power bank is essential to the electronic gadget user. The new application such as android application needs to use high power of energy. In addition the biggest problem with the latest models of smartphones is that the battery life was drain very short. Most of them can survive for only one day and they can get drained even faster than that depending on the applications that are being used. This power bank is essential because it makes possible for people to charge their gadgets without electrical outlet available. Power bank is actually a casing fitted with specific capacity rechargeable battery that was specially designed to hold on to energy and store it until it needs to be transferred to another device. Capacity of power bank can hold up to 30000 mAh. This is a number that will certainly increase when the devices require more charge and more capacity. This is an amazing project for travellers who need to be able to charge their phones in situations that are usually going to make it hard to find an energy source.

II. METHODOLOGY

The general method use in this study to achieve the objectives of the project is based on the Figure 1.

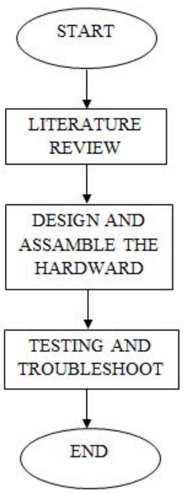

Figure 1: Flow chart of project

The flow chart shows the basic steps of completing this project:

Step 1: Literature review
Start with literature review about power bank using VAWT. A lot of information can be derived from research journals, reports and other sources.

Step 2: Design and assemble the hardware
Design circuit power bank and wind turbine model. List down all components and assemble the hardware for power bank. In hardware construction procedures, step by step is performed consist of exposing, developing, etching, stripping, drilling and soldering.

Step 3: Testing and troubleshoot
After the prototype have done, testing part and troubleshoot for the hardware. This is the final which determines whether the project succeeds or not.

This study of power bank using wind turbine have three main part of development. There are part of wind turbine which is known as VAWT, part of control unit and development of storage using of wind turbine. The Figure 2 showed the flow chart of power bank using VAWT.

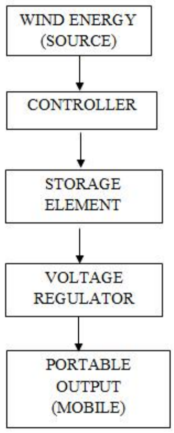

Figure 2: Flow chart of power bank

Step 1: Development of wind turbine.

The energy conversion process of wind system using wind turbines includes the rotation of blades that convert the wind energy into kinetic energy on the shaft and then convert to an electrical energy. In this study, VAWT used as a turbine where the main rotor run vertically. The advantages of VAWT are its simple construction, the lack of necessity of over speed control, the acceptance of wind from all directions, the limitation in mechanical design due to the control system and the electric generators that are set up statically on the ground [3]. In general, there are two types of VAWT, the Darrieus and Savonius types. There are three common blades for the Darrieus, which are Squirrel Cage Darrieus, H-Darrieus and Egg Beater Darrieus [4]. Darrieus wind turbine is need high speed with low torque machine. Generally Darrieus requires manual push from external power source to start turning as the starting torque is very low but it difficult to self-starting.The Savonius was used because this wind turbine is slow rotating with high torque machine and it can starts at low wind speed. It has low-noise system and can work with any wind direction [6]. The Energy Company has developed a Cycloid law for variable-blade VAWT by using guide rod and cam, which is more efficient and has good starting performance, but with a complex structure [7].

Figure 3: Vertical axis wind turbine (VAWT)

Step 2: Development of regulator / control unit.

The basic components of power bank are battery 1.2 Volt which is having capacity of 1900 mAh per battery, LED, motor fan 12V, resistor 150 ohm, capacitor, voltage regulator, charge controller and wire. All of component arranged to attach at strip board follow the positive and negative direction. The components will attach using solder method. In the case of a wind system, wind turbine from dc motor fan is used as a generator that will be charge the battery. The voltage regulator used which is LM 7805 to regulated power battery level 5volt as the output of this power bank to charge our gadget. Resistor 150ohm and LED were used in series to make sure control the electrical current that flows through them in one direction. A capacitor is similar to a battery because it can store and release Electric energy but capacitors work differently from batteries. Batteries release steady voltage for a longer period of time, while most small capacitors store only enough energy for a few minutes of voltage. Charge controller or charge regulator function is to preserve the batteries from overcharging. It regulates the voltage and current that is coming from the wind turbine going to the battery. If there is no regulation, the batteries will damage from overcharging .The figure 4 showed the circuit of power bank.

