Study of Mobile Power Bank Using Small Horizontal - axis Wind Turbine (HAWT)

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Abstract: **This paper presents the study of mobile power bank using small wind generator adapted from the Horizontal-axis Wind Turbine (HAWT) characteristics. This project use wind energy produced by a moving car with different speeds as their main source to charge power bank whereby the source is a part of Renewable Energy (RE). This paper will show how the kinetic energy produced by the wind energy passed through the small wind generator to supply power source for the power bank to be charged. The objective of this study is to develop power bank with the exist of wind energy as its main source and to study the Horizontal-axis Wind Turbine (HAWT) characteristics on Direct Current (DC) fan used to generate power. Also, to construct the realibility of the Nickel-Metal Hydride (NiMH) battery type used to store power in terms of electrical power. The scope of study for this project is to develop a power bank using Horizontal-axis Wind Turbine (HAWT) characteristic with source of wind energy by a moving vehicle . The expected finding is amount of power needed to be stored at the rechargeable battery. The expectation of the project is to maintain the system with a sufficient reliability, very useful and security is not to be ignored.**

Keyword - Renewable energy (RE), Kinetic energy, Horizontally-axis wind Turbine (HAWT), Nickel-Metal Hydride (NiMH), Direct Current (DC), wind energy, wind generator.

I. INTRODUCTION

Renewable energy (RE) is the energy that comes from the natural resources which can be used to generate electric energy. There are several types of RE available in this world such as wind, solar, biomass, and also wave. These renewable energy are the alternative energy to the world users as they can helps to overcome the problem in lacking raw materials and sources that our world are facing nowadays. In addition, these energy cannot be exhausted and is constantly renewed The perspective of renewable energy is to make strategies for sustaining the development of energy sources and energy savings on the demand side which can help to minimize the cost of supplying electric power as this energy is a free source. Consequently, large-scale renewable energy implementation plans must include strategies for integrating renewable sources in coherent energy systems influenced by energy savings and efficiency measures. [1]. As in Malaysia, most of energy generation are currently looking for another alternative resources to generate electricity after so long dependent on coal and fuel. It is because the knowledge and indication of RE is very useful and more applicable

Among the resources of RE available, the wind energy is one of the fastest growing energy technology in the world and considered as one resources that meet the needs of modern societies in reducing the dependence on coal and fuel [2]. Peninsular Malaysia experiences monsoon seasons which influenced to the wind energy. However, in Malaysia, wind energy conversion is a serious consideration. In present technology, wind energy in Malaysia is not suitable to generate electricity commercially or wind is not particularly good in Malaysia as compared to the UK or Denmark [3]. On top of that, the present status of renewable energy in Malaysia has been also discussed in the paper as well. It has been found that among all the renewable energy sources, solar energy is the most prospective one in Malaysia [4].

Troughout the problem occured about the condition of natural wind energy in Malaysia , the knowledge of RE which is wind energy is still be applied to this project in order to observe the effectiveness of the wind energy itself as the source of electric supply to charge power bank. Some improvisation has been made whereby this project obtained the source of wind energy from a moving car. This matter is definitely meets the objective since the objective of this paper is to approach a portable gadget called mobile power bank towards wind energy as their power source to store energy which is more convenient instead of using usual electric power supply. Besides that, from the facts of wind energy all about, it can be said that anything that relates to the wind energy, it will relate to the use of wind turbine

Once the wind turbine is built the energy produced does not cause green house gases or other pollutants [5]. Wind turbine is a device that play important role in wind energy which converts kinetic energy from the wind into electrical energy. There are two types of wind turbine in this study which implements RE that relates to wind energy, which are Horizontal-axis Wind Turbine (HAWT) and also Vertical-axis Wind Turbine (VAWT). As for this paper, it only focused on Horizontal-axis Wind Turbine (HAWT) characteristics in order to adapt it to the small wind generator for the project. In modern wind turbines the output power for wind speeds above the nominal wind speed is limited by the adjustment of the rotor blade angles. The adjustment is performed with the pitch system. For cost reasons, in small wind turbines simple mechanical pitch systems are used actuated by centrifugal force and thus depending on the rotor speed and the blade mass [7]. The a wind turbine used for charging batteries may be referred to as a power bank or wind charger. The small turbine are used for applications such as battery charging. The implementation and the process of kinetic energy from the wind into electrical energy is significantly adapted to tested and investigated to form a gadget called mobile power bank.

