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Development of Wind Mini Generator by Using Air Conditioner Air Waste

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Abstract: The Development of Wind Mini Generator by Using Air Conditioner Air Waste is a renewable energy system that can be applied for the residential and industrial sectors which is beneficial to the user by harnessing free energy. The main objective is to produce a small wind power generation system that can be used as supplementary and backup power. This system emphasizes the kinetic energy from air waste released by the air conditioner compressor to convert it into electrical energy by the generator. The advantage of using the air conditioner air waste is that it has a relatively stable wind speed every time, although it is not as high as the wind speed available in nature. Two generators used are direct current generators (DC) with different ratings. From the result, the first generator cannot charge the battery while the second generator can charge the battery, but it takes a significant amount of time to fully charged the battery.

Keywords: Renewable Energy, Generator, Wind Speed, Battery, Wind Turbine

1.0 INTRODUCTION

Electricity generation is the process of producing electricity from primary energy sources. Essentially, there are two kinds of sources non-sustainable sources and sustainable sources. As for non-sustainable sources, it is very limited and can be diminished since have been utilized for an extensive period. This energy source takes hundreds of millions of years to be developed again. Nonetheless, an issue with the energy sources is their environmental effect such as their ignition prompts a lot of air pollution. Meanwhile, renewable sources are constantly replenished by natural processes. These are including wind, solar, tidal, water, and biomass. This source is a clean energy source, which means it has minimal to zero pollution and greenhouse gas emissions [1].

Nowadays, the primary source of electricity generation is non-renewable energy such as fossil fuel. Consequently, non-renewable energy produces harmful gasses such as carbon dioxide and greenhouse emissions that can create pollution thus, worsen human health and the environment. Other than that, owing to the increased demand, energy prices are becoming costly every day. Thus, it is needed to develop innovative forms of producing more energy that is environmentally friendly and can reduce the cost of electricity to ensure that citizens lead a happy, fulfilled, and comfortable life.

The objective is to develop and design a wind mini generator by using an air conditioner air waste system prototype that can be used either for homes or other buildings that have an air conditioner installed. Nowadays, every house, office building, school, and factories were using an air conditioner unit, rather than letting this air waste free off direction it is better to utilize it by applying the wind mini generator so the power can be generated from it. From the system implementation, there are no harmful gases and smoke will be released such as carbon dioxide and Sulphur dioxide that can harm the people and the environment.

Next, this system is designed to produce a small power generation system that can be used as supplementary and backup power. By applying this system, the user or consumer will get benefits from it as the generated power from the generator will be stored in the battery, this can be used in case of emergency when the outage of power happens. Furthermore, helping the consumers on reducing their monthly electricity bills by providing an alternate energy source of off-grid electricity to be utilized.

1.1 Wind Power Plant from Air Conditioning Exhaust using L Savonius Wind Turbine

Gumilar et al. (2019) stated that the residual wind from the air conditioner will be converted into electrical energy with the use of the wind generator. The main benefit of using the waste heat from the air conditioning compressor is that the wind speed is reasonably constant every time, though not quite as large as the wind speeds present in nature [2]. The system used two different types of generators which is

AC and DC in generating electricity and a comparison of output has been made to know which one was the suitable electricity generator. As for the AC generator, it provides less voltage output but with a little higher current output compared to the DC generator. As for the DC generator, it generates a much higher voltage than the AC generator but with a little lower current as compared to the AC generator. From here we know that the DC generator is much more suitable for electricity generation. When the technology is implemented in homes, there is no more waste of energy from the use of the air conditioner as the waste energy can be used to light up the lights in front of the house or room [3]. In future studies, the authors recommended investigating other simpler and lighter types of turbines so that the turbines can rotate quicker and generate higher voltages [4].