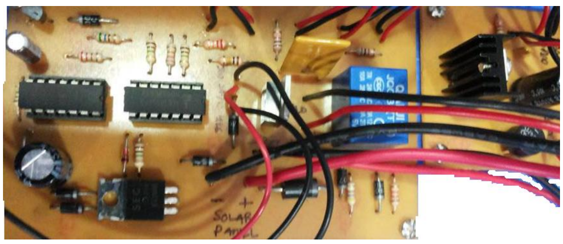

Figure 4: Circuit of power bank

Step 3: Development of storage element.

The amount of electricity wind energy that produced throughout the wind blow during the whole day is high. Therefore, a reliable energy storage device required to store that energy. A few type of storage device for wind turbine are compressed air, flywheel, super-capacitors, super-conducting and magnets. In this study, the battery used for storage device. Basically, the charging protocol depends on the size and type of the battery being charge storage. In this study, the batteries used were six of AA rechargeable batteries from Nickel-metal hydride (Ni-MH) battery. One major reason for use Ni-MH is its longer life and operation reliability, particularly where the battery is exposed to daily and regular cycling at various depths of discharge [8]. That is significant features for wind turbine applications. These types of batteries have reusable, eco-friendly and low self-discharge which is its capacity drops to about 80% in a year under open circuit voltage conditions after this rate remains within 5% loss per annum. These batteries also can be recharged up to 2,100 times and retains 65-70% capacity after five years in storage. A wind energy battery is expected to give a long life with a daily shallow charge or discharge cycle. These types of batteries have a timer to cut off charging current at a fixed time.

Figure 5: Battery for storage device

III. RESULT AND DISCUSSION

The results for voltage and current that generated when wind turbine operate are presented and tested on 11 reading for speed of wind blow. Table 1 shows the mean wind speed that produce voltage and current wind turbine at Bukit Bandaraya study area. The highest speed of turbine is determined as 110km/h with 0.72V while the lowest speed of turbine is 10 km/h with 0.10 V. That means the range voltage that produce when wind turbine operates between 0.10V until 0.72V. It shows the VAWT that produce a small voltage. Table 1 also shows that the current produce also small. The highest current is 0.72V when 110km/h while the lowest current is 0.10 V when 10 km/h.

As can be seen, the voltages that produce from wind turbine is a rotating machine which converts the kinetic energy of wind into mechanical energy is small. This is because many factor from the size, design and type of wind turbine. The Savonius used is vertical wind turbine that low efficiency. Another factor because motor dc that we selected to use as a generator.

TABLE I. VALUE OF SPEED, VOLTAGE AND CURRENT FOR WIND TURBINE

Speed (km/h)	Voltage fan(V)	Current fan (mA)	Power fan (mW)
10	0.100	0.215	0.0215
20	0.110	0.218	0.0240
30	0.140	0.223	0.0312
40	0.170	0.425	0.0723
50	0.290	0.835	0.2422
60	0.370	1.045	0.3867
70	0.420	1.401	0.5883
80	0.490	1.523	0.7462
90	0.550	1.645	0.9045
100	0.660	1.766	1.0596
110	0.720	1.832	1.3190

From the Table 1, power curve of wind turbine created. The power curve of a wind turbine is a graph that indicates how large the electrical power output will be for the turbine at different wind speeds. Figure 6 shows power curve and operation of wind power generation system. The power curve shows that when speed increases, the level of power rises rapidly. In very low wind speed, it still produces power in small scale. The wind turbine will begin to rotate then generate electrical power when the speed at 10km/h. However, normally the power output will reaches the maximum limit. This limit to the generator output is called the rated power output and the wind speed at which it is reached is called the rated output wind speed but in the graph, it does not reach maximum speed because the data collected at 10km/h until 110km/h. Generally, the design of the turbine at higher wind speeds is arranged to limit the power to this maximum level and there is no further rise in the output power.

