A Hydroelectric Energy Generator Model with A Monitoring System to Generate Electricity in Sapang Payong, Hermosa Bataan

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Abstract— In recent years, electricity use in residential and commercial settings has grown in popularity. As a result of the rapidly increasing demand, some regions, particularly those located in more remote areas, do not have a supply of energy. Hydroelectricity, a dependable renewable resource and one of the options, can help to partially meet the ever-increasing demand for power. This model of hydroelectric generator will produce hydropower. The power needed to light a home is produced by converting the kinetic energy of running water into electrical energy. Hydroelectric power can take advantage of the renewable resource that is present in moving water and convert it into usable electricity by routing the water through an Archimedes turbine, which transforms the kinetic energy of the running water into mechanical energy. After that, the generator takes the mechanical energy and converts it into electrical energy. The flow rate and the RPM must be taken into account in order to select the generator that is best for a given application (RPM). A monitoring system is used to keep track of the turbine speed, output voltage, and current of the generator. The proximity, current, and voltage sensors will all send data to the Arduino, which will then process it and output the results for LCD display.

Indexed Terms— Hydroelectric Energy generator, Hermosa Bataan, Monitoring system, Renewable energy, turbine.

I. INTRODUCTION

In the entire nation, electricity was primarily used for space conditioning, cooking, lighting, and recreation. The average amount of electricity used in the Philippines per year in 2020 was 897 kilowatt hours, slightly less than in 2019. Electricity was the most frequently used source of light in every area. The NCR has the greatest proportion of households utilizing electricity for lighting, at 97.3 percent. Region III (93.4%), Region IVA (92.8%), Region I (91.8%), Region II (84.1%), and CAR (84.1%) came in second and third, respectively. Given this, it is crucial to have a backup energy source, such as renewable energy, especially for people who live in remote areas and don't have access to electricity, such as indigenous people.

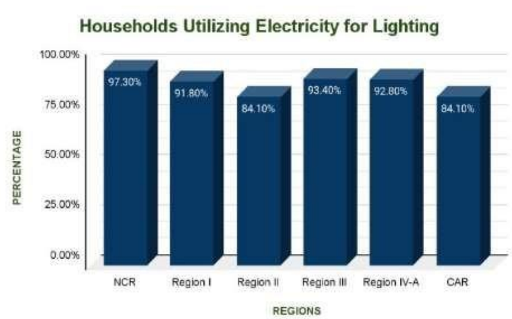

Figure 1. Household utilizing electricity for Lighting as of 2020

Providing people with dependable power is challenging, particularly in rural areas. Reliable energy supplies are a constant challenge for people trying to lead normal lives and build a strong community economy. Nearly one-third of Filipinos are either without power or frequently experience brownouts. The country continues to experience energy instability despite having more access to power. The government relies heavily on coal power and extensive transmission lines to meet the country's rising energy needs; as a result, rural areas struggle to keep up with urban areas in terms of access to electricity. As a result of this strategy, power prices have gone up, there are now larger energy distribution gaps between urban and rural areas, and the system is less reliable.

The Philippines, which is endowed with abundant renewable energy resources such as geothermal (heat from the earth), biomass (energy from plants), solar, wind, and hydropower (water flowing), has made significant progress in utilizing these resources. For example, it is currently the second-largest geothermal power producer in the world. Although it has an abundant supply of water, a water catastrophe is about to occur. There are 216 lakes, 22 significant marshes, swamps, and reservoirs, making up the majority of the country's 421 principal river basins' 421 principal river basins' total potential for water resources. The researchers can use this information to consider using hydroelectric energy, also known as water energy, as a source of energy. R. Sultan claims that. Using the earth's water cycle to its advantage, hydroelectric power produces electricity, according to I. Yuksel et. al. (2009). Where the water from the earth's surface evaporates, condenses into clouds, returns to earth, and then flows into the ocean. According to the United States, hydroelectric power has the following advantages. Unlike power plants that burn fossil fuels, hydropower does not pollute the environment, according to the Department of Energy. It also produces its own energy rather than relying on outside sources. Hydropower also provides clean water, assistance with irrigation, and flood mitigation in addition to producing energy. Public access to the reservoir is made possible thanks to some hydropower, which benefits the populace.

When the river's water level is at its lowest, the distance between the river and the ground floor of the house is 1 meter. For our prospective location where the project will be implemented, the river in Sapang Payong Bataan has a higher elevation compared to the household. According to the respondents, the barrier separating the river and the households has an estimated width of 3 meters. A higher elevation of water has more potential energy to produce electricity, which is converted into rotational motion turbines as the water falls and spins the turbine blades, according to Calgary's energy education (2021). There is a lot of uncertainty surrounding every project. In this work, a methodology for tracking the installation of the hydroelectric projects' systems is developed, enabling regular measurement of physical progress metrics. Finding goals and objectives for a project can be challenging due to its complexity, which could have an impact on its duration, cost, and quality. The project's goal is to develop more features for system monitoring that can be used with our prototype. The creation of a high reliability prototype is another goal of researchers working on the advancement of electronic technology. The entire monitoring system is controlled by electronic components like sensors, which transmit input signals to a microcontroller that has been programmed by an Arduino. A microcontroller that provides the entire circuitry with a control signal. Numerous sensors that are programmed in the system control the monitoring of the prototype.