1.2 Energy Harvesting from Cooling Tower by Vertical Axis Wind Turbine (VAWT)

As written by Rahman et al. (2015) the alternative sources of wind for electricity generation can be harnessed from the exhaust air system such as blowers or cooling towers used in buildings or the industrial sector [5]. Ventilation towers are widely used to remove heat from power-generating systems, water-cooled refrigeration, air conditioning, and industrial processes [6]. For this system, a vertical axis wind turbine (VAWT) is utilized to be inserted at the cooling tower outlet since it has a few points of interest such as a much simpler, gearbox that can place on the ground and did not produce much noise. Next, the objective of the system is to measure the electricity that can be generated and investigate the impact of the system on the cooling tower. According to the journal the average output voltage and current generated are 1.72V and 0.0034A respectively and the system implemented did not have any adverse effect on the cooling tower system [7]. For future development, the authors suggested switching the generator motor, improving the structure of the blade, and modifying the component with lighter materials [8].

1.3 Mini Wind Turbine for Small-Scale Power Generation and Storage (Archimedes Wind Turbine Model)

According to Ozeh et al. (2018), the Archimedes wind turbine features an advanced blade design for a far more powerful wind energy harvesting capacity [9]. The design, power output, wind test of Archimedes wind turbine, and potential of energy production were presented. For this system, the power generated from the wind turbine will be used to charge cell phones as proof to meet the objective of the proposed system which is small-scale power storage with a power bank [10]. It is stated here that the blades of the wind turbine play an important role as to produce more power that can be harvested from the wind. Hence, this leads to the innovation of the blade design produced by the Archimedes wind turbine.

This system also used a 12V DC motor as a wind turbine generator and a digital wind anemometer to measure the velocity of the wind. The result shows that the maximum output of voltage and current is at 5.3V and 1.92A respectively at 35 m/s wind speed. The Archimedes mini-wind turbine prototype shows that it is an effective design for improved wind energy harvesting efficiency as it is indeed very effective at low wind levels and has a capacity for higher power efficiency than the conventional mini horizontal axis wind turbine in the same operational conditions [11]. The authors claim that the prototype was able to generate enough power to charge a mobile phone, which could also be deposited in a 5V-compliant battery bank for later usage [12]-[15].

2.0 MATERIALS AND METHODS

In this section the method used and process flow of the development of wind mini generator by using air conditioner air waste including block diagram, flowchart, and hardware used are discussed and clarified briefly.

A. DC Generator and Wind Turbine Blade

Figure 1 shows the DC Generator and Wind Turbine Blade used for this system. As for this system, two DC generators with different ratings were used [16]. DC generator is an electrical machine where capacity is to change over mechanical energy into DC electrical energy. It comprises primarily of the armature, the field coils that serve as electromagnets in it. The method of energy alteration follows the concept of energetically induced electromotive force [17]. The DC Generator is the main component where the voltage and current generated will base on the generator's rating.

Figure 1: DC Generator and Wind Turbine Blade

The type and design of the wind turbine blade or propeller for this system is three blade type which is a typical blade used with the horizontal axis wind turbine (HAWT) as shown in Figure 1. If more than three blades were used, it will generate greater wind resistance, slow down the production of electricity and thereby become less efficient than three blades [18]. The blade is made of PVC pipe and the material is lenient and durable.

B. Charge Controller

The charge controller is a device that prevents the battery overcharged by the generated power from the wind generator [19]. In other words, charge controllers are built to provide a continuous, accurate measurement of the battery voltage level, let the users know when the battery is full, and stop excess power from accessing the battery by cutting the voltage and current from being delivered to the battery. Figure 2 shows the charge controller used for the system.

Figure 2: Charge Controller

C. Battery

The lead acid battery is a secondary cell which means it can be recharged [20]. As for this system, the battery serves as the storage power bank for the generated power produced by the wind generator as well as the power supply to the DC to AC inverter. The battery that has been chosen is a 12 Volt lead acid battery that is rechargeable, and Figure 3 shows the 12V battery that is used for the system.

Figure 3: 12V Battery

D. DC to AC Power Inverter

The inverter is one of the main components to be used in this system to operate the home appliances such as to light up bulbs or lamps [21]. Furthermore, the DC power generated by the system of wind turbines has no wave at all, which is the basic, direct current flow. Hence, for it to be functional, it has to imitate the waveform of the AC power coming from the grid (the sine wave) to ensure that the generated output is in precisely the same phase as the grid electricity supply. Figure 4 shows the picture of the DC to AC power inverter.

