Development of a Pendulum Driven Electric Generator

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Abstract—**The Pendulum Driven Electric Generator is an alternative indoor source of electricity that converts gravitational energy into electrical energy. As the pendulum arm swings through the presence of neodymium magnets the unit collects and stores the gravity and converted into electricity. The prototype can produce 8.4 watts per hour up to 201.6 Watts electricity in daily generation. Pendulum Driven Electric Generator is assembled with permanent magnet assembly, pendulum arm assembly, shaft and pulley belt system platform assembly, MPPT charge controller fixture assembly, power control box fixture assembly, battery housing assembly, generator fixture and the pendulum device cover assembly. The generator is a user-friendly machine as it can be easily placed at homes and offices in any climatic condition. The machine does not need any hazardous forms of fuel for generating electricity. Test results showed that the generator produces enough to generate electrical power during operation to charge up the battery bank. The machine was evaluated by a group of 25 experts using the TUP Evaluation Instrument for Prototypes. The unit was assessed "Excellent/Highly Acceptable" by the evaluators, which proves that it can generate electricity enough to charge electronic gadgets. The use fiber reinforced plastic and high power storage batteries are recommended. This implies that the prototype help to the prospective users to serve as an alternative indoor lighting and charging any electronic gadgets, and attained the desired end.**

Keywords— pendulum generator, electricity generation, alternative energy

I. INTRODUCTION

Almost everything is run by energy in nature whether it is a living thing or non-living things such as machine, engines and the likes. It requires energy to perform proper operation. Urban areas in the Philippines are well informed of the benefits and advantages of technologies used for their daily lives. However, in rural areas they can also adapt to technological advancement.

December 2008, the Philippines enacted Republic Act (RA) No. 9513, also known as the Renewable Energy

Act of 2008. The Implementing Rules and Regulations were issued in May 2009. The law affirmed the government's commitment to accelerate the exploration and development of Philippine renewable energy resources.

RA 9513 declared the State's policy to achieve energy security by reducing reliance on fossil fuels and minimizing exposure to price fluctuations in oil markets. The government agencies tasked to implement the law include the Department of Energy, the Energy Regulatory Commission, and the National Renewable Energy Board.

In some areas in the Philippines, electrical installation is more expensive and difficult to reach areas like islands which is insufficient sources of lighting. Likewise in some parts of the world, lightings are provided through expensive and polluting fuel. Kerosene lamps are hazardous to health and environment which constantly requires replenishment. Fumes which are produced from the burning of biomass fuels can cause cataracts and eye infections. Likewise smoke emission, which is the equivalent to smoking two packets of cigarettes every day is detrimental to health.

To help mitigate the premises cited above, the proponent to develop a Pendulum driven Electric Generator is a device that has a distinctive utilizing kinetic energy into mechanical energy. This mechanical energy can be used for specific tasks such as grinding, grain, pumping water and driving a generator. The various processes mechanical energy it converts into electricity that is supplied to the power grid or individual users.

(Mincher, 1993) The Philippine strength crisis. Ecologist. 23. 228-233. The continual shortage of electricity in the Philippines, which has been inflicting normal electricity cuts all through the country, is specifically extreme in the largest island, Mindanao, where over 90% of the provide comes from hydroelectric dams. Because of a decline in rainfall and water tiers due to deforestation, these dams have been unable to meet the demands of Mindanao's rapid industrialization. Local and indigenous, agencies are calling for a trade of energy policy closer to the building of

smaller installations, the conservation of strength and the setting of the needs of people earlier than these of industry; however the nation is intending with controversial schemes for extra large-scale dams and a geo-thermal electricity station in the Mount Apo National Park.

In consideration with the development of this project is the pendulum power which is coming from the massive gravitational forces. One of the major mechanisms of this project is the oscillatory movement of pendulum with mass that serves to rotate the Direct Current motor which produces electrical energy to charge up the battery pack. As part of the goal of this project is to have high lighting efficiency and prolong the lifespan of charging process at lower power consumption. To ensure that to make this goal happen, the light-emitting-diode (LED) will be part of this project.

Light-emitting-diode (LED) is one of the greatest creations of human in term of lighting. The luminance of LED is far superior compared to yellow type lamp and consumes less power considerably. Charging of battery pack is through the oscillatory movement of the pendulum to rotate DC motor to produce considerable amount of electrical power.

In view of the problem cited, there is a need to develop a pendulum driven Electric Generator that can be used throughout the day and night and under any climatic condition with zero running costs. This study can also help in frequent electrical power shortage in different places affected by any unpredictable natural disaster such as typhoons, earthquakes and other natural calamities.

Research Objectives

General Objective:

To develop of a Pendulum Driven Electric Generator

Specific

Objectives:

1. To design a Pendulum Driven Electric Generator that serves as an alternative indoor lighting system for rooms, homes and offices in any climatic condition with the following features:
   1.1. Re-charge the battery of any electronic gadget using universal serial bus and electrical outlets.
   1.2. Provides alternative energy source.
   1.3. Functions day and night.
2. To construct the prototype as designed.
3. Test and improve the performance of the developed prototype in terms of its functionality and efficiency; and
4. Evaluate the prototype in accordance to an improved set of criteria in order to determine its performance.