Power bank is a battery charger used to charge some gadget that suits for its function. While mobile power bank is a device that is portable and easy to bring anywhere anytime and it is very useful gadget for a traveller or anybody. This kind of device or application is such an applicable device especially for a mobile phone that use android system that usually use more battery for their system itself. Thus, with the use of mobile power bank, this problem can be improved and it becomes more applicable yet friendly users with the use of renewable energy like wind energy. On top of that, this mobile power bank is to make people life easier especially for a traveller by having a portable electric supply which is mobile power bank.

An electrical battery is a device that can convert chemical energy into electrical energy. Batteries come in many shapes and sizes, and may be composed of a myriad of different chemicals, but all batteries can be classified under two categories, primary batteries and secondary batteries. Primary batteries are meant to be used once and then discarded. Alkaline batteries are the most common primary battery type, but there are several other types as well. Secondary batteries are designed to be recharged and used again and again.

The Nickel-Metal Hydride (NiMH) batteries are a very common type of secondary battery. The lead-acid batteries found in cars are also considered secondary batteries. Maintaining the power balance leads to high fluctuations in the battery charge and discharge currents. This is in contrast with the smooth and limited charge and discharge currents that are recommended by battery manufacturers. Uncontrolled use of batteries will shorten the battery lifespan very fast; however frequent conditioning of the batteries may reduce this effect significantly [6]. For this project, NiMH battery type is used and it is a rechargeable battery which is very suitable for the power bank product or system.

II. METHODOLOGY

In order to set the target and achieve the objective of this project, there are are several procedures that must be constructed. As for this paper, there are two parts of procedure needed in which it is visulize in terms of flowchart and block diagram. The first procedure is the flowchart of the overall project operation. While the second procedure is the flowchart of the project system.

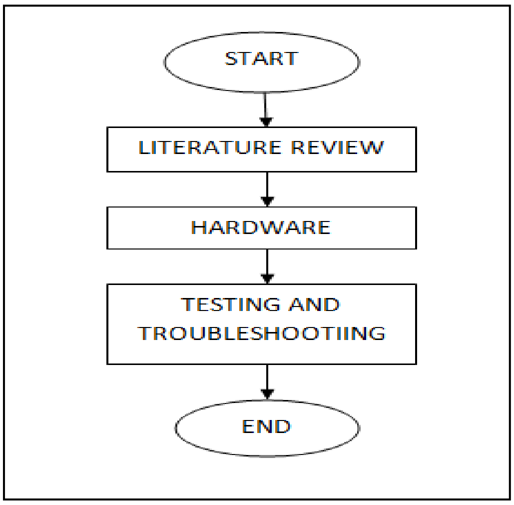

Figure 2.1 : Flowchart of overall project operation

Refer to the Figure 2.1 above, it shows the overall project operation. It starts with the literature review.

A. Literature Review

For the literarture part, it consist of overview and a critical evaluation by doing a research upon the problem statement of the project. the title of the project, the overview, the problem statement is constructed and done in order to achieve the objective of the project itself.

B. Hardware Part

After that, proceed with the hardware. For this part, all the components used to construct a circuit of power are determined and the connection between them is done. The connection of direct current fan as the wind generator and the power bank part is done one by one respectively. Here, the part of work were devided into three parts which are the input part, internal part and lastly the output part.

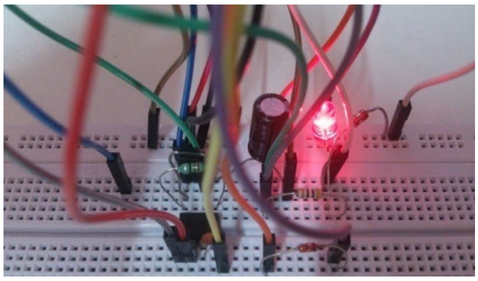

Figure 2.2: circuit for power bank

C. *Testing and Troubleshooting*

Then, proceed with the testing and troubleshooting. For this section, all the problem occured about the hardware part were determined by testing the system of the project as it is completed as well as the condition of each component and device used are done before the hardware part started. The project is then been improvised according to the problem occured and then undergo the troubleshoot part in order to obtain the desired output. Some adjustment and component replacement due to component damage or defect also has been done in this section.