The researchers want to build all of these embedded monitoring systems. By having a water reservoir, a gate or valve to regulate how much water comes out, and an exit or area where the water flows after flowing downward, it also improved our mechanical skills. Causing the flow of water to generate energy as it flows downhill or over an embankment. To turn turbine blades and produce electricity, water can be used. The objective is to create a hydroelectric energy system that can generate power and transport it to areas without access to other sources of energy while operating in continuous water.

II. RELATED LITERATURE AND STUDIES

This chapter provides a short overview that includes the concepts of finished research and generalization. Those included in this part will help the researchers to familiarize that the study is relevant and well-presented to our aims. The information contained in this paper is primarily based on studies and literature relating to this study.

According to Wolfram, et al. (2012) and M. Kanagawa et al (2008). Electricity plays an important role in a developing world, hence the advancement of it affects the rapid growth of energy consumption. Due to household incomes, the development of technology which result in using more appliances, and urbanization. as stated on the 2011 Household Energy Consumption Survey (HECS), About 87% of 21 million Filipino household use electricity from the, and it is the most commonly used source of energy along with at least one-third of those household other source like kerosene, fuelwood, charcoal, and LPG. And because of the global implementation of lockdown measures, the demand for electricity in commercial and industrial operations has decreased, while the demand for residential electricity has risen since most people spend their time at home working, doing various activities, and even attending classes [IEA, 2020]. Electricity matter household-level evidence from the Philippines (Pepino, V. M. et al, 2021) the researchers discover that having stable power has a beneficial effect on the income levels of Filipino households. They discover the critical nature of not just providing and growing access to energy, but also supplying households with high-quality and reliable electricity, particularly in neglected rural communities. 20% of Filipino households are not yet linked to the grid, while a further 20% have degraded electricity quality. However, boosting the quality of power alone may not be enough to increase the welfare of low-income populations unless their living conditions are improved as well. These enhancements must be made within the context of a broader infrastructure and rural development strategy, as well as an efficient regulatory environment. Their findings have major policy implications for decision makers weighing the relative merits of various infrastructure initiatives. Subsequently, investment decisions regarding the distribution of power to remaining impoverished areas have global and local implications in terms of potential environmental externalities. Benefitcost analysis should consider at least three alternatives, as described in Ravago and Roumasset (2018): new substations and associated distribution networks along major transmission grids; extending and expanding existing off-grid distribution networks; and providing standalone (e.g. solar) facilities and very small, multi-household networks, including the option of charging stations for rechargeable batteries. Alternative 1 may imply a continued reliance on fossil-fuel-based power, which results in harmful greenhouse gas emissions. Due to the comparatively low quality of power generated it may deliver fewer benefits to households.

C. Zafirah, et al (2016), stated that to determine the potential specifications and ideal architecture for an Archimedes Screw Turbine that may generate the most efficiency. The researchers experimented with two design parameters: the number of helix turns and the turbine blades. Furthermore, to simulate the optimal turbine design based on these two factors, computational fluid dynamics (CFD) methods with constant boundary conditions such as steady state flow condition, isentropic flow, and isothermal temperature were used. As a conclusion, they find that reducing the number of helix turns will improve turbine efficiency, with the maximum numerical turbine efficiency of 81 % with 2 helix turns and 2 blades.

K. Shahverdia, et al (2019), stated that the performance of the Archimedes screw is presented as a function of screw length, flight number, and inclination angle. The best screw, with the highest efficiency, was a screw with a 20-degree inclination angle, with a 90.83 percent efficiency. Muhammad I.M, et al (2019), stated that, in direct measurements without a gear system, the output power of an

Archimedes screw turbine is low. Furthermore, to optimize the torque generated by the Archimedes screw turbine, a turbine gearbox system must be added to convert torque to speed and produce high output power.

Archimedes screw turbine has become more attractive for lower head sites, as its heads can be set as low as 1 m, moreover especially suited to sites with large flows. Sara et al (2021), stated that Archimedes turbines can run efficiently at low head and high range discharge. This can be used in places without access to the national grid. Elbatran, A.H. et al (2015), Western renewable energy and Industries have developed the Archimedean screw as a relatively novel method to generate electrical energy from a low-head source.