II. METHODOLOGY

Project Design

Pendulum Driven Electric Generator will be designed to provide alternative lighting system in the community. It can be use all throughout day and night and under any climatic condition with zero running costs. This study can also help in frequent electrical power shortage in different places affected by any unpredictable natural disaster such as typhoons, earthquakes and other natural calamities. Pendulum mechanism is powered by generator through the process of perpetual energy. It produces a certain DC voltage to charge-up the battery pack. Through with the inverter regulates power as a source of alternating current to light-up the 12v LED's.

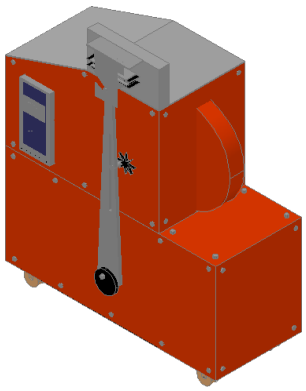

Figure 1. *Isometric Drawing of the Pendulum Driven Electric Generator*

Figure 1 shows the Isometric Design of the Pendulum Driven Electric Generator. It has several parts, namely: Pendulum Frame Assembly, Permanent Magnet, Pendulum bob, Generator Assembly, bearing, Shafting Pulley Belt Assembly, Battery Pack, MPPT Charger Controller and Power Inverter.

The machine is equipped with MPPT charge controller to protect the batteries from over charging whenever the batteries meet their full capacity. The machine has a simple voltage multiplier mounting to

the power controller box that regulates the flow of electricity to be distributed to any portable gadgets.

1. The battery housing frame assembly encloses and protect the battery to avoid laying down to the ground.
2. The shaft and pulley belt system assembly rotate to transmit the mechanical energy to the generator assembly.
3. The generator assembly convert mechanical energy transmitted by the shaft and pulley belt assembly into electrical energy.
4. The pendulum frame assembly support to the pendulum arm and bob.
5. The permanent magnet assembly stabilize the movement of pendulum arm.
6. The power control box assembly attachment of all wiring connection from pendulum driven electric generator.
7. The MPPT charge controller assembly absorb the electrical supply coming from generator assembly.
8. The pendulum driven electric generator housing assembly encloses and protect all the component inside the device.

Project Development Fabrication Procedure

1. Battery Housing Frame Procedure:
   - 1.1. Battery Housing Frame
     - 1.1.2. Cut four pieces of 2 x 2 inches x 3mm angle bar with a dimension of 75 centimetres (cm) for length, 36 centemetres for height and 30 centemetres for width.
     - 1.1.3. Tack all of the cutted angle bar based from specific dimensions provided using welding machine.
     - 1.1.4. Trace squareness of each corner and distribute the squares equally distance with each other.
     - 1.1.5. Tack cross brace of flat bar for the support of battery.
     - 1.1.6. Perform full welding process to the battery housing frame to ensure durability of the assembly.

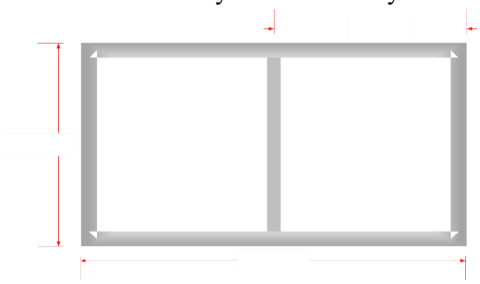

Figure 2. *Top View of Battery Housing Frame*

2. Shafting and Pulley Belt System Platform Assembly
   - 2.1. Shaft and Pulley Belt System Platform
     - 2.1.1. Cut four pieces of 2x2 inches x3mm angle bar with a dimension of 25 centimetres (cm) for length, 14 centemetres for height and 25 centemetres for width.
     - 2.1.2. Tack together based from specific design and dimensions using welding machine.
     - 2.1.3. Monitor the squareness of each corner and distribute the squares equally distance with each other.
     - 2.1.4. Drill 4x6mm hole on the top of fixture for the mounting of pulley system
     - 2.1.5. Perform full welding process to assemble Shaft and Pulley Belt System Platform.

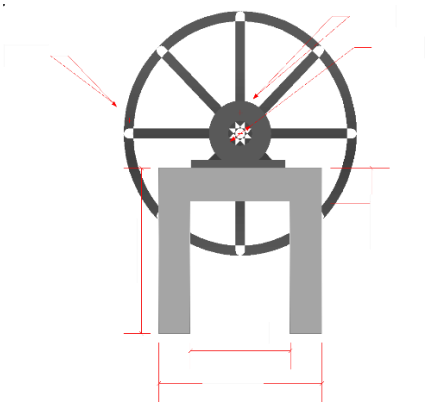

Figure 3. *Front View of Shaft and Pulley Belt System Platform*

   - 2.2. Shaft
     - 2.2.1. Cut the 1inch diameter of round bar with dimension of 33 cm long.
     - 2.2.2. Drill the both end of round bar with a hole of 8mm for the lock attachment of pendulum guide.
     - 2.2.3. Drill the middle part of round bar with a hole of 8mm for the lock attachment of pulley belt system.
     - 2.2.4. Finish the surface of the drilled hole using 400gsm sand paper.