III. CONTROL SYSTEM INVOLVE

This mobile power bank project orders how the implementation of wind energy could affect the small Horizontal-axis Wind Turbine (HAWT) in order to charge or to give energy to the power bank. Therefore upon completing this project, the control system can be split into two segments which are the control system of the small wind turbine and also power bank (energy storage)

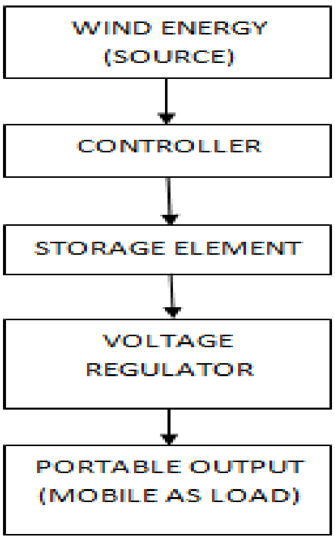

Figure 3.1: Block diagram for Project System

A. *Small wind turbine for Wind Energy Part*

In this project, small wind turbine is used as the main part to obtain energy from the wind. Whereby, the wind will flow through it and the effects of the movement fan of the turbine itself will produce energy and then flow to the power bank part. Since this project is focused on the small and DC system, therefore as for the turbine, the device used acted as indicator for this project is direct current fan (DC fan). Whereby the design applied characteristics of the the horizontal-axis wind turbine (HAWT). This because we want to capture do the HAWT design could give positive respond to the power bank by storing energy into it.

According to the block diagram in Figure 3.2, it starts with the wind energy, whereby the source is obtained from a moving car with certain speed. The speed of a moving car will determine the voltage and current of the input system. The component used at this part is 12V Direct Current (DC) fan. Wind generated from the moving car will give input to the internal part of the system. The energy conversion process of Wind system using wind turbine includes the rotation of blades that converts wind energy into kinetic energy on the shaft and then convert to an electrical energy. As what have been discussed in the introduction part, the type of wind turbine used is HAWT type.

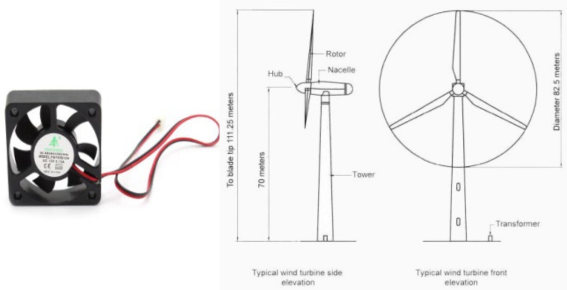

Figure 3.2: DC fan and HAWT design

First, it captures the kinetic energy (energy of movement) from wind, this is the energy that allow the turbine blades to spin. The energized blades spin a shaft inside the tower, and that shaft in turn spins an electrical generator. The generator takes the incoming kinetic energy and converts it to electrical energy.

B. *Power Bank (energy storage)*

- *Controller*

To enable a more efficient use of batteries, a DC coupled structure has been presented in [8]. A first interest is that the battery bank is connected to the dc-bus via a DC/DC converter and, so makes it possible to obtain an optimised charge/discharge operation mode [9].

- *Storage Element*

Power bank is significant with the call of battery bank. With that significant name, it is effectively more than one battery used. The number of battery used in this power bank depends upon the voltage require to operate the electrical equipment. As for this project, the battery used are rechargeable battery a brand of “eneloop” of AA size rechargeable battery with 1900mAh capacity for each. Basically, the charging protocol depends on the type and size of the battery being charge storage. AA rechargeable batteries from Nickel-metal hydride (Ni-MH) battery. One major reason with the using of that battery is, it has longer life span and better operation reliability. A good characteristic of battery is selected because power bank is a gadget that deals with a daily used and thus the battery is exposed to daily and regular cycling at various depths of discharging [10].