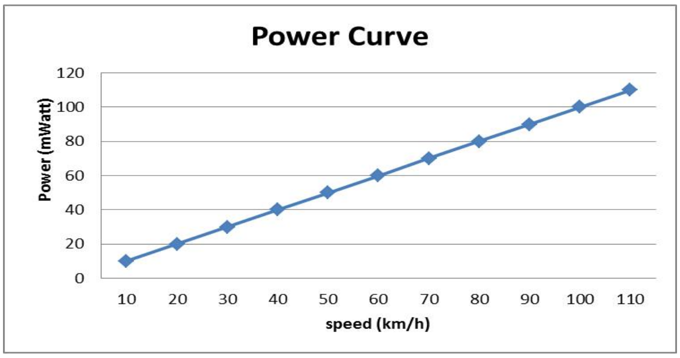

Figure 6 : Power Curve for wind turbine

For a single NiMH battery is considered fully recharged when its no-load voltage is about 1.2 volts to 1.4 volts. So the combined voltage of the battery pack would be about 7.2 volts to 8.4 volts, when fully charged. Table 2 showed the voltage and current across batteries during charging.

Before we start take a reading for battery that connected to the wind turbine, the battery need to discharge. The first reading for battery is 5.38V and the last reading for 110km/h is 6.26 V whereas the maximum voltage for battery is 7.2. When speed 10km/h, voltage increase to 5.41V and the table shows that when speed increases, the voltage is rises. The reading for current between 1.422 mA to 0.203mA.That shows current that store at battery is small value.

TABLE II. VALUE OF POWER, VOLTAGE AND CURRENT FOR NI-MH BATTERIES

Speed (km/h)	Voltage battery(V)	Current battery (mA)	Power (mW)
10	5.410	1.422	7.693
20	5.460	1.321	7.213
30	5.530	1.244	6.880
40	5.570	1.045	5.821
50	5.620	0.845	4.749
60	5.740	0.783	4.494
70	5.790	0.634	3.671
80	5.820	0.562	3.271
90	6.030	0.453	2.732
100	6.110	0.345	2.108
110	6.260	0.203	1.271

Below are the characterization graphs of the current plotted across the voltage. of the NiMH batteries. It shows that current is inversely proportional to the voltage. The value of current obtained become lower as voltage increases. As voltage in the battery increases, the current that will flow into the battery will be low. This is because it slowly reach its maximum or nominal voltage. The power obtained is very small.

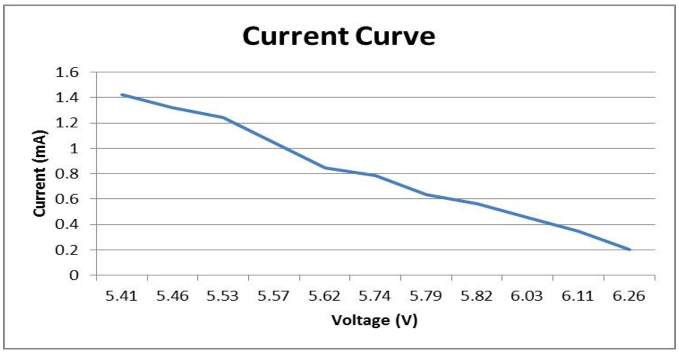

Figure 7 : Current Curve for Ni-MH battery

From figure 8, the graph is for power versus voltage for batteries during wind turbine is operate. Its shows that power also will be reduced as voltage increases. Based on the results obtained, that mean this power bank using VAWT is produce power but in small value. The output of the power bank should be 5V in order to charge mobile phone

