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Development and Evaluation of Small-Scale Wind Powered Electricity Generator

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ABSTRACT

With electricity being the well-used form of energy and as a part of our daily necessities, problems due power interruptions and not having access to electricity became a concern. But with the advent of technology, we can use ways to generate clean energy to use on a minor scale. The researcher aims to show how many things around you can be used to create clean energy and how this act can help increase your curiosity to science. Using recyclable materials and common items in making a small-scale wind powered electricity generator is a good source of electricity for emergencies and to those who do not have access to electricity. Using a turbine to receive wind, a small dynamo to generate electricity, and a power bank to measure how strong electricity generation is, the device was created that could generate sufficient current at a minimum speed of 30 mph. By testing at different speeds at equal distances, the device was successful at creating the necessary current to start charging the power bank. With the results observed from the device, it was able to serve its purpose to give a sustainable and practical source of electricity.

Key words : electricity, small-scale wind powered generator, recyclable material.

1. INTRODUCTION

In our modern world now, electricity has been one of our main sources of energy that powers most of our conventional tools used for comfort and development. While access to electricity is easy to most of the population, some cannot afford or does not have access at all. A world without electricity is unthinkable as we depend on the lifeblood of "electricity" [1].. It is crucial especially during the pandemic today, where the things that people can do became limited. Today, 86% of the world has access to electricity and a billion of people are experiencing "energy poverty" or the lack of access to electricity [10], 2019). This is where the researchers provide a solution by using clean energy as a resource. Wind powered generators are one of the most used clean energy generators that relies on wind to generate power. By building a device that can generate free electricity at a low-cost, this would help many areas with little access to electricity access it without spending too much on any other projects

The main objective of this study will be to create a small- scale wind powered electricity generator using common materials such as dynamo and recyclable materials. That is to: Observe the maximum and the minimum amount of power that can be created with wind; to provide a homemade alternative to natural electricity generation; and to create enough power to charge a 7-watt battery cellphone.

This research aims to provide an alternative way to use dynamos for electricity generation. The expected generator is easy to make and the materials to be used are common. The researcher aims to spread knowledge on how dynamos can be used to create things that can help life be more comfortable. The researcher aims to show how many things around you can be used to create clean energy and how this act can help increase your curiosity to science. The device only uses at least one dynamo. The electricity generated is limited to the presence of the strong wind and the total power created will only be enough to charge a phone. The device only uses at least one dynamo. The electricity generated is limited to the presence of the strong wind and the total power created will only be enough to charge a phone.

2. RELATED LITERATURE

Electricity has been used globally since its discovery. It brought changes to our lives and became an essential. Along with those changes are problems such as safety, friendliness to the environment, outage and generation in which the people up until now, are still trying to innovate to make our lives even better. These problems are also common in our country. In this study, electricity and its generation must be understood thoroughly to meet the objectives.

2.1 Electricity

"Electricity is the part and parcel of our modern life and it is the most widely used form of energy" [9]. Back then, burning fuel powers the world. It all began when Benjamin Franklin experimented on his kite which started the dawn of the understanding of electricity. Thomas Edison and Nikola Tesla invented what would be the most important factor of current, namely the Direct current and the Alternating current which will be used by the entire modern electric world. Electricity is not natural in nature thus it has to be generated.

"Majority of the electricity that is generated uses Faraday's law, the electromagnetic induction. This law led to new technologies that even brought up the misconception of free energy. Energy only becomes free if we don't have to pay for the generation of it; hence we resort to abundant sources of energy that we can convert into electricity" [4]. With the wind being so abundant and free all over the world, it is one of the optimal sources of energy we could use as a potential "free" energy. Using rotor blades to receive the kinetic energy of the wind, we can take it and use it to rotate a generator which will generate electricity through a dynamo with the energy stored in a battery for later use

"The use of the wind as an energy source is increasing and growing worldwide" [13] The use of this technology is well operational all over the world with the set-up of wind farms to receive the wind from places with strong winds. The most important aspect of a wind powered generator are the dynamos, turbines, and wind speeds for rotating the turbines.

2.2 Dynamo

Michael Faraday performed his seminal experimental research on electromagnetic induction and created the first dynamo, a machine for continuously converting rotational mechanical energy into electrical energy. The machine was a conducting disc, rotating between the poles of a permanent magnet, with the voltage/current obtained from brushes contacting the disc [14]. Dynamos work by generating a magnetic field from one of the magnets which gets cut or disrupted by the rotating turbine that holds a magnet. The disruption causes a reaction that frees the electrons that will be captured on the coiled wires around the first magnet.