Figure 3.3: Nickel-metal hydride (Ni-MH) battery

- *Voltage Regulator*

Voltage regulator is a deviced used in the power circuit in order to refulates the voltage flows into the circuit before gives out certain output. without the voltage regulator system, the amount of voltage flows into the system could damage the power bank itself because every circit and battery have their limit to support the capacity that has been set.

- *Portable Output (for Load)*

Portable output or in this project is the battery. Battery acts as the load in order to store energy in terms of electrical energy. This part will be charged up to several time as the battery used is a rechargeable type with special characteristic of Ni-MH advantages.

IV. RESULTS AND DISCUSSION

Every project should be tested in order to show the performance of the system in the project itself. As for this project, it has been tested under two (2) different condition. The two different conditions are, test system of dc fan where the wind energy passes through it and the reading at the batteries when the system of energy flow through it in order to be charged. Again, for this project DC fan was used to represent the wind turbine of HAWT type. Each testing at DC Fan and at the rechargeable battery were tested under two (2) different vehicles which are by motorcycle and by car.

- *TEST SYSTEM OF DC FAN (HAWT)*

TABLE I: TEST SYSTEM OF DC FAN (HAWT) BY MOTORCYCLE

Speed (km/h)	Speed (m/s)	Voltage of fan (V)	Current of fan (mA)	Power of fan (mW)
10	2.78	0.51	4.13	2.11
20	5.56	0.93	4.87	4.53
30	8.33	1.55	5.72	8.87
40	11.11	2.05	6.51	13.35
50	13.89	2.55	6.83	17.42
60	16.67	3.07	7.45	22.87
70	19.44	3.27	7.51	24.56
80	22.22	4.04	7.58	30.62
90	25.00	4.58	7.69	35.22
100	27.78	4.89	7.87	38.48
110	30.56	5.15	8.07	41.56

TABLE II: TEST SYSTEM OF DC FAN (HAWT) BY CAR

Speed (km/h)	Speed (m/s)	Voltage of fan (V)	Current of fan (mA)	Power of fan (mW)
10	2.78	0.51	4.14	2.11
20	5.56	0.93	4.75	4.42
30	8.33	2.31	5.71	13.19
40	11.11	4.30	6.18	26,57
50	13.89	4.62	6.49	29.98
60	16.67	5.16	6.85	35.34
70	19.44	5.43	7.10	38.55
80	22.22	5.61	7.58	45.52
90	25.00	5.84	7.69	44.91
100	27.78	6.12	7.87	48.16
110	30.56	6.37	8.17	52.04

Based on Table I and Table II above, the DC fan was tested under certain value of speeds (km/h). From the different speeds (km/h), value for voltage (V), current (A) and power (W) were recorded. Based on the values recorded, the values of voltage (V) increases as the speed of both different vehicles are increased. The value of current (mA) also increased accordingly to the speed (km/h). Values of power obtained were in terms of miliwatt (mW) since current obtained were in miliampere (mA). As for the lowest speed (km/h) which is 0 km/h for both vehicles, the value of voltage at DC Fan for both motorcycle and car were the same which is 0.51V. Whereby, at the highest speed for both vehicles that is 110 km/h the value of voltage of DC Fan for motorcycle records a lower value compare to value of DC Fan for car. The values recorded for both motorcycle and car at the highest speed were 5.15V and 6.37V respectively. The value of power (mW) recorded by using the Power Formula below:

$$P\ (W) = I\ (A) \times V\ (V) \qquad (1)$$

From the table obtained before, several graphs were constructed in order to make comparicon upon the performance of the DC Fan to both conditons . The graphs constructed were as below :