The highly efficient Archimedean screw can generate electricity all year round 24 h/day, whilst maintaining the natural flow of the river; in fact, being one of a few systems that can maintain or even improve the wildlife in and around the river. Stergiopoulou et al. (2011) presented a series of modern Archimedean low head hydropower turbine plants and proved that Archimedean screw is an excellent alternative solution for a clean environment and sustainable development. Raza et al. (2013), proposed an analytical prototype of low head Archimedes screw, where they found that the screw efficiency depended basically on the flow rate and the inclination angle. They also found that water capacity increased and efficiency decreased with few inclined angles and vice versa, while the maximum model efficiency recorded was 86%.

An electric generator is a device that converts mechanical energy from an external source to electrical energy. Kumar, K. (2019), A dynamo is a type of generator that produces electricity. By utilizing a commutator, this dynamo generates direct current Dynamos were the first industrial-scale generators. The dynamo converts mechanical rotation into pulsating direct current through the use of revolving wire coils and magnetic fields. A dynamo machine consists of a fixed structure known as the stator that generates a constant magnetic field and a collection of spinning windings known as the armature that rotate within that field.

In the locale, the vertical height measured between the hydro intake water level and the water level at the point of release is the head. A permanent magnet generator is appropriate to use. Aldiansyah, A. (2021), with the potential of low water head energy and relatively small water discharge, it takes a quiet round generator to be applied to the possibility of existing energy. The development of a Permanent Magnet Generator (PMG), being an alternative considering the pole construction of the rotor, is relatively simple compared to conventional generators, so it technically requires more number of rotor poles in the effort to lower the speed of the nominal dial generator, for a permanent magnet generator used its own reinforcement system. This reinforcement system is used in brushless alternator generators and a relatively easy maintenance system that could potentially be applied to micro- hydropower plant low head.

Mishra, R. S. (2014), PMG evaluation is based on maximum power extraction and energy conversion efficiency normalized by system cost through a more straightforward electro-mechanical design for the hydrokinetic system. Experimental results have demonstrated that the proposed prototype possesses higher efficiency with reduced energy losses and manufacturing costs. It represents cost-competitive alternative energy for power supply for civilian applications in remote areas or an option for expeditionary applications. Permanent magnet generators enhanced system performance by improving several parameters: minimum maintenance, no heat problems inside the bobbins, double the power production at lower RPM, and improved electricity production cost compared to using the radial generator, which needs more excellent rotational rates.

Fekri, H et al. (2019) stated three phase permanent magnet generator design is easy to construct and maintain. One of the main features of this machine is putting the magnets on the surface, which makes the construction of the machine easier. The overlapped three-phase winding improves the quality of voltages and power of the machine. Ion, Catalin & Marinescu, Corneliu. (2013) stated that an active area of study is being done on the utilization of three-phase induction generators for the source of power in non-conventional energy systems. A three-phase induction machine that possesses an appropriate balancing circuit is an alternative that can be relied upon.

The researchers monitor the generator's output with current, voltage and proximity sensors and use the data to improve the prototype. According to Mnati et al., (2017), the voltage sensor circuit is designed to detect a maximum alternating current voltage of less than 250 VAC using the components shown in Figure 1. The voltage sensing circuit that they used in the study is shown in Figure 2 illustrates a differential attenuator following a 230 VACrms with a tolerance of less than 5 VACpp. The circuit's output waveform (5 VAC) is offset by DC voltage (about 2.5 V), and the amplitude can be adjusted via a potentiometer up to 5 V. The circuit's output is connected directly to the Arduino microcontroller’s ADC pin.

III. MATHEMATICAL MODEL

To begin the project's design, you will need the parts and components listed below.

COMPONENT	DESCRIPTION	BASE QTY
Turbine System	The system consists of Archimedes turbine, piping	1
	system and gearing system to run the whole function of the prototype	
3-Phase Generator	Produces three AC waves every cycle, ensuring constant voltage per one cycle	1
Firefly Bulb 5W	Serve as the output	2
PCB Board	it is a non conductive material in which the traces connects the electronic components on the board to form a circuit.	1
Arduino Uno	Programmable device used to input the source codes that will run the monitoring	1
Proximity Sensor	uses to measure the distance the shaft and the support bearing of the turbine.	1
Current sensor	uses to measure the current of the generator.	1
Voltage Sensor	uses to measure voltage of the generator.	1
Submersible Pump (rental fee)	It operates by pushing water toward the top to produce an infinite cycle.	2
Gear system set	used in a water turbine to boost a low-speed turbine shaft's rotational speed.	1
2-lines X 16-characters LCD display	Serve as the output display for monitoring	1
Electronics parts set (Resistor, capacitor, diode)	Used to build the whole monitoring system	17
LM317 IC	Adjustable three-terminal positive-voltage regulator that can produce 1.25 V to 37 V.	1