Electricity can be generated in different ways, each with advantages and disadvantages. Wind power in particular, cannot cause any pollution and they could be either small- scale or larger depending on their purpose. Generating electricity from the wind requires a dynamo. A dynamo is an equipment that transforms kinetic energy to electrical energy (Kumar Guduru & Suresh, 2015). They were the first electrical generators capable of delivering power for industry, and the foundation upon which many other later electric-power conversion devices were based, including the electric motor, the alternating-current alternator and the rotary converter. A study in Vel University used dynamo in generating energy from the rotation of the wheel of a two-wheeled vehicle. Instead of using wind, they took the idea and used the motion of the wheels in generating electricity. The researchers` goal was to store energy in a battery that could be used for further use especially during the power cut periods or rural places where electricity is limited. The study suggests that it is possible to generate electricity using dynamo [11].

2.3 Energy Problems

Our government of the Philippines is committed to reducing the country's dependence on imported oil, thus using other ways of generating electricity that will be used by the citizens [12]

The development of the Philippines in terms of socio-economic growth and economic development depends on energy usage of the people [7]. In terms of energy use, conventional fossil fuels (oil and gas) are the main source for its primary energy demands. According to the 2011 primary energy consumption of the Philippines, 31% of the consumption was met by oil, 20% by coal, 22% by geothermal, 12% by biomass, 6% by hydro and 1% by other renewable energy like wind, solar and biofuel. The country's primary energy supply consists of 60% fossil fuels and 40% renewable energy but as time passes by, renewable energy declines. This is a significant challenge for our country because, as time passes, people's energy consumption rises, resulting in a demand for more energy sources.

With the rising demand for energy, more energy processing facilities will be required. With more facilities, there will be a need for more space to construct and maintain. Cleanliness will become a problem as a result of these factors. Having a clean source or producer of energy is critical to us, the environment and for the future.

Another problem that is observable as of today is that some places in the Philippines, especially rural areas, have no power and their ways of life differ compared to the rest. They pretty much deserve what the rest have since electricity nowadays is basically a necessity. In urban areas, "brownout" is a common term. It means a reduction or restriction of availability of electrical power in a particular place. Some places like Luzon have a high demand for electricity which can result in unscheduled outages. This situation in particular is a hassle especially during crucial times where you need electricity.

2.4 Electricity Generation Studies

Researchers from Seville University explained how the wind turbine of wind energy extraction works. The horizontal-axis wind turbine is the most extensively used method in asynchronous and permanent magnet generators [3]. The transformation of the energy from the wind into mechanical energy is being processed in the rotor of the turbine. The electricity being generated depends on speed and it makes the system more expensive to build and maintain. DC current feeds rotor electromagnets by rectifying part of the electricity generated. The main objective of the generator is to transform the mechanical energy captured by the rotor of the wind turbine into electrical energy that will be injected into the utility grid. Asynchronous generators are commonly used in wind turbine applications with fixed speed or variable speed control strategies while permanent magnets are recently being used.

A study in Vel University used a dynamo in generating energy from the rotation of the wheel of a two-wheeler vehicle. Instead of using wind, the researchers had the idea to use the motion of the wheels in generating electricity. The researchers` goal was to store energy in a battery that could be used for further use especially during the power cut periods or rural places where electricity is limited. The study suggests that it is possible to generate electricity using a dynamo (Rubini et al., 2017).

Researchers from France made a prototype of a wind powered generator using dynamo and a broken bicycle [15]. The study suggests that the prototype is capable of satisfying the modest electrical needs of a household and the device has low technicalities. The generator used in the prototype is a large-scale generator.

Electricity is friendly to the environment, but electricity generation is not completely. Several studies are being implemented to find new methods of electricity generation along with studies that utilize power generation to the things that require energy for efficiency. At the moment, wind power has been considered as the most environment-friendly and important renewable generation technology [2]. Wind power transforms mechanical energy to electrical energy in the dynamo by capturing wind. With the situation we are currently experiencing, free electricity that could be accessed anytime is crucial for emergency purposes or even on a daily basis.

3. METHODOLOGY

The whole experiment is divided into two parts, the creation of the device and its experimental set-up. In the creation of the device, the process is divided into: Gathering of the materials, Creation of the device, and the acquisition of the vehicle. The experimental set-up is done by traveling at varying speeds to generate electricity. It is done by traveling slowly first and then gradually increasing the speed. Collecting the data of the increase of electricity generation is done by measuring the amount charged in the power bank. Further details will be explored in this section.