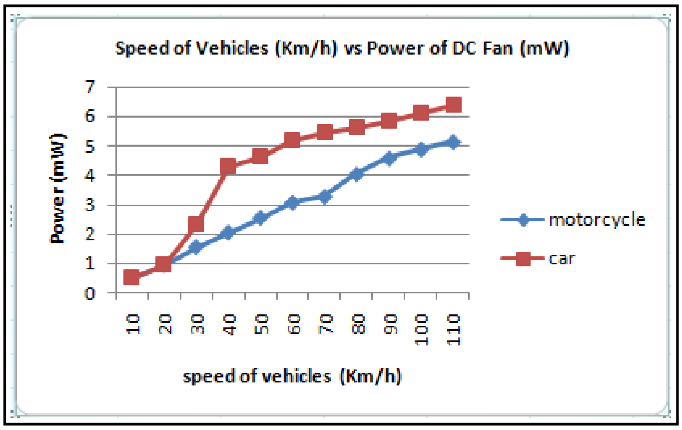

Figure 4.1: Graph of Speed (Km/h) vs. Power of fan (mW)

Graph above shows the comparison of Power (mW) of DC Fan for both motorcycle and car. The graph constructed show that as the speed of vehicles increases the power also increases. From the graph also, it can be seen that all the value points plotted for car having a higher value as compared to values plotted for motorcycle. The reason it happened was due to the engine size or cubic centimeter (cc) of the vehicle itself. The bigger the cubic centimeter (cc) of a vehicle, the faster the vehicle can move in terms of speed.

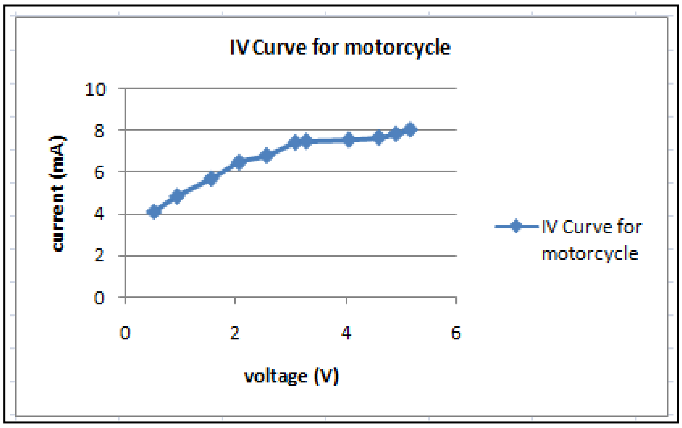

Figure 4.2: Graph of Voltage (V) vs Current (mA)

Graph above shows the current (mA) versus voltage (v) curve or known as the IV Curve. The graph shows that the voltage and current increase whenever the speen given to the turbine or fan is increased.

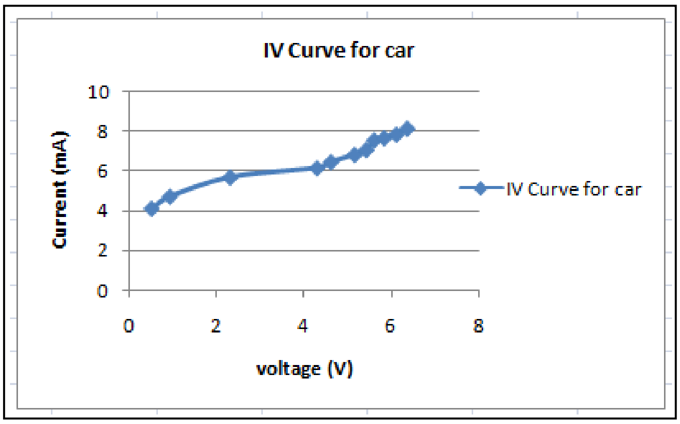

Figure 4.3: Graph of Voltage (V) vs Current (mA)

The Figure 4.3 above illustrates the value of voltage and current. Also known as IV Curve. The graph shows that the voltage and current increase whenever the speen given to the turbine or fan is increased.

- *TEST SYSTEM OF RECHARGEABLE BATTERY (NiMH)*

Next voltage and current of the Ni-MH batteries during charging for wind energy obtained by a moving motorcycle and car. Before the test is done, the batteries used must be discharged first. The purpose action is to record how much voltage and current can be stored during charging.