Table 1: Material Requirements

Flowchart of the Research Design/Process Flowchart

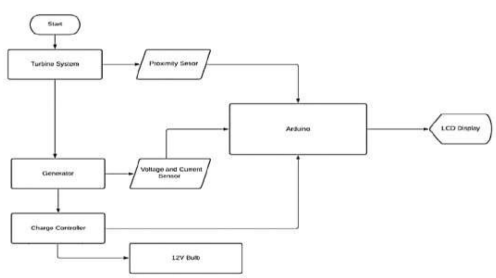

Figure 2. Research Design Flowchart

Height of the river (low tide) from the ground floor of the household 1.5 m within the turbine system, a pipe connects to the source of water and turns the Archimedes screw turbine, which is connected to a proximity sensor that measures the turbine's revolutions per minute (RPM). The gearbox was then used to convert the Archimedes turbine's torque to speed in order to achieve a high-power output. The permanent magnet generator's output will be routed through a charge controller to power two 12volt bulbs. For data collection, the Generator is connected to a voltage and current sensor. Finally, the Arduino processes the data collected from the sensors, including the proximity, voltage, and current sensors, and outputs it to an LCD.

According to residents of Sapang Payong, Hermosa, Bataan, there is no electricity in their neighborhood. The main source of electricity that they employed is a battery that can light two bulbs and a port. And these batteries have a battery life of up to 12 hours.

Furthermore, the river is 3 meters higher than the household. The river's width varies between 25 and 30 meters, with a depth of 6 meters at high tide and 4 meters at low tide. Furthermore, practically all of the residences have the same layout, with the height of the water from the river at low tide being 1.5 meter higher than the ground floor of the households. The water flows to a reservoir known as "Lobo-Lobo," which is commonly used to control the water from the fishpond. This reservoir has a length of 30 meters, a width of 35 meters, and a depth of 5 meters, and it is utilized by almost all of the fishpond

Width	25-30 m
Depth (high tide)	6 m
Depth (low tide)	4 m
Height of the river (low tide) from the ground floor of the household	1.5 m

Table 2: Parameter of the River

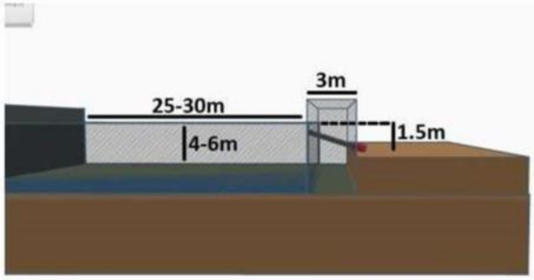

Figure 3: Parameters of the River

The parameters of the river are drawn using the data obtained from the interview. The river's length is 25-30 meters, its depth is 6 meters (high tide) and 4 meters (low tide), the distance between the river and the home is 3 meters, and the height of the river when low tide from the household is 1.5 m.

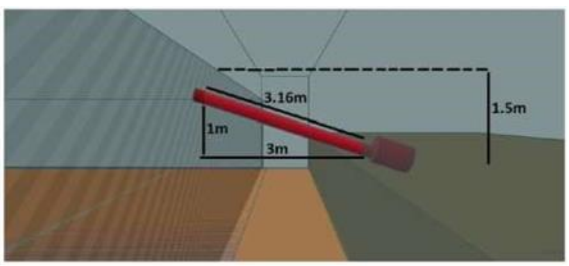

Figure 4: Height difference of the river (low tide) from the ground floor of the household

Since the height difference between the river at low tide and the ground floor of the house is 1.5 m, the researchers made the height difference between the pipe's inlet and the ground floor 1 m, ensuring that water flows constantly from the pipe.

Pipe's Diameter	0.0762 m
Length of the Pipe	3.16 m
Head	1.5 m
Angle	18 º
Height of inlet from the ground	1 m
Width of the barrier	3 m

Table 3: Parameter of the Prototype

The researchers used the parameters of the river from the height of the pipe inlet, width of the barrier, the height difference of the water from the river when low tide from the ground floor of the household, and the length of the pipe to have the same flow rate when the study places on the locale.

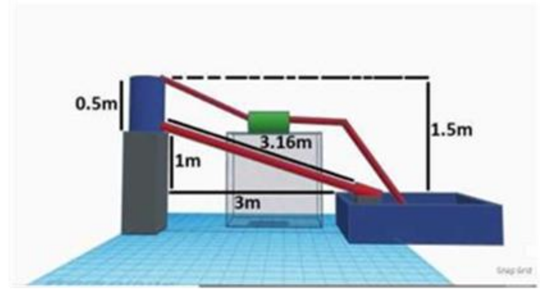

Figure 5: Parameters of the prototype

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IV. Formulas to determine the gravitational flow rate of the pipe:

Gravitational Flow Rate

In the field of water resources, the Manning equation is a commonly used formula. It can be used to calculate flow in an open channel; some examples of this are streams, rivers, and man-made open channels such as pipes. Moreover, it is also used to calculate friction losses in a channel, calculate pipe capacity, test the performance of an area-velocity flow meter, and many more.