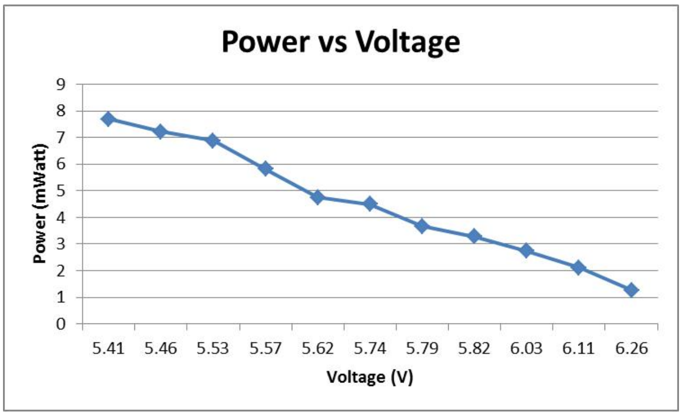

Figure 8: Power versus Voltage for Ni-MH battery

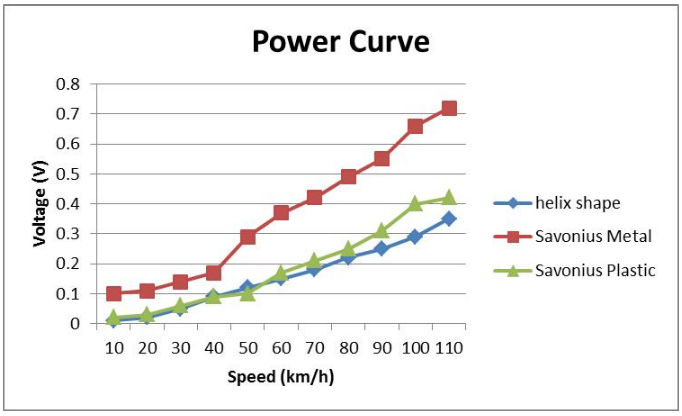

Figure 9: Power Curve for different three type of VAWT

Based on the table 3, that shows the reading voltage for three types for vertical axis wind turbine. There are helix shape, Savonius from metal with have 3 blade and Savonius from plastic with have 4 blades. The result shows that Savonius shape are the bast performance other helix shape. Generally, Helical wind turbine be used in areas with higher wind speeds while Savonius wind turbine can starts at low wind speed.in addition, Savonius shape from metal with 3blade give the best performance than Savonius shape from plastic with 4 blade . Its shows that factor of size, quantity and pattern of blade is give effect to performance to rotating it.

TABLE III. VALUE VOLTAGE READING WHEN TROUBLESHOOT IN 3 DIFFERENT SHAPE OF VAWT

Speed (km/h)	Voltage (V)		
	Helix shape (VAWT)	Savonius (metal and 3 balde)	Savonius (plastic and 4 blade)
10	0.01	0.100	0.02
20	0.02	0.110	0.03
30	0.05	0.140	0.06
40	0.09	0.170	0.09
50	0.12	0.290	0.10
60	0.15	0.370	0.17
70	0.18	0.420	0.21
80	0.22	0.490	0.25
90	0.25	0.550	0.31
100	0.29	0.660	0.40
110	0.35	0.720	0.42

IV. CONCLUSION

In this study, the prototype power bank using small of VAWT has been presented. The power bank using battery as a storage element will be charge Ni-MH batteries using wind energy as a main source. Based on results obtained, it is proof from the objectives that NiMH batteries can stored energy by using VAWT. It's also verify the performant of small VAWT in term at its capability to produce electricity but the size, type and quantity of blade are effect the performant to produce electricity.

For recommendation this study, the high efficiency of motor dc needed to improve generator. It's also can use stepper motor to get high efficiency. The pattern, quantity and size of blade VAWT needed more suitable to gain amount of electricity. Hence ,the future researcher can also consider of new way to trap that wind power blowing at a significant angle and height Moreover, using horizontal axis wind turbine can be used to implement as a wind turbine for power bank. Thus, the result obtained can be compare to determine which one is reliable to power bank using wind energy.

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