TABLE III: TEST SYSTEM OF RECHARGEABLE BATTERY BY MOTORCYCLE

Speed (km/h)	Speed (m/s)	Voltage of battery (V)	Current of battery (mA)	Power of battery (mW)
0	0	3.32	7.51	24.93
10	2.78	3.89	7.33	28.51
20	5.56	4.16	7.18	29.87
30	8.33	4.55	6.89	31.35
40	11.11	4.73	6.73	31.83
50	13.89	5.10	6.54	33.35
60	16.67	5.37	6.31	33.88
70	19.44	5.78	6.26	36.18
80	22.22	6.15	6.02	37.02
90	25.00	6.43	5.83	37.49
100	27.78	6.61	5.65	37.35
110	30.56	6.84	5.42	37.07

TABLE IV: TEST SYSTEM OF RECHARGEABLE BATTERY BY CAR

Speed (km/h)	Speed (m/s)	Voltage of battery (V)	Current of battery (mA)	Power of battery (mW)
0	0	2.53	6.57	16.62
10	2.78	2.91	6.49	18.89
20	5.56	3.32	6.35	21.08
30	8.33	3.42	6.19	21.17
40	11.11	3.69	5.92	21.84
50	13.89	3.82	5.85	22.35
60	16.67	4.00	5.63	22.52
70	19.44	4.49	5.51	24.74
80	22.22	4.68	5.12	23.96
90	25.00	5.01	4.81	24.10
100	27.78	5.45	4.75	25.89
110	30.56	5.73	4.63	26.53

Based on the Table III and IV, it can be seen clearly that as speed of motorcycle and car increases the value of voltage (V) increases while the value for current recorded in miliampere (mA) decreases. Also, the power calculation is the same with the power calculation used at the HAWT design of fan and in this part, the value of power calculated increases. From the table of rechargeable battery before, the graph were constructed in order to see the performance of the rechargeable battery.

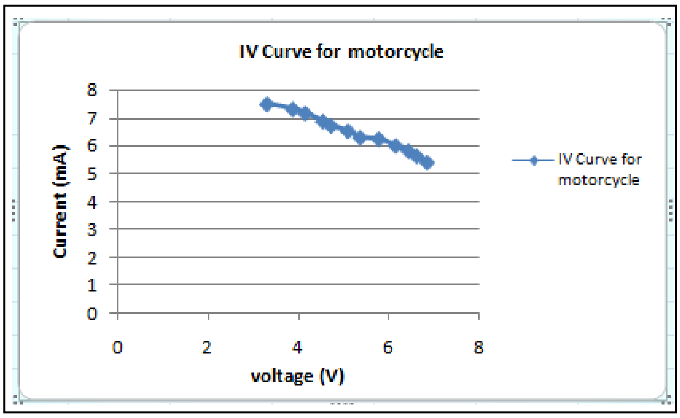

Figure 4.4: Graph of voltage (V) vs. Current (mA)

Graph at Figure 4.4 above also know as IV curve. This shows the performance of the rechargeable battery as the speed increases and more wind energy was obtained. From the graph, it can be seen that as the voltage increase and the current decreases accordingly.

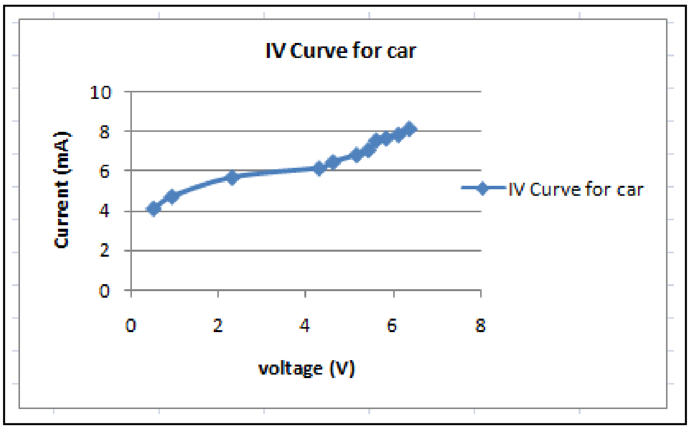

Figure 4.5: Graph of voltage (V) vs. Current (mA)

Graph at Figure 4.5 above also know as IV curve. This shows the performance of the rechargeable battery the speed increases and more wind energy is obtained. From the graph, it can be seen that as the voltage increases the current decreases.