Figure 4: DC to AC Power Inverter

2.1 METHOD

The details of the methodology in developing the Development of Wind Mini Generator by Using Air Conditioner Air Waste' is included. This methodology briefly explains the overall block diagram and flow chart in Figure and Figure 6 respectively.

A. Block Diagram

Figure 5 shows the overall block diagram consisting of the input, system, and output. The input or source of the device system is the air waste from the air conditioner compressor. The system is the part where the process of generating electricity happened. The components in the system include wind turbine blades, a DC generator, a charge controller, a battery, and a DC-to-AC inverter. The output is the consumer load, where the appliances such as lamps or bulbs will be used to test the system. The output generated here is AC as the DC power generated by the DC Generator has been converted by the inverter

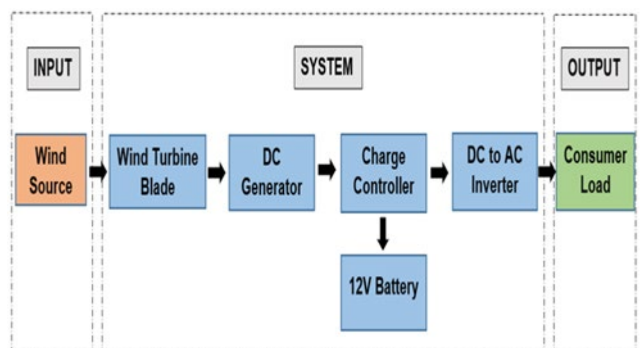

Figure 5: Block Diagram of the System

B. Flowchart

The flow chart is a workflow of the process for the whole system. Figure 6 shows the flowchart of the system. As for the system, the developed system is positioned in front of the exhaust air system or air conditioner compressor unit to initiate the blade of the wind turbine. The generated air waste by the compressor will act as the source of energy to produce electricity. Next, the DC generator is used which transformed the kinetic energy from the air waste into electrical energy from the principle of electromagnetic induction. If the generator is not rotated by the air, the system would start again from the beginning until the blade starts to spin.

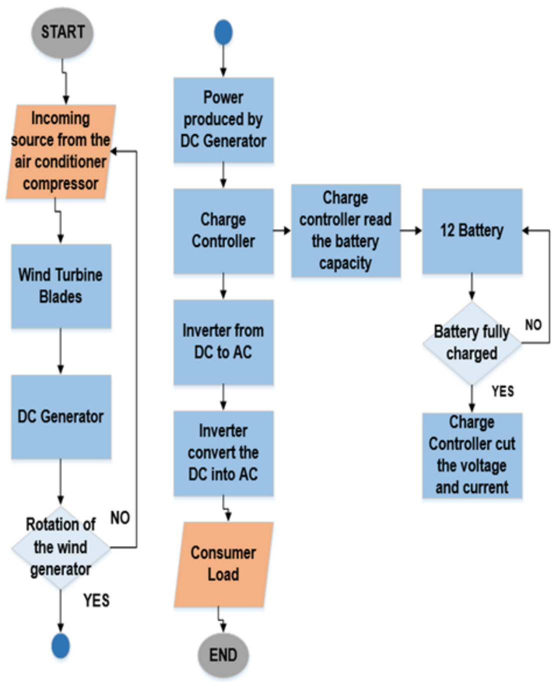

Figure 6 Flow Chart

The generated dc electrical energy will pass through the charge controller, which will control the battery and avoid the battery being overcharged, if the battery stated fully charged the charge controller automatically cut the voltage and current from charging the battery. At the same time, if the battery capacity is low the controller will be triggered again and direct the electrical energy generated by the DC generator to the battery. The electrical energy from the battery will be used by the inverter to convert from DC to AC and last the consumer load where the test will be carried out using the AC appliances.