3.1 Gathering of Materials. In this stage, the proponents gathered the materials to be purchased or obtained from its respective locations as provided in the Material Availability Checklist. The materials needed for this project are shown in table 1 below.

Table 1: List of Materials used of the Study

Item Number	Item
1	Wind Turbine from Computer Fan
2	Cable Receiver
3	Barbeque Sticks
4	Plastic Tube
5	Electric motor from damage printer
6	Metallic Screws
7	Vulcaseal
8	Recycled USB port
9	#18 AWG speaker wire
10	7805 Regulating transistors
11	1 pc Zener diode 24V
12	1 pc Photo board 7x9cm
13	1 pc Bridge Diode
14	1 Jumper wire
15	2 pcs capacitor 35 volts 2200mF
16	5 pcs Epoxy

3.2 Creation of the device. The researchers constructed a small-scale wind powered electricity generator prototype using the materials mentioned in table 1. The 12 inches PVC pipe with 6 inches diameter was used for the body of the device. The Vulcaseal and 5 epoxy were used as the adhesives to stick different components into the device. RS-550 Motor DC served as the dynamo of the device which would generate the electricity. Computer fans were used as the blades of the turbine to catch the kinetic energy of the wind. The wires are the ones that would transfer the electricity created by the dynamo and it was used on other electrical components of the device. Voltmeter was used to check the voltage created by the dynamo relative to its rotation to check whether the device works or not. Wires which have the capability to determine the current generated (A) were used. Lastly, the power bank which has a percentage indicator was used to determine the percentage of energy generated (%) and will be used to store the energy.