1. Flow rate due to gravity

$Q = AV$

Where:

A=cross-sectional area of flow perpendicular to the flow direction

V= cross-sectional average velocity of the flow

Cross-section Area of the Pipe 1.1

$$A = \frac{\pi}{4} D^2$$

Where D = diameter of the pipe

Cross-sectional Average Velocity 1.2

$$V = \frac{k}{n} \mathrm{Rh}^{\frac{2}{3}} S^{\frac{1}{2}}$$

Where:

V=Hydraulic Radius

S= bottom slope

k= conversion constant (SI units or U.S. customary units)

n= Manning Roughness Coefficient.

1.1.1 Manning's roughness coefficient (n) depends on the materials used. The value selection can greatly affect the computational result, so it is often chosen from a table of set constants. With the prototype, we use Polyvinyl Chloride with Manning's Roughness value of 0.009 - 0.011.

n=0.009-0.11

Surface Material	Manning's Roughness Coefficient - n -
Asbestos cement	0.011
Asphalt	0.016
Brass	0.011
Brick and cement mortar sewers	0.015
Canvas	0.012
Cast or Ductile iron, new	0.012
Clay tile	0.014
Concrete – steel forms	0.011
Concrete (Cement) - finished	0.012
Concrete – wooden forms	0.015
Concrete - centrifugally spun	0.013
Copper	0.011
Corrugated metal	0.022
Earth, smooth	0.018
Earth channel - clean	0.022
Earth channel - gravelly	0.025
Earth channel - weedy	0.030
Earth channel – stony, cobbles	0.035
Floodplains – pasture, farmland	0.035
Floodplains - light brush	0.050
Floodplains - heavy brush	0.075
Floodplains - trees	0.15
Galvanized iron	0.016
Glass	0.010
Gravel, firm	0.023
Lead	0.011
Masonry	0.025
Metal - corrugated	0.022
Natural streams - clean and straight	0.030
Natural streams - major rivers	0.035
Natural streams – sluggish with	0.040
Natural streams, very poor condition	0.060
Plastic	0.009
Polyethylene PE – Smooth with smooth inner walls	0.009 – 0.015
Polyethylene PE – Corrugated with smooth inner walls	0.018 – 0.025
Polyvinyl Chloride PVC –with smooth inner walls	0.009 – 0.011
Rubble Masonry	0.017 – 0.022
Steel – Coal-tar enamel	0.010
Steel - smooth	0.012
Steel – New unlined	0.011
Steel - Riveted	0.019
Vitrified clay sewer pipe	0.013 – 0.015
Wood - planed	0.012
Wood stave pipe, small diameter	0.013
Wood stave pipe, large diameter	0.12 – 0.013

Table 4: Surface Material Values as a Relation of Manning Roughness Coefficient

1.1.2 Hydraulic Radius

$$R_{\mathrm{h}} = \frac{A}{P}$$

Where:
P = perimeter of the cross-section (Length of the Pipe)

1.1.3 Bottom Slope

$$R_{\mathrm{h}} = \frac{A}{P}$$

By using the algebraic formula slope=rise divided by run, by picturing the pipe as being a line on an x-y grid.
Where:
Δy = change in the vertical distance
Δx= change in horizontal distance
Computations to determine the gravitational flow rate of the pipe

1.2 Cross-section Area of the Pipe

A=D2
A=(0.0762)2
A=0.00766m2

(2)

1.2.1 Hydraulic Radius

The Value of A can be found at equation (2)

$$R_h = \frac{A}{P}$$

$$R_h = \frac{0.00766m^2}{3.16m^2}$$

$$R_h = 0.00242m$$

(3)

1.2.2 Bottom Slope

$$V = \frac{k}{n} R_h^{\frac{2}{3}} S^{\frac{1}{2}}$$

$$V = \frac{1}{0.009} (0.00242m)^{\frac{2}{3}} (0.333m)^{\frac{1}{2}}$$

$V = 1.16m/s$

(5)

1. Calculate the volumetric flow rate using the value of A at equation (2) and V at equation (5)

Q = AV

Q = (0.00766m2) (1.16m/s)

Q =0.00885 m3/s

Q =8.85 l/s

(6)

Note: That the parameters of the piping systems of the locale and the prototype are the same

Width	25-30 m
Depth (high tide)	6 m
Depth (low tide)	4 m
Height of the river (low tide) from the ground floor of the household	1 m

Table 5: Parameters of the River

2. Hydroelectric Power Equation

The potential energy of water is used to calculate a river's power output, which can be identified using the hydropower formula.