C. Wiring Layout

Figure 7 shows the wiring layout for the system. The wiring layout is the basic wiring diagram sketched to show the basic and general overview of the wind mini generator by using air conditioner air waste. The wiring connection is highlighted to ensure understanding and avoid the confusion when assembly process of the system is being made.

3.0 RESULT

The results of the Development of the Wind Mini Generator by Using Air Conditioner Air Waste are using two different DC generators with different ratings and the comparison is discussed below. The result also used 4 types of different wind speeds (m/s) to clearly show the outcome and how much power was produced by this system.

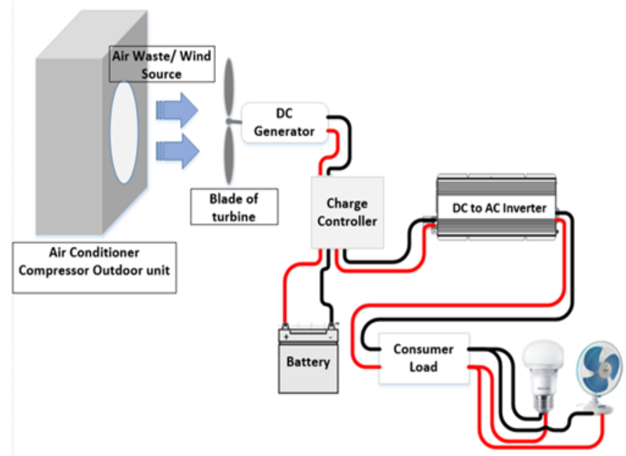

Figure 7: Wiring Layout for the System

3.1 DC Generator Specificaion Comparison

DC motor is one of the most important components in building a small wind turbine because the produced power will be directly generated from this component. The volts-to-rpm ratio is the key to finding a suitable motor to be used as a small power generation system and the formula is volts-to-rpm ratio = rated voltage/ rpm. The higher the volts to rpm ratio, the more suitable the motor and to produce more voltage. Table 1 shows the comparison of the DC generators.

Table 1: Comparison of DC Generator

	Rated Power (W)	Rated Voltage (V)	Rated Speed (rpm)	Volts to Speed Ratio (V/rpm)
DC Generator 1	100	12	3350	0.004
DC Generator 1	55	120	2500	0.048

Note that the first dc generator has high-rated power which is 100W, the rated voltage is 12V, the rated rpm is 3350 rpm and the volts-to-rpm ratio is 0.004 V/rpm. Here we can see the volts to rpm ratio is very small thus make it the motor not suitable for the power generation system. Besides, the second dc generator rated power is a little bit lower which is 55W but has a high rated voltage of 120V. The rated rpm is 2500 rpm and the volts-to-rpm ratio is 0.048 V/rpm. The second generation has a very high volts-to-rpm ratio which makes it suitable for a power generation system.

3.2 Result and Output of DC Generator 1

Table 2 shows the result obtained for motor generator 1 by using 4 wind source which is air conditioner compressor wind, table fan speed 1, table fan speed 2, and table fan speed 3. Note that by using different wind sources, the wind speed is also changed and measured in m/s. From the tabulated result, it can be assuming the voltage produced here is not enough to charge the battery whereas the 12v battery needs at least 12.7 V to start charging. The highest voltage value here is only 2.61 V by using table fan speed 3 as the wind turbine source where the wind speed is at 5.2 m/s. Although, the current produced by this motor generator is quite good. This is because the overall specification motor generator is not enough to make use of the wind speed at 5.2 m/s.

Table 2: Output from DC Generator 1

	Wind Speed (m/s)	DC Output Voltage (V)	Output Current (A)	Power (W)	AC Output Voltage (V)	Charge Battery
Air-Con Compressor (2 HP)	4.0	1.92	0.41	0.8	234	NO
Table Fan (Speed 1)	4.2	1.91	0.42	0.8	231	NO
Table Fan (Speed 2)	4.8	2.19	0.50	1.1	235	NO
Table Fan (Speed 3)	5.2	2.61	0.53	1.38	235	NO

From the tabulated result, the output voltage for AC is between 231 V to 235 V by using the DC to AC power inverter. The power inverter can convert 12V DC to 220V – 240V AC hence the result output voltage for AC from the tabulated result is in the range. The output voltage AC is compulsory to use the AC appliances such as lamps, a fan, and many more. From the experiment that has been carried, out the system manages to light up two AC lamps, and a table fan and charge the mobile phone.