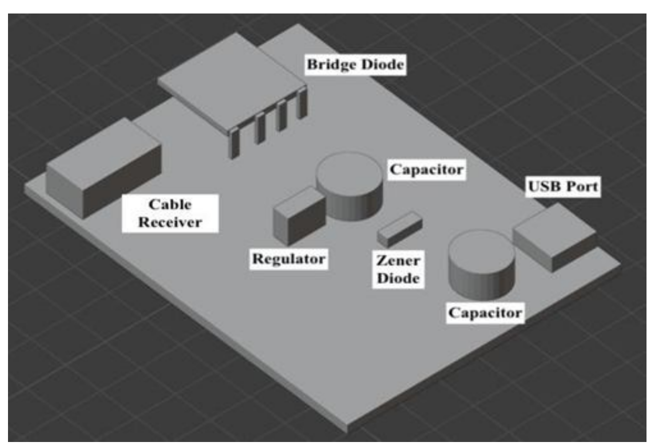

Figure 1: Plan of the Electronic Part of the Device

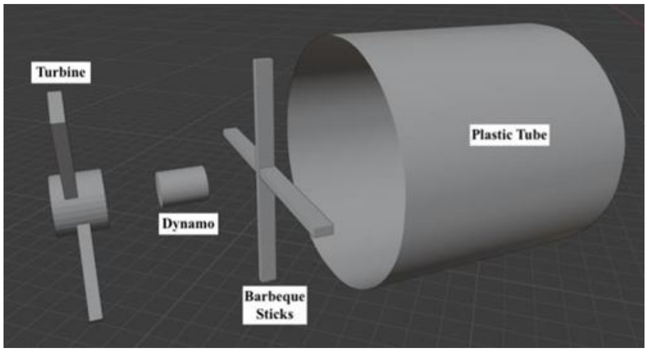

Figure 2: Plan of the Turbine Part of the Device

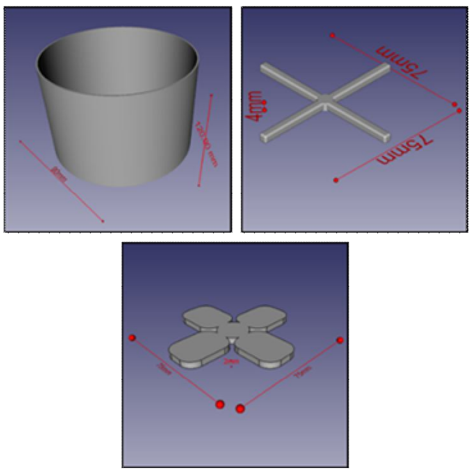

Figure 3: Measurements of the Turbine Part

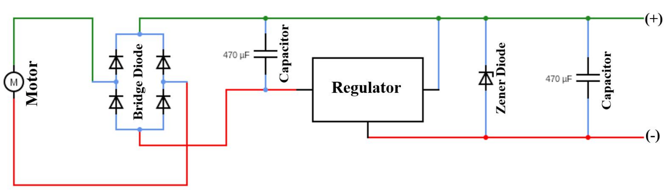

Figure 4: Wiring Diagram of the Electronic Part of the Device

3.3 Acquisition of a usable vehicle. The researchers used a single motor vehicle with sufficient travel speeds for the device to generate enough energy to charge a phone during travel and sustain its speed for the current to be stable. The road located at Brgy. San Luis End point of Gingoog City (Medina border line) to San Juan Road, Gingoog City was used as the testing site to avoid disturbing the citizens with the experiment. It is important that the vehicle and the road should be of standard quality to negate biases in the results.

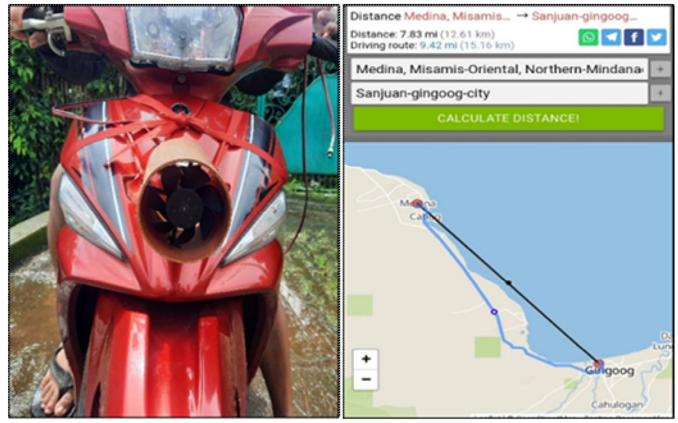

Figure 5: Vehicle Used and Testing Site

3.4 Experimental set-up. The device was attached on the front part of the single motor vehicle where there is a large amount of wind generated and the wires were connected to the processing unit which connects to the power bank ready for charging. Six tests were conducted starting from 20 km/hr., 30km/hr., 40 km/hr., 50 km/hr., 60 km/hr., and 80 km/hr. This step tests at which speed will provide the right electric current that is strong enough to charge the phone.

Evaluation and Data gathering was recorded using excel for the tables and linear correlation. Data was presented through these tables below.

Table 2. Percentage of Energy Generated (%) at Different Speeds

Vehicle Speed (km/hr)	Distance Traveled (km)	Percentage of Energy Generated (%)		
		Trial 1	Trial 2	Trial 3
20	12.61			
30	12.61			
40	12.61			
50	12.61			
60	12.61			
80	12.61			

Table 3. Voltage Generated (V) at Different Speeds

Vehicle Speed (km/hr)	Distance Traveled (km)	Voltage Generated (V)		
		Trial 1	Trial 2	Trial 3
20	12.61			
30	12.61			
40	12.61			
50	12.61			
60	12.61			
80	12.61			

Table 4. Current Generated (A) at Different Speeds

Vehicle Speed (km/hr)	Distance Traveled (km)	Current Generated (A)		
		Trial 1	Trial 2	Trial 3
20	12.61			
30	12.61			
40	12.61			
50	12.61			
60	12.61			
80	12.61			

Lastly, the Analysis of Variance or ANOVA, a tool that can interpret whether the statistical differences between the means of the independent variable groups are significant, was used to calculate whether the data gathered have significant differences to conclude whether the experiment is a success.

4. RESULTS AND DISCUSSION

The experiment's results are as follows, based on careful preparation and data collection:

Table 5. Percentage of Energy Generated (%) at Different Speeds

Vehicle Speed (km/hr)	Distance Traveled (km)	Percentage of Energy Generated (%)		
		Trial 1	Trial 2	Trial 3
20	12.61	0	0	0
30	12.61	1	1	1
40	12.61	1	1	1
50	12.61	2	3	3
60	12.61	4	4	4
80	12.61	7	7	7

Table 6. Statistical Analysis of the Percentage of Energy Generated (%) at Different Speed using ANOVA

Percentage

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	99.611	5	19.922	358.600	.000
Within Groups	.667	12	.056		
Total	100.278	17			significant

Sig at 0.05

Table 5 shows the raw data table of the percentage of energy generated (%) at different speeds in the same distance. Percentage of energy generated (%) at different speeds obtained closer values from 3 trials at varying speeds on the same distance traveled.

