INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH AND ANALYSIS

ISSN(print): 2643-9840, ISSN(online): 2643-9875

Volume 06 Issue 05 May 2023

DOI: 10.47191/ijmra/v6-i5-12, Impact Factor: 7.022

Page No. 1902-1923

Development of Vertical Axis Wind Turbine Charger as Alternative Power Source

Reymundo M. Maggay

Isabela State University

ABSTRACT: The study was focused on the development of Vertical Axis Wind Turbine Charger with D.C Air Compressor to address power shortage in the coastal area in the Province of Isabela. This project development research tried to achieve the following objectives; a) Design and Construct Vertical Axis Wind Turbine Charger with D.C Air Compressor; b) Test the functionality of the project by conducting various activities concerning to basic electrical and electronics circuits, blade adjustment and experiments; c) Determine the acceptability of the project in terms of functionality, workability, durability, safety and instructional applicability as evaluated by the respondents; and d) Make an activity manual to supplement the developed project.

The five-point's Likert's scale was used to determine the descriptive meaning of the indicators of the variables used. Furthermore, the Weighted Average Mean (WAM) was used to interpret the equivalent meaning of the data gathered. The Analysis of Variance (ANOVA) was employed to determine the significant difference between the evaluations of the respondents. The completed project was evaluated by selected twenty (20) technology instructors 25 students, ten (10) Engineers from Isabela State University-Ilagan, Roxas, San Mateo, Cauayan Campus and TESDA Ilagan

Evaluation result shows that the project obtained an overall mean of 4.52 which means the Vertical Axis Wind Turbine Charger is "HIGHLY ACCEPTABLE" to the evaluators based on the criteria of functionality, aesthetics, workability, durability, economy, safety and instructional applicability.

INTRODUCTION

All over the world electronics industry has made a good impact to each in every one of us, thousands of products was innovated to gratify the need of every individual that alter human capability to do work and make people productive and ease in their offices, industry and even in for the purpose of safety. This technology harnesses every people around the globe and binds them closer for a better relation as human.

However, with the growing production of electronics products and together with population inflation, the consumption of energy increases and the adequacy of energy source are not enough to supply the need of the people. Hence, the Department of Energy continually looks for other source to provide the demand of the people. However, renewable energy sources also considers addressing the need of the people around the world, the established hydro power plant and wind mill in the Philippines through the help of different neighboring countries can contributes to the need of the country.

On the other hand, wind energy has a great emphasis on the renewable energy source; numbers of researches had been designed and completed to achieve a sustainable renewable energy source. One of the focus today is the Vertical Axis Wind turbine that was introduce by Savoniuos in 70's and Darreous in 80's to 90's , there are designed come up with to the most appropriate and more efficient wind turbine in terms of design, construction and materials that replace to giant horizontal axis wind turbine that occupy wide land area and maintenance.

Piyush Gulve et. al. (2014) designed and constructed vertical axis wind turbine to provide electrification in the rural areas which is more economical compared to regular rate in the urban areas. RA 9153, supportive to Renewable Act of 2008, promoting the development, utilization and commercialization of renewable energy sources to promote socio economic of rural areas, adoption of clean energy to mitigate climate change, minimize the country's exposure to price fluctuations, reduce the country's dependence on fossil fuels and increase the utilization of renewable energy by providing fiscal and non-fiscal incentives.

In the Region, specifically in Isabela some areas don't have enough supply of electricity. Many of these areas utilized Photovoltaic cell to charge their battery. But the problem is in case of irregular weather they cannot accumulate enough energy from the solar panel which they can used in 24 hours that why many of them seeking help for other alternative solution to be utilized especially in the remote and coastal areas where in supply of energy are limited due to distance and high amount of their gas to maintain their composite generator, other problem there is Photovoltaic cell is expensive low wattage and high maintenance and not all of them can afford to purchase bigger and most appropriate solar panel.

Good response to the different legislations promoting the development, utilization and commercialization of Renewable Energy Resources, the researcher taking up Master of Arts in Industrial Education conceptualized the idea of combined solar energy/wind energy for more efficient and accessible source of electricity. The researcher believes that this process will give sufficient energy sources, reduce electricity consumption and help the world in producing ecofriendly source of energy.

The development of this project will be possible if there are available materials and design that can infiltrate different weather condition in the country, a design with good quality in terms of aerodynamic, efficiency, fast charging system, work for a long period of time and there are available parts in case of repair. Hence, the researcher came up with the Development of Vertical Axis Wind Turbine as Alternative Power Source.

OBJECTIVE OF THE STUDY

The objective of this study was to developed and evaluates Vertical Axis Wind Turbine as Alternative Power Source in term of its functionality, aesthetic, durability, workability, economy, safety, and Instructional applicability.

Specifically, the study aimed to:

1. Design and Construct Vertical Axis Wind Turbine Charger with D.C Air Compressor.
2. Test the functionality of the project by conducting various activities concerning to basic electrical and electronics circuits, blade adjustment and experiments;.
3. Determine the acceptability of the project in terms of functionality, workability, durability, safety and instructional applicability as evaluated by the respondents.
4. Make an activity manual that can be used from the developed project.

Null Hypothesis

There is no significant difference between the evaluations of respondents in terms of functionality, aesthetics, workability, durability, safety, economy and instructional applicability.

Scope and Limitation of the Study

The researcher will focus on the development and evaluation of the Vertical Axis Wind Turbine Charger with D.C Air Compressor. It was developed for the purpose of addressing brownout, provide services in the off-grid and remote areas and promote the utilization of Green Energy around the Isabela.

The evaluators of the study are from the different campuses of Isabela State University namely, Cauayan, Ilagan, San Mateo, Angadanan campus and Techical and Vocational Skills and Development (TESDA) City of Ilagan Campus for the school year 2020-2021. The respondent of this research are Electrical and Electronics Technology Instructors, Electrical Engineer, Mechanical Engineers and Student of this University.

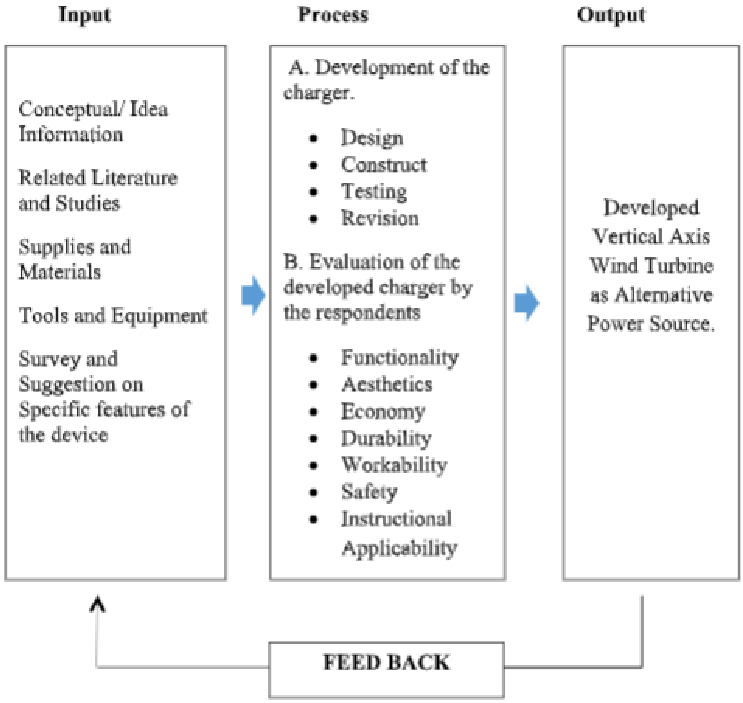
This study were limited to design and development of vertical axis wind turbine Charger with D.C Air Compressor which was evaluated by the respondent in terms of functionality, aesthetics, workability, durability, safety, economy and instructional applicability. The results of evaluation served as the basis for determining the acceptability of the device called Vertical Axis Wind Turbine Charger with D.C Air Compressor. The data were gathered using questionnaire from Technical University of the Philippines. Hence finding of the study was therefore only true to the basis for similar studies. The table below presents the itemized number of respondents as follows:

Table1. Itemized Number of respondents

Campus	**Number of Engineer Respondents**	**Number of Electrical /Electronic Teacher Respondents**	**Number of Electrical /Electronic Student Respondents**	**Frequency**
ISU Angadanan	3	4		7
ISU Ilagan	2	5	25	32
ISU San Mateo	1	8		9
ISU Cauayan	1	3		4
TESDA Ilagan	3			3
TOTAL				**55**

Conceptual Framework

The conceptual framework that guides the researcher in conducting this study is shown in Figure. 1 below



METHODOLGY

This chapter presents the method of research design, data gathering procedure, and analysis of data.

Research Design

This research used the Project Development Method (PDM) in which the researcher conceptualizes the design and specification of the Vertical Axis Wind Turbine as Alternative Power Source for lighting, charging and ventilation purposes.

Figure 2. Illustration of the Project

Sources of Data

The respondent of the study were selected technology instructors, electrical engineers mechanical engineer and students from the different campuses of Isabela State University including Technical Education Skill and Development Authority (TESDA) Ilagan, Isabela Campus to evaluate the project.

Research Locale

The research was conducted at the barangay Tangcul City of Ilagan, Isabela and tested at the different location for the improvement of the project.

Data Gathering Procedure

A permission to conduct an evaluation to the study was requested from the Office of the Executive Office and Campus Administrator of Isabela State University including Technical Education Skills and Development Authority (TESDA) Superintendent for approval.

After permission was granted, the administration of the questionnaires followed. Direction in relation to the accomplishment of questionnaires was explained to the respondents. Copies of the questionnaires-checklist were retrieved after being accomplished by the respondents.

Meanwhile, the interview technique was used to gather the firsthand information in relation to the performance and efficiency of the project. Moreover, the observation method was also applied to determine the whole structure of the project particularly its acceptability to the users. The data gathered through administered and retrieved questionnaire-checklist from the respondents were tallied, statistically analyzed and interpreted.

Analysis of Data

The five-point Likert's scale was used to determine the descriptive meaning of the indicators of the variables used. Furthermore, the Weighted Average Mean (WAM) was used to interpret the equivalent meaning of the data gathered. The Analysis of Variance (ANOVA) was applied to determine the significance difference between the evaluations of the respondents on the general acceptability of the project in terms of functionality, aesthethics, workability, durability, safety, economy and instructional applicability.

Data Analysis Procedure

The 5-point Likert's scale was used on the general data acceptability in terms of functionality, aesthetics, workability, durability, safety, economy and instructional applicability.

Scale	Numerical Rating	Descriptive Rating
5	4.50-5.00	Highly Acceptable
4	3.50-4.49	Very Acceptable
3	2.50-3.49	Acceptable
2	1.50-2.49	Fairly Acceptable
1	1.00-1.49	Not Acceptable

PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

Project Description

Numerous of testing was conducted to attain the project more acceptable in term s of function, aesthetics, durable, workable, economy, safe and applicable for instruction. The functionality of the Vertical Axis Wind Turbine was tested with the use of natural air fuel this is used to determine the generated power output of the charger and also identify the rotational speed of the turbine which is very important in terms workability and efficiency of the project. The wind turbine is located in a place where wind is enough to drive the blade, when the turbine is rotating this is the time to measure the power output of the generator. Other adjustment for the turbine is to be conducted after observing the rotational speed using RPM metering application using android phone.

Development Procedure

Development of the proposed project proceeded through planning, designing, constructing, testing, demonstrating, evaluating and making necessary revision to improve the project. The planning was done with the adviser and through the collaboration of electrical and electronics instructors.

Project Design

Figure 3. Illustration of Completed Project

Figure 4. Parts of the Vertical Axis Wind Turbine

LEGEND

A. Upper blade of the turbine upper part
B. Lower blade of the turbine lower part
C. Spindle and Arm
D. Hub of the turbine
E. 12V/50Amp Alternator
F. 30 watts Solar Panel

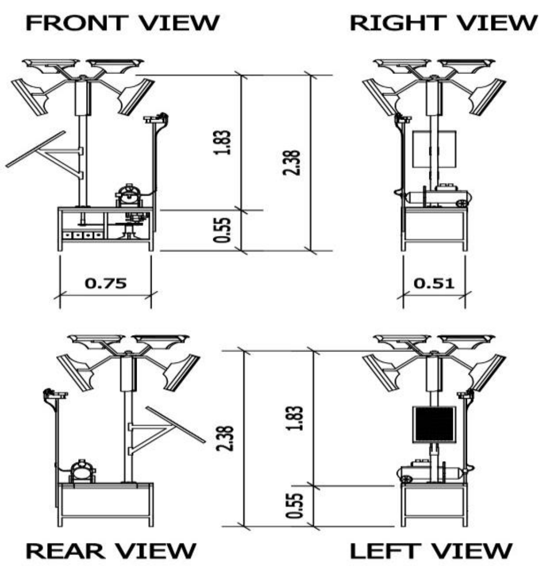


Figure 5. Orthographic view of the Vertical Axis Wind Turbine Charger

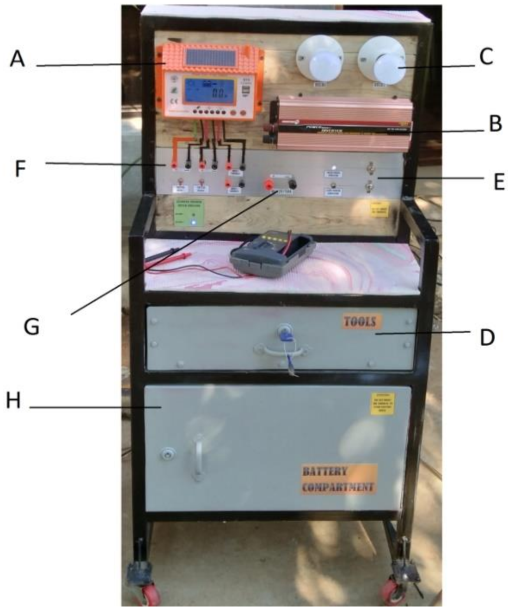


Figure 6. Parts of the charging controller

LEGEND

A. 60Amp MPPT Sola Power Controller.
B. 2000 watts 12v to 220 power Inverter
C. 12 Volts 10 watts Led Bulb
D. Tool Compartment
E. Main Switch
F. Solar Controller input and output terminal.
G. 50 amp 12volts battery terminal
H. Battery Compartment

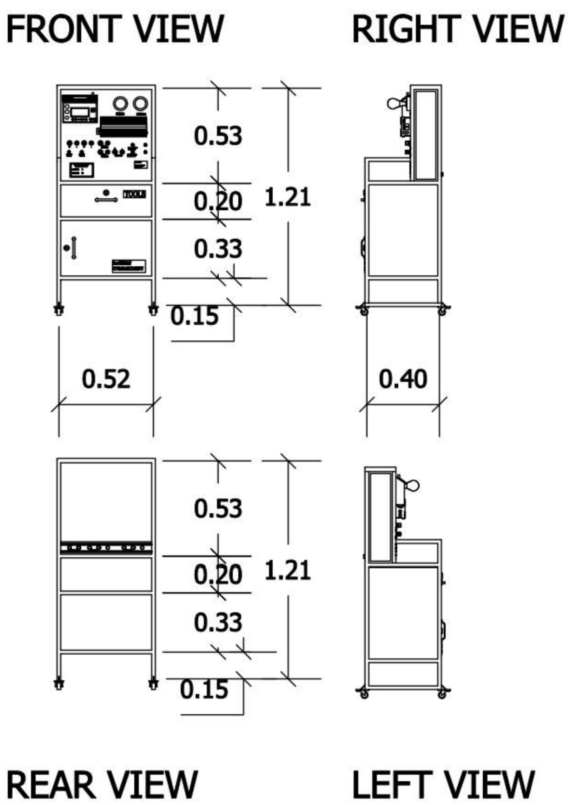


Figure 7. Ortographic view of the controller of the charger

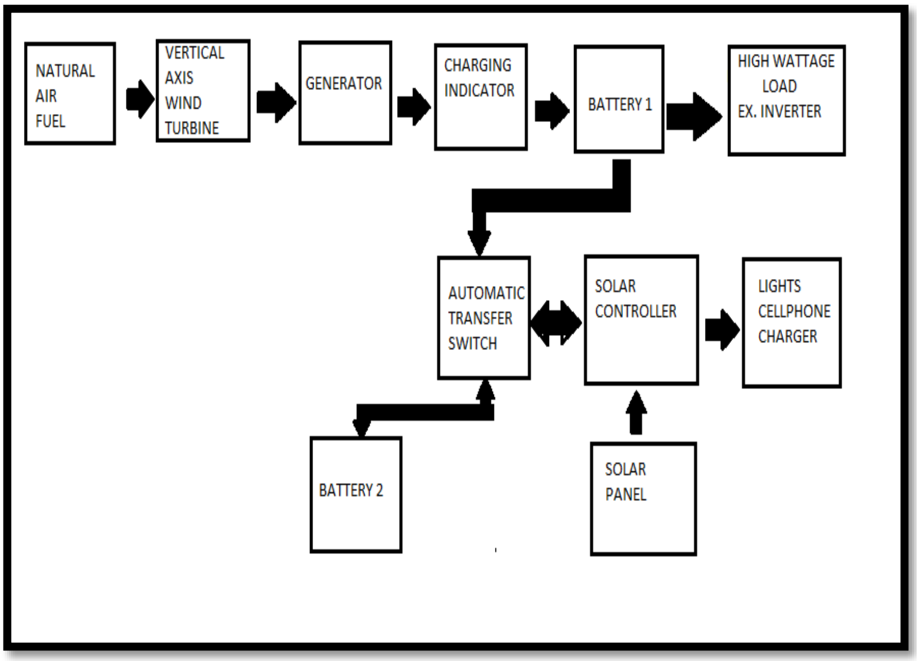


Figure 8. Interconnection Parts of the Vertical Axis Wind Turbine as Alternative Source

Construction Procedure

The following procedures are made for the construction of Vertical Axis Wind Turbine Charger with DC Air Compressor

a. Securing Supplies and Materials. The researcher shall spend seven (15) days purchasing and securing all the supplies and materials needed to construct the vertical axis wind turbine charger with D.C air compressor.

Table 2. Tools and equipment used in the construction of the project and their respective function

Table 2. Tools and Equipment

Tools Needed and Function	Function
Wrench	Combination of a couple with a force along its axis, used for gripping and turning nuts, bolts and pipes
Screw Driver	Tighten or loosen screw
Pliers	Cut wires and excess component terminals
Soldering Iron	Join components wiring and terminals
Riveter	Bind Plain sheet materials
Welding Machine	Join metal works
Grinder	Grind sharp edges and cut metal pipes
Hand drill	Bore a hole for binding purpose
Improvise Plain Sheet Bender	Bend plain sheet and molded PVC pipe
Permanent marker	Mark line to be cut or bend

1. **Construction of the air foils.** The air foil was constructed using the following procedure

a. Make a design and Lay-out of the turbine.
b. Prepare all the necessary materials in constructing the turbine
c. Measure and cut the pieces of PVC plastic
e. Properly bend the PVC pipe using heater with the use of bender
g. Slowly mold the blade with the use of heat gun to attain the intended design

Figure 9. Constructed air foils of the turbine

4. Construction of the Hub and Spindle of the Vertical Axis Wind Turbine

a. Measure and Cut the metal pipe to the according to the size
b. Properly weld the improvise hub for the bearing and shafting
c. Insert the bearing at both end of the metal pipe to assemble a hub.
d. Cut the Shafting according to the length and insert to the hub.
e. make a stopper to the shaft to prevent deterioration during the operation.
f. Make a hole to the improvise base of the hub
g. Insert the hub to the base and weld it firmly.

Figure 10. shows the assembled spindle and the Vertical Axis Wind Turbine

5. Construction of the metal housing of the generator

a. Cut the square tube in their respective measurement.
b. Assemble the base.
c. Weld the steel plate on the housing top of the base.
d. Make a hole to the steel plate for the attachment of the hub.
e. Grind all sharp edges to prevent accidents.

Figure 11. shows the construction of the Vertical Axis Wind Turbine base housing

6. Construction of the charger controller cabinet.

a. Cut and weld the square tube for the housing.
b. Make a compartment for the battery and drawer for the tools and other materials.
c. Grind sharp edges of the housing.
d. Spray primary coating for the housing of the controller
e. Spray desired color for the housing.
f. Mount the solar controller to the housing
g. Connect all other controller and relay following the diagram.
h. Connect all terminals, binding post, and fuse to the controller
i. Conduct testing to the controller
j. Make some adjustment if necessary.

Figure 12. shows the back and front actual picture of the controller

Testing Procedures

After all major parts were placed in their respective place the project was tested in different phases (1) Speed of the Turbine base on wind speed and (2) Voltage output of the generator. Table below shows the different power output of the generator. A mobile application (Zephyrus Wind Meter) was used to determine the wind speed and a Digital Multi-tester was used to measure the voltage output of the charger.

Figure 13. shows different location during testing of the Vertical Axis Wind Turbine

Figure 14. shows the actual testing for the turbine charger system.

Table 3. table shows the generated power output from natural wind fuel of the project in to boosted and none boosted power output.

Table 3. Wind Speed and Power Output of the Generator

Parameter name of the wind turbine	Wind Speed (m/s)	None Boosted Output (V)	Boosted Power Output (V)
Power data at different wind speeds	4	0v	0v
	4.5	0v	0v
	5	0v	0v
	5.5	1V	0V
	6	1.5 v	0V
	6.5	3v	5.5V
	7	4v	6.8V
	7.5	5.7v	7V
	8	8.2v	10.2V
	8.5	8.7v	10.5V
	9	9.3v	10.7V
	9.5	9.7v	10.9V
	10	10v	11v
	10.5	10.1v	11.2V
	11	10.5v	11.5V
	11.5	11v	11.6V
	12	11.1v	11.7
	12.5	11.5v	11.9V
	13	11.8v	12.9V

Testing and Revision

Table 4. Shows the different testing and revision in the completed project

Parts	Revision
Vertical Axis Wind Turbine	Turbine was revised due to difficulty on rotation form plane type of blade to concave type to oppose the wind velocity in each rotation.
Hub	The hub was revised into different size, high, and bearing to use to become more lighter and easy to dissemble.
Housing/base	The base or housing of the project to reduce the weight of the project
Alternator	The alternator was replace into lower amperage to address the difficulty of the turbine to rotate

2. Bills of Supplies and Materials

The following materials are to be used by the researcher in constructing the device. The descriptive presentation of the supplies and materials used in the construction of the project is shown below.

Table 5. Projected Bills of supplies and Material with their Corresponding Price

Qty	Unit	Item Description	Unit cost	Estimated cost
1	Pc.	50Amp/ DC Generator	1,500	1,500
1	Pc	2SM Battery	2200	2200
1	Pc	7AH Battery	500	500
1	3Meter	4" inch Pipe	550	550
1	3Meter	¾ inch pipe	300	300
1	3Meter	3 " inch Flat Bar	300	300
3	3Meter	1 inch Tubular pipe	300	900
1	pc	30 watts solar panel	1500	1500

1	pc	MPPT Solar Charger Controller 60 Amp.	2500	2500
2	Pcs	12 volts 10 watts LED Bulb	140	280
1	Pair	Binding Post	50	100
1	Pair	Battery Clip	70	70
5	Meter	# 14 Automotive wire	40	200
2	Liter	Primer Paint	180	360
6	Pcs	Green/Red/Black/Gray Spray Paint	100	600
1	Liter	Body Filler	85	85
1	Pc	12 inch Diameter metal Pulley	350	370
Total				**Php.12,315**

Table 6. Overhead Cost of the Project

Other Expenses	Amount	Total
1. Electric Bill	1500	1500
2. Transportation Cost	500	500

Table 6 below shows the overhead cost of the project. It will computed based on the electricity consumption/bill in constructing the project at approximately Php 1500 for 15 days, and the transportation cost amounting to Php 500 with a total of Php 2000.

Cost of the Project

Table 7. Total Cost of the Project

Materials	**12,315**
Overhead Cost	**2000**
Total	**14,315**

Table 7 will shows the total cost of the project which will be computed based on the amount of materials Php 12,315 and overhead Php 2000 Cost in developing the project. The total cost is Php 14,315

Figure 15. The Actual System of the Turbine

Figure 15 shows the actual set-up of the project a combination of wind turbine and 30 watts solar panel composed of 60 Amp MPPT solar power controllers and various controllers like relay to interchange the battery from the controller. Each charger has separate battery to maintain or recharge. Each battery has main switches for safety purposes. The Wind Turbine and Solar Charger will be set-up in the open field to harvest wind and sun. The controller should be turn at ON state to collect all the harvested energy come from the two charging device. The Wind Turbine usually charge during afternoon at 3:00 PM to 5:00 PM. The solar charger harvest enough energy during sun hour this is usually at 11:00 AM to 1:00 PM when the sun is strong and bright the more power to be collected.

Figure 16. Actual test for the solar panel

Figure 16 show the controller of the solar panel and the electronically controlled Automatic Transfer Switch (ATS) this is to test the transfer of battery during the day. This controller equipped with MPPT solar controller and 2000 watts 12 Volts-220Volts Inverter and Battery. The two batteries can be used during day and night the bigger sized (2SM) car battery usually used during night especially heavy load and the smaller one (7Ah) is can be used during the day when smaller load is needed.

Figure 17. Testing of the Vertical Axis Wind Turbine

Figure 17 shows actual testing in the vertical axis wind turbine it was located in windy place to measure power output wind from the generator, during the test the voltage output of the generator is unstable due to wobbly wind speed and it takes an hour the battery to charges. With the use of mobile application (Zephyrus Wind Meter) the gustiness of the wind can be measure to show the time and speed of the wind. A digital Multi-Tester was used to determine the voltage charge from the battery.

Figure 18. Testing of 2000 Watts Inverter

Figure 18 show electric ventilator to test how long the harvested power to be consumed and it takes 24 hour that the harvested power was consumed with particular load.

Instructional Applicability

Activity No. 1 Basic Vertical Axis Wind Turbine Charger Wiring System

Warning: Before installing the system basic knowledge in electrical and electronics circuit is important the electronic device may cause permanent damage in case of wrong connection. Do not attempt to short both terminal of the battery the cause explosion and risk your limbs and life.

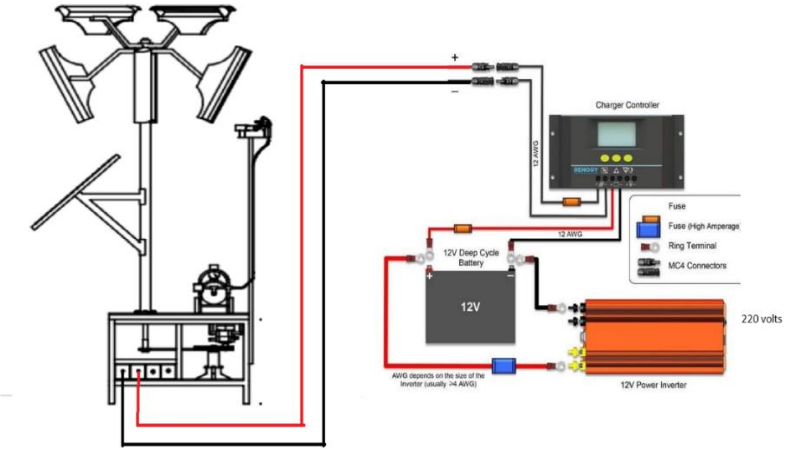


Figure 19. Actual connection of the vertical axis wind turbine, controller and inverter.

Instruction

1. Prepare all the necessary tools and material in cinnecting the system.ex Screw Driver, Multi-Tester etc.
2. Put the Vertical Axis Wind Turbine Charger in an open area where the wind is available.
   Note: Big trees, buildings, and other high rise facility may affect the performance of the turbine.
3. Mount the controller in proper places for installation
4. Connect the charger in the controller, follow correct procedure in connecting the charger, battery and the inverter.
5. Test the controller to determine it works properly.
6. Test the inverter with the used of 220 volts appliances.

Activity No. 2

Basic Solar Charger Wiring Diagram

Warning: Before installing the system basic knowledge in electrical and electronics circuit is important the electronic device may cause permanent damage in case of wrong connection. Do not attempt to short both terminal of the battery the cause explosion and risk your limbs and life.

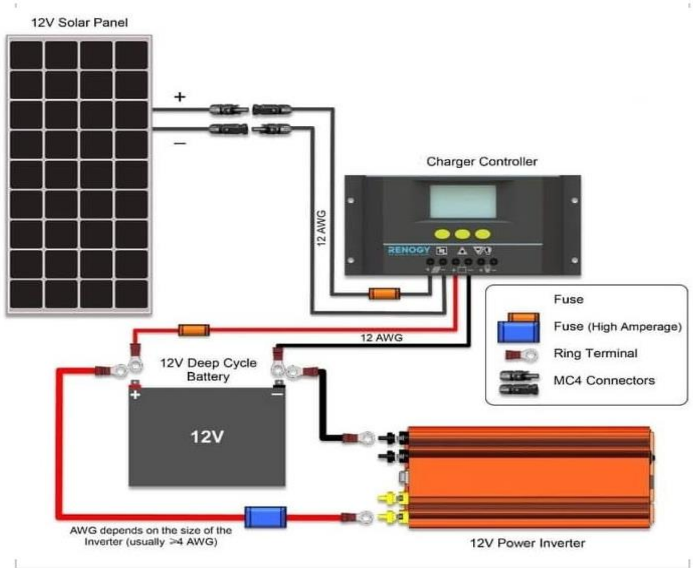


Figure 20. Actual connection of the solar panel in controller and inverter.

Instruction

1. Prepare all the necessary tools and material in cinnecting the system.ex Screw Driver, Multi-Tester etc.
2. Put the Solar Panel Charger in an open area where the sun is available.

   Note: Big trees, buildings, and other high rise facility may affect the performance of the Solar panel.
3. Mount the solar power controller in proper places for installation.
4. Connect the charger in the controller, follow correct procedure in connecting the charger, battery and the inverter.
5. Test the controller to determine it works properly, voltage from the solar panel, battery level and temperature is can be seen in the LCD display of the controller
6. Test the inverter with the used of 220 volts appliances.It can also test with the use of Volt meter and Multi-tester.

Activity No. 3

Voltage Measurement for the Vertical Axis

Wind Turbine Battery Charger with Natural Wind Source

Warning: Before installing the system basic knowledge in electrical and electronics circuit is important the electronic device may cause permanent damage in case of wrong connection. Do not attempt to short both terminal of the battery the cause explosion and risk your limbs and life.

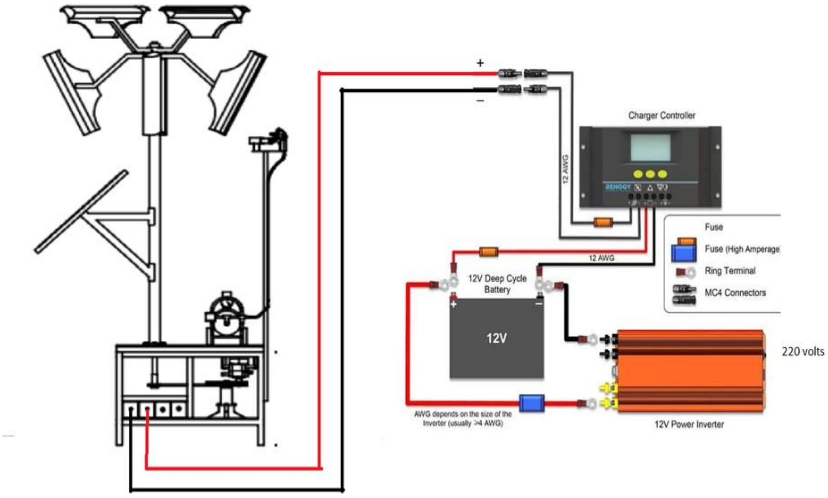


Figure 21. Actual Connection for testing

Instruction

1. With the use of the of the table below measure the voltage output of the vertical axis wind turbine from the different wind speed with the use of natural wind source.

	Power output of the generator		
Wind Speed	Ex. 4 m/s	Ex 6 m/s	Ex. 8 m/s
Natural Wind source	11 volts	11.9 volts	12 Volts

Activity No. 4

Voltage Measurement for the Vertical Axis

Wind Turbine Battery Charger with Simulated Wind Source

Warning: Before installing the system basic knowledge in electrical and electronics circuit is important the electronic device may cause permanent damage in case of wrong connection. Do not attempt to short both terminal of the battery the cause explosion and risk your limbs and life.

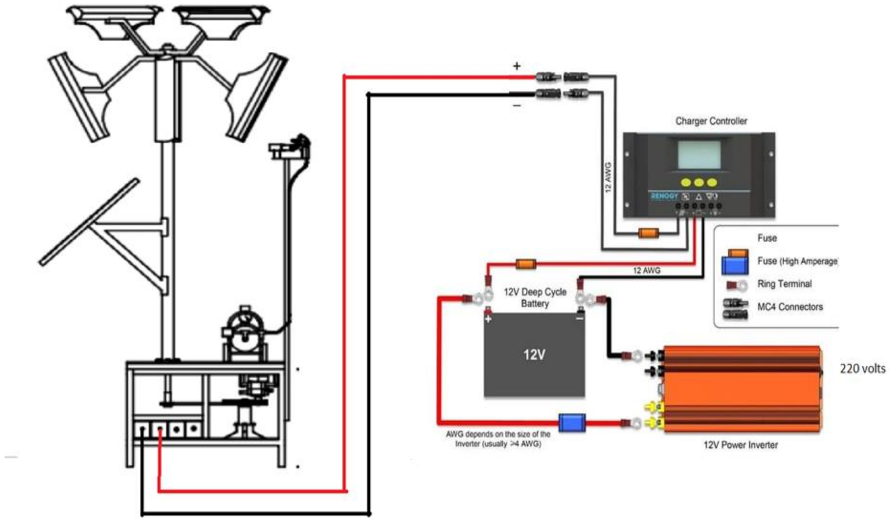


Figure 22. Voltage Measurement for the Vertical Axis

Wind Turbine Battery Charger with Simulated Wind Source

Instruction

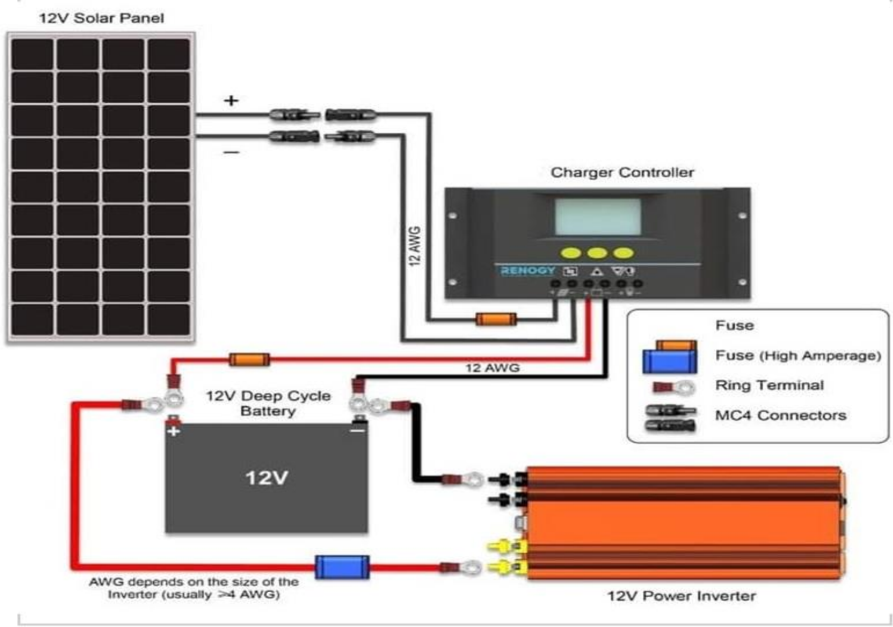
1. With the use of the of the table below measure the voltage output of the vertical axis wind turbine from the different wind speed with the use of simulated wind source.

	Power output of the generator		
Wind Speed	Ex. 4 m/s	Ex 6 m/s	Ex. 8 m/s
Simulated Wind source	11 volts	11.9 volts	12 Volts

Activity No. 5

Voltage Measurement for Solar Charger

Warning: Before installing the system basic knowledge in electrical and electronics circuit is important the electronic device may cause permanent damage in case of wrong connection. Do not attempt to short both terminal of the battery the cause explosion and risk your limbs and life.



Development of Vertical Axis Wind Turbine Charger as Alternative Power Source

Instruction

1. Prepare all the necessary tools and materials
2. Connect all the sytem of the charger following the diagram
3. Following the table below measurre the voltage output of the solar panel within the sun hour.

	Power output of the Solar Panel during Sun Hour			
Sun Hour	Ex. 11:00 A.M	Ex 11:30 Am	Ex. 12:00 PM	Ex. 1:00
	13 volts	15 volts	18 Volts	20 Volts

Description of the parts and function of the Completed Project

Vertical Axis Wind Turbine. This is the main part of the project that operates using natural air fuel. The turbine is made of PVC plastic and the spindle is made of metal also with the base. The VAWT charger composed of 12-14 volts DC generator which will be utilized to charge the battery. The project is also provided with terminal, fuse, switch and indicators to determine the power output.

Solar Power Controller. This device is used to control the voltage input of the solar panel (PVC). This is also used to determine the status of the battery and load. The solar controller has a safety features to protect load in case of over lading. The controller has digital indicators to identify easily the status of the battery, solar panel and also can be used in the VAWT charger.

Battery. This material is used to store voltage from the D.C charger and can be used to energize lights and other DC appliances.

Relay switch. This is located at the back of the controller used to transfer D.C supply to the controller during day and night.

Evaluation of the Project

1. **Acceptability of the developed project in term of different criteria.**

Table 8. Level of Acceptability of the Completed Project According to Functionality

Indicators	Respondents						Grand Mean	Description
	Electrical Engineer		Teachers		Students			
	Mean	Description	Mean	Description	Mean	Description		
Functionality								
Provision of comfort and convenience.	4.6	(HA)	4.65	(HA)	4.83	(HA)	4.69	(HA)
Ease of Operation	4.3	(VA)	4.6	(HA)	4.63	(HA)	4.51	(HA)
Quality of Outputs	4.3	(VA)	4.5	(HA)	4.67	(HA)	4.49	(HA)
Overall Mean							**4.56**	**(HA)**

Table 8 show the level of acceptability of the developed Vertical Axis Wind Turbine charger in terms of functionality. The rating of the electrical engineer in (1) Provision of comfort and convenience found the mean of 4.6 = (Highly Acceptable) the teachers rate found the mean of 4.65= (Highly Acceptable) and the student rate found the mean of 4.83 =(Highly Acceptable) on the (2) Ease of Operation the engineer rated the project with the mean of 4.3 =(Very Acceptable) the teachers is 4.6 =(Highly Acceptable) and the students found the mean of 4.63 = (Highly Acceptable) 0n the (3) Quality of outputs the engineer rated the project with the mean of 4.3 =(Very Acceptable) the teachers is 4.5 =(Highly Acceptable) and the students found the mean of 4.67 = (Highly Acceptable). The respondent rated the functionality of the Vertical Axis Wind Turbine Charger as "Highly Acceptable with the overall mean of 4.56. The respondent find the project "highly acceptable" in term of its (1) provision of comfort and convenience; (b) ease of operation; and (c) quality of output with the grand mean of 4.69, 4.51, and 4.49 respectively. This goes that the functionality of the project is highly acceptable. Hence, the project is indeed useful in energizing remote and coastal areas. In support on the given allegation Tedy Harsanto et. al(2014) investigated the Design and Construction of Vertical Axis Wind Turbine Triple-Stage Savonius Type as the Alternative Wind Power Plant. This study focuses on design and construction of a simple wind turbine which can operate with low wind speed. Thus, if the project is functional it is accepted.

Table 9. Level of Acceptability of the Completed Project According to Aesthetic

Indicators	Respondents						Grand Mean	Description
	Electrical Engineer		Teachers		Students			
	Mean	Description	Mean	Description	Mean	Description		
Aesthetics								
1. Color appeal	4.6	(HA)	4.3	(VA)	4.5	(HA)	4.47	(VA)
2. Attractiveness of design	4.4	(VA)	4.6	(HA)	4.75	(HA)	4.58	(HA)
3. Appropriateness of size	4.4	(VA)	4.65	(HA)	4.71	(HA)	4.59	(HA)
Overall Mean							**4.54**	**(HA)**

As to aesthetics the project, The rating of the electrical engineer when it comes to (1) Color appeal found the mean of 4.6 = (Highly Acceptable) the teachers rate found the mean of 4.3= (Very Acceptable) and the student rate found the mean of 4.5 =(Highly Acceptable) on the (2) Attractiveness of design the engineer rated the project with the mean of 4.4 =(Vey Acceptable) the teachers is 4.6 =(Highly Acceptable) and the students found the mean of 4.75 = (Highly Acceptable) on the (3) Appropriateness of the size engineer rated the project with the mean of 4.4 =(Very Acceptable) the teachers is found the mean of 4.65 =(Highly Acceptable) and the students found the mean of 4.71 = (Highly Acceptable). The respondent rated the Vertical Axis Wind Turbine Charger as "Highly Acceptable" with the overall mean of 4.54. The respondent find the project "highly acceptable" in term of its (1) color appeal, (2) Attractiveness of design, (3) Appropriateness of size with the grand mean of 4.47, 458 and 4.59 respectively. An implication could be given that the appearance of the project is attractive. It also show that the design is appropriate. Canceran (2019) confirms tha implication given by the given by the present researcher. He said that the attraction of a constructed project is the appropriateness of the design. The design must agree with size, shape and portability of the project.

Table 10. Level of Acceptability of Completed Project According to Workability

Indicators	Respondents						Grand Mean	Description
	Electrical Engineer		Teachers		Students			
	Mean	Description	Mean	Description	Mean	Description		
Workability								
1. Availability of materials	4.2	(VA)	4.9	(HA)	4.5	(A)	4.53	(HA)
2. Availability of technical expertise	4.3	(VA)	4.6	(HA)	4.67	(HA)	4.52	(HA)
3. Availability of tools and machine for fabrication works	4.4	(VA)	4.7	(HA)	4.87	(HA)	4.66	(HA)
Over all Mean							**4.57**	**(HA)**

Meanwhile, Table 10 Present the acceptability of the project in terms of workability. The rating of the electrical engineer when it comes to (1) Availability of materials found the mean of 4.2 = (Very Acceptable) the teachers rate found the mean of 4.9= (Highly Acceptable) and the student rate found the mean of 4.5 =(Highly Acceptable) on the (2) Availability of technical expertise the engineer rated the project with the mean of 4.3 =(Highly Acceptable) the teachers is 4.6 =(Highly Acceptable) and the students found the mean of 4.67 = (Highly Acceptable) on the (3) Availability of tools and machines for fabrication works the engineer rated the project with the mean of 4.4 =(Very Acceptable) the teachers is found the mean of 4.7 =(Highly Acceptable) and the students found the mean of 4.87 = (Highly Acceptable). The respondent rated the Vertical Axis Wind Turbine Charger as "Highly Acceptable" with the overall mean of 4.57. The respondent find the project "highly acceptable" in term of its (1) Availability of materials, (2) Availability of technical expertise, (3) Availability of tools and machines for fabrication works with the grand mean of 4.53, 4.52 and 4.66 respectively. This shows that the project is workable. It was designed and constructed in accordance with its purpose. Chika Ogunoh (2017) analyzed the design and construct vertical axis wind turbine for small scale. The vertical axis wind turbine was designed, fabricated and tested to meet the challenge of environmental pollution and low cost of operation since there is no cost for fueling. The federal government should embark on the project of wind turbine which helps to solve the problem of global warming and still produces electric power. Good project are highly accepted due to its function and workability.

Table 11. Level of Acceptability of Completed Project According to Durability

Indicators	Respondents						Grand Mean	Description
	Electrical Engineer		Teachers		Students			
	Mean	Description	Mean	Description	Mean	Description		
Durability								
1. Quality of materials	4.4	(VA)	4.55	(HA)	4.6	(HA)	4.52	(HA)
2. Resistance to stress	4.2	(VA)	4.35	(VA)	4.71	(HA)	4.42	(VA)
3. Resistance to deformation	4.2	(VA)	4.25	(VA)	4.75	(HA)	4.40	(VA)
Overall Mean							**4.44**	**(VA)**

Table 11 reflects the acceptability of the project as per durability. The electrical engineer rated the (1) Quality of materials with the mean of 4.4 = (Very Acceptable) the teachers rate found the mean of 4.55= (Highly Acceptable) and the student rate found the mean of 4.6 =(Highly Acceptable) when it comes to (2) Resistance to stress the engineer rated the project with the mean of 4.2 =(Very Acceptable) the teachers is 4.35 =(Very Acceptable) and the students found the mean of 4.71 = (Highly Acceptable) also when it comes to (3) Resistance to Deformation the engineer rated the project with the mean of 4.2 =(Very Acceptable) the teachers is found the mean of 4.25 =(Very Acceptable) and the students found the mean of 4.75 = (Highly Acceptable). The respondent rated the Vertical Axis Wind Turbine Charger as "Very Acceptable" with the overall mean of 4.44. The respondent find the project " acceptable" in term of its (1) Quality of materials, (2) Resistance to stress, (3) Resistance to deformation with the grand mean of 4.52, 4.42 and 4.40 respectively. This implies that the project is long lasting and can resist any shock. Bacem Zgha et al (2019) made an Analyses of Dynamic Behavior of Vertical Axis Wind Turbine in Transient. In order to get the appropriate aerodynamic torque, the effect of each parameter is studied in this work. This means that if the project is properly designed and constructed, it is durable.

Table 12. Level of Acceptability of Completed Project According to safety.

Indicators	Respondents						Grand Mean	Description
	Electrical Engineer		Teachers		Students			
	Mean	Description	Mean	Description	Mean	Description		
Safety								
1. Absence of toxic/hazardous materials	4.4	(VA)	4.65	(HA)	4.65	(HA)	4.56	(HA)
2. Provision of protection device	4.3	(VA)	4.6	(HA)	4.83	(HA)	4.58	(HA)
3. Absence of sharp edges	4.2	(VA)	4.5	(HA)	4.58	(HA)	4.43	(VA)
Overall Mean							**4.52**	**(HA)**

As to the level of acceptability of the developed project in terms of safety The rating of the electrical engineer when it comes to (1) Absence of toxic/hazardous materials they found the mean of 4.4 = (Very Acceptable) the teachers rate found the mean of 4.65= (Highly Acceptable) and the student rate found the mean of 46.5 =(Highly Acceptable) on the (2) Provision of safety protection the engineer rated the project with the mean of 4.3 =(Acceptable) the teachers is 4.6 =(Highly Acceptable) and the students found the mean of 4. =83 (Highly Acceptable) on the (3) Absence of sharp edges the engineer rated the project with the mean of 4.2 = (Very Acceptable) the teachers is found the mean of 4.5 = (Highly Acceptable) and the students found the mean of 4.58 = (Highly Acceptable). The respondent rated the Vertical Axis Wind Turbine Charger as "Acceptable" with the overall mean of 4.52. The respondent find the project "Highly Acceptable" in term of its (1) Absence of toxic/hazardous materials, (2) Provision of protection device, (3) Absence of sharp edges with the grand mean of 4.53, 4.52 and 4.66 respectively. This shows that the project is safe. It is safe and easy to maintain. Arce (2019) stated that the well designed and constructed project are safe to use. Therefore, this project is friendly to use.

Table 13. Level of Acceptability of Completed Project According to Economy

Indicators	Respondents						Grand Mean	Description
	Electrical Engineer		Teachers		Students			
	Mean	Description	Mean	Description	Mean	Description		
Economy								
1. Economy in terms of materials needed	4.5	(HA)	4.4	(VA)	4.58	(HA)	4.66	(HA)
2. Economy in terms of time/labor spent	4.5	(HA)	4.3	(VA)	4.46	(VA)	4.42	(VA)
3. Economy in terms of machine/s required	4.4	(VA)	4.35	(VA)	4.79	(HA)	4.51	(HA)
Overall Mean							**4.46**	**(VA)**

Table 13 Present the acceptability of the project in terms of Economy. The rating of the electrical engineer when it comes to (1) Economy in terms of materials needed found the mean of 4.5 = (Highly Acceptable) the teachers rate found the mean of 4.4= (Very Acceptable) and the student rate found the mean of 4.58 =(Highly Acceptable) on the (2) Economy in terms of time/labor spent the engineer rated the project with the mean of 4.5 =(Highly Acceptable) the teachers is 4.3 =(Very Acceptable) and the students found the mean of 4.42 = (Very Acceptable) on the (3) Economy in terms of machine/s required the engineer rated the project with the mean of 4.4 =(Very Acceptable) the teachers is found the mean of 4.35 =(Very Acceptable) and the students found the mean of 4.79 = (Highly Acceptable). The respondent rated the Vertical Axis Wind Turbine Charger as "Highly Acceptable" with the overall mean of 4.57. The respondent find the project "acceptable" in term of its (1) Economy in terms of materials needed (2) Economy in terms of time/labor spent (3) Economy in terms of machine/s required with the grand mean of 4.66, 4.42 and 4.51 respectively. This shows that the project is inexpensive. Velasco (2018) confirmed that the finding of the researcher that the acceptability can be evaluated in its economical aspect. The project should be economical in all aspect. As the projects operate there must not much consumption occurred.

Table 14. Level of Acceptability of Completed Project According to Instructional Applicability

Indicators	Respondents						Grand Mean	Description
	Electrical Engineer		Teachers		Students			
	Mean	Description	Mean	Description	Mean	Description		
Instructional Applicability								
1. Improvement in skills in voltage/current measurement and constructing vertical axis wind turbine(Psychom otor)	4.5	(HA)	4.7	(HA)	4.79	(HA)	4.66	(HA)

2. Enhancement of knowledge and information transfer (Cognitive)	4.7	(HA)	4.35	(VA)	4.67	(HA)	4.57	(HA)
3.Reinforcement of student enthusiasm and interest (Affective)	4.5	(HA)	4.6	(HA)	4.67	(HA)	4.59	(HA)
Over all mean							**4.6**	**(HA)**

Along the level of acceptability of the project as per instructional applicability, The rating of the electrical engineer in (1) Improvement in skills in voltage/current measurement and constructing vertical axis wind turbine found the mean of 4.5=(Highly Acceptable) the teacher found the mean of 4.7 = (Highly Acceptable) and the student found the mean of 4.79 = (Highly Acceptable) on the (2) Enhancement of knowledge and information about the project found a mean of 4.7 =(Highly Acceptable) the teachers is 4.35 =(Acceptable) and the students found the mean of 4.67 = (Highly Acceptable) on the (3) Reinforcement of student enthusiasm and interest the engineer rated the project with the mean of 4.5 =(Highly Acceptable) the teachers is found the mean of 4.6 =(Highly Acceptable) and the students found the mean of 4.67 = (Highly Acceptable). The respondent rated the Vertical Axis Wind Turbine Charger as "Highly Acceptable with the overall mean of 4.6. The respondent find the project "highly acceptable" in term of its (1) Improvement in skills in voltage/current measurement and constructing vertical axis wind turbine(Psychomotor) (2) . Enhancement of knowledge and information transfer (Cognitive) (3) 3.Reinforcement of student enthusiasm and interest (Affective)This implies that the project is highly relevant in shopwork instruction along electronics and electrical technolgy. Bermaldez (2016) confirms the implication of a developed trainer is designed with different electrical applications this will develop the skills and knowledge of the student in electrical technology depends on the activities complete.

Summary of the Rating Given by Respondents on the Overall Acceptability of the Completed Project

Table 15. The General Level of Acceptability of the Completed Project

CRITERIA	RATING	
	OVERALL MEAN	REMARKS
Functionality	4.56	Highly Acceptable
Aesthetic	4.54	Highly Acceptable
Workability	4.57	Highly Acceptable
Durability	4.44	Very Acceptable
Safety	4.52	Highly Acceptable
Economy	4.46	Highly Acceptable
Instructional Applicability	4.6	Highly acceptable
Grand Mean	**4.52**	**Highly Acceptable**

As shown in table 14, the completed Vertical Axis Wind Turbine Charger with DC air Compressor receive mean of 4.56, 4.54,4.57, 4.44, 4.52, 4.46, and 4.6 for its functionality, aesthetics, workability, durability, safety economy and instructional applicability respectively, The project was perceived to be acceptable by the respondents in all criteria presented. This implies that the project is acceptable for charging and instructional purposes. Sakamoto 2019 confirms that a well designed and constructed Vertical Axis Wind Turbine is Highly significant to address the shortage of electrical supply in the 7000 Island in the Philippines.

Comparison in the level of Acceptability of the Turbine according to the different criteria

Table 16. Comparison on the level of acceptability of the project based on the evaluation by varied groups.

Criteria	F-value	p-value	Decision	Difference
Functionality	1.831	0.171	Do not reject Ho	Not significant
Aesthetics	0.535	0.589	Do not reject Ho	Not significant

Workability	4.381	0.018	Reject Ho	Significant
Durability	5.008	0.010	Reject Ho	Significant
Safety	1.685	0.196	Do not reject Ho	Not significant
Economy	1.474	0.239	Do not reject Ho	Not significant
Instructional Applicability	0.288	0.751	Do not reject Ho	Not significant

The results of the Analysis of Variance (ANOVA) test show that there is no significant difference in evaluation of respondents in terms of functionality (F = 1.831; p-value = 0.171 > 0.05), aesthetics (F = 0.535; p-value = 0.589 > 0.05), safety (F = 1.685; p-value = 0.196 > 0.05), economy (F= 1.474; p-value = 0.239 > 0.05), and instructional applicability (F= 0.288; p-value = 0.751 > 0.05). This means that respondents have similar evaluation for functionality, aesthetics, safety, economy, and instructional applicability of the machine.

As for Workability (F=4.381, p-value = 0.018 < 0.05), and Durability (F=5.008, p-value = 0.010 < 0.05) the respondents significantly differ in their evaluation. To determine where the differences occur among the respondents, a post hoc analysis using Scheffe was performed. The analyses reveal that for workability, respondents electrical engineers and students differ in their evaluation with students having a higher mean rating (p-value = 0.021 < 0.05; mean difference = -0.425). In terms of durability, same groups (electrical engineers and students) differ significantly in their evaluation, with students having a higher mean score (p-value = 0.034; mean difference = -0.483).

SUMMARY

This study was focused on the development and evaluation of a charging device called Vertical Axis Wind Turbine as Alternative Power Source. The device was constructed with different materials such as PVC plastic pipe, metal pipe, metal plate, DC generator, solar panel, solar power controller, mechanical relay and battery.

Power inverter was incorporated for to utilize in various appliances with working voltage of 220 volts. The project was made from locally available resources and materials. In addition, an Activity Manual was produced to show the functionality and Applicability of the Vertical Axis Wind Turbine as Alternative Source. Specifically, the study aims to;

1. Design and construct Vertical Axis Wind Turbine Battery Charger with DC Air Compressor.
2. Test the functionality of the charger by conducting actual testing in the different location and condition of the area.
3. Conduct revision of the charger for further improvement of its features and capabilities.

The completed project obtained an average mean of rating of 4.52 which shows that the developed project was Acceptable as perceived by the experts. The production cost of the project was Fifteen thousand Five-hundred Sixty five (15, 565.00). This amount is cheaper when compared to the prices of commercially available vertical axis wind turbine in the market.

CONCLUSIONS

In light of the aforementioned findings, the study concludes that the Vertical Axis Wind Turbine as Alternative Power Source is can be developed using resources and material available in the local market. The developed project is functional, aesthetics, workable, durable, safe economical and with instructional applicability. It is very useful source of renewable energy in the community especially remote areas and can be used in electrical and electronics subjects.

RECOMMENDATIONS

Based on the findings and conclusions, the following recommendations are offered:

1. The vertical axis wind turbine DC charger should be test in constant wind speed.
2. The blade is supposed to be fiber glass
3. The pulley should be plastic to make more lighter
4. Additional harness to avoid accident when typhoon comes
5. A similar study should be conducted so as to increase the number of instructional devices in technology areas.

REFERENCES

1) Arce (2019) “Construction and Evaluation of Automotive Charging System Trainer”, Marikina Polytechnic College, Sta Elena Marikina City
2) Bernaldez (2016) “Multi-Purpose Electrical Trainer”, Marikina Polytechnic College, Sta Elena Marikina City

3) Canceran, Romeo (2019) “Improvised Solar-Powered Multi-Purpose Operational Amplifier and Trainer Board”, Marikina Polytechnic College, Sta Elena Marikina City
4) Caluya, Junar (2015) “Development of Telluric Current Device”, Isabela State University-Ilagan Campus, Ilagan Isabela
5) Chika O,Danie E, Moses A et.al.(2017) “Design and Construction of Vertical Axis Wind Turbine” Mechanical Engineering Technology Federal Polytechnic, Oko, Anambra State Nigeria
6) Delos Santos, Angelica A. (2017) “Renewable Energy in the Philippines”, Department of Energy Philippines
7) Gulve P. Dr. Barve S.B (2014)” Design and Construction of Vertical Axis Wind Turbine”, MIT College of Engineering, Pune, India
8) Hernandez (2016) “Improvised Solar Power Electrical Trainer”, Marikina Polytechnic College, Sta Elena Marikina City
9) Möllerström, Erik” (2015) “Vertical Axis Wind Turbine Tower Dynamics and Noise” Uppsala University.Sweden
10) Nikam D.A, Kherde S.M (2015) Literature Review on Design and Development of Vertical Axis Wind Turbine” Dr. Sau Kamalatai Gawaii Institute of Engineering & Technolgy, Darapur, India
11) Velasco, Reymund (2018)” Customized Multi Purposed Photovoltaic Powered Device with Automatic Transfer Switch”, Isabela State University-Ilagan Campus, Ilagan Isabela
12) Vivek C.M Gopikrishnan P. et al (2017)” A review on Vertical and Horizontal Axis Wind Turbine”,Perijar Maniammai University, Thanjaur, India
13) Sakamoto et. al (2019) “Nikkei Asian Review Tokyo/Manila”, Tokyo Japan
14) Other Sources
15) Journal
16) Añonuevo (2014) at Inter Aksyon.com
17) Internet Websites
18) http:// www.wikepedia.com
19) http:// www.electronics lab.ph