Figure 8 shows the graph output of dc generator 1, here we can see the output voltage (V), current (A), and, power (W). Here the highest output is from the table fan speed 3 with 5.2 m/s where it produces 2.61V, 0.53A, and 1.38W respectively. We can conclude that the higher the wind speed the more voltage, current, and power will be generated

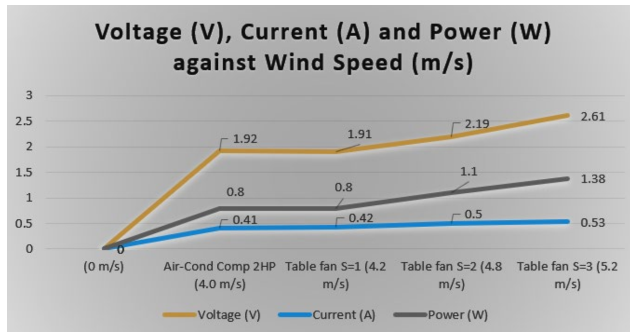

Figure 8: Graph output of DC Generator 1

3.3 Result and Output of DC Generator 2

Table 3 shows that the overall voltage and power generated from motor generator 2 is very high from the previous one but the downside here is the current produced is very small. The reason behind this due to the rated power of this generator is less and with the high rated voltage. We can use the power formula P=IV to get the maximum current that this motor can generate. Hence, I=55W/120V = 0.46A, this current is only when the motor rotates at the maximum rpm. However, with enough voltage here this motor manages to charge the battery 12V, but it will take a long time to be fully charged.

Table 3: Output from DC Generator 2

	Wind Speed (m/s)	DC Output Voltage (V)	Output Current (A)	Power (W)	AC Output Voltage (V)	Charge Battery
Air-Con Compressor (2 HP)	4.0	23.7	32.3	0.8	234	YES

Table Fan (Speed 1)	4.2	24.8	33.4	0.82	231	YES
Table Fan (Speed 2)	4.8	32.2	36.1	1.2	235	YES
Table Fan (Speed 3)	5.2	37.0	42.5	1.6	235	YES

The AC output voltage recorded here is ranging between 231V to 235V. As we can see, the value of AC output voltage is not much different, this is because the power inverter used for the system is very stable and has a good conversion efficiency of up to 90%. The input for the inverter is a 12V battery. The power generated by the wind turbine system will be stored in a 12V battery and then, the power from the battery will be used by the inverter to convert 12V DC to 220V to 240V AC. The system manages to light up two AC lamps, and a fan, and charge a mobile phone.

The graph in Figure 9 shows the output of the dc generator 2, we can see clearly that the voltage generated is very high because the volts-to-rpm ratio is good for the small power generation system. The current obtained is low but still acceptable and capable to charge the battery. Hence, the power is also a little bit higher than the previous motor generator.

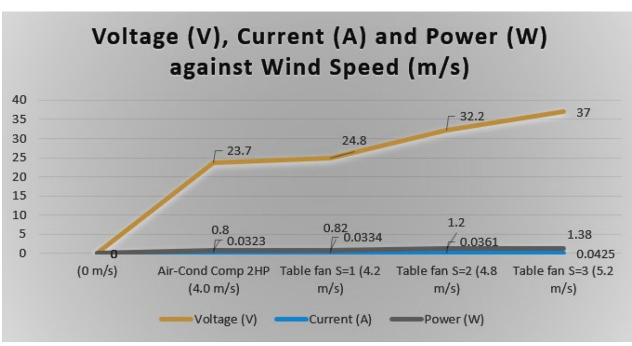

Figure 9: Graph output of DC Generator 2

3.4 Comparison between Generators 1 and 2

The voltage data collected from motor generator 1 is by far lower than the data from motor generator 2. The minimum voltage data is when using the air-conditioner compressor as a wind source at 4.0 m/s wind speed motor generator 1 produces 1.92V while motor generator 2 produces 23.7V. While the maximum output collected is at a wind speed of 5.2 m/s where motor generator 1 successfully produced 2.61V and motor generator 2 produced 37V.