Whereas table 6 shows the statistical analysis of the percentage of energy generated (%) at different speeds at same distances using ANOVA. Table 6 indicated the sum of squares between groups, within groups and its total. The total sum of squares is 100.278 with a degree of freedom of 17. The level of significance is 0.000 which indicates the rejection of the null hypothesis in the statistical test.

Table 7. Voltage Generated (V) at Different Speeds

Vehicle Speed (km/hr)	Distance Traveled (km)	Voltage Generated (V)		
		Trial 1	Trial 2	Trial 3
20	12.61	0	0	0
30	12.61	4.39	4.39	4.39
40	12.61	4.52	4.51	4.52
50	12.61	4.6	4.64	4.62
60	12.61	4.72	4.76	4.74
80	12.61	4.84	4.84	4.84

Table 8. Statistical Analysis of the Voltage Generated (V) at Different Speed using ANOVA

Voltage

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	53.771	5	10.754	77430.112	.000
Within Groups	.002	12	.000		
Total	53.773	17			significant

Sig at 0.05

Table 7 shows the raw data table of voltage generated (V) at different speeds in the same distance. Voltage generated (V) at different speeds obtained closer values from 3 trials at varying speeds on the same distance traveled.

Whereas table 8 shows the statistical analysis of the voltage generated (V) at different speeds at same distances using ANOVA. Table 8 indicated the sum of squares between groups, within groups and its total. The total sum of squares is .153 with a degree of freedom of 17. The level of significance is 0.000 which indicates the rejection of the null hypothesis in the statistical test.

Table 9. Current Generated (A) at Different Speeds

Vehicle Speed (km/hr)	Distance Traveled (km)	Current Generated (A)		
		Trial 1	Trial 2	Trial 3
20	12.61	0	0	0
30	12.61	0.18	0.18	0.18
40	12.61	0.21	0.21	0.21
50	12.61	0.24	0.24	0.24
60	12.61	0.25	0.26	0.26
80	12.61	0.27	0.28	0.28

Table 10. Statistical Analysis of the Current Generated (A) at Different Speed using ANOVA

Current

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.153	5	.031	2752.100	.000
Within Groups	.000	12	.000		
Total	.153	17			significant

Sig at 0.05

Table 9 shows the raw data table of current generated (A) at different speeds in the same distance. Current generated (A) at different speeds obtained closer values from 3 trials at varying speeds on the same distance traveled.

Whereas table 9 shows the statistical analysis of the current generated (A) at different speeds at same distances using ANOVA. Table 9 indicated the sum of squares between groups, within groups and its total. The total sum of squares is .153 with a degree of freedom of 17. The level of significance is 0.000 which indicates the rejection of the null hypothesis in the statistical test.

With the advent of technological advancement in the 21st century, electrical power is in great demand due to increasing electrical consumption of different gadgets and devices in different fields of life. Electricity also provides means of amusement, radio, television, and cinema, which are the most popular forms of entertainment as the result of electricity. In this study, the percentage of energy generated, voltage generated and current generated at different speeds at same distances were assessed that are likely to describe the functionality and effectivity of the device.

Percentage of Energy Generated (%)

One of the common approaches that are applied in the field of technological advancement as it provides information on the device's condition is the percentage of energy generated (%) study. Wind turbines use blades to collect the wind's kinetic energy. Wind flows over the blades creating lift which causes the blades to turn. The blades are connected to a dynamo that turns an electric generator, which produces and generates electricity (U.S. Energy Information Administration 2020).

Table 5 shows the statistical data of the percentage of energy generated (%) at different speeds in the same distance. Results revealed that at a speed of 20 km/hr., there is no energy generated in three trials; at a speed of 30 km/hr., three trials obtained approximately 1% energy generation; at a speed of 40 km/hr., three trials had 1 % energy generation; at a speed of 50 km/hr., trial 1 had 2% energy generation while trial 2 and 3 had 3% energy generation; at a speed of 60km/hr., three trials had 4% energy generation; and in 80km/hr., the energy generated in three trials had 7% energy produced.

Table 6 depicts that as the speed of the vehicle increases at the same distance, the higher the percentage of energy generated (%). The statistical analysis of the percentage of energy generated (%) at different speeds at same distances using ANOVA indicated the sum of squares between groups of 99.611, within groups with .667 and its total 100.278 with a degree of freedom of 17. The mean square between groups is 12.922 and within groups of 0.056 at Frequency 358.600. The level of significance is 0.000 which indicates the rejection of the null hypothesis in the statistical test.