Ph = ρ .g . h .Q Where:

Ph = Hydraulic power (W)

ρ = density of water (998 kg/m³)

g = acceleration of gravity, (9.81 m/s²)

h = head or the usable fall height

Q = flow rate

Ph = ρ .g . h .Q

Ph = (998 kg/m³)) (9.81m/s) (1.5 m) (0.00885m3/s)

Ph = 130 W

(7)

3. Formula for Archimedes Turbine Dimension/ Drive System Dimension

3.1 Radius of the central tube

Rin = ρ. Rout Where:

Rin = inner radius

Rout = outer radius

ρ = radius ratio

Number of Blades	Radius Ratio	Volume per Turn Ratio
2	0.5369	0.0512
3	0.5357	0.0588
4	0.5353	0.0655
5	0.5352	0.0696

Table 6: Ratio parameters of Archimedes screw for various numbers of blades

3.2.1 Archimedes Turbine Efficiency

$$\eta = \frac{2a + 1}{2a + 2}$$

$$a = \frac{R_{out}}{\delta h}$$

$$\delta h = \frac{H}{N}$$

Where:

H = head (drop head)

N = number of the blades

3.2.2 Volume moved per revolution

$$Vu = \frac{2\pi^2 Rout^2}{\tan\theta} . (\lambda . \nu)$$

Where:

Vu= Volume moved per revolution

θ = is the angle of the turbine

(λ . ν) = Volume per turn ratio

3.2.3 Speed

$$n = 60\frac{Q}{Vu}$$

3.2.4 Formula for the mechanical shaft power

Pm = η . Ph

Pm = mechanical shaft power
η = efficiency of the turbine
Ph = hydraulic power

3.2.5 Formula of the torque screw

$$M = \frac{P_m\,60}{2\pi\,.\,n}$$

Ph = mechanical shaft power
M = torque of the screw
n = rpm

3.4 Gear Ratio

$$GR = \frac{D_1}{D_2} = \frac{n_1}{n_2} = \frac{d_1}{d_2}$$

Where:
GR= gear ratio
D1 = number of driver teeth
D2 = number driven teeth
n1 = speed of the first gear
n2 = speed of the second gear
d1 = torque of the first gear
d2 = torque of the second gear

3.4.1 Calculation for the radius of the central tube using the value of pitch ratio at table 5 and Rout is equal to 0.12 m

Rin = ρ. Rout
Rin = 0.5369. 0.12m
Rin = 0.064 m
(8)

3.4.2 Calculation for the efficiency of the turbine.

$$\eta = \frac{2a + 1}{2a + 2}$$

$$a = \frac{0.1}{0.75} = 0.133333$$

$$\delta h = \frac{1.5}{2} = 0.75$$

$$\eta = \frac{(2)(\frac{0.1}{0.75}) + 1}{(2)\frac{0.1}{0.75} + 2}$$

η = 0.5588 *or* 55.88%
(9)

3.4.3 Computation for the volume moved per revolution using the value of Rout and having the angle of the turbine at 20º, and the volume per turn ratio can be seen at table 5.

Vu = (λ . ν)
Vu = λ . (0.0512)
Vu = 0.00651 m²
(10)

3.4.4 Computation for the speed of the turbine utilizing the value flow rate at equation (6) and the value of volume moved per revolution at equation (10).

n = 60 n = 81.63 rpm
(11)

3.4.5 Computation for the mechanical shaft power using the value of η at equation (9) and *Ph* at equation (7).

Pm = η . Ph
Pm = 0.5588 x 130W
Pm = 72.644W
(12)

3.4.6 Computation for the value of torque screw using the value of at equation (12) and n at equation (11).

$$M = \frac{P_m\,60}{2\pi\,.\,n}$$

$$M = \frac{72.644W \times 60}{2 \times \pi \times 81.63}$$

M = 8.5 *Nm*
(13)

3.4.7 Calculation for gear ratio

$$GR = \frac{D_1}{D_2} = \frac{n_1}{n_2} = \frac{d_1}{d_2}$$

$$GR = \frac{6}{65}$$

GR = 0.09
(14)

Calculating the value of N2 using the value of at N1equation (11).

d2 = GR . d1
d2 = 0.09 x 8.5 Nm
d2 = 0.765 Nm
(16)

Note: That the average revolution per minute (rpm) of 500 and the torque is 0.5 NM are needed to drive the 8 watts.

Data Processing Procedure and Statistical Treatment
By supporting the goal of this study, a statistical method of the study to consider the relation of two statistical data, the RPM (Revolution per Minute) and Flowrate. Using the Correlational Analysis Statistical Approach. (Gogtay & Thatte, 2017) A correlation analysis yields a correlation coefficient with values ranging from -1 to 1. A correlation coefficient of +1 indicates that two variables are perfectly related in a positive linear manner, a correlation coefficient of -1 indicates that two variables are perfectly related in a negative linear manner, and a correlation coefficient of 0 indicates that there is no linear relationship between the two variables under consideration. There is a correlation between the water flow rate and the revolutions per minute taken into consideration when generating the entire system and producing outputs in the prototype. Data was gathered through a time testing responses.