The current and power of the motor generator are directly proportional to the wind speed, where the value will be increased upon the increase of the wind speed. The current from motor generator 1 is higher compared to the current from motor generator 2 due to the difference in motor generator rating. However, the power generated by both motor generators is almost the same.

The power here is calculated by using the power formula P=IV, where p is power, I is the current generated, and V is the voltage generated by the motor. For motor generator 1 although the current is high, the voltage is too low for charging the battery which makes it not suitable for this type of motor generator to make a small power generation system. For motor generator 2 the voltage value is very high, but the current is relatively small, but when it is still managed to charge the battery but in a long time to be fully charged.

3.5 Comparison between

The battery is the one of important components of this system as it is used as a storage bank or power storage to store the generated electricity and used as a power supply by the inverter to convert DC into AC electricity. From the data collected from the testing that has been done, we can calculate the time taken for the 12Ah lead acid battery to be fully charged. The calculation will be used the data from motor generator 2.

Table 4 shows the time taken to battery fully charged. The calculation is divided into two groups the first one is the time taken for the battery to be fully charged with a battery below 50% capacity and the second one is the time taken for the battery to be fully charged with a battery more than 50% capacity. Note that the calculations also include the 20% losses that occur when charging the battery

Table 4: The time taken to battery fully charged

Wind Speed (m/s)	Time Taken to Battery Charge Fully	
	Battery Below 50% (Hours)	Battery Above 50% (Hours)
Air-Con Compressor (Wind Speed 4m/s)	432	216
Table Fan Speed 1 (Wind Speed 4.2m/s)	421.2	211.2
Table Fan Speed 1 (Wind Speed 4.8m/s)	288	144
Table Fan Speed 1 (Wind Speed 5.2m/s)	216	108

4.0 DISCUSSION

The resulting finding shows that the two motor generators with different ratings have been used for the system. These two motor generators have their advantages and drawbacks where the value of the result has been measured and discussed. The output generated from the Development of a Wind Mini Generator by using Air Conditioner Air Waste is influenced by several factors such as the wind speed itself, motor generator rating, blades of the wind turbine, and the angle of the wind turbine when accepting the wind source. Next, the higher the wind speed the more motor shaft rotation (rpm) thus more power will be generated. As well as the higher volts to rpm ratio the more suitable voltage output will be produced by the motor generator. The design of the system structure can be improved as the design here is too heavy and big. The overall system is good and can be further improved in the future so that it can be implemented for residential and industrial areas.

5.0 CONCLUSION

The usage of air conditioner compressor air waste as a source of wind can be applied not only for residential but also to the industrial sector where a lot of air conditioners are installed and much bigger air conditioner horsepower ratings been used thus, this system application is very suitable as it will produce more power. The bigger horsepower of the air conditioner, the more air waste and higher wind speed that will be produced resulting in more power will be generated from the system. By applying the system, the users can make use of free clean energy and convert it into power thus can save their electricity costs and having their backup power for emergency use. The goal of the system is to make use of the wind waste produced by the air conditioner compressor thus generating the power and electricity from it by applying a wind mini generator. All the components used in the system have been tested and the data obtained have been analyzed and discussed. The overall system is good and functional, and all the objective is successfully achieved.

Even though the system is successful but there is a lot of space for improvement that can be done. For future recommendation, it is recommended to change the motor generator to a more suitable one that has more rating such as higher volts to rpm ratio and higher rated power and current. This can make the system produce more power with less rotation (rpm) and generate enough power even with low wind speed. Second, by redesigning the structure of the wind turbine. The present structure is very big and heavy which uses a lot of space hence, by redesign and replacing the existing material it will make the structure lighter in weight and use less space.

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