PV curve also been constructed according to Table III and IV. The graph were as below :

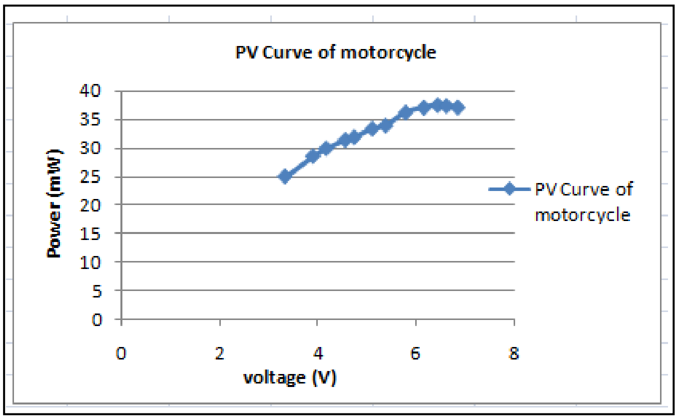

Figure 4.6: Graph of voltage (V) vs. Power (mW)

Figure 4.6 above shows the performance of the rechargeable battery as the speed increases and more wind energy is obtained. Graph above also know as PV curve. Whereby, as the voltage increase the power increased accordingly. Means that, the NiMH type of battery could be charged and store energy.

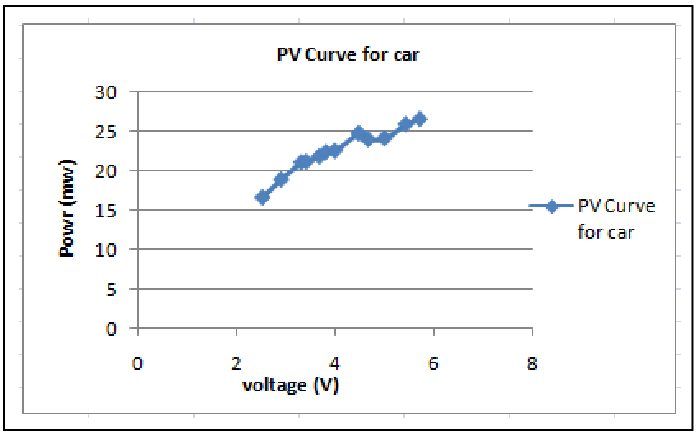

Figure 4.7: Graph of voltage (V) vs. Power (mW)

Graph at figure 4.7 above also know as PV curve. This shows the performance of the rechargeable battery as the speed increases effect the increasing value of the voltage and thus, more wind energy is obtained. From the graph, it can be seen that as the power values increases the value of voltage of battery increases.

V. CONCLUSION

This paper suggest a new indicator in order to apply the knowledge of RE in daily gadget or device. After completing this project, it shows that wind energy produced by a moving vehicle could give power and could charge battery for purpose activities. Therefore the objective is achieved since there is energy stored in the rechargeable battery of the power bank. Based on the results, 5V of power energy can be produced at 110km/h by a moving motorcycle vehicle while by a moving car at the same speed, it produced 6.37V. Thus, with the value obtained, it shows that by using a small 12V DC fan which acts as a small HAWT is acceptable. This can prove that HAWT design is suitable yet acceptable design for power bank.

VI. RECOMMENDATION

As for the recommendation, in order to build a quality wind powered power bank there should be some requirement that must be focused on. The requirement involves in choosing the material of wind turbine, the power system of the wind turbine such as the voltage (V), current (A), and also the power that the turbine cane generate (W). Since there is several type of motor in the turbine, therefore it is important to know the internal part of the turbine since motor could play an important role to get better performance. Besides that the process to build a power bank should be more detailed such as in using the components and also devices. This is because a component and a device used can give different results according to the desire output. Thus, material with a lighter in weight yet strong built and the use of Stepper DC motor are recommended for the input part. While for the internal part of power bank, DC-DC step up voltage is needed in order to have a better quality power bank yet can be used longer time. On top of that, the rechargeable battery type of Ni-MH is the most recommended battery type since it is quality in life cycle and can store energy and be rechargeable up to certain high number of cycle.

VII. ACKNOWLEDGEMENT

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