The correlation coefficient's value determines the correlation data's strength:

No correlation - 0.
Weak correlation - 0.1- 0.39.
Moderate correlation - 0.4 - 0.69.
Strong correlation - 0.7 - 0.99.
Perfect correlation - 1.

Scatter plots are commonly used to illustrate the relationship between variables when providing correlation data. The degree of the correlation and the direction between the variables can be seen visually. A positive relationship is indicated when the data points are near the gradient line and have a positive gradient. The connection is negative if the slope is negative.

Using their time responses, considering the up and down flow of water in the prototype. The given data are presented in table.

Number of trials	FLOWRATE 1 (DOWN)	FLOWRATE 2 (UP)
1	8.2	8.4
2	8.4	8.5
3	8.6	8.6
4	8.5	8.8
5	8.8	8.8
6	8.9	8.9

Table 7: Actual testing of flow rate

$$\text{mean (flow rate 1)} = \frac{xi}{n} = \frac{51.4}{6} = 8.57\ L/s$$

$$\text{mean (flow rate 2)} = \frac{xi}{n} = \frac{51.52}{6} = 8.67\ L/s$$

$$\text{Average} = \frac{x}{2} = \frac{8.57 + 8.67}{2} = 8.62\ L/s$$

The strength of a correlation between quantitative variables is typically measured using a statistic called Pearson's Correlation Coefficient (or Pearson's r).

By getting the called Pearson's Correlation Coefficient (r), the two set of variables will considered as the array for the equation. Using the Excel function, correlation presented instantly.

Array 1 = Flow rate 1
Array 2 = Flow rate 2
y = corre(array1,array2) = = 0.67x + 2.927
R2 = 0.774
= √0.774
r = 0.879772698 (Strong correlation)

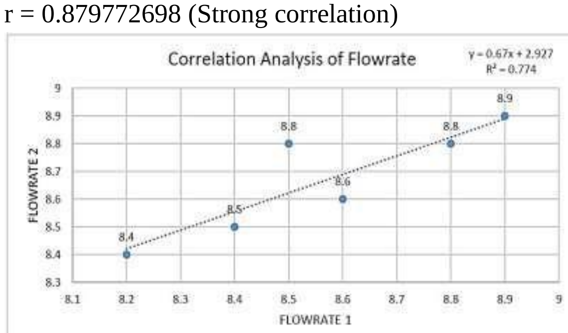

Figure 6: Correlation Analysis of Flow rate

A Scatter Plot showing the correlation between the two. It illustrates that the flow rate (down) and flow rate (up) had a Strong correlation.

Moreover, the correlational analysis between the relationship of flow rate downwards and revolution per minute in 6 trials will be considered.

Number of trials	FLOWRATE 1 (DOWN)	FLOWRATE 2 (UP)
1	58	8.84 W (58)
2	59	8.9 W
3	52	8.5 W
4	55	8.75 W
5	53	8.51 W
6	57	8.62 W

Table 8: Actual Testing of RPM and Two Load Input

Array 1 = Revolution per Minute
Array 2 = two bulbs
y = corre(array1,array2) = = 06.749x + 23.812
R2 = 0.7715
r= 0.87835 (Strong correlation)

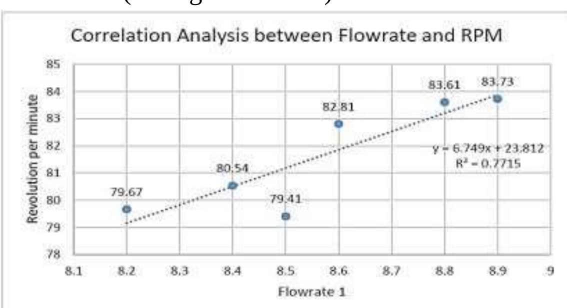

Figure 7: Correlation Analysis of the RPM and Two bulbs

Figure 7 shows the correlation analysis of the flowrate downwards and the revolution per minute it also have a strong correlation meaning that the RPM and the flow rate down can support the desired output.

Actual Power Consumption

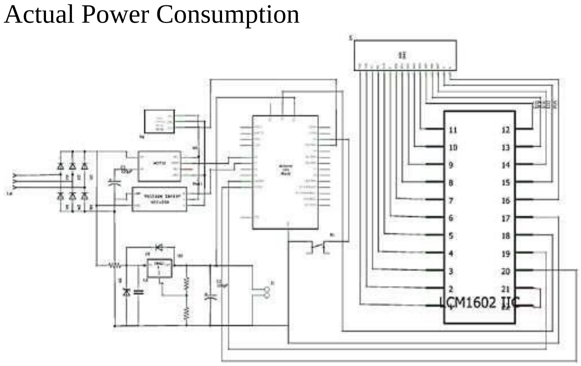

Figure 8: Schematic Diagram of Monitoring System

In order to get the actual power, add all the specifications of the materials used.