Voltage Generated (V)

Appliances and electronics are designed to run on typically two main categories of voltage required to operate them. There are also different currents of electricity used to deliver energy, direct current (DC) and alternating current (AC). Alternating current can reverse the direction of flow and is more cost effective and efficient to deliver energy into homes. Also, it is easy to manipulate and change the voltage of alternating current with a transformer. Certain appliances require a specific amount of voltage to run effectively. In most cases, if an appliance does not match the corresponding voltage connection, then the appliance simply will not work (Appliance Connection 2021).

In this study, the researchers used alternating current (AC) to manipulate and change the voltage of alternating current with the use of a capacitor included in the device. Table 7 shows the statistical data of the voltage generated (V) at different speeds in the same distance. Findings indicated that at a speed of 20 km/hr., there is no voltage generated in three trials; at a speed of 30 km/hr., trial 1, 2 and 3 obtained 4.39v; at a speed of 40 km/hr., two trials had varying voltage production trial 1 having 4.52v, trial 2 obtaining 4.51v and trial 3 of 4.52v; at a speed of 50 km/hr., trial 1 had 4.6v, trial 2 had 4.64v and trial three obtained 4.62v; at a speed of 60km/hr., three trials had varying results having trial 1 in 4.72v, trial 2 of 4.76v and trial3 of 4.74v; and in 80km/hr., the voltage generated in three trials got 4.84v.

Table 8 depicts that as the speed of the vehicle increases at the same distance, the higher the voltage produced (V). The statistical analysis of the voltage generated (V) at different speeds at same distances using ANOVA indicated the sum of squares between groups of 53.771, within groups with .002 and its total 53.773 with a degree of freedom of 17. The mean square between groups is 10.754 and within groups of 0.000 at Frequency 77430.112. The level of significance is 0.000 which indicates the rejection of the null hypothesis in the statistical test.

Current Generated (A)

Every electrical appliance has an electricity energy rating, which, via a label, shows how much energy those typical appliances use to function. An electric current is a stream of charged particles such as electrons or ions, moving through an electrical conductor. It is measured as the net rate of flow of electric charge through a surface or into a control volume. Electric current is the movement of electrons through a wire. Electric current is measured in amperes (amps) and refers to the number of charges that move through the wire per second (Science World Society 2021).

Table 9 shows the statistical data of the current generated (A) at different speeds in the same distance. Data showed that at a speed of 20 km/hr., there is no current generated in three trials; at a speed of 30 km/hr., trial 1, 2 and 3 obtained 0.18A; at a speed of 40 km/hr., three trials had current production of 0.21A; at a speed of 50 km/hr., trial 1, trial 2 and 3 had 0.24A current production; at a speed of 60km/hr., three trials had varying results having trial 1 in 0.25A, trial 2 of 0.26A and trial 3 of 0.26A; and in 80km/hr., the current generated in three trials had 0.27A, 0.28A and 0.28A.

Table 10 depicts that as the speed of the vehicle increases at the same distance, the higher the current produced (A). The statistical analysis of the current generated (A) at different speeds at same distances using ANOVA indicated the sum of squares between groups of .153, within groups with .000 and its total .153 with a degree of freedom of 17. The mean square between groups is .031 and within groups of 0.000 at Frequency 2752.100. The level of significance is 0.000 which indicates the rejection of the null hypothesis in the statistical test.

5. CONCLUSION AND RECOMMENDATION

Due to frequent power interruption which affects the functionality of gadgets and devices, the researchers come up with the idea to create a sustainable supply of electricity. With the aid of the constructed and evaluated small-scale wind powered electricity generator, the existing problem was addressed through a practical device. From the findings of the study, it is concluded that the device denotes an effective outgrowth to the existing issue. Using different variables and statistical product and service solution (SPSS) software, the level of significance for the three parameters was evaluated. The null hypothesis was rejected in the statistical test, indicating that the device's performance was more reliable.

Percentage of energy generated, voltage generated, and current generated are the three parameters used to assess the quality and effectiveness of the device. Results revealed that as the speed of the vehicle increases at same distances, the percentage of energy generated also increases in appropriate proportion as well as the results obtained in the voltage generated and the current generated. Thus, this indicates that the device constructed was able to serve its purpose to provide a sustainable and practical source of electricity. Furthermore, the results of this study will serve as a baseline information for future studies. The study further recommends the following:

1. The device should be tested in a four-wheel vehicle to support the result of the study and to validate further the results of this study.
2. Improve the design of the device to be commercially acceptable.
3. Create a design applicable to a larger scale for gadgets that require higher voltage input

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