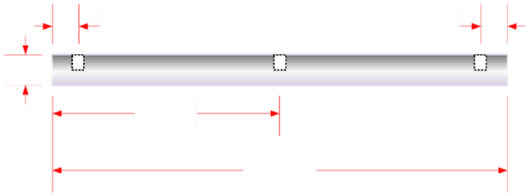

Figure 4. *Front View of Shaft*

3. Generator Fixture Assembly
   3.1. Generator Fixture
   3.1.1. Cut four pieces of 2x2 inches x3mm angle bar having a dimension of 17 cm length.
   3.1.2. Cut four pieces of 2x2 inches x3mm angle bar having a dimension of 9cm height.
   3.1.3. Tack together eight pieces of 2x2 inches x3mm angle bar to form square shape as generator stand.
   3.1.4. Measure 1cm at the corner top of generator stand.
   3.1.5. Drill and use 8mm bit in the 1cm mark at the corner top of generator stand.
   3.1.6. Remove the sharp edges in the holes of the generator stand.
   3.1.7. Position and full weld the generator stand to the battery housing frame.

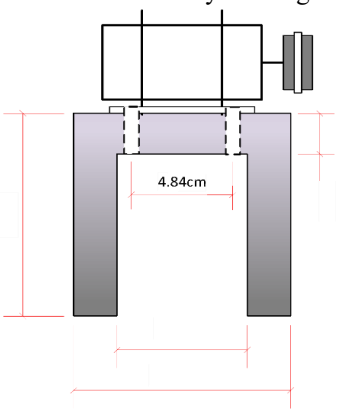

Figure 5. *Front View of Generator Fixture*

4. Permanent Magnet Fixture Assembly
   4.1. Permanent Magnet Fixture
   4.1.1. Cut the 2x4 inches x5mm flat bar with a dimension of 13 cm length and 8 cm width.
   4.1.2. Measure and mark 1 cm on the both side of flat bar.
   4.1.3. Make a hole of 8mm on the marked on both side of the flat bar.
   4.1.4. Position and set the alignment of permanent magnet fixture.
   4.1.5. Full weld the permanent magnet fixture.

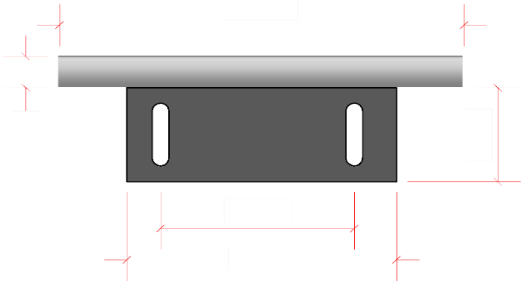

Figure 6. *Top View of Permanent Magnet Fixture*

5. Pendulum Arm Assembly
   5.1. Pendulum Arm
   5.1.1. Shape the T6 aluminum plate as pendulum medium using milling machine.
   5.1.2. Make slotting on the center of T6 aluminum plate with the dimension of 0.60 cm width and 26 cm long.
   5.1.3. Bore the one end of T6 aluminum plate with the dimension of 6 and 4 cm diameter.
   5.1.4. Drill other end of T6 Aluminum plate at 2cm
   5.1.5. Remove the excess burrs of the pendulum arm assembly.

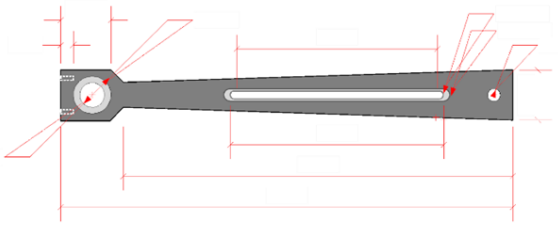

Figure 7. Front View of Pendulum Arm

6. MPPT Charge Controller Fixture Assembly
   6.1. MPPT Charge Controller Fixture
   6.1.1. Cut 2 pieces 1 cm x 3mm of flat bar with a dimension of 13 cm long.
   6.1.2. Drill at 4x6mm diameter both end of 2 pieces flat bar.
   6.1.3. Make a thread of 6mm of the flat bar.
   6.1.4. Set and align the flat bar as MPPT Power Controller Fixture.
   6.1.5. Full weld the alignment of MPPT Power Controller Fixture into Angle bar support.

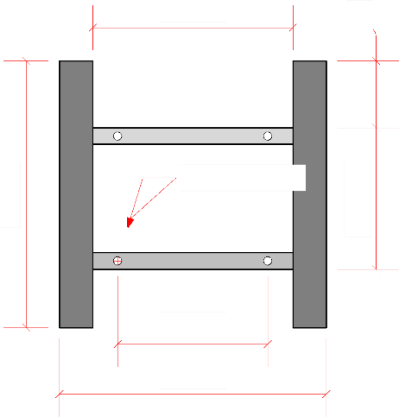

Figure 8. *Front View of MPPT Charge Controller Fixture*

7. Power Control Box Fixture Assembly
   7.1. Power Control Box Fixture
   7.1.1. Fabricate a galvanized iron sheet into a rectangular box with a dimension of 4x28x13cm.

7.1.2. Mark and drill at 6mm diameter of 2x2inches x3mm angle located in battery housing frame.
7.1.3. Position and screw the improvise power control box.

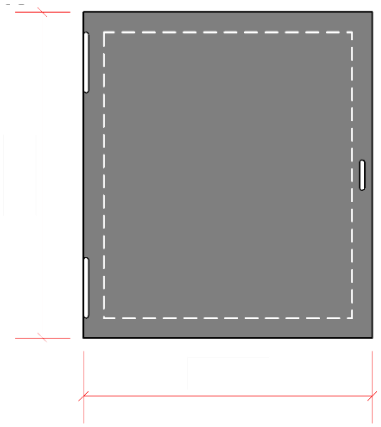

Figure 9. *Top View of Power Control Box Fixture*

8. Pendulum Device Cover Assembly
8.1. Pendulum Device Front Cover
8.1.1. Cut of gauge 18 aluminum sheet into rectangular shape with a dimension 32 cm width and a length of 74 cm.
8.1.2. Make a hole with 4x6mm diameter.
8.1.3. Cut aluminum sheet for upper part cover at 54 cm length and 34 cm width and other specific shape.
8.1.4. Make a hole with 6x6mm diameter.
8.1.5. Remove all excess part and sharp edges of aluminum sheet.
8.1.6. Make bead shape into rectangular aluminum sheet.
8.1.7. Position and ready for painting.

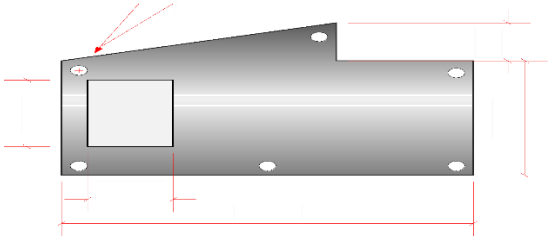

Figure 10. *Front View of Upper part cover of Pendulum*

Figure 11. *Front View of lower part Cover Pendulum Device*

8.2. Pendulum Device Back Cover
8.2.1. Cut of gauge 18 aluminum sheet into rectangular shape with a dimension 32 cm width and a length of 74 cm.
8.2.2. Make a hole with 4x6mm diameter.
8.2.3. Cut aluminum sheet for upper part cover at 56 cm length and 39 cm width and other specific shape.
8.2.4. Make a hole with 6x6mm diameter.
8.2.5. Remove all excess part and sharp edges of aluminum sheet.
8.2.6. Make bead shape into rectangular aluminum sheet.
8.2.7. Position and ready for painting.

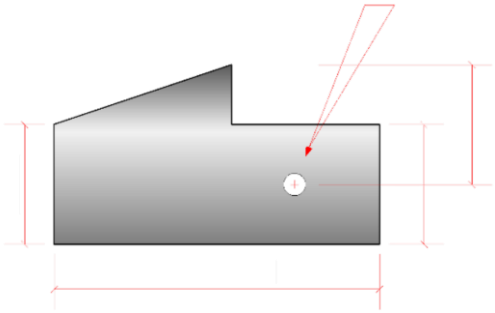

Figure 12. *Front View of upper part cover behind the Pendulum Device*

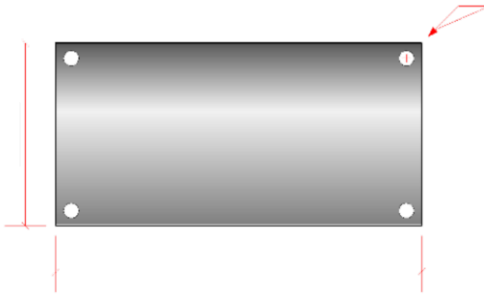

Figure 13. *Front View of lower part cover behind the Pendulum Device*

8.3. Pendulum Device Side Cover
8.3.1. Cut of gauge 18 aluminum sheet into rectangular shape with a dimension 30 cm width and 74 cm of height.
8.3.2. Trace for 1inch each side and distribute the squares equally distant with each other.
8.3.3. Cut the excess parts of traced corner of the side cover.
8.3.4. Do the same procedure on the other corner of side cover.
8.3.5. Bend the squares of 90 degrees with respect to the large part of the pendulum frame.
8.3.6. Drill at 8x6mm for the hole.
8.3.7. Remove sharp edges of rectangular aluminum sheet.

8.3.8. Position and ready for painting.

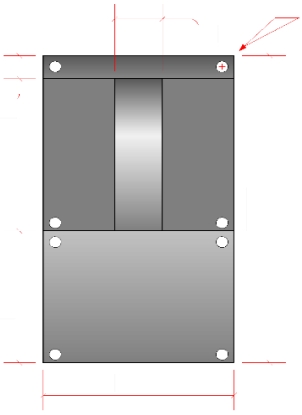

Figure 14. *Side View of lower part cover behind the Pendulum Device*

9. Assembly

9.1. Position and set the 12v battery storage to the battery housing frame assembly.

9.2. Mount the cylindrical shaft, pulley belt assembly on the fixture.

9.3. Align and Mount the generator assembly to the designated area of battery housing frame assembly securing the with bolts and nuts.

9.4. Attached the permanent magnet assembly on the top of shaft pulley belt assembly.

9.5. Connect the pendulum arm assembly with their bearing attachment to the shaft pulley belt assembly.

9.6. Put the MPPT charger controller assembly to the fixture and power control box beside the 12v battery with the presence of bolts and nuts.

9.7. Affix and enclose all part assembly with the gauge 18 aluminum sheet fabricated cover securely for the safety purposes.

The design of the Pendulum Driven Electric Generator is based from some complication that might be encountered during the testing and actual operation that might cause to the performance of the machine. The design of the pendulum arm and their assembly may solve the rapid dumping of pendulum. The use of the four mounted permanent magnet helps the pendulum assembly to oscillate continuously. The use of the low torque 12V DC motor as the generator of the Pendulum Driven Electric Generator meets the electrical output of the prototype of at least 8.4 Watts at 60 minutes to 24 hours of operation.

Operation and Testing Procedure

To ensure that the Pendulum Driven Electric Generator will function well, a series of tests and operations will be conducted. The test will be done by carrying out the standard procedures in operation to see if the intended applications and machine behavior will be achieved.

Operation Procedure

1. Locate the prototype in a safe place area and safely inspect the installation and construction before starting the unit.
2. Switch-On the inverter to energize the support driver.
3. Check positioning of neodymium magnet to oscillate pendulum as well as the generator to generate electricity.
4. Monitor the MPPT charge controller to determine if the generator producing electricity.
5. Check the MPPT charge controller to determine if the battery is charging and the current is properly generated for 12DCV-220ACV.
6. Inspect the condition of the generator.
7. If the machine functions well, you can start charging of electronic device and lighting bulb of 12DCV capacity.

Testing Procedure

The testing of Pendulum Driven Electric Generator focused on the power produced or the voltage and current output of electric generator versus the total input of electric generation by the pendulum.

During the testing, the machine was run in 60 minutes and then read and recorded the voltage and current output produced by the generator.

In theory, the electrical power produce by the pendulum can be compute using this formula:

$P = T\varrho \times 2\pi N/60$

Where:

P = Electrical power produce by the pendulum; Tq = Torque produces by the pendulum;

N = Minimum revolution per minute of the generator; Generator power can also be compute using this formula:

$P = VI$

Where:

P = Electrical Power;

V = Voltage output of the generator; and I = Current output in term of Ampere.

The overall efficiency of the machine can also be computed through the power of Pendulum Battery

which is the Power input against the Power output known as the Volt/Ampere generated by the generator as shown in the formula.
n = (P out / P in) x 100%

Initial readings were gathered after the inspection of the machine during the conduct of the test run. A trial sheet was filled out with the outcome of the testing as shown in Table 1.

Table 1. Sample of the Trial Sheet to be use on actual testing

Trial	*Total Daily Electric Generation (Watts)*	*Total of Battery Discharge/Consumed (Watts)*
1		
2		
3		

In determining the efficiency of the Pendulum Driven Electric Generator, it can be computed using the formula: Eff. = (Power output / Power input) x 100%

Where:
Power output is the Total Energy Consumption; and the Power input is the Total Energy Charging Evaluation Procedure

The evaluation of the developed prototype will involve two stages: The Project Demonstration and the Final Evaluation to determine the performance of the prototype, a survey will be conducted.
This study will adopt the Technological University of the Philippines (TUP) formulated and validated Evaluation Instrument for Prototype Development with the following criteria: functionality, aesthetics, workability, durability, economy and safety.
The following were undertaken during the evaluation: The prototype will be presented to the evaluators composing of ten (10) mechanical engineers, Ten (10) prospected end-users that operate the prototype and five (5) electrical engineers. These people are selected because of their level of expertise and experience in the process.

1. Evaluators will be accompanied the researcher to test the performance of the Pendulum Unit and were allowed to inspect the prototype.
2. The researcher will be accommodated the queries of the respondents.
3. Questionnaires will be given to the evaluators.
4. The collated data will be tabulated and computed for the mean of each criterion as well as the overall mean.
5. Results will be interpreted using the equivalent descriptive rating shown in table 2.

Table 2. *Numerical Rating and Its Equivalent*

Numerical Rating	*Description*
5.0	Excellent/Highly Acceptable
4.0	Very Good/Very Acceptable
3.0	Good/Acceptable
2.0	Fair/Acceptable
1.0	Poor/Not Acceptable

III. RESULTS AND DISCUSSION

This section presents the project description, project structure, project capabilities, and limitations, as well as project evaluation which includes the test results.

Project Description
The Pendulum Driven Electric Generator is designed to address the problems of the power shortage, the dependency on the use of fossil fuels as the main source of power generation and the effects of global warming due to carbon emissions of the power plants using fossil fuels to generate electricity.

Figure 15. *Pendulum Driven Electric Generator*

The Pendulum Driven Electric Generator harnesses the oscillation process caused by the horizontal movement of the pendulum and converts it into electrical energy. The generator stand-alone and run any climatic condition to harness the gravitational movement horizontally and convert it into

electricity. The pendulum arm of the generator harvests the gravitational energy and rotates the shafting mechanism connected to the permanent magnet generator converting mechanical energy into electrical energy.

The horizontal movement of the pendulum generator caused by the gravitational force and magnetic strength will produce 201.6 Watts at about 24 hours to charge up the storage battery. The MPPT Charge Controller is attached to the output of the electric generator to determine the power generation of the machine. The Power Control Box is connected at the end of the generator to convert and regulate the voltage output of the machine and also stabilize the power output even when the pendulum does not run. The Permanent Magnet Assembly is designed to have a constant repulsion to the opposing magnet and avoiding any damping experience of the pendulum. The Pendulum Device Cover Assembly provide to achieve aesthetic design and the safety of the operators during operation.

Project Structure

The Pendulum Driven Electric Generator is made up of several components such as the Permanent Magnet Assembly, Pendulum Arm Assembly, Shaft and Pulley Belt System Platform Assembly, MPPT Charge Controller Fixture Assembly, Power Control Box Fixture Assembly, Battery Housing Assembly, Generator Fixture and the Pendulum Device Cover Assembly. The machine is designed to be stable the movement of pendulum arm and strong enough to with-stand during the charging process of the battery.

Figure 16. *Permanent magnet Assembly*

Permanent Magnet Assembly is made of carbon steel bar that hold the sets of magnet position vertically along the pendulum arm.

Figure 17. *Pendulum Arm Assembly*

The arm of the Pendulum Driven Electric Generator is made of T6 Aluminum Plate since it is lightweight and stronger compared to galvanized iron sheet. It can easily replace whenever it is worn out.

Figure 18. *V-belt of the Pendulum Driven Electric Generator*

A belt is a loop of flexible material used to link two or more rotating shafts mechanically, most often parallel. A chain drives in order to transmit power from one rotating shaft to another.

Figure 19. *Pulley of the Pendulum Driven Electric Generator*

A pulley is a wheel on an axis or shaft that is designed to support movement and change of direction or transfer of power between the shaft and cable or belt.

Figure 20. *Cylindrical Shafting of the Pendulum Driven Electric Generator*

Cylindrical round steel bar are used in the shafting of the Pendulum Driven Electric Generator since steel bar can allow the torsional pressure during the horizontal movement of the pendulum arm together with Pulley Belt Assembly and transmit power to the generator.

Figure 21. *Power Converter Box Assembly*

Power Converter Box Assembly serves as controlling the power generated from the Generator. Diodes and voltage multiplier were used to the system of the device to direct the flow of current storing to the battery.

Figure 22. *MPPT Charge Controller Assembly of Pendulum Driven Electric Generator*

MPPT Charge Controller Assembly installed and works as overcharging protection, power rate monitoring during charging operation in the battery.

Figure 23. *DC permanent magnet motor*

A 12Volts Direct Current (DC) permanent magnet motor was used as the generator of the Pendulum Driven Electric Generator. The shaft of the DC permanent magnet motor has a less torque required to rotate the shaft and generate electricity unlike the other DC motor.

Figure 24. *12V DC battery storage*

12VDC battery can store power generated by the Pendulum Driven Electric Generator and also can stabilize the power output of the machine.

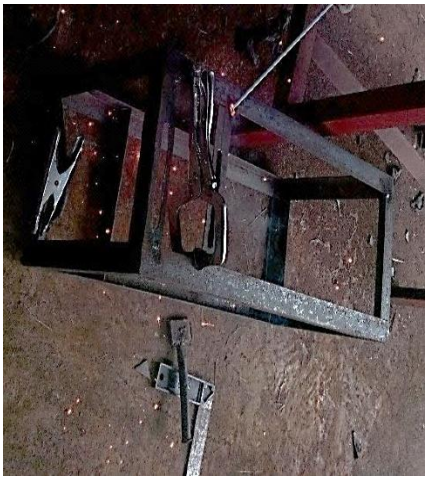

Figure 25. *Battery Housing Assembly*

The Battery Housing Assembly serves as the foundation of the whole unit that is why 2 x 2 inches x 3 millimeter angle bar were used. One of the characteristic of steel or iron bent at a right angle is use to support for structural framework that makes angle bar perfect to use on the other parts of the Generator Assembly to make the unit become stable.

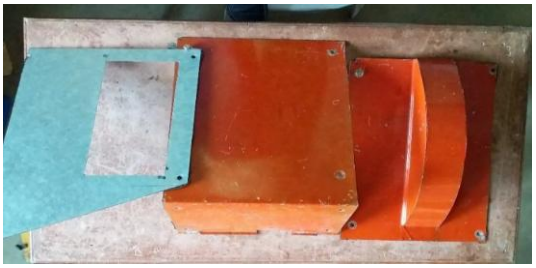

Figure 26. *Pendulum Housing Wall Assembly*

The material for the Pendulum Housing Wall Assembly is galvanized iron sheet and stainless steel sheet to ensure it covers for safety the structure of the generator. Since the galvanized iron sheet and stainless steel sheet are lighter in weight also it is malleable and can be easily bent into the preferred contour or forms.

Project Test Results

The device was tested several times before subjecting to the actual evaluation to assess the performance of the prototype. The generator is fixed properly and secured its tightness for the safety of operator. Wiring connection are properly installed in the unit to be attached in the MPPT charge controller to be able to monitor the voltage and current output during the operation. Pendulum arm are well installed in the frame to ensure that the damping cannot be experience when the time meets during oscillation process. After all the measuring equipment and the generator machine are set and secured, the testing were conducted.

During the test run of the prototype and as soon as the generator reach the allotted time, selected team member records the current, voltage, the time of battery charging and the performance of the machine. The initial performance of the Pendulum Driven Electric Generator was done at the San Narciso, Quezon. The generator was tested for its functionality, how it will execute during the oscillation of the pendulum, and how much will the generator produce electricity.

The testing proper was conducted at Madulao Catanauan, Quezon. In testing of the prototype with oscillation time of 1 hour up to 24 hours to identify the current amount of charging in battery and the performance of the unit. After the generator attains the desired time, Voltage and Current output were monitored and recorded.

General Calculation of Pendulum Driven Electric Generator

Magnetic Strength

Where:

Br = Remanence Field Independent of Magnets Geometry (According to Standard Physical Chart)

Z = Thickness of the Magnet Coating

L = Length of the Block

W = Width of the Block

D = Thickness of the Block

$$B = \frac{Br}{\pi}\left\{\left[arctan\frac{LW}{2z\sqrt{4z^2+L^2+W^2}}\right]-\left[arctan\frac{LW}{2(D+z)\sqrt{4(D+z)^2+L^2+W^2}}\right]\right\}$$

B = Tesla

Tesla is the magnetic strength measuring unit of magnet which repels the Pendulum bob.

Rotational Speed of the Pulley

Pendulum oscillation = 60 osc./min. = 1/sec

Pulley @ diameter 17inches = Equal to the oscillation of 60 rpm

Pulley @ diameter 1.5inches (Dynamo)

Sample computation of the circumference of 17 and 1.5 inches of the pulley = C=2πr

Formula of rotational speed @ diameter 1.5 inches Pulley = Ø 1.5" rpm C of Ø17" Pulley C of Ø1.5" Pulley x 60

Formula to Compute the Electrical Generation of Pendulum Driven Electric Generator

Where:

m = Mass of the Pendulum Bob

g = 9.8 m/s (Acceleration due to gravity)

L = Length of the Pendulum

D = Distance of the Pendulum Oscillation

Θ = Angle between Center position of oscillation

Force Produce by the Pendulum

Where:

F = mg sinθ

Torque Produce by the Pendulum

Where:

Tq = FxD

Time period of the Pendulum

Where:

T = 2πLg

Electrical Power Produce by the Pendulum Driven Electric Generator

Where:

P = Tϱ×2πN60

The sets of formula is generated are used in terms of operation of the Pendulum Driven Electric Generator. The capability of magnetic strength, rotational speed of the pulley, force produce by the pendulum, torque produce by the pendulum, time

period of the pendulum and the electrical power produce by the electric generator all of these are of the unit.

Table 4. *Voltage Capacity of Pendulum Driven Electric Generator*

Percentage Level of the Battery Charged (%)	*Battery charged in Volts (V)*	*Battery charged in Current (I)*	*Battery charged in Watts (W)*
20	11.8	153.25	1808.35
40	12.2	158.44	1932.97
60	12.7	164.93	2094.61
80	13.2	171.43	2262.88
100	13.9	180.52	2509.23

Table 4 shows are the measurements of battery life capacity of the Pendulum Driven Electric Generator to sustain the charging process of an electronic gadget and to light-up the number of LED bulb in specific time required of the unit.

Table 5. *Daily Electric Generation of Pendulum Driven Electric Generator*

Battery Charging Time (Min)	*Average Voltage Generated (V)*	*Current Generated (I)*	*Watts Generated (W)*	*Total Daily Electric Generation (W)*
60	14	0.6	8.4	201.6

The table 5 shows are the measured time and daily electric generation of charging during the oscillation of the Pendulum Driven Electric Generator. The time of electric generation storing the battery bank were collected and identify in daily set of pendulum oscillation activity.

Table 6. *Charging time of Pendulum Electric Generator*

Charging Indicator of storage battery (%)	*Time of charging (Hours)*	*Battery life status in Volts (V)*	*Battery life status in Watts (W)*
20	36 min, 23s	11.8	1808.35
40	3hrs, 013min	12.2	1932.97
60	3h, 51min, 28s	12.7	2094.61
80	1h, 04min, 05s	13.2	2262.88
100	1h, 47min, 30s	13.9	2509.23
Total	10hrs, 53min, 30s		Battery full

Table above are typically used to specify a battery's expected life of the Pendulum Driven Electric Generator, as the number of charge cycles affects life more than the mere passage of time.

Table 7. *Individual Charging Time Consumed with respect to the number of bulbs and electronic gadgets*

LED Bulb and Electronic Gadgets	*Charging Time Consumed (Hrs.)*	*Total Electric Power Consumed (Watts)*	*Remaining Battery Life (Watts)*	*Capacity of Battery Life (Watts)*
3pcs LED bulb (15w)	8	120		2,389.23
Laptop (64.98w)	2	129.96	2,346.78	2,509.23
Cellphone (10w)	2	20		2,489.23

Table 7 are the expression of the Total electric power consumed and charging time consumed of the Pendulum Driven Electric Generator with respect to the number of bulbs and electronic gadgets. When the battery bank is in the state of being full charge the electronic gadget and LED bulb allows to charge up in utilize the electric generation storing the battery with respect to the required or allotted time of the unit.

Computation of the Overall Efficiency of the Pendulum Driven Electric Generator

To get the efficiency of the Pendulum Driven Electric Generator, the computed Total Energy Consumed is the input and computed Remaining Battery Life is the output of the Pendulum Driven Electric Generator. The efficiency of the Pendulum Driven Electric Generator is represented with the use of formula (TEC / TPC) x 100%,

TEC = Total Energy Consumption

TPC = Total Power Charging

where:

Table 8. *Efficiency of charging by the Pendulum Driven Electric Generator with respect to the number of bulb and electronic Gadgets*

LED Bulb and	*Charging Time*	*Total Energy*	*Total Energy*	*Efficiency of the*

Electronic Gadgets	*Elapsed (Hrs.)*	*Charging (INPUT Watts)*	*Consumption (OUTPUT Watts)*	*Pendulum Driven Electric Generator (%)*
Cellphone (10w)	2	201.6	20	9.92
Laptop (64.98w)	2	201.6	149.96	74.38
3pcs LED bulb (15w)	8	201.6	120	59.52

Project Capabilities and Limitations

Pendulum Driven Electric Generator is an alternative power converter that transform the gravitational energy into electricity. The generator is a movable machine that can be set in a safe place at home. It can used only as an alternative indoor lighting source and charge-up the battery of notebooks, laptop, and any electronics gadget with the presence of Universal Serial Bus in specific time required.

Since the unit is design as a back-up source of electricity were it use only a small 12VDC permanent generator. It provides a limited amount of electric generation to charge-up the battery bank in a certain period of time. Compared to the other generators are designed in a wide range of application it produce the bulk amount of electrical generation needs. Therefore, the usage of Pendulum Driven Electric Generator execute to generate electricity in a limited range of application to the respective number of electronic gadgets required.

Project Evaluation Results

The evaluation on the performance of the developed prototype is based on the six (6) criteria included in the Technological University of the Philippines formulated evaluation instrument, namely: functionality, aesthetic, workability, durability, economy and safety.

Results of the evaluation conducted showed that end-user and the expert were the highly satisfied with the outcome of the project with an overall mean of 4.52. Safety aspect has the highest rating since the machine does not need any hazardous forms of fuels in generating electricity unlike other the electric generating machine that burns fuels and produces smokes that may affect the environment. Table 9 share the summary of the evaluation conducted.

Table 9. *Summary of Project Evaluation Results*

Criteria	*Mean*	*Descriptive Rating*
Functionality	4.56	Excellent/Highly Acceptable
Aesthetic	4.49	Very Good/Very Acceptable
Workability	4.44	Very Good/Very Acceptable
Durability	4.48	Very Good/Very Acceptable
Economy	4.48	Very Good/Very Acceptable
Safety	4.68	Excellent/Highly Acceptable
Overall Mean	4.52	Excellent/Highly Acceptable

Functionality, the evaluators presented a descriptive rating of Excellent/Highly Acceptable with a mean rating of 4.56. This means that the prototype was easy to use in generating electricity.

On Aesthetics, the evaluators presented a descriptive rating of Very Good/Very Acceptable with a mean rating of 4.49. Shows that the weight and shape of the unit was designed to be light and appropriate enough to place in at home.

On Workability, the evaluators presented a descriptive rating of Very Good/Very Acceptable with the mean rating of 4.44. Workability have the lowest rating to considerate in developing the prototype this will need a highly technical skills and suitable machineries in order to provide a Pendulum Driven Electric Generator.

On Durability, the evaluators provided a descriptive rating of Very Good/Very Acceptable with the mean of 4.48. The evaluators determined that the device was strong enough to withstand during oscillation process.

On Economy, the evaluators gave a descriptive rating of Very Good/Very Acceptable with the mean rating of 4.48. Since the materials and supplies used in the unit can be found in the local market and can easily replace.

On Safety, the evaluators gave a descriptive rating of Excellent/Highly Acceptable with the mean rating of 4.68. Safety feature has the highest rating since the machine is the safest human to harm and the environment in producing electricity. The prototype does not need any hazardous process in generating electricity.

IV. CONCLUSIONS

The following are the conclusions attained based on the findings and evaluations conducted in the study.

The Pendulum Driven Electric Generator was successfully designed and developed to generate 201.6 watts in daily electric generation to light-up LED bulb and charge electronics gadgets.

The prototype can supply an 8.4 watts electrical output per hour.

The prototype is a great help to the end users to serve as an alternative indoor lighting and charging any electronic gadgets.

The Pendulum Driven Electric Generator got a mean of 4.52 with the descriptive rating of Excellent/Highly Acceptable.

The prototype attested that the gravity force is a medium in converting electrical energy.

Based on the findings and conclusions achieved in this study, the following are recommended to improve the Pendulum Driven Electric Generator:

The researcher scale-up the Pendulum Driven Electric Generator to generate a larger amount of electric current.

Install additional instrument/gauge for data gathering and monitoring.

Future researchers encourage to further enhance the capability and capacity of study.

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