Bulb = 3 W
Current sensor =0.2 W
Voltage sensor = 0.1 W
Proximity sensor 0.15 W
Arduino = 0.2 W
LCD = 0.1
Actual Power = 6W + 0.2W + 0.1W + 0.15W + 0.2W +0.1 W
Actual power= 6.75 W

Note: The total consumption must be 80% of the total power input power input.

Power Input = (.2 x 6.75) + 6.75 = 8.1 WC

IV. RESULTS AND DISCUSSION

This section covers the discussion of the prototype created using the ideas covered in the most recent chapter as well as the findings regarding how the generation of energy using moving water can result in an output that is adequate to light a home.

Project Technical Description

A brief technical description of the project is made to understand further the workings of components integrated with the designs. In order to achieve an infinite flow of water from head to turbine, the submersible pump is important to create an infinite amount of water flowing from reservoir to turbine system. The process starts from the headwater of the reservoir with the height of 1m from inlet to ground, from head to turbine system connected of a PVC pipe with a diameter of 0.0762m and distance length of 3.16m. The flow rate of water from head to turbine is 8.63 liter per second, and the flow rate of the submersible pump from ground to head is 8.7 liter per second. A gearing system is located at the back of a turbine, the driver has 65 teeth, and the driven has 6 teeth with a gearing ratio of 10:1. As a result, one revolution of the driver is equal to 10 revolutions of a driver. With that, the rpm of the driver is multiplied by 10 in the driven. The permanent magnet generator, to achieve an 8 watts output, requires a 500 rpm with the load of two bulbs and a monitoring system. From the head to the turbine, the water flow rate is 8.63 liter per second, which can generate the turbine with the rpm of 58 in the driver. It can multiply it by ten from the driven. The rpm of the prototype with load is 580 revolution per minute.

It is sufficient to produce an 8 watts power output.

Parameter	Input	Output	RPM
Voltage	17.52 V	12 V	84
Current	0.3 A	0.2 A	
Power	5.1 W	2.5 W	

Table 9: Result of No Load

Parameter	**No Load**
Voltage	8 V
Current	0.08 A
Power	1.44 W
RPM	102

Table 10: Result of One Bulb

Parameter	**Input**	**Output**	**RPM**
Voltage	15.41 V	12 V	61
Current	0.57 A	0.49 A	
Power	8.78 W	5.88 W	

Table 11: Result of Two Bulb

According to the findings in table 9 entitled "results of no load," the charge controller and monitoring system are capable of generating a steady output power of 1.4 watts. As a result, table 11: Results for one bulb shows that it can generate an input power of 5.1 W and 2.4 W of output power. Table 12: Results for two bulbs show that it can generate an input power of 8.78 W and 5.88 W of output power. Furthermore, the constant output the the prototype generates is 12 V.

V. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusion

The goal of providing electricity to illuminate a home was achieved, according to the study's findings, and it can be inferred from the data collection and testing that the researchers carried out. The data shows that producing an infinite cycle of water can be possible through getting the mean of both flow rate in table 8: Actual testing of flow rate. The prototype creates an endless supply of water because the mean value of both flow rates was close to each other.

To make the relationship between the two easier to understand, the revolutions per minute (RPM) and two bulbs' input power must be displayed. The researchers use a method known as Pearson's Correlation Coefficient to determine the type of relationship that exists between the two. The correlational coefficient value of 0.878351 in Figure 11: Correlational Analysis of RPM and Two Bulbs Input indicates a positive strong correlation, indicating that the RPM and Two Bulbs Input Power had a relationship with each other. It can be seen that both the generator and the turbine are capable of producing the required output because the computation of the speed and torque of the generator is comparable to the computation of the speed and torque of the turbine, which was derived from the collected data. The researchers were also successful in lighting two bulbs during the testing. The LCD screen showed the input voltage and current required to successfully turn on those two bulbs.

The summary of the first objective is to utilize a submersible water pump and a water reservoir to have an infinite water cycle. We measure the flow rate when the turbine is flowing through the reservoir and back to the drum using a time trial in which it proves that the supply of water is infinite by getting the mean of both flow rates.

The findings of the second of objective is the Archimedes turbine drive the permanent magnet generator and produces 8 watts of electricity. From the data, in relation to the computation the speed and the torque of the turbine have a value in which the computed value is close to the computed value of the speed and torque of the of the generator.

The summary of the third objective is regulating the power in order to generate a constant output. The measured constant output is 12v.

Findings on the fourth objective is the monitoring system monitors the RPM of the turbine and the input voltage and current of the generator. As a result of this, the power output matches the required power to illuminate the